Land Information System (LIS)

LIS 7.8 Users Guide

Version 7.0, 5 Jun 2026

Table of Contents

1. Introduction . . . 1
   1.1. What's New . . . 1
2. Background . . . 3
   2.1. LIS . . . 3
   2.2. LIS core . . . 3
3. Preliminary Information . . . 5
   3.1. Commands . . . 5
   3.2. File names . . . 5
4. Obtaining the Source Code . . . 6
   4.1. Important Note Regarding File Systems . . . 6
   4.2. Release Source Code . . . 6
   4.3. master branch . . . 7
   4.4. Source files . . . 7
   4.5. Documentation . . . 8
5. Building the Executable . . . 9
   5.1. LISF Dependencies . . . 9
   5.2. Build Instructions . . . 9
6. Running the Executable . . . 23
   6.1. Command line arguments . . . 23
7. Testcases . . . 24
   7.1. Public tests . . . 24
   7.2. Internal tests . . . 24
8. Output Data Processing . . . 26
   8.1. Fortran binary output format . . . 27
   8.2. GRIB1 output format . . . 27
   8.3. NetCDF output format . . . 27
9. LIS config File . . . 28
   9.1. Overall driver options . . . 28
   9.2. Runtime options . . . 36
   9.3. Forecast runmode . . . 46
   9.4. Data assimilation . . . 47
   9.5. Bias estimation . . . 51
   9.6. Radiative Transfer/Forward Models . . . 85
   9.7. Optimization and Uncertainty Estimation . . . 88
   9.8. Parameters . . . 101
   9.9. Forcings . . . 110
   9.10. Supplemental forcings . . . 130
   9.11. Land surface models . . . 146

9.12. Sublevel land surface models . . . 199
9.13. Lake models . . . 201
9.14. Open water models . . . 202
9.15. Land slide models . . . 202
9.16. Irrigation . . . 204
9.17. Routing . . . 205
9.18. Runoff . . . 223
9.19. Model output configuration . . . 225
9.20. Defining a time interval . . . 227
10. Specification of Input Forcing Variables . . . 228
11. Model Output Specifications . . . 230
12. User Support . . . 240
12.1. Requesting Help . . . 240
12.2. Bug Reports . . . 240
Appendix A: Frequently Asked Questions . . . 242
Appendix B: LIS Binary File Convention . . . 243
B.1. Introduction . . . 243
B.2. Byte order . . . 243
B.3. Storage organization . . . 243
B.4. Missing/undefined values . . . 243
B.5. File name extension convention and access code samples . . . 243
Appendix C: LIS source tree . . . 245
Appendix D: What's New (continued) . . . 265
D.1. Version 7.5 . . . 265
D.2. Version 7.4 . . . 265
D.3. LIS 7.3 . . . 266
D.4. LIS 7.2 . . . 269
D.5. LIS 7.1 . . . 270
D.6. LIS 7.0 . . . 270
D.7. LIS 6.2 . . . 271
D.8. LIS 6.1 . . . 272
D.9. LIS 6.0 . . . 272
D.10. LIS 5.0 . . . 273
D.11. LIS 4.2 . . . 273
D.12. LIS 4.1 . . . 273
D.13. LIS 4.0.2 . . . 273
D.14. LIS 4.0 . . . 273
D.15. LIS 3.1 . . . 274
D.16. LIS 3.0 . . . 274
Appendix E: Revision history . . . 275
Appendix F: CSIRO Open Source Software License Agreement (variation of the BSD / MIT

License) 277
References 280

Chapter 1. Introduction

This is the Land Information System (LIS) User's Guide. This document describes how to download and install the code and data needed to run the LIS executable for LIS revision 7.8. It describes how to build and run the code, and finally this document also describes how to download output data-sets to use for validation.

This document consists of 12 sections, described as follows:

1. **Introduction**: the section you are currently reading.
2. **Background**: general information about the LIS project.
3. **Preliminary Information**: general information, steps, instructions, and definitions used throughout the rest of this document.
4. **Obtaining the Source Code**: the steps needed to download the source code.
5. **Building the Executable**: the steps needed to build the LIS executable.
6. **Running the Executable**: the steps needed to prepare and submit a run, also describes the various run-time configurations.
7. **Testcases**: describes the LIS test cases.
8. **Output Data Processing**: the steps needed to post-process generated output for visualization.
9. **LIS config File**: describes the user-configurable options.
10. **Specification of Input Forcing Variables**: describes the user-configurable input forcing variable options.
11. **Model Output Specifications**: describes the user-configurable output variable options.
12. **User Support**: describes how to request help from and provide feedback to the LISF development team.

1.1. What's New

1.1.1. Version 7.8

1. Includes new router
   - HyMAP3
2. Includes new crop model
   - AquaCrop v7.2
3. Includes additional surface models
   - SnowModel version April-2021 — for newer versions, contact Glen Liston: glen.liston@colostate.edu
4. Includes new runmodes
   - forecast runmode for NoahMP401 and Openwater
   - RAPID ensemble mode

- ParFlow coupling for Noah and NoahMP
- NoahMP groundwater coupling through NUOPC Cap

5. Supports additional metforcing datasets
    - Met Office Global and Regional Ensemble Prediction System - global ensemble (MOGREPS-G) forecasts
    - GALWEM radiation
    - IMERG V8
6. Supports additional data assmilation observation datasets
    - Snow and Ice Products (SNIP) analysis
    - SWOT water level observations
    - Weather Satellite Follow-on Microwave (WSF-M) soil moisture

Chapter 2. Background

This section provides some general information about the LIS project.

2.1. LIS

Land Information System (LIS) is a flexible land surface modeling and data assimilation framework developed with the goal to integrate satellite- and ground-based observational data products and advanced land surface modeling techniques to produce optimal fields of land surface states and fluxes. The LIS infrastructure provides the modeling tools to integrate these observations with model forecasts to generate improved estimates of land surface conditions such as soil moisture, evaporation, snow pack, and runoff, at 1km and finer spatial resolutions and at one-hour and finer temporal resolutions. The fine scale spatial modeling capability of LIS allows it take advantage of the EOS-era observations, such as MODIS leaf area index, snow cover, and surface temperature, at their full native resolution. LIS features a high performance and flexible design, provides infrastructure for data integration and assimilation, and operates on an ensemble of land surface models (LSM) for extension over user-specified regional or global domains. LIS is designed using advanced software engineering principles to enable reuse and community sharing of modeling tools, data resources, and assimilation algorithms. The system is designed as an object-oriented framework, with abstractions defined for customization and extension to different applications. These extensible interfaces allow the incorporation of new domains, LSMs, land surface parameters, meteorological inputs, data assimilation and optimization algorithms. The extensible nature of these interfaces and the component style specification of the system allow rapid prototyping and development of new applications. These features enable LIS to serve both as a Problem Solving Environment (PSE) for hydrologic research to enable accurate global water and energy cycle predictions, and as a Decision Support System (DSS) to generate useful information for application areas including disaster management, water resources management, agricultural management, numerical weather prediction, air quality and military mobility assessment.

LIS currently includes a comprehensive suite of subsystems to support uncoupled and coupled land data assimilation. A schematic of the LIS framework with the associated subsystems are shown in the Figure below. The LIS-LSM subsystem, which is the core of LIS, supports high performance, interoperable and portable land surface modeling with a suite of community land surface models and input data. Further, the LIS-LSM subsystem is designed to encapsulate the land surface component of an Earth System model. The LIS-WRF subsystem supports coupled land-atmosphere modeling through both one-way and two-way coupling to the WRF atmospheric model, leading to a hydrometeorological modeling capability that can be used to evaluate the impact of land surface processes on hydrologic prediction. The Data Assimilation (LIS-DA) subsystem supports multiple data assimilation algorithms that are focused on generating improved estimates of hydrologic model states. Finally, the Optimization (LIS-OPT) subsystem supports a suite of advanced optimization and uncertainty modeling tools in LIS.

2.2. LIS core

The central part of LIS software system is the LIS core that controls program execution. The LIS core is a model control and input/output system (consisting of a number of subroutines, modules written in Fortran 90 source code) that drives multiple offline one-dimensional LSMs. The one-

dimensional LSMs such as CLM and Noah, apply the governing equations of the physical processes of the soil-vegetation-snowpack medium. These land surface models aim to characterize the transfer of mass, energy, and momentum between a vegetated surface and the atmosphere. When there are multiple vegetation types inside a grid box, the grid box is further divided into “tiles”, with each tile representing a specific vegetation type within the grid box, in order to simulate sub-grid scale variability.

The execution of the LIS core starts with reading in the user specifications, including the modeling domain, spatial resolution, duration of the run, etc. Section Running the Executable describes the exhaustive list of parameters specified by the user. This is followed by the reading and computing of model parameters. The time loop begins and forcing data is read, time/space interpolation is computed and modified as necessary. Forcing data is used to specify the boundary conditions to the land surface model. The LIS core applies time/space interpolation to convert the forcing data to the appropriate resolution required by the model. The selected model is run for a vector of “tiles” and output and restart files are written at the specified output interval.

Some of the salient features provided by the LIS core include:

- Vegetation type-based “tile” or “patch” approach to simulate sub-grid scale variability.
- Makes use of various satellite and ground-based observational systems.
- Derives model parameters from existing topography, vegetation, and soil coverages.
- Extensible interfaces to facilitate incorporation of new land surface models, forcing schemes.
- Uses a modular, object oriented style design that allows “plug and play” of different features by allowing user to select only the components of interest while building the executable.
- Ability to perform regional modeling (only on the domain of interest).
- Provides a number of scalable parallel processing modes of operation.

Please refer to the software design document for a detailed description of the design of LIS core. The LIS reference manual provides a description of the extensible interfaces in LIS. The “plug and play” feature of different components is described in this document.

Chapter 3. Preliminary Information

This section provides some preliminary information to make reading this guide easier.

3.1. Commands

Commands are written with a fixed-width font. E.g.:

```
% cd /path/to/LIS
```

```
% ls
```

"... compiler flags, then run `gmake`."

NOTE	The `%` symbol represents the command-line prompt. You do **not** type that when entering any of the commands.

3.2. File names

File names are written in italics. E.g.:

/path/to/LIS/src

Chapter 4. Obtaining the Source Code

This section describes how to obtain the source code needed to build the LIS executable.

Beginning with Land Information System Framework (LISF) public release 7.3, the LIS source code is available as open source under the Apache License, version 2.0. (Please see Apache's web-site for a copy of the license.) LIS is one of the three main components of LISF (LDT, LIS, and LVT).

From LIS public release 7.1rp1 through 7.2, the LIS source code is available as open source under the NASA Open Source Agreement (NOSA). Please see LISF's web-site for a copy of the NOSA.

Due to the history of LIS' development, versions of the LIS source code prior to 7.1rp1 may not be freely distributed. Older source code is available only to U.S. government agencies or entities with a U.S. government grant/contract. LISF's web-site explains how qualified persons may request a copy of older source code.

NOTE	All users are encouraged to go to LISF's web-site to fill in the Registration Form and join the mailing list.

4.1. Important Note Regarding File Systems

LIS is developed on Linux/Unix platforms. Its build process expects a case sensitive file system. Please make sure that you unpack and/or `git clone` the LISF source code into a directory within a case sensitive file system. In particular, if you are using LIS within a Linux-based virtual machine hosted on a Windows or Macintosh system, do not compile/run LIS from within a shared folder. Move the LISF source code into a directory within the virtual machine.

4.2. Release Source Code

The LISF public release 7.8 source code is available both on LISF's web-site under the "Source" menu and on GitHub under the NASA-LIS organization at https://github.com/NASA-LIS/LISF under the "Releases" link.

After downloading the LISF tar-file:

Step 1

Create a directory to unpack the tar-file into. Let's call it *TOPLEVELDIR*.

Step 2

Place the tar-file in this directory.

```
% mv LISF_public_release_7.8.0.tar.gz TOPLEVELDIR
```

Step 3

Go into this directory.

```
% cd TOPLEVELDIR
```

Step 4

Unzip and untar the tar-file.

```
% tar xzf LISF_public_release_7.8.0.tar.gz
```

4.3. master branch

The LIS source code is maintained in a git repository hosted on GitHub. If you wish to work with the latest development code (in the master branch), then you must use the `git` client to obtain the LISF source code. If you need any help regarding `git` or GitHub, please go to https://github.com.

Step 1

Create a directory to clone the code into. Let's call it *TOPLEVELDIR*.

Step 2

Go into this directory.

```
  % cd TOPLEVELDIR
```

Step 3

Clone the master branch.

```
% git clone https://github.com/NASA-LIS/LISF
```

4.4. Source files

Unpacking or cloning the LISF source code (according to the instructions in Section Obtaining the Source Code) will create a directory named *LISF*. The LIS specific source code is in *LISF/lis*.

NOTE	The directory containing the LIS source code, *LISF/lis*, will be referred to as *$WORKING* throughout the rest of this document.

The structure of *LISF/lis* is documented in Appendix LIS source tree.

4.5. Documentation

Processed documentation for each release may be found on LISF's web-site under the "Docs" menu. Starting with LISF public release 7.4, processed documentation may also be found on GitHub under the NASA-LIS organization at https://github.com/NASA-LIS/LISF under the "Releases" link.

Processed documentation for the master branch is available on GitHub under the NASA-LIS organization's GitHub pages at https://nasa-lis.github.io/LISF/.

Chapter 5. Building the Executable

This section describes how to build the source code and create LIS' executable: named *LIS*.

Please see Section Important Note Regarding File Systems for information regarding using a case sensitve file system for compiling/running LIS.

5.1. LISF Dependencies

Please first read the companion document *LISF Installation Guide*. This document describes the required and optional libraries used by LISF. It also describes the supported development environments.

5.2. Build Instructions

Step 1

Perform the steps described in Section Obtaining the Source Code to obtain the source code.

Step 2

Go to the *$WORKING* directory. This directory contains two scripts for building the LIS executable: *configure* and *compile*.

Step 3

Set the appropriate LIS environment variables. These are used to control the compilation of LIS and to specify the locations of the required and optional libraries.

Variable	Description	Usage
LIS_ARCH	Architecture	required
LIS_FC	Fortran 90 compiler	required
LIS_CC	C compiler	required
LIS_MODESMF	path to ESMF module files	required
LIS_LIBESMF	path to ESMF library files	required
LIS_OPENJPEG	path to openJPEG library	required
LIS_ECCODES	path to ecCodes library	required
LIS_NETCDF	path to NetCDF library	required
LIS_HDF4	path to HDF4 library	optional (required to use HDFEOS2)
LIS_HDF5	path to HDF5 library	optional
LIS_HDFEOS	path to HDFEOS2 library	optional

Variable	Description	Usage
LIS_MINPACK	path to MINPACK library	optional
LIS_CRTM	path to CRTM library	optional
LIS_CRTM_PROF	path to LIS-CRTM Profile library	optional
LIS_CMEM	path to LIS-CMEM library	optional
LIS_LAPACK	path to LAPACK library	optional
LIS_PETSC	path to PETSc library	optional
LIS_JPEG	path to JPEG library	optional (use system libjpeg by default)
LIS_RPC	path to RPC library	optional (use system RPC library by default)

Set the LIS_ARCH environment variable based on the system you are using. The following commands are written using Bash shell syntax.

For a Linux system with the Intel Fortran compiler

```
% export LIS_ARCH=linux_ifc
```

For a Linux system with the GNU Fortran compiler

```
% export LIS_ARCH=linux_gfortran
```

For a Cray system with the Intel Fortran compiler

```
% export LIS_ARCH=cray_ifc
```

For a Cray system with the Cray Fortran compiler

```
% export LIS_ARCH=cray_cray
```

For an IBM system with the GNU Fortran compiler

```
% export LIS_ARCH=ibm_gfortran
```

Note that the LIS_CC variable must be set to a C compiler, not a C++ compiler. A C++ compiler may mangle internal names in a manner that is not consistent with the Fortran compiler. This will cause errors during linking.

You may encounter errors either when trying to compile LIS or when trying to run LIS because the compiler or operating system cannot find these libraries. To fix this, you must add these libraries to your LD_LIBRARY_PATH environment variable. For example, say that you are using ESMF, ecCodes, NetCDF, and HDF5. Then you must execute the following command (written using Bash shell

syntax):

```
% export
LD_LIBRARY_PATH=$LIS_HDF5/lib:$LIS_LIBESMF:$LIS_NETCDF/lib:${LIS_ECCODES}/lib:$LD_LIBR
ARY_PATH
```

It is suggested that you set these environment variables in a modulefile [1] to load or in an environment script to source before compiling and/or running LIS.

Step 4

Run the *configure* script first by typing:

```
% ./configure
```

This script will prompt the user with a series of questions regarding support to compile into LIS.

Example

An example execution of the configure script is shown below:

```
% ./configure
------------------------------------------------------------------------
Setting up configuration for LIS
Parallelism (0-serial, 1-dmpar, default=1):
Optimization level (-3=strict checks with warnings, -2=strict checks, -1=debug,
0,1,2,3, default=2):
Assume little/big_endian data format (1-little, 2-big, default=2):
Use GRIBAPI/ECCODES? (0-neither, 1-gribapi, 2-eccodes, default=2):
Enable AFWA-specific grib configuration settings? (1-yes, 0-no, default=0):
Use NETCDF? (1-yes, 0-no, default=1):
NETCDF version (3 or 4, default=4):
NETCDF use shuffle filter? (1-yes, 0-no, default = 1):
NETCDF use deflate filter? (1-yes, 0-no, default = 1):
NETCDF use deflate level? (1 to 9-yes, 0-no, default = 1):
Use HDF4? (1-yes, 0-no, default=1):
Use HDF5? (1-yes, 0-no, default=1):
Use HDFEOS? (1-yes, 0-no, default=1):
Use MINPACK? (1-yes, 0-no, default=0):
Use LIS-CRTM? (1-yes, 0-no, default=0):
Use LIS-CMEM? (1-yes, 0-no, default=0):
Use LIS-LAPACK? (0-no, 1-mkl, 2-lapack/blas, 3-lapack/refblas, default=0):
Use PETSc? (1-yes, 0-no, default=0):
Enable USAF LIS75 SM DA codes? (1-yes, 0-no, default=0):
------------------------------------------------------
 configure.lis file generated successfully
------------------------------------------------------
Settings are written to configure.lis in the make directory.
If you wish to change settings, please edit that file.

To compile, run the compile script.
------------------------------------------------------------------------
```

At each prompt, select the desired value. If you desire the default value, then you may simply press the Enter key.

Most of the configure options are be self-explanatory. Here are a few specific notes:

- for `Parallelism (0-serial, 1-dmpar, default=1):`, dmpar refers to enabling MPI
- for `Assume little/big_endian data format (1-little, 2-big, default=2):`, select the default value of 2. By default, LIS reads and writes binary data in the big endian format. Only select the value of 1, if you have reformatted all required binary data into the little endian format.
- for `Use GRIBAPI/ECCODES? (0-neither, 1-gribapi, 2-eccodes, default=2):`, select the default value of 2. Technically, GRIB support is not required by LIS; however, most of the commonly used met forcing data are in GRIB, making GRIB support a practical requirement. ecCodes is ECMWF's replacement to their GRIB-API library. GRIB-API is supported only for historical reasons; thus, please use ecCodes.

IMPORTANT	GRIB-API support is now deprecated. Future releases will support only ecCodes.

- for `Use LIS-CRTM? (1-yes, 0-no, default=0):`, if you wish to enable LIS-CRTM2EM support, then you must also enable LIS-CMEM support. So for `Use LIS-CMEM? (1-yes, 0-no, default=0):`, you must also select 1.
- for `Use LIS-CMEM? (1-yes, 0-no, default=0):`, if you wish to enable LIS-CMEM support, then you must also enable LIS-CRTM. So for `Use LIS-CRTM? (1-yes, 0-no, default=0):`, you must also select 1.
- for `Use LIS-LAPACK? (0-no, 1-mkl, 2-lapack/blas, 3-lapack/refblas, default=0):`, select the type of LAPACK library that you have installed. This is used with `Use PETSc? (1-yes, 0-no, default=0):`. If you select 0 for `Use PETSc?`, then select 0 for `Use LIS-LAPACK?`. If you select 1 for `Use PETSc?`, then select `Use LIS-LAPACK?` according to the following table:

Selection	Description
0	No LAPACK needed / Use system LAPACK
1	LAPACK in Intel MKL
2	liblapack / libblas
3	liblapack / librefblas

  For example, on a Cray system using the Cray compilers, select 0 because the linker will find Cray's LAPACK libraries.

Note that due to an issue involving multiple definitions within the NetCDF 3 and HDF 4 libraries, you cannot compile LIS with support for both NetCDF 3 and HDF 4 together.

Note that if you compiled NetCDF 4 without compression, then when specifying `NETCDF version (3 or 4, default=4):`, select 3. Then you must manually append `-lnetcdff` to the `LDFLAGS` variable in the *make/configure.lis* file.

Step 5

Compile the LIS source code by running the *compile* script.

```
% ./compile
```

This script will compile the libraries provided with LIS, the dependency generator and then the LIS source code. The executable *LIS* will be placed in the *$WORKING* directory upon successful completion of the *compile* script.

Step 6

Finally, copy the *LIS* executable into your running directory, *$RUNNING*. (See Section Running the Executable.)

5.2.1. Customizing the build via LIS plugins

Various components within LIS are considered plugins, meaning that they are optional and may be enabled/disabled at compile-time. By default, most plugins are enabled, only 1) the restricted components, which are not available in the public releases of LIS, 2) components still under development, 3) and old/unsupported components are disabled by default. If you wish to compile LIS with its default plugin configuration, then simply follow the above six steps. You may skip the rest of this section. If you wish to toggle whether a plugin is enabled/disabled, then you must create a *user.cfg* file.

Enabling/disabling a component

To toggle an optional plugin from its default enabled/disabled state, you must create a *user.cfg* file in the *make* sub-directory of the LIS source code.

The format of this file is:

component name: On/Off

where the value “On” indicates to compile the component into the LIS executable, and where “Off” indicates to exclude the component. And where possible the component name matches the string found in the plugins/LIS_pluginIndices.F90 file.

Note that comments may be added to the user.cfg file. The “#” character marks the beginning of the comment.

For example, if you want to compile all default components of LIS except for Noah 2.7.1, then create a *user.cfg* file containing the follow line:

Example user.cfg file

Noah.2.7.1: Off

Below is a list of all optional components that may be enabled/disabled along with their default settings.

NOTE	Not all the optional components listed below are available in the public release of LIS.

Please do not copy this whole list into a *user.cfg* file. Create a *user.cfg* file containing only the components that you want to toggle.

Table 1. Running modes

Component name	**Default state**
retrospective	On
AGRMET ops	On
WRF coupling	On
GCE coupling	Off

Component name	Default state
param estimation	On
RTM forward	On
ensemble smoother	On
forecast	On

Table 2. Metforcings

Component name	Default state
Metforcing template	On
LDT-generated	On
CLIM-Standard	On
GenEnsFcst	On
PPTEnsFcst	On
GDAS	On
GDAS T1534	On
GEOS5 forecast	On
GEFS forecast	On
ECMWF	On
GSWP1	On
GSWP2	On
AGRMET	Off
PRINCETON	On
NLDAS2 grib	On
NLDAS2 netcdf	On
GLDAS	On
GFS	On
MERRA2	On
GEOS-IT	On
ERA5	On
CMAP	On
CHIRPS2	On
TRMM 3B42RT	On
TRMM 3B42RTV7	On
TRMM 3B42V6	On
TRMM 3B42V7	On

Component name	Default state
CPC CMORPH	On
GPM IMERG	On
CPC STAGEII	On
CPC STAGEIV	On
NARR	On
RFE2(daily)	On
SCAN	On
AGRMET radiation (polar stereographic)	On
PLUMBER2	On
Bondville	On
TRIGRS test	Off
SNOTEL	On
RFE2(GDAS bias-corrected)	On
VIC processed forcing	Off
PALS station forcing	On
PET USGS	On
NAM242	On
WRFout	On
COAMPSout	On
WRFoutv2	On
WRF AK	On
AWAP	On
AWRAL	On
HiMAT GMU	On
Loobos	On
MRMS	On
GDDP	On
GALWEM forecast	On
GALWEM-GE forecast	On
MOGREPS-G forecast	On

Table 3. Parameters

Component name	Default state
MODIS real-time	Off

Component name	Default state
ALMIPII LAI	On
NESDIS weekly	On
SPORT	On
VIIRS	On
ALMIPII GFRAC	On
ALMIPII roughness	On
ALMIPII albedo	On
ALMIPII emissivity	On

Table 4. RTMS

Component name	Default state
CRTM	Off
CRTM2	On
CRTM2EM	On
CMEM	On
Tau Omega	On

Table 5. Applications

Component name	Default state
GLS	On
TRIGRS	On

Table 6. Routing

Component name	Default state
HYMAP router	Off
HYMAP2 router	On
HYMAP3 router	On
NLDAS router	On
RAPID router	Off

Table 7. Irrigation

Component name	Default state
Sprinkler	On
Flood	On
Drip	On

Table 8. DA

Component name	Default state
Direct insertion	On
EnKF	On
EnSRF	On
EKF	On
EnKS	On
PF	On
DA OBS syntheticsm	On
DA OBS syntheticwl	On
DA OBS HYDROWEBWL	On
DA OBS syntheticsnd	On
DA OBS syntheticSnowTB	On
DA OBS SNODEP	On
DA OBS USAFSI	On
DA OBS PMW_snow	On
DA OBS ANSA_SCF	On
DA OBS ESACCI_sm	On
DA OBS THYSM	On
DA OBS LPRM_AMSREsm	On
DA OBS SMMR_SNWD	On
DA OBS SSMI_SNWD	On
DA OBS ANSA_SNWD	On
DA OBS GCOMW_AMSR2L3SND	On
DA OBS SNODAS	On
DA OBS WUSUCLA	On
DA OBS SMOPS_ASCATsm	On
DA OBS SMOPS_SMOSsm	Off
DA OBS SMOPS_AMSR2sm	Off
DA OBS SMOPS_SMAPsm	Off
DA OBS SMOS_NESDIS	On
DA OBS NASA_SMAPsm	On
DA OBS SMOS_NRTNN_L2sm	On
DA OBS SMAP_E_OPLsm	On

Component name	Default state
DA OBS NASA_SMAPvod	On
DA OBS ASO_SWE	On
DA OBS MCD15A2H_LAI	On
DA OBS GLASS_LAI	On
DA OBS VIIRS_GVF	On
DA OBS CDFS_GVF	On
DA OBS GLASS_Albedo	On
DA OBS MODISSPORT_LAI	On
DA OBS NRT_SMAPsm	On
DA OBS pildas	On
DA OBS GRACE	On
DA CDF TRANSFER NASA SMAPSM	On
DA OBS SWOT WL	On
DA OBS SNIP	On
DA OBS WSF sm	On

Table 9. Bias estimation

Component name	Default state
bias estimation	On

Table 10. Perturbations

Component name	Default state
perturbations	On

Table 11. Optimization / Parameter estimation

Component name	Default state
OPTUE ES	On
OPTUE LM	On
OPTUE GA	On
OPTUE SCEUA	On
OPTUE MCSIM	On
OPTUE RWMCMC	On
OPTUE DEMC	On
OPTUE DEMCz	On
PE OBS template	On

Component name	Default state
PE OBS pesynsm1	On
PE OBS ISCCP_Tskin	On
PE OBS wgPBMRsm	On
PE OBS CNRS	On
PE OBS AMSRE_SR	On
PE OBS LPRM_AMSREsm	On
PE OBS EmptyObs	On
PE OBS ARM	On
PE OBS Macon_LS_data	On
PE OBS Global_LS_data	On
PE OBS Ameriflux	On
PE OBS FLUXNET	On
PE OBS USDA_ARSsm	On
PE OBS ARSsm	On
PE OBS ISMNsm	On
PE OBS SMAPsm	On
PE OBS UAsnow	On
PE OBJFUNC LS	On
PE OBJFUNC LM	On
PE OBJFUNC LL	On
PE OBJFUNC P	On

Table 12. Surface models

Component name	Default state
LSM template	On
Noah.2.7.1	On
Noah.3.2	On
Noah.3.3	On
Noah.3.6	On
Noah.3.9	On
NoahMP.3.6	On
NoahMP.4.0.1	On
RUC.3.7	On
CLM.2	On

Component name	Default state
VIC.4.1.1	On
VIC.4.1.2	On
AWRAL.6.0.0	On
Mosaic	On
HySSIB	On
JULES.4.3	Off
JULES.5.0	Off
JULES.5.1	Off
JULES.5.2	Off
JULES.5.3	Off
JULES.5.4	Off
JULES.5.x	Off
CABLE	On
FASST	Off
CLSM F2.5	On
GeoWRSI.2	On
LSM RDHM.3.5.6	Off
SUMMA.1.0	Off
Crocus.8.1	Off
SNOWMODEL	Off
Flake.1.0	Off
NoahMP-GL.3.9.1.1	On
template glacier	On
template open water	On
AquaCrop v7.2	On

Table 13. Forecast algorithms

Component name	Default state
ESP boot	On
ESP conventional	On

Rebuild LIS

After creating a *user.cfg* file you must recompile the LIS source code. First go into the *make* directory and clean up.

```
% cd make
% gmake realclean
% cd ..
```

Now you may recompile LIS.

```
% ./compile
```

NOTE

If you enable the SnowModel by adding

```
SNOWMODEL: On
```

to your *user.cfg* file, then you must modify the *make/configure.lis* file by adding `-mcmodel=medium` to the `FFLAGS77` and `FFLAGS` variables.

[1] See the “Creating a Custom Modulefile” document found at https://nasa-lis.github.io/LISF/

Chapter 6. Running the Executable

This section describes how to run the LIS executable.

First you should create a directory to run LIS in. It is suggested that you run LIS in a directory that is separate from your source code. This running directory shall be referred to as *$RUNNING*. Next, copy the LIS executable into your running directory.

```
% cp $WORKING/LIS $RUNNING
```

The single-process version of `LIS` is executed by the following command issued in the *$RUNNING* directory.

```
% ./LIS
```

The parallel version of `LIS` must be run through an `mpirun` script or similar mechanism. Assuming that MPI is installed correctly, the LIS simulation is carried out by the following command issued from in the *$RUNNING* directory.

```
% mpirun -np N ./LIS
```

The `-np N` flag indicates the number of processes to use in the run, where you replace `N` with the number of processes to use. On a multiprocessor machine, the parallel processing capbabilities of LIS can be exploited using this flag.

Some systems require that you submit your job into a batch queue. Please consult with your system adminstrator for instructions on how to do this.

Note that before running LIS, you must set your environment to have an unlimited stack size. For the Bash shell, run

```
% ulimit -s unlimited
```

To customize your run, you must modify the *lis.config* configuration file. See Section LIS config File for more information.

6.1. Command line arguments

`LIS [-f <file> | --file <file>]`

`-f <file>`, **`--file <file>`**

specifies the name of the lis run-time configuration file.

By default, LIS expects the run-time configuration options to be defined in a file named *lis.config*. Use this command line argument to specify an alternate run-time configuration file.

Chapter 7. Testcases

This section describes how to obtain and how to use the testcases provided by the LISF development team.

There are two categories of testcases: public tests and internal tests.

7.1. Public tests

The new LIS framework (LISF) set of public testcases includes a full end-to-end suite of LDT, LIS, and LVT cases that build off each other with several different steps. The suite of testcases includes generating model parameter and assimilation-based input files using LDT, running the Noah land surface model (LSM) for a sample "open-loop" (or baseline) experiment and a data assimilation (DA) experiment using LIS, and then comparing output from the sample experiments using LVT.

The new public testcases are available from our main LIS webpage:

https://lis.gsfc.nasa.gov/lis-testcases

All required input and data files are bundled with each of the cases from the above website. Also, documentation is provided that accompanies each of the cases for additional details and information.

7.2. Internal tests

The main purpose of these testcases is for the LISF development team to internally test various components of the LIS source code. These testcases are comprised of three parts: a *testcases* sub-directory included in the LIS source code, input data, and output data.

For these testcases, we do not provide any of the input or output datasets, but users are welcome to use the config files in these subdirectories as a guide to setting up their own individual experiments and for their own testing purposes.

7.2.1. The *testcases* Sub-directory

The layout of the *testcases* sub-directory matches the layout of the top-level *lis* directory. For example, LIS contains support for processing GDAS forcing data. These routines are in *lis/metforcing/gdas*. The testcase for GDAS is in *lis/testcases/metforcing/gdas*.

These testcase sub-directories contain several files. For example, the *src/testcases/metforcing/gdas* testcase contains these main files:

1. *README*

   contains instructions on how to run the testcase.

2. *ldt.config*

   is the configuration file for LDT to process input parameters for the testcase.

3. *lis.config*

   is the configuration file for LIS to run the testcase.

4. *MODEL_OUTPUT_LIST.TBL*

   is the configuration file to set the output for the testcase.

5. *output.ctl*

   is a GrADS descriptor file. This file is used with GrADS to plot the output data that you will generate when you run LIS. You may also read this file to obtain metadata regarding the structure of the output files. This metadata is useful in helping you plot the output using a different program.

Chapter 8. Output Data Processing

This section describes how to process the generated output in various formats. The generated output can be written in a Fortran binary, GRIB, or NetCDF format. See Section Runtime options for more details.

The output data-sets created by running the LIS executable are written into sub-directories of the *$RUNNING/OUTPUT/SURFACEMODEL/* directory. Please note that *$RUNNING/OUTPUT/SURFACEMODEL/* is created at run-time, and that *OUTPUT* is a user-configurable name. See Section Runtime options. The output data consists of ASCII text files and model output in some binary format.

For example, assume that you performed the Noah 3.3 test case.

This run will produce a *$RUNNING/OUTPUT/* directory. This directory will contain:

File Name	Synopsis
SURFACEMODEL.d01.stats	Statistical summary of output
SURFACEMODEL	Directory containing output data

The *SURFACEMODEL* directory will contain sub-directories of the form *YYYY/YYYYMMDD*, where *YYYY* is a 4-digit year and *YYYYMMDD* is a date written as a 4-digit year, 2-digit month and a 2-digit day; both corresponding to the running dates of the simulation.

For this example, *SURFACEMODEL* will contain a *2002/20021030* sub-directory.

Its contents are the output files generated by the executable. They are:

- *LIS_HIST_200210300000.d01.gs4r*
- *LIS_HIST_200210300300.d01.gs4r*
- *LIS_HIST_200210300600.d01.gs4r*
- *LIS_HIST_200210300900.d01.gs4r*
- *LIS_HIST_200210301200.d01.gs4r*
- *LIS_HIST_200210301500.d01.gs4r*
- *LIS_HIST_200210301800.d01.gs4r*
- *LIS_HIST_200210302100.d01.gs4r*

Note, each file name contains a date-stamp marking the year, month, day, hour, and minute that the data correspond to. The output data files for other land surface models are similar. Here the *gs4r* extension corresponds to the Fortran binary output format. The output data files for other binary formats are similar.

The actual contents of the output files depend on the settings in the *lis.config* configuration file and the “Model output attributes file” file defined within the *lis.config* configuration file. See Section Model output configuration.

8.1. Fortran binary output format

For the Fortran binary format, LIS writes the output data as 4-byte REALs in sequential access mode.

The order in which the variables are written is the same order as in the statistical summary file; e.g., *SURFACEMODEL.d01.stats*.

The generated output can be written in a 2-D grid format or as a 1-d vector. See Section Runtime options for more details. If written as a 1-d vector, the output must be converted into a 2-d grid before it can be visualized. This is left as an exercise for the reader.

8.2. GRIB1 output format

GRIB1 is a self-describing data format. The output files produced in GRIB1 can be inspected by using either the utility `wgrib` (http://www.cpc.ncep.noaa.gov/products/wesley/wgrib.html) or the utility `grib_dump` (provided with GRIB-API; see Section [ssec_requiredlibs]).

8.3. NetCDF output format

NetCDF is a self-describing format. The output files produced in NetCDF can be inspected by using the utility `ncdump` (provided with NetCDF; see Section [ssec_requiredlibs]).

Chapter 9. LIS config File

This section describes the options in the *lis.config* file.

9.1. Overall driver options

`Running mode:` specifies the running mode used in LIS. Acceptable values are:

Value	Description
“retrospective”	Retrospective mode
“RTM forward”	RTM forward mode
“AGRMET ops”	AFWA AGRMET mode
“WRF coupling”	Coupled WRF mode
“GCE coupling”	Coupled GCE mode
“parameter estimation”	Parameter estimation mode
“ensemble smoother”	Ensemble smoother mode
“forecast”	Forecast simulation mode

Example lis.config entry

```
Running mode: retrospective
```

`Number of nests:` specifies the number of nests used for the run. Values 1 or higher are acceptable. The maximum number of nests is limited by the amount of available memory on the system. The specifications for different nests are done using white spaces as the delimiter. Please see below for further explanations. Note that all nested domains should run on the same projection and same land surface model.

Example lis.config entry

```
Number of nests: 1
```

`Number of surface model types:` specifies the number of surface model types used for the run. Values of 1 through `LIS_rc%max_model_types` (currently equal to 3) are acceptable.

Example lis.config entry

```
Number of surface model types: 1
```

`Surface model types:` specifies the surface model types used for the run. Acceptable values are:

Value	Description
LSM	land surface model

Value	Description
Lake	lake model
Glacier	glacier model
Openwater	open water surface type

Example lis.config entry

```
Surface model types: LSM
```

`Surface model output interval:` specifies the surface model output interval.

See Section Defining a time interval for a description of how to specify a time interval.

Example lis.config entry

```
Surface model output interval: 3hr
```

`Land surface model:` specifies the land surface model to run. Acceptable values are:

Value	Description
none	template lsm
Noah.2.7.1	Noah version 2.7.1
Noah.3.2	Noah version 3.2
Noah.3.3	Noah version 3.3
Noah.3.6	Noah version 3.6
Noah.3.9	Noah version 3.9
Noah-MP.3.6	Noah-MP version 3.6
Noah-MP.4.0.1	Noah-MP version 4.0.1
RUC.3.7	RUC version 3.7
CLM.2	CLM version 2.0
VIC.4.1.1	VIC version 4.1.1
VIC.4.1.2	VIC version 4.1.2.l
Mosaic	Mosaic
HySSiB	Hy-SSiB
GeoWRSI.2	GeoWRSI version 2.0
JULES.5.0	JULES version 5.0
CABLE.1.4b	CABLE version 1.4b
AquaCrop.7.2	AquaCrop version 7.2
“CLSM F2.5”	Catchment Fortuna-2_5

Value	Description
RDHM.3.5.6	RDHM 3.5.6 (SAC-HTET and SNOW-17)
AWRAL.6.0.0	AWRA-L version 6.0.0

Example lis.config entry

```
Land surface model: Noah.2.7.1
```

`Number of subLSMs:` specifies the number of sub-level LSMs or specialized models that may interface with other LSMs in LIS. Entry here can be set to 1 with having a surface model type specified, such as "LSM", and set to 1.

Example lis.config entry

```
Number of subLSMs:              1
```

`subLSM models:` specifies the sub-level land surface model to run. Acceptable values are:

Value	Description
none	template lsm
Crocus8.1	Crocus version 8.1 snow model
SnowModel	Glen Liston's SnowModel snow model

Example lis.config entry

```
subLSM models:              "Crocus8.1"
```

`Lake model:` specifies the lake model to run. Acceptable values are:

Value	Description
FLAKE.1.0	FLAKE version 1.0

Example lis.config entry

```
Lake model:
```

`Open water model:` specifies the open water model to run. Acceptable values are:

Value	Description
"template open water"	template open water model

Example lis.config entry

```
Open water model:
```

`land slide model:` specifies the land slide model to run. Acceptable values are:

Value	Description
"GLS"	GLS model
"TRIGRS"	TRIGRS model

Example lis.config entry

```
land slide model:
```

`Number of subLSMs:` specifies the number of subLSMs to run. Acceptable values are: 0 : no subLSM; 1 : One subLSM

`subLSM models:` specifies the subLSMs to run. Acceptable values are:

Value	Description
Crocus8.1	Crocus snow model model

Note: To run a standalone version of the Crocus, the user needs to set: `Land surface model: "none"`

`Number of met forcing sources:` specifies the number of met forcing datasets to be used. Acceptable values are 0 or higher.

Example lis.config entry

```
Number of met forcing sources: 1
```

`Met forcing chosen ensemble member:` specifies the desired ensemble member from a given forcing data source to be assigned across all LIS ensemble members. This option is enabled only if the met forcing data source contains its own ensembles.

Example lis.config entry

```
Met forcing chosen ensemble member:
```

`Blending method for forcings:` specifies the blending method to combine forcings when one or more forcing datasets are used. Acceptable values are:

Value	Description
overlay	Datasets are overlaid on top of each other in the order they are specified. For example, the forcing dataset in the second column is overlaid on top of the forcing dataset in the first column. In other words, the forcing data specified in the second column will be used in place of forcing data that is specified in the first column, for locations within the spatial extent of the second column's forcing data. As an example, a user could specify a forcing dataset with a global extent in the first column and a forcing dataset with a regional extent in the second column. All locations within the regional extent of the second column's forcing data will use that data as forcing, while locations outside of this regional extent will use data from the global extent of the first column's forcing data. This continues for the number of met forcing sources specified, with the right-most column having the higher priority to be used as forcing, given its spatial extent. Choose this method when using just one forcing dataset.
ensemble	Each forcing dataset is assigned to a separate ensemble member.

Example lis.config entry

```
Blending method for forcings: overlay
```

`Met forcing sources:` specifies the met forcing data sources for the run. The values should be specified in a column format. Acceptable values for the sources are:

Value	Description
"none"	None
"GDAS"	GDAS
"GEOS5 forecast"	GEOS5 Forecast
"GEFS forecast"	GEFS Forecast
"ECMWF"	ECMWF
"GSWP1"	GSWP1
"GSWP2"	GSWP2
"AGRMET"	AGRMET
"PRINCETON"	Princeton

Value	Description
“NLDAS2 grib”	NLDAS-2 GRIB-1 format
“NLDAS2 netcdf”	NLDAS-2 v020 netCDF-4 format
“GLDAS”	GLDAS
“GFS”	GFS
“MERRA2”	MERRA2
“GEOS-IT”	GEOS-IT
“CMAP”	CMAP
“TRMM 3B42RT”	TRMM 3B42RT
“TRMM 3B42RTV7”	TRMM 3B42RTV7
“TRMM 3B42V6”	TRMM 3B42V6
“TRMM 3B42V7”	TRMM 3B42V7
“CPC CMORPH”	CMORPH from CPC
“GPM IMERG”	GPM IMERG data from NASA
“CPC STAGEII”	STAGEII from CPC
“CPC STAGEIV”	STAGEIV from CPC
“NARR”	North American Regional Reanalysis
“RFE2(daily)”	Daily rainfall estimator
“RFE2(GDAS bias-corrected)”	RFE2 data bias corrected to GDAS
“CHIRPS2”	UCSB CHIRPS v2.0 precipitation dataset
“SCAN”	SCAN
“AGRMET radiation”	AGRMET radiation
“Bondville”	Bondville site data
“SNOTEL”	SNOTEL data
“VIC processed forcing”	VIC processed forcing
“PALS station forcing”	PALS station forcing
“PET USGS”	USGS PET 1.0 deg
“NAM242”	NAM 242 AWIPS Grid -- Over Alaska
“WRFout”	WRF output
“WRFoutv2”	NCAR-WRF 4km output
“WRFoutv2”	NCAR-WRF 4km output forcing
“WRF AK”	NCAR-WRF Alaska domain forcing
“LDT-generated”	LDT-generated forcing files
“CLIM-Standard”	Forcing climatologies (LDT-generated)

Value	Description
“GenEnsFcst”	Generic ensemble forecast reader
“PPTEnsFcst”	Precipitation-only ensemble forecast reader
“AWAP”	AWAP precipitation data
“GDAS T1534”	NCEP-specific GDAS T1534 forcing data
“ERA5”	ERA5 reanalysis meteorology
“AWRAL processed forcing”	AWRA-L processed forcing
“PLUMBER2”	PLUMBER2 forcing
“GDDP”	NEX GDDP forcing
“COAMPSout”	COAMPS output forcing
“GALWEM forecast”	GALWEM 17km or 0.25deg deterministic forecast reader
“GALWEM-GE forecast”	GALWEM-GE forecast reader

Example lis.config entry

```
Met forcing sources: GDAS
```

`Topographic correction method (met forcing):` specifies whether to use elevation correction for base forcing. Acceptable values are:

Value	Description
“none”	Do not apply topographic correction for forcing
“lapse-rate”	Use lapse rate correction for forcing
“slope-aspect”	Apply slope-aspect correction for forcing
“lapse-rate and slope-aspect”	Apply both lapse-rate and slope-aspect corrections
“micromet”	Apply Glen Liston’s MicroMet corrections to forcing fields

Example lis.config entry

```
Topographic correction method (met forcing):  "lapse-rate"
```

`Enable spatial downscaling of precipitation:` specifies whether to use spatial downscaling of precipitation. Acceptable values are:

Value	Description
0	Do not enable spatial downscaling
1	Enable spatial downscaling

Example lis.config entry

```
Enable spatial downscaling of precipitation: 0
```

`Spatial interpolation method (met forcing):` specifies the type of interpolation scheme to apply to the met forcing data. Acceptable values are:

Value	Description
“bilinear”	bilinear scheme
“budget-bilinear”	conservative scheme
“neighbor”	neighbour scheme

Bilinear interpolation uses 4 neighboring points to compute the interpolation weights. The conservative approach uses 25 neighboring points. If the conservative option is turned on, it is used to interpolate the precipitation field only (to conserve water). Other fields will still be interpolated with the bilinear option.

Example lis.config entry

```
Spatial interpolation method (met forcing): bilinear
```

`Spatial upscaling method (met forcing):` specifies the type of upscaling scheme to apply to the met forcing data. Acceptable values are:

Value	Description
“average”	averaging scheme

Please note that not all met forcing readers support upscaling of the met forcing data.

Example lis.config entry

```
Spatial upscaling method (met forcing): average
```

`Temporal interpolation method (met forcing):` specifies the type of temporal interpolation scheme to apply to the met forcing data. Acceptable values are:

Value	Description
linear	linear scheme
trilinear	uber next scheme

The linear temporal interpolation method computes the temporal weights based on two points. Ubernext computes weights based on three points. Currently the ubernext option is implemented only for the GSWP forcing.

Example lis.config entry

```
Temporal interpolation method (met forcing): linear
```

`Enable new zterp correction (met forcing):` specifies whether to enable the new zterp correction. Acceptable values are:

Value	Description
.false.	do not enable
.true.	enable

Defaults to `.false.`.

This is a scalar option, not per nest.

This new zterp correction addresses an issue that potentially can occur at sunrise/sunset for some forcing datasets when running at small time steps (like 15mn). In some isolated cases, SWdown may have a large unrealistic spike. This correction removes the spike. It also can affect SWdown around sunrise/sunset by up 200 W/m2. Users are advised to run their own tests and review SWdown to determine which setting is best for them.

For comparison against older LIS runs, set this option to `.false.`.

Example lis.config entry

```
Enable new zterp correction (met forcing): .false.
```

9.2. Runtime options

`Forcing variables list file:` specifies the file containing the list of forcing variables to be used. Please refer to the sample forcing_variables.txt (Section Specification of Input Forcing Variables) file for a complete specification description.

Example lis.config entry

```
Forcing variables list file:     ./input/forcing_variables.txt
```

`Output methodology:` specifies whether to write output as a 1-D array containing only land points or as a 2-D array containing both land and water points. 1-d tile space includes the subgrid tiles and ensembles. 1-d grid space includes a vectorized, land-only grid-averaged set of values. Acceptable values are:

Value	Description
“none”	Do not write output
“1d tilespace”	Write output in a 1-D tile domain

Value	Description
“2d gridspace”	Write output in a 2-D grid domain
“1d gridspace”	Write output in a 1-D grid domain
“2d ensemble gridspace”	Write individual ensemble member output

When writing output using the “2d gridspace” setting with ensembles enabled, LIS will average the ensemble members into one field to write into the output file; when using the “2d ensemble gridspace” option, LIS will write each ensemble member into the output file.

Note that the “2d ensemble gridspace” setting requires setting the `Output data format:` option to “netcdf”.

Example lis.config entry

```
Output methodology: "2d gridspace"
```

`Output model restart files:` specifies whether to write model restart files. Acceptable values are:

Value	Description
0	Do not write restart files
1	Write restart files

Example lis.config entry

```
Output model restart files:   1
```

`Output data format:` specifies the format of the model output data. Acceptable values are:

Value	Description
“binary”	Write output in binary format
“distributed binary”	Write output in distributed binary format where each processor writes outputs for the respective local domain
“grib1”	Write output in GRIB-1 format
“grib2”	Write output in GRIB-2 format
“netcdf”	Write output in netCDF format

Example lis.config entry

```
Output data format: netcdf
```

`Output naming style:` specifies the style of the model output names and their organization. Acceptable values are:

Value	Description
“2 level hierarchy”	2 levels of hierarchy
“3 level hierarchy”	3 levels of hierarchy
“4 level hierarchy”	4 levels of hierarchy
“WMO convention”	WMO convention for weather codes
“557WW streamflow convention”	557WW convention for streamflow output
“557WW medium range forecast convention”	557WW convention for medium range forecast output

Example lis.config entry

```
Output naming style: "3 level hierarchy"
```

NOTE

The “557WW streamflow convention” and “557WW medium range forecast convention” have 4 additional settings:

`AGRMET security classification:` used with 557WW streamflow convention, 557WW medium range forecast convention, or AGRMET Ops runmode.

`AGRMET distribution classification:` used with 557WW streamflow convention, 557WW medium range forecast convention, or AGRMET Ops runmode.

`AGRMET data category:` used with 557WW streamflow convention, 557WW medium range forecast convention, or AGRMET Ops runmode.

`AGRMET area of data:` used with 557WW streamflow convention, 557WW medium range forecast convention, or AGRMET Ops runmode.

See Section AFWA/AGRMET for more information.

Example lis.config entry

```
Output naming style: "557WW streamflow convention"
AGRMET security classification:     U
AGRMET distribution classification: C
AGRMET data category:               ANLYS
AGRMET area of data:                GLOBAL
```

`Number of dimensions in the lat/lon output fields:` specifies the number of dimensions to use when writing the latitude and longitude fields of the LIS output. This is an optional entry. If this entry is not used, LIS will attempt to write the lat/lon fields in 1D. If the projection being used is not compatible with 1D, LIS will write in 2D. Acceptable values are:

Value	Description

"1D"	1 dimensional latitude and longitude output (Note: Only the latlon projection supports 1D output)
"2D"	2 dimensional latitude and longitude output

Example lis.config entry

```
Number of dimensions in the lat/lon output fields:          "1D"
```

`Enable output statistics:` specifies whether to write the ASCII statistics file for the output data. Acceptable values are:

Value	Description
.true.	Enable writing of the statistics file
.false.	Disable writing of the statistics file

Defaults to `.false.`.

Example lis.config entry

```
Enable output statistics: .true.
```

`Output GRIB Table Version:` specifies GRIB table version.

`Output GRIB Center Id:` specifies GRIB center id.

`Output GRIB Subcenter Id:` specifies GRIB sub-center id.

`Output GRIB Grid Id:` specifies GRIB grid id.

`Output GRIB Process Id:` specifies GRIB process id.

`Output GRIB Packing Type:` specifies the algorithm used to pack data into the GRIB message. Acceptable values are:

grid_simple	grid_simple
grid_jpeg	grid_jpeg (GRIB-2 only) Do not use. There is an open issue regarding packing constant data with grid_jpeg.

Though untested, there are more packingType available as listed at https://confluence.ecmwf.int/display/ECC/GRIB+Keys

Example lis.config entry

```
Output GRIB Table Version: 130
Output GRIB Center Id:     173
Output GRIB Subcenter Id:    4
Output GRIB Grid Id:        11
Output GRIB Process Id:      1
Output GRIB Packing Type:  grid_simple
```

For GRIB-2 try:

Example lis.config entry

```
Output GRIB Table Version:  13
Output GRIB Center Id:     173
Output GRIB Subcenter Id:    4
Output GRIB Grid Id:         0
Output GRIB Process Id:      1
Output GRIB Packing Type:  grid_simple
```

`Start mode:` specifies if a restart mode is being used. Acceptable values are:

Value	Description
restart	A restart mode is being used
coldstart	A cold start mode is being used, no restart file read

When the cold start option is specified, the program is initialized using the LSM-specific initial conditions (typically assumed uniform for all tiles). When a restart mode is used, it is assumed that a corresponding restart file is provided depending upon which LSM is used. The user also needs to make sure that the ending time of the simulation is greater than model time when the restart file was written.

Example lis.config entry

```
Start mode: coldstart
```

The start time is specified in the following format:

Variable	Value	Description
`Starting year:`	integer 2001 – present	specifying starting year
`Starting month:`	integer 1 – 12	specifying starting month
`Starting day:`	integer 1 – 31	specifying starting day
`Starting hour:`	integer 0 – 23	specifying starting hour
`Starting minute:`	integer 0 – 59	specifying starting minute

Variable	Value	Description
`Starting second:`	integer 0 – 59	specifying starting second

Example lis.config entry

```
Starting year:                          2002
Starting month:                         10
Starting day:                           29
Starting hour:                          1
Starting minute:                        0
Starting second:                        0
```

The end time is specified in the following format:

Variable	Value	Description
`Ending year:`	integer 2001 – present	specifying ending year
`Ending month:`	integer 1 – 12	specifying ending month
`Ending day:`	integer 1 – 31	specifying ending day
`Ending hour:`	integer 0 – 23	specifying ending hour
`Ending minute:`	integer 0 – 59	specifying ending minute
`Ending second:`	integer 0 – 59	specifying ending second

Example lis.config entry

```
Ending year:                            2002
Ending month:                           10
Ending day:                             31
Ending hour:                            1
Ending minute:                          0
Ending second:                          0
```

`LIS time window interval:` specifies the interval at which the LIS run loop cycles, used in the "ensemble smoother" running mode.

Example lis.config entry

```
LIS time window interval:
```

`Undefined value:` specifies the undefined value. The default is set to -9999.

Example lis.config entry

```
Undefined value: -9999
```

`Output directory:` specifies the name of the top-level output directory. Acceptable values are any 40

character string. The default value is set to OUTPUT. For simplicity, throughout the rest of this document, this top-level output directory shall be referred to by its default name, *$WORKING/LIS/OUTPUT*.

Example lis.config entry

```
Output directory: OUTPUT
```

`Diagnostic output file:` specifies the name of run time diagnostic file. Acceptable values are any 40 character string.

Example lis.config entry

```
Diagnostic output file: lislog
```

`Number of ensembles per tile:` specifies the number of ensembles of tiles to be used. The value should be greater than or equal to 1.

Example lis.config entry

```
Number of ensembles per tile: 1
```

The following options are used for subgrid tiling based on vegetation

`Maximum number of surface type tiles per grid:` defines the maximum surface type tiles per grid (this can be as many as the total number of vegetation types).

Example lis.config entry

```
Maximum number of surface type tiles per grid: 1
```

`Minimum cutoff percentage (surface type tiles):` defines the smallest percentage of a cell for which to create a tile. The percentage value is expressed as a fraction.

Example lis.config entry

```
Minimum cutoff percentage (surface type tiles): 0.05
```

`Maximum number of soil texture tiles per grid:` defines the maximum soil texture tiles per grid (this can be as many as the total number of soil texture types).

Example lis.config entry

```
Maximum number of soil texture tiles per grid: 1
```

`Minimum cutoff percentage (soil texture tiles):` defines the smallest percentage of a cell for which to create a tile. The percentage value is expressed as a fraction.

Example lis.config entry

```
Minimum cutoff percentage (soil texture tiles): 0.05
```

`Maximum number of soil fraction tiles per grid:` defines the maximum soil fraction tiles per grid (this can be as many as the total number of soil fraction types).

Example lis.config entry

```
Maximum number of soil fraction tiles per grid: 1
```

`Minimum cutoff percentage (soil fraction tiles):` defines the smallest percentage of a cell for which to create a tile. The percentage value is expressed as a fraction.

Example lis.config entry

```
Minimum cutoff percentage (soil fraction tiles): 0.05
```

`Maximum number of elevation bands per grid:` defines the maximum elevation bands per grid (this can be as many as the total number of elevation band types).

Example lis.config entry

```
Maximum number of elevation bands per grid: 1
```

`Minimum cutoff percentage (elevation bands):` defines the smallest percentage of a cell for which to create a tile. The percentage value is expressed as a fraction.

Example lis.config entry

```
Minimum cutoff percentage (elevation bands): 0.05
```

`Maximum number of slope bands per grid:` defines the maximum slope bands per grid (this can be as many as the total number of slope band types).

Example lis.config entry

```
Maximum number of slope bands per grid: 1
```

`Minimum cutoff percentage (slope bands):` defines the smallest percentage of a cell for which to create a tile. The percentage value is expressed as a fraction.

Example lis.config entry

```
Minimum cutoff percentage (slope bands): 0.05
```

`Maximum number of aspect bands per grid:` defines the maximum aspect bands per grid (this can be

as many as the total number of aspect band types).

Example lis.config entry

```
Maximum number of aspect bands per grid: 1
```

`Minimum cutoff percentage (aspect bands):` defines the smallest percentage of a cell for which to create a tile. The percentage value is expressed as a fraction.

Example lis.config entry

```
Minimum cutoff percentage (aspect bands): 0.05
```

This section specifies the 2-d layout of the processors in a parallel processing environment. There are two ways that the user can specify the 2-d layout.

One way is the user can specify the number of processors along the east-west dimension and north-south dimension using `Number of processors along x:` and `Number of processors along y:`, respectively. Note that the layout of processors should match the total number of processors used. For example, if 8 processors are used, the layout can be specified as 1x8, 2x4, 4x2, or 8x1. **When choosing this way, the option `Decompose by processes:` must be set to `.false.`.** This way is useful when you must match a specific layout.

The other way is the user can allow LIS to create a load-balanced layout based on the number of processes. For example, if 8 processors are used, LIS will create a 4x2 layout where each process contains roughly the same amount of land-based grid-cells. When this way is chosen, LIS ignores both the `Number of processors along x:` and the `Number of processors along y:` options. This way is useful when your running domain contains a large number of ocean-based grid-cells, which would result in many under-utilized processes when using a specified layout.

Acceptable values for `Decompose by processes` are:

Value	Description
.false.	Do not decompose by processes. Use `Number of processors along x:` and `Number of processors along y:` to create the specified layout.
.true.	Do decompose by processes.

Defaults to `.false.`.

Further, this section also allows the specification of halos around the domains on each processor using `Halo size along x:` and `Halo size along y:`.

Example lis.config entry

```
Decompose by processes:          .false.
Number of processors along x:    2
Number of processors along y:    2
Halo size along x: 0
Halo size along y: 0
```

`Routing model:` specifies the routing model to run. Acceptable values are:

Value	Description
none	do not use a routing model
"NLDAS router"	use the NLDAS router
"HYMAP router"	use the HyMAP router
"HYMAP2 router"	use the HyMAP2 router
"HYMAP3 router"	use the HyMAP3 router
"RAPID router"	use the RAPID router

`External runoff data source:` Specifices the data source to be used for reading the surface runoff and baseflow fields for offline routing.

Acceptable values are:

Value	Description
"LIS runoff output"	Use LIS outputs
~~"GLDAS1 runoff data"~~ Disabled	~~Use the GLDAS1 outputs~~
~~"GLDAS2 runoff data"~~ Disabled	~~Use the GLDAS2 outputs~~
~~"NLDAS2 runoff data"~~ Disabled	~~Use the NLDAS2 outputs~~
~~"MERRA2 runoff data"~~ Disabled	~~Use the MERR2 outputs~~
~~"ERA interim land runoff data"~~ Disabled	~~Use ERA-Interim-Land outputs~~
~~"GWB MIP runoff data"~~ Disabled	~~Use the Global Water Budget (GWB) model intercomparison project outputs~~

`Number of application models:` specifies the number of application models to run.

Example lis.config entry

```
Routing model: none
External runoff data source: "LIS runoff output"
Radiative transfer model: none
Number of application models: 0
```

9.3. Forecast runmode

This section specifies the choice of forecast options.

`Forecast forcing source mode:` specifies the forecast run-mode and source option (e.g., ensemble streamflow prediction, or ESP), and depends on the number of forcing datasets selected. Acceptable values are:

Value	Description
"ESP conventional"	ESP conventional method
"ESP boot"	ESP bootstrapping method

Example lis.config entry

```
Forecast forcing source mode:      "ESP conventional"
```

`ESP conventional start time of the forcing archive:` specifies the ESP conventional forcing start date (YYYY MM DD).

`ESP conventional end time of the forcing archive:` specifies the ESP conventional forcing end date (YYYY MM DD).

`ESP conventional include targeted forecast year:` is an option if the user wants to include the year from the historical archive that is the same target year being forecasted. This is to provide a check of the climatology, but it is not recommended for hindcast evaluations.

Example lis.config entry

```
ESP conventional start time of the forcing archive: 1982 1 1
ESP conventional end time of the forcing archive:   2010 1 1
ESP conventional include targeted forecast year:     1 1
```

`ESP boot sampling time window interval:` specifies the ESP bootstrapping ("boot") temporal sampling window.

`ESP boot start time of the forcing archive:` specifies the ESP bootstrapping ("boot") forcing start date (YYYY MM DD).

`ESP boot end time of the forcing archive:` specifies the ESP bootstrapping ("boot") forcing end date (YYYY MM DD).

Example lis.config entry

```
ESP boot sampling time window interval:      "10da"
ESP boot start time of the forcing archive:  1982  1 1
ESP boot end time of the forcing archive:    2010  1 1
```

`Forecast forcing start mode:` specifies the type of forecast start mode, either coldstart or restart. If

restart is specified, a restart file name needs to be supplied.

Example lis.config entry

```
Forecast forcing start mode:          "coldstart"
```

`Forecast forcing restart filename:` specifies the restart filename.

Example lis.config entry

```
Forecast forcing restart filename:    "LIS_RST_CLSMF25_201005050000.d01.nc"
```

9.4. Data assimilation

This section specifies the choice of data assimilation options.

`Number of data assimilation instances:` specifies the number of data assimilation instances. Valid values are 0 (no assimilation) or higher.

Example lis.config entry

```
Number of data assimilation instances: 0
```

`Data assimilation algorithm:` specifies the choice of data assimilation algorithms. Acceptable values are:

Value	Description
“none”	None
“Direct insertion”	Direct Insertion
“EnKF”	GMAO EnKF data assimilation
“EnKS”	GRACE ensemble Kalman filter data assimilation

Example lis.config entry

```
Data assimilation algorithm: none
```

`Data assimilation set:` specifies the “assimilation set”, which is the instance related to the assimilation of a particular observation. Acceptable values are:

Value	Description
“none”	none
“Synthetic SM”	Synthetic soil moisture
“Synthetic SWE”	Synthetic SWE
“Synthetic LST”	Synthetic LST

Value	Description
“Synthetic(Multilayer) sm”	Synthetic multi-soil moisture observation types
“Synthetic L-band Tb”	Synthetic L-band brightness temperature observations
“ISCCP LST”	ISCCP LST
“AMSR-E(NASA) soil moisture”	AMSRE L3 soil moisture daily gridded data (HDF format)
“AMSR-E(LPRM) soil moisture”	AMSRE L3 soil moisture daily gridded data (HDF format)
“ESA CCI soil moisture”	ESA CCI soil moisture
“Windsat”	Windsat
“Windsat C-band”	Windsat C-band
“ANSA SWE”	ANSA SWE
“ANSA SCF”	ANSA SCF
“ANSA snow depth”	ANSA snow depth
“SMMR snow depth”	SMMR snow depth
“SMMI snow depth”	SMMI snow depth
“AMSR-E SWE”	AMSR-E SWE
“PMW snow”	PMW-based SWE or snow depth
“MODIS SCF”	MODIS SCF
“GRACE TWS”	GRACE TWS
“SMOPS-ASCAT soil moisture”	SMOPS-ASCAT soil moisture
“ASCAT (TUW) soil moisture”	ASCAT (TUW) soil moisture
“GCOMW AMSR2 L3 snow depth”	AMSR2 (GCOMW) L3 snow depth
“GCOMW AMSR2 L3 soil moisture”	AMSR2 (GCOMW) soil moisture
“SMAP(NASA) soil moisture”	NASA SMAP soil moisture
“SMAP(NRT) soil moisture”	Near-real time SMAP soil moisture
“PILDAS SM”	PILDAS soil moisture
“SMOS L2 soil moisture”	SMOS L2 soil moisture
“SMOS(NESDIS) soil moisture”	NESDIS SMOS soil moisture
“SNODEP”	AFWA SNODEP
“USAFSI”	USAF Snow and Ice Analysis
“SNIP”	USAF SNow and Ice Product
“SMAP(NASA) vegetation optical depth”	NASA L-band vegetation optical depth
“MCD15A2H LAI”	MODIS MCD15A2H v006 LAI product

Value	Description
“SMOS NRT NN soil moisture”	SMOS Level 2 Soil Moisture Near Real Time Neural Network
“THySM”	Thermal Hydraulic disaggregation of Soil Moisture
“SNODAS”	SNODAS snow depth
“GLASS LAI”	GLASS Leaf Area Index (LAI)
“GLASS Albedo”	GLASS Albedo (black-sky and white-sky)
“SWOT water level”	SWOT water surface elevation
“WSF soil moisture”	WSF-M (Weather Satellite Follow-on) soil moisture

Example lis.config entry

```
Data assimilation set: none
```

`Data assimilation exclude analysis increments:` specifies whether the analysis increments are to be skipped. This option is typically used along with the dynamic bias estimation algorithm. The user can choose to apply only the bias increments or both the bias increments and analysis increments. Acceptable values are:

Value	Description
0	Apply analysis increments
1	Do not apply analysis increments

Example lis.config entry

```
Data assimilation exclude analysis increments:     0
```

`Data assimilation output interval for diagnostics:` specifies the output diagnostics interval.

See Section Defining a time interval for a description of how to specify a time interval.

Example lis.config entry

```
Data assimilation output interval for diagnostics: 1da
```

`Data assimilation number of observation types:` specifies the number of observation species/types used in the assimilation.

Example lis.config entry

```
Data assimilation number of observation types: 0
```

`Data assimilation output ensemble spread:` specifies whether to output the ensemble spread. Acceptable values are:

Value	Description
0	Do not output the ensemble members
1	Output the ensemble members

Example lis.config entry

```
Data assimilation output ensemble spread: 0
```

`Data assimilation output processed observations:` specifies whether the processed, quality-controlled observations are to be written (Note that a corresponding observation plugin routine needs to be implemented). Acceptable values are:

Value	Description
0	Do not output the processed observations
1	Output the processed observations

Example lis.config entry

```
Data assimilation output processed observations: 0
```

`Data assimilation output innovations:` specifies whether a binary output of the normalized innovations is to be written. Acceptable values are:

Value	Description
0	Do not output the innovations
1	Output the innovations

Example lis.config entry

```
Data assimilation output innovations: 0
```

`Data assimilation use a trained forward model:` specifies whether to use a trained forward model. Acceptable values are:

Value	Description
0	Do not use a trained forward model
1	Use a trained forward model

`Data assimilation trained forward model output file:` specifies the name of the output file for the trained forward model. The training is done by LDT, and thus, this file is produced by LDT.

Example lis.config entry

```
Data assimilation use a trained forward model: 0
Data assimilation trained forward model output file: none
```

`Data assimilation scaling strategy:` specifies the scaling strategy. Acceptable values are:

Value	Description
none	Do not use any scaling
“Linear scaling”	Apply a linear scaling strategy
“CDF matching”	Scales observations using CDF matching

Example lis.config entry

```
Data assimilation scaling strategy: none
```

`Data assimilation observation domain file:` specifies the observation domain file, which will be used as the domain to compute the innovations.

Example lis.config entry

```
Data assimilation observation domain file: ascat_cdf_domain.nc
```

9.5. Bias estimation

`Bias estimation algorithm:` specifies the dynamic bias estimation algorithm to use. Acceptable values are:

Value	Description
“none”	No dynamic bias estimation
“Adaptive bias correction”	NASA GMAO dynamic bias estimation

Example lis.config entry

```
Bias estimation algorithm: none
```

`Bias estimation attributes file:` ASCII file that specifies the attributes of the bias estimation. A sample file is shown below, which lists the variable name first. This is followed by the nparam value (0-no bias correction, 1- constant bias correction without diurnal cycle, 3- diurnal sine/cosine bias correction, 5 - semi-diurnal sine/cosine bias correction, 2-“time of day” bias correction with 2 separate bias estimates per day, 4 - “time of day” bias correction with 4 separate estimates per day, 8 - “time of day” bias correction with 8 separate bias estimates per day), tconst (which describes the time scale relative to the temporal spacing of the observations), and trelax (which specifies temporal relaxation parameter, in seconds)

Example bias estimation attributes file

#nparam tconst trelax
Soil Temperature
1.0 0.05 86400.0

Example lis.config entry

```
Bias estimation attributes file:
```

`Bias estimation restart output frequency:` Specifies the frequency of bias restart files.

See Section Defining a time interval for a description of how to specify a time interval.

Example lis.config entry

```
Bias estimation restart output frequency: 1da
```

`Bias estimation start mode:` This option specifies whether the bias parameters are to be read from a checkpoint file. Acceptable values are:

Value	Description
none	Do not use a bias restart file
read	Use a bias restart file

Example lis.config entry

```
Bias estimation start mode: none
```

`Bias estimation restart file:` Specifies the restart file to be used for initializing bias parameters

Example lis.config entry

```
Bias estimation restart file: none
```

`Perturbations start mode:` specifies if the perturbations settings should be read from a restart file. Acceptable values are:

Value	Description
coldstart	None (cold start)
restart	Use restart file

Example lis.config entry

```
Perturbations start mode: coldstart
```

`Apply perturbation bias correction:` specifies whether to apply the Ryu et al. algorithm, (JHM

2009), to forcing and model states to avoid undesirable biases resulting from perturbations. Acceptable values are:

Value	Description
0	Do not apply
1	Apply

Example lis.config entry

```
Apply perturbation bias correction:
```

`Perturbations restart output interval:` specifies the perturbations restart output writing interval.

See Section Defining a time interval for a description of how to specify a time interval.

Example lis.config entry

```
Perturbations restart output interval: 1da
```

`Perturbations restart filename:` specifies the name of the restart file, which is used to initialize perturbation settings if a cold start option is not employed.

Example lis.config entry

```
Perturbations restart filename: none
```

`Forcing perturbation algorithm:` specifies the algorithm for perturbing the forcing variables. Acceptable values are:

Value	Description
“none”	None
“GMAO scheme”	GMAO perturbation algorithm

Example lis.config entry

```
Forcing perturbation algorithm: none
```

`Forcing perturbation frequency:` specifies the forcing perturbation interval.

See Section Defining a time interval for a description of how to specify a time interval.

Example lis.config entry

```
Forcing perturbation frequency: 1hr
```

`Forcing attributes file:` ASCII file that specifies the attributes of the forcing (for perturbations) A

sample file is shown below, which lists 3 forcing variables. For each variable, the name of the variable is specified first, followed by the min and max values in the next line. This is repeated for each additional variable.

Example forcing attributes file

#varmin varmax
Incident Shortwave Radiation Level 001
0.0 1300.0
Incident Longwave Radiation Level 001
-50.0 800.0
Rainfall Rate Level 001
0.0 0.001

Example lis.config entry

```
Forcing attributes file: none
```

`Forcing perturbation attributes file:` ASCII file that specifies the attributes of the forcing perturbations. A sample file is shown below, which lists 3 forcing variables. There are three lines of specifications for each variable. The first line specifies the name of the variable. The second line specifies the perturbation type (0-additive, 1-multiplicative) and the perturbation type for standard deviation (0-additive, 1-multiplicative). The third line specifies the following values in that order: standard deviation of perturbations, coefficient of standard deviation (if perturbation type for standard deviation is 1),standard normal max, whether to enable zero mean in perturbations, temporal correlation scale (in seconds), x and y -correlations and finally the cross correlations with other variables.

Example forcing perturbation attributes file

#ptype std std_max zeromean tcorr xcorr ycorr ccorr
Incident Shortwave Radiation Level 001
1 0
0.50 2.5 1 86400 0 0 1.0 -0.5 -0.8
Incident Longwave Radiation Level 001
0 1
50.0 0.2 2.5 1 86400 0 0 -0.5 1.0 0.5
Rainfall Rate Level 001
1 0
0.50 2.5 1 86400 0 0 0.8 0.5 1.0

Example lis.config entry

```
Forcing perturbation attributes file: none
```

`State perturbation algorithm:` specifies the algorithm for perturbing the state prognostic variables. Acceptable values are:

Value	Description
“none”	None
“GMAO scheme”	GMAO perturbation algorithm

Example lis.config entry

```
State perturbation algorithm: none
```

`State perturbation frequency:` specifies the prognostic variable perturbation interval.

See Section Defining a time interval for a description of how to specify a time interval.

Example lis.config entry

```
State perturbation frequency: 1hr
```

`State attributes file:` ASCII file that specifies the attributes of the prognostic variables. A sample file is shown below, which lists 2 model state variables. For each variable, the name of the variable is specified first, followed by the min and max values in the next line. This is repeated for each additional variable.

Example state attributes file

#name varmin varmax
SWE
0.0 100.0
Snowdepth
0.0 100.0

Example lis.config entry

```
State attributes file: none
```

`State perturbation attributes file:` ASCII file that specifies the attributes of the prognostic variable perturbations. A sample file is provided below, which follows the same format as that of the forcing perturbations attributes file:

Example state perturbation attributes file

#perttype std std_max zeromean tcorr xcorr ycorr ccorr
SWE
1 0
0.01 2.5 1 10800 0 0 1.0 0.9
Snowdepth
1 0
0.02 2.5 1 10800 0 0 0.9 1.0

Example lis.config entry

```
State perturbation attributes file: none
```

`Observation perturbation algorithm:` specifies the algorithm for perturbing the observations. Acceptable values are:

Value	Description
"none"	None
"GMAO scheme"	GMAO perturbation algorithm

Example lis.config entry

```
Observation perturbation algorithm: none
```

`Observation perturbation frequency:` specifies the observation perturbation interval.

See Section Defining a time interval for a description of how to specify a time interval.

Example lis.config entry

```
Observation perturbation frequency: 1hr
```

`Observation attributes file:` ASCII file that specifies the attributes of the observation variables. A sample file is provided below, which follows the same format as that of the forcing attributes file and state attributes file.

Example observation attributes file

#error rate varmin varmax
ANSA SWE
10.0 0.01 500

Example lis.config entry

```
Observation attributes file: none
```

`Observation perturbation attributes file:` ASCII file that specifies the attributes of the observation variable perturbations. A sample file is provided below, which follows the same format as that of the forcing perturbations attributes file:

Example observation perturbation attributes file

#perttype std std_max zeromean tcorr xcorr ycorr ccorr
ANSA SWE
0 10 2.5 1 10800 0 0 1

Example lis.config entry

```
Observation perturbation attributes file: none
```

`IMS data directory:` specifies the location of the IMS data.

Example lis.config entry

```
IMS data directory:
```

9.5.1. Synthetic Soil Moisture Assimilation

`Synthetic soil moisture data directory:` specifies the directory for the synthetic soil moisture data.

`Synthetic soil moisture model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology)

`Synthetic soil moisture observation CDF file:` specifies the name of the observation CDF file.

`Synthetic soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

Example lis.config entry

```
Synthetic soil moisture data directory:       ./input/dainput/SynSM/
Synthetic soil moisture model CDF file:       lsm.cdf.nc
Synthetic soil moisture observation CDF file: obs_cdf.nc
Synthetic soil moisture number of bins in the CDF:
```

9.5.2. PILDAS Soil Moisture Assimilation

`PILDAS soil moisture data directory:` specifies the directory for the PILDAS soil moisture data.

`PILDAS use scaled standard deviation model:` specifies whether the observation error standard deviation is to be scaled using model and observation standard deviation.

`PILDAS soil moisture model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology)

`PILDAS soil moisture observation CDF file:` specifies the name of the observation CDF file.

`PILDAS soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

Example lis.config entry

```
PILDAS soil moisture data directory:       ./input/...
PILDAS use scaled standard deviation model: 1
PILDAS soil moisture model CDF file:       lsm.cdf.nc
PILDAS soil moisture observation CDF file: obs_cdf.nc
PILDAS soil moisture number of bins in the CDF:
```

9.5.3. Synthetic Soil Moisture (multiple observation types) Assimilation

`Synthetic multi-sm data directory:` specifies the directory for the synthetic soil moisture data (multi-levels).

Example lis.config entry

```
Synthetic multi-sm data directory: ./input/dainput/SynSM/
```

9.5.4. Synthetic SWE Assimilation

`Synthetic SWE data directory:` specifies the directory for the synthetic snow water equivalent data.

Example lis.config entry

```
Synthetic SWE data directory:           ./input/dainput/SynSWE/
```

9.5.5. Synthetic LST Assimilation

`Synthetic LST data directory:` specifies the directory for the synthetic land surface temperature data

Example lis.config entry

```
Synthetic LST data directory:           ./input/dainput/SynLST/
```

9.5.6. Synthetic L-band Tb Assimilation

`Synthetic L-band Tb data directory:` specifies the directory for the synthetic brightness temperature data

Example lis.config entry

```
Synthetic L-band Tb data directory:           ./input/dainput/SynTb/
```

9.5.7. Synthetic SND Assimilation

`Synthetic SND data directory:` specifies the directory for the synthetic snow depth data.

Example lis.config entry

```
Synthetic SND data directory:
```

9.5.8. ISCCP Tskin Assimilation

`ISCCP Tskin data directory:` specifies the directory for the International Satellite Cloud Climatology Project (ISCCP) LST data.

`ISCCP Tskin scale data:` specifies if the LST observations are to be scaled or not (0 — no scaling, 1 — scale data).

`ISCCP Tskin model mean data file:` specifies the name of the file containing the monthly mean values from the LSM.

`ISCCP Tskin model std data file:` specifies the name of the file containing the monthly standard deviation values from the LSM.

`ISCCP Tskin obs mean data file:` specifies the name of the file containing the monthly mean values of the observations.

`ISCCP Tskin obs std data file:` specifies the name of the file containing the monthly standard deviation values of the observations.

Example lis.config entry

```
ISCCP Tskin data directory: '../ISCCP/'
ISCCP Tskin scale data:     0
ISCCP Tskin model mean data file: ../SND_Input/noah_mean
ISCCP Tskin model std data file: ../SND_Input/noah_std
ISCCP Tskin obs mean data file: ../SND_Input/isccp_obs_mean
ISCCP Tskin obs std data file: ../SND_Input/isccp_obs_std
```

9.5.9. AMSR-E (NASA) soil moisture assimilation

`NASA AMSR-E soil moisture data directory:` specifies the directory for the AMSR-E (NASA/NSIDC) soil moisture data.

`NASA AMSR-E soil moisture scale observations:` specifies if the observations are to be rescaled (using CDF matching).

`NASA AMSR-E soil moisture model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology).

`NASA AMSR-E soil moisture observation CDF file:` specifies the name of the observation CDF file.

`NASA AMSR-E soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

Example lis.config entry

```
NASA AMSR-E soil moisture data directory:       'input'
NASA AMSR-E soil moisture scale observations:   1
NASA AMSR-E soil moisture model CDF file:       lsm_cdf.nc
NASA AMSR-E soil moisture observation CDF file: obs_cdf.nc
NASA AMSR-E soil moisture number of bins in the CDF: 100
```

9.5.10. AMSR-E (LPRM) soil moisture assimilation

`AMSR-E(LPRM) soil moisture data directory:` specifies the directory for the AMSR-E (LPRM) soil

moisture data.

`AMSR-E(LPRM) soil moisture use raw data:` specifies if the the raw fields (in wetness units) or scaled fields (in volumetric units) are to be used.

`AMSR-E(LPRM) use scaled standard deviation model:` specifies if the observation error standard deviation is to be scaled using model and observation standard deviation.

`AMSR-E(LPRM) model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology).

`AMSR-E(LPRM) observation CDF file:` specifies the name of the observation CDF file.

`AMSR-E(LPRM) soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

Example lis.config entry

```
AMSR-E(LPRM) soil moisture data directory:       'input'
AMSR-E(LPRM) soil moisture use raw data:          0
AMSR-E(LPRM) use scaled standard deviation model: 1
AMSR-E(LPRM) model CDF file:                      lsm_cdf.nc
AMSR-E(LPRM) observation CDF file:                obs_cdf.nc
AMSR-E(LPRM) soil moisture number of bins in the CDF: 100
```

9.5.11. WindSat soil moisture assimilation

`WindSat soil moisture data directory:` specifies the directory for the WindSat soil moisture data.

`WindSat scale observations:` specifies if the observations are to be rescaled (using CDF matching).

`WindSat model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology).

`WindSat observation CDF file:` specifies the name of the observation CDF file.

`WindSat number of bins in the CDF:` specifies the number of bins in the CDF.

Example lis.config entry

```
WindSat soil moisture data directory:       'input'
WindSat scale observations:                  1
WindSat model CDF file:                      lsm_cdf.nc
WindSat observation CDF file:                obs_cdf.nc
WindSat number of bins in the CDF:           100
```

9.5.12. WindSat C-band soil moisture assimilation

`WindSat C-band soil moisture data directory:` specifies the directory for the WindSat C-band soil moisture data.

`WindSat C-band scale observations:` specifies if the observations are to be rescaled (using CDF matching).

`WindSat C-band model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology).

`WindSat C-band observation CDF file:` specifies the name of the observation CDF file.

`WindSat C-band number of bins in the CDF:` specifies the number of bins in the CDF.

Example lis.config entry

```
WindSat C-band soil moisture data directory:       'input'
WindSat C-band scale observations:                  1
WindSat C-band model CDF file:                      lsm_cdf.nc
WindSat C-band observation CDF file:                obs_cdf.nc
WindSat C-band number of bins in the CDF: 100
```

9.5.13. SNODEP Assimilation

`SNODEP data directory:` specifies the directory for the SNODEP data.

`SNODEP mesh resolution:` specifies the resolution of the SNODEP mesh (8 or 16).

`SNODEP naming convention:` specifies the naming convention of the SNODEP data. Acceptable values are:

Value	Description
“LIS”	YYYYMMDD/SNODEP/SNODEP_16_NH_YYYYMMDDHH.GR1
“other”	SNODEP_16_NH_YYYYMMDDHH.GR1

Example lis.config entry

```
SNODEP data directory:                 ./FORCING/AFWA1
SNODEP mesh resolution:                8
SNODEP naming convention:              LIS
```

9.5.14. USAFSI Assimilation

`USAFSI data directory:` specifies the directory for the USAFSI data.

`USAFSI netcdf filename prefix:` specifies the prefix of the USAFSI dataset. If prefix is “usafsi”, file name will be “usafsi_yyyymmddhh.nc.”

Example lis.config entry

```
USAFSI data directory:                  ./FORCING/USAFSI
USAFSI netcdf filename prefix:         usafsi
```

9.5.15. SNIP Assimilation

`SNIP data directory:` specifies the directory for the SNIP data.

`SNIP netcdf filename prefix:` specifies the prefix of the SNIP dataset. If prefix is "SNIP", then the file name will be "SNIP_yyyymmddhh.nc."

Example lis.config entry

```
SNIP data directory:                   ./FORCING/SNIP
SNIP netcdf filename prefix:          SNIP
```

9.5.16. ANSA SWE Assimilation

`ANSA SWE data directory:` specifies the directory for the ANSA SWE data.

`ANSA SWE lower left lat:` specifies the lower left latitude of the ANSA domain. (cylindrical latitude/longitude projection)

`ANSA SWE lower left lon:` specifies the lower left longitude of the ANSA domain. (cylindrical latitude/longitude projection)

`ANSA SWE upper right lat:` specifies the upper right latitude of the ANSA domain. (cylindrical latitude/longitude projection)

`ANSA SWE upper right lon:` specifies the upper right longitude of the ANSA domain. (cylindrical latitude/longitude projection)

`ANSA SWE resolution (dx):` specifies the resolution of the of the ANSA domain along the east-west direction.

`ANSA SWE resolution (dy):` specifies the resolution of the of the ANSA domain along the north-south direction.

Example lis.config entry

```
ANSA SWE data directory:                  ./ANSASWE
ANSA SWE lower left lat:                  -89.875
ANSA SWE lower left lon:                  -179.875
ANSA SWE upper right lat:                  89.875
ANSA SWE upper right lon:                 179.875
ANSA SWE resolution (dx):                  0.25
ANSA SWE resolution (dy):                  0.25
```

9.5.17. ANSA Snow Covered Fraction (SCF) Assimilation

`ANSA SCF data directory:` specifies the directory for the ANSA SCA data.

`ANSA SCF lower left lat:` specifies the lower left latitude of the ANSA domain. (cylindrical latitude/longitude projection)

`ANSA SCF lower left lon:` specifies the lower left longitude of the ANSA domain. (cylindrical latitude/longitude projection)

`ANSA SCF upper right lat:` specifies the upper right latitude of the ANSA domain. (cylindrical latitude/longitude projection)

`ANSA SCF upper right lon:` specifies the upper right longitude of the ANSA domain. (cylindrical latitude/longitude projection)

`ANSA SCF resolution (dx):` specifies the resolution of the of the ANSA domain along the east-west direction.

`ANSA SCF resolution (dy):` specifies the resolution of the of the ANSA domain along the north-south direction.

`ANSA SCF local time for assimilation:` specifies the local time for performing the ANSA SCF assimilation; LIS will find the closest time depending on model timestep.

`ANSA SCF field name:` specifies the name of the SCF field to be assimilated in the ANSA SCF data file.

`ANSA SCF file name convention:` specifies the name convention of the ANSA SCF file; currently supported: **YYYYMMDD**, **YYYYDOY**.

`ANSA SCF use triangular-shaped observation error:` specifies whether to use a triangular-shaped observation error as follows (De Lannoy et al., 2012): $std = std * scf_obs$ if $scf_obs <= 50$; $std = std * (100 - scf_obs)$ if $scf_obs > 50$; otherwise, std remains to be the same as read in from the observation perturbation attributes file.

`ANSA SCF using EnKF with DI:` specifies whether to used rule-based direct insertion approach to supplement EnKF when model predicts zero or full snow cover for all ensemble members. The entries after this are needed only if 1 is specified here.

`ANSA SCF direct insertion methodology:` specifies which rule to use when model predicts snow and observation says no snow. Acceptable values are:

Value	Description
“standard”	use Rodell and Houser (2004)
“customized”	use Liu et al. (2013)

`ANSA SCF amount of SWE (mm) to add to model:` specifies how much SWE to add to model when observation sees snow while model predicts no snow.

`ANSA SCF maximum SWE melt rate (mm/day):` specifies the SWE melt rate if “customized” is chosen for

the direction insertion methodology.

`ANSA SCF threshold of model SWE to be removed at once:` specifies the threshold of model SWE to be removed when observation says no snow.

`ANSA SCF length of snowmelt period in days:` specifies the length of the typical snowmelt period in the region.

`ANSA SCF threshold of observed SCF for snow presence:` specifies the threshold of observed SCF for indicating snow presence.

`ANSA SCF threshold of observed SCF for snow non-presence:` specifies the threshold of observed SCF for indicating snow non-presence.

`ANSA SCF threshold of model SWE(mm) for snow non-presence:` specifies the threshold of model SWE for indicating snow absence.

`ANSA SCF threshold of observed SCF for non-full snow cover:` specifies the threshold of observed SCF which indicates non-full snow cover.

Example lis.config entry

```
ANSA SCF data directory:           ./ANSA_SCF_UCO
ANSA SCF lower left lat:           35.025
ANSA SCF lower left lon:           -112.475
ANSA SCF upper right lat:          43.975
ANSA SCF upper right lon:          -105.525
ANSA SCF resolution (dx):          0.05
ANSA SCF resolution (dy):          0.05
ANSA SCF local time for assimilation:                      10.0
ANSA SCF field name:                                       "/ansa_interpsnow"
ANSA SCF file name convention:                             "ansa_all_YYYYMMDD.h5"
ANSA SCF use triangular-shaped observation error:          1
ANSA SCF using EnKF with DI:                               1
ANSA SCF direct insertion methodology:                     "customized"
ANSA SCF amount of SWE (mm) to add to model:               10
ANSA SCF maximum SWE melt rate (mm/day):                   50
ANSA SCF threshold of model SWE to be removed at once:     20
ANSA SCF length of snowmelt period in days:                15
ANSA SCF threshold of observed SCF for snow presence:      0.4
ANSA SCF threshold of observed SCF for snow non-presence:  0.1
ANSA SCF threshold of model SWE(mm) for snow non-presence: 5
ANSA SCF threshold of observed SCF for non-full snow cover: 0.7
```

9.5.18. ANSA snow depth Assimilation

`ANSA snow depth data directory:` specifies the directory for the ANSA snow depth data.

`ANSA snow depth lower left lat:` specifies the lower left latitude of the ANSA domain. (cylindrical latitude/longitude projection)

`ANSA snow depth lower left lon:` specifies the lower left longitude of the ANSA domain. (cylindrical latitude/longitude projection)

`ANSA snow depth upper right lat:` specifies the upper right latitude of the ANSA domain. (cylindrical latitude/longitude projection)

`ANSA snow depth upper right lon:` specifies the upper right longitude of the ANSA domain. (cylindrical latitude/longitude projection)

`ANSA snow depth resolution (dx):` specifies the resolution of the ANSA domain along the east-west direction.

`ANSA snow depth resolution (dy):` specifies the resolution of the ANSA domain along the north-south direction.

`ANSA snow depth use IMS data for snow detection:` specifies whether to use IMS data for snow detection. Acceptable values are:

Value	Description
0	Do not use IMS data
1	Use IMS data

`ANSA snow depth IMS data directory:` specifies the location of the IMS data directory.

`ANSA snow depth use MODIS (MOD10C1) data for snow detection:` specifies whether to use MODIS (MOD10C1) data for snow detection. Acceptable values are:

Value	Description
0	Do not use MODIS (MOD10C1) data
1	Use MODIS (MOD10C1) data

`ANSA snow depth MOD10C1 data directory:` specifies the location of MODIS (MOD10C1) data.

Example lis.config entry

```
ANSA snow depth data directory:                  ./ANSASNWD
ANSA snow depth lower left lat:                  -89.975
ANSA snow depth lower left lon:                  -179.975
ANSA snow depth upper right lat:                  89.975
ANSA snow depth upper right lon:                 179.975
ANSA snow depth resolution (dx):                  0.05
ANSA snow depth resolution (dy):                  0.05
ANSA snow depth use IMS data for snow detection:
ANSA snow depth IMS data directory:
ANSA snow depth use MODIS (MOD10C1) data for snow detection:
ANSA snow depth MOD10C1 data directory:
```

9.5.19. SMMR snow depth Assimilation

`SMMR snow depth data directory:` specifies the directory for the SMMR snow depth data.

Example lis.config entry

```
SMMR snow depth data directory:                  ./SMMR
```

9.5.20. SSMI snow depth Assimilation

`SSMI snow depth data directory:` specifies the directory for the SSMI snow depth data.

`SSMI snow depth use IMS data for snow detection:` specifies whether to use IMS data for snow detection. Acceptable values are:

Value	Description
0	Do not use IMS data
1	Use IMS data

`SSMI snow depth IMS data directory:` specifies the location of the IMS data.

`SSMI snow depth use MODIS (MOD10C1) data for snow detection:` specifies whether to use MODIS (MOD10C1) data for snow detection. Acceptable values are:

Value	Description
0	Do not use MODIS (MOD10C1) data
1	Use MODIS (MOD10C1) data

`SSMI snow depth MOD10C1 data directory:` specifies the location of the MODIS (MOD10C1) data.

Example lis.config entry

```
SSMI snow depth data directory:                  ./SSMI
SSMI snow depth use IMS data for snow detection:
SSMI snow depth IMS data directory:
SSMI snow depth use MODIS (MOD10C1) data for snow detection:
SSMI snow depth MOD10C1 data directory:
```

9.5.21. AMSR-E SWE Assimilation

`AMSR-E SWE data directory:` specifies the directory for the SSMI snow depth data.

Example lis.config entry

```
AMSR-E SWE data directory:                  ./AMSRE_SWE
```

9.5.22. MODIS snow cover fraction assimilation

`MODIS SCF data directory:` specifies the directory for the MODIS snow cover fraction data.

`MODIS SCF use gap filled product:` specifies whether the gap-filled product is to be used (1-use, 0-do not use).

`MODIS SCF cloud threshold:` Cloud cover threshold to be used for screening observations (in percentage).

`MODIS SCF cloud persistence threshold:` Cloud cover persistence threshold to be used for screening observations (in days).

Example lis.config entry

```
MODIS SCF data directory: ./MODIS
MODIS SCF use gap filled product: 1
MODIS SCF cloud threshold: 90
MODIS SCF cloud persistence threshold: 3
```

9.5.23. PMW snow depth or SWE assimilation

`PMW snow data directory:` specifies the directory for the PMW SWE or snow depth data.

`PMW snow data file format (HDF4, HDF-EOS, HDF5):` specifies the file format of the PMW snow data. Currently, three options are supported: HDF4, HDF-EOS, and HDF5

`PMW snow data coordinate system (EASE, LATLON):` specifies the coordinate system of the PMW snow data. Currently two options are supported: EASE and LATLON.

`PMW snow data variable (SWE, snow depth):` specifies which variable to assimilate: SWE or snow depth

`PMW snow data unit (m, cm, mm, inch):` specifies the unit of the snow data; currently only units of m, cm, mm, inch are supported

`PMW snow data use flag (1=yes, 0=no):` specifies whether to use the data flags that come along with the PMW snow data in the same file

`PMW snow data flag - number of invalid values:` specifies the number of invalid values in the flag field of the PMW snow data

`PMW snow data flag - invalid values:` specifies the invalid values of the flag field of the PMW snow data

`PMW snow data - number of additional invalid values:` specifies the number of additional invalid values in the actual data field of the PMW snow data

`PMW snow data - additional invalid values:` specifies the invalid values of the actual data field of the PMW snow data

`PMW snow data - apply min/max mask:` specifies whether to use min/max data values for quality control of the PMW snow data

`PMW snow data minimum valid value:` specifies the minimum valid value of the PMW snow data

`PMW snow data maximum valid value:` specifies the maximum valid value of the PMW snow data

`PMW snow data scale factor:` specifies the scale factor of the PMW snow data

`PMW snow data file name convention:` specifies the file name convention of the PMW snow data; currently only the following two formats are supported: **YYYYMMDD** and **YYYYDOY** note that the PMW snow reader assumes that the data files are stored in corresponding year directory as follows: datadir/YYYY/*YYYMMDD*

`PMW snow data assimilation local time:` specifies the local time in hours to apply the assimilation (usually corresponding to the overpass time)

`PMW snow data - apply mask with GVF (1=yes, 0=no):` specifies whether to use greenness vegetation fraction as mask for assimilation; 1 is suggested unless confidence is high with the PMW snow data (e.g., those that are bias corrected against station data) in dense vegetation area. If “1” is chosen, LIS will not assimilate PMW snow data in those areas with gvf \textgreater 0.7.

`PMW snow data - apply mask with landcover type (1=yes, 0=no):` specifies whether to use landcover type as mask for assimilation. If “1” is chosen, LIS will not assimilate PMW snow data in areas with forest land cover.

`PMW snow data - apply mask with LSM temperature (1=yes, 0=no):` specifies whether to use model-based temperatures as mask for assimilation. if “1” is chosen, LIS will not assimilate PMW snow data in areas with a skin temperature or surface soil temperature higher than 5 degree C according to the LSM. This mask should be used with care if the LSM temperatures are known to be biased.

The following 8 configuration lines are for HDF5+LANTON datasets only

`PMW snow data lower left lat:` specifies the lower left latitude of the dataset.

`PMW snow data lower left lon:` specifies the lower left longitude of the dataset.

`PMW snow data upper right lat:` specifies the upper right latitude of the dataset.

`PMW snow data upper right lon:` specifies the upper right longitude of the dataset.

`PMW snow data resolution (dx):` specifies horizontal resolution dx of the dataset.

`PMW snow data resolution (dy):` specifies vertical resolution dy of the dataset.

`PMW (HDF5) snow data field name:` specifies the name of the snow data field in the dataset for assimilation.

`PMW (HDF5) snow data flag field name:` specifies the name of the snow data flag field to use as a mask for assimilation; this must be specified if the `PMW snow data use flag (1=yes, 0=no):` option is set to 1.

The following 4 configuration lines are for HDF4+EASE datasets only

`PMW (HDF4) snow data NL SDS index (-1, 0, 1, 2, ⋯):` specifies the index of the SDS of the NL grid in the PMW snow data; valid index starts from 0; use -1 if no SDS for the NL grid is to be assimilated.

`PMW (HDF4) snow data SL SDS index (-1, 0, 1, 2, ⋯):` specifies the index of the SDS of the SL grid in the PMW snow data; valid index starts from 0; use -1 if no SDS for the NL grid is to be assimilated.

`PMW (HDF4) snow data flag NL SDS index (-1, 0, 1, 2, ⋯):` specifies the index of the flag SDS of the NL grid in the PMW snow data; this must be specified if the `PMW snow data use flag (1=yes, 0=no):` option is set to 1.

`PMW (HDF4) snow data flag SL SDS index (-1, 0, 1, 2, ⋯):` specifies the index of the flag SDS of the SL grid in the PMW snow data; this must be specified if the `PMW snow data use flag (1=yes, 0=no):` option is set to 1.

The following 6 configuration lines are for HDF-EOS+EASE datasets only

`PMW (HDF-EOS) NL grid name:` specifies the name of the NL grid.

`PMW (HDF-EOS) SL grid name:` specifies the name of the SL grid.

`PMW (HDF-EOS) NL SDS name:` specifies the name of the SDS in the NL grid.

`PMW (HDF-EOS) SL SDS name:` specifies the name of the SDS in the SL grid.

`PMW (HDF-EOS) NL snow data flag SDS name:` specifies the name of the data flag SDS in the NL grid; this must be specified if the `PMW snow data use flag (1=yes, 0=no):` option is set to 1.

`PMW (HDF-EOS) SL snow data flag SDS name:` specifies the name of the data flag SDS in the SL grid; this must be specified if the `PMW snow data use flag (1=yes, 0=no):` option is set to 1.

Example lis.config entry

```
# all datasets
PMW snow data directory:                          "./input/ANSA_OI"
PMW snow data file format (HDF4, HDF-EOS, HDF5):  "HDF5"
PMW snow data coordinate system (EASE, LATLON):   "LATLON"
PMW snow data variable (SWE, snow depth):         "snow depth"
PMW snow data unit (m, cm, mm, inch):             "mm"
PMW snow data use flag (1=yes, 0=no):                1
PMW snow data flag - number of invalid values:       2
PMW snow data flag - invalid values:                 -1  0
PMW snow data - number of additional invalid values: 0
PMW snow data - additional invalid values:           494 496 504 596 508 510
PMW snow data - apply min/max mask:                  1
PMW snow data minimum valid value:                   0
PMW snow data maximum valid value:                   5000
PMW snow data scale factor:                          1.0
PMW snow data file name convention:                  "ansa_all_YYYYMMDD.h5"
PMW snow data assimilation local time:               2.0
PMW snow data - apply mask with GVF (1=yes, 0=no):             0
PMW snow data - apply mask with landcover type (1=yes, 0=no):  0
PMW snow data - apply mask with LSM temperature (1=yes, 0=no): 0

# HDF5 & LATLON datasets only
PMW snow data lower left lat:                     50.025
PMW snow data lower left lon:                    -172.975
PMW snow data upper right lat:                    75.725
PMW snow data upper right lon:                   -130.025
PMW snow data resolution (dx):                   0.05
PMW snow data resolution (dy):                   0.05
PMW (HDF5) snow data field name:                 "ansa_swe_depth"
PMW (HDF5) snow data flag field name:            "ansa_swe_depth_flag"

# HDF4 & EASE datasets only
PMW (HDF4) snow data NL SDS index (-1, 0, 1, 2, ...):       0
PMW (HDF4) snow data SL SDS index (-1, 0, 1, 2, ...):       -1
PMW (HDF4) snow data flag NL SDS index (-1, 0, 1, 2, ...):  1
PMW (HDF4) snow data flag SL SDS index (-1, 0, 1, 2, ...):  -1

# HDF-EOS and EASE datasets only
PMW (HDF-EOS) NL grid name:                  "Northern Hemisphere"
PMW (HDF-EOS) SL grid name:                  "Southern Hemisphere"
PMW (HDF-EOS) NL SDS name:                   "SWE_NorthernDaily"
PMW (HDF-EOS) SL SDS name:                   "SWE_SouthernDaily"
PMW (HDF-EOS) NL snow data flag SDS name:    "Flags_NorthernDaily"
PMW (HDF-EOS) SL snow data flag SDS name:    "Flags_SouthernDaily"
```

9.5.24. GRACE TWS Assimilation

`GRACE data directory:` specifies the directory for the GRACE TWS data (processed data from LDT).

`GRACE use reported measurement error values:` specifies whether to use the spatially distributed reported measurement errors in the GRACE data for specifying observation errors. Acceptable values are:

Value	Description
0	Do not use
1	Use

Example lis.config entry

```
GRACE data directory:                  ./GRACEOBS
GRACE use reported measurement error values:
```

9.5.25. SMOPS ASCAT soil moisture assimilation

`SMOPS ASCAT soil moisture data directory:` specifies the directory for the SMOPS ASCAT soil moisture data.

`SMOPS ASCAT model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology).

`SMOPS ASCAT observation CDF file:` specifies the name of the observation CDF file.

`SMOPS ASCAT soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

`SMOPS ASCAT CDF read option:` specifies whether to read all months of or to read month by month from a monthly CDF file.

Acceptable values are:

Value	Description
0	Read all months
1	Read month by month

NOTE Select 0 for yearly CDF data.

`SMOPS ASCAT use realtime data:` specifies whether to use the 6 hour data feed instead of the daily data feed. Acceptable values are:

Value	Description
0	Use daily data feed
1	Use 6 hour data feed

`SMOPS ASCAT soil moisture use scaled standard deviation model:` specifies whether to use scaled standard deviation. This generates and uses spatially distributed observation errors by scaling the specified observation error standard deviation by a factor of the model standard deviation to the

observation standard deviation. ($e \mapsto e \times m_\sigma / o_\sigma$)

`SMOPS ASCAT naming convention:` specifies the naming convention of the SMOPS soil moisture data. Used when reading the 6-hour data feed. Acceptable values are:

Value	Description
"LIS"	YYYY/NPR_SMOPS_CMAP_DYYYYMMDDHH.gr2
"AGRMET ops"	smops_dYYYYMMDD_sHH0000_cness.gr2 or NPR_SMOPS_CMAP_DYYYYMMDDHH.gr2, depending on date

For "AGRMET ops", dates before 2017-10-05 use the smops_dYYYYMMDD_sHH0000_cness.gr2 naming convention; dates on or after 2017-10-05 use the NPR_SMOPS_CMAP_DYYYYMMDDHH.gr2 naming convention.

NOTE When reading the daily data feed, the naming convention is "LIS".

`SMOPS ASCAT version:` specifies the version of the SMOPS datasets. Defaults to "date-based". Acceptable values are:

Value	Description
"date-based"	Assume the version of the dataset based on date. (default)
"1.3"	Treat the dataset as version 1.3.
"2.0"	Treat the dataset as version 2.0.
"3.0"	Treat the dataset as version 3.0.
"NESDIS V3.0 REGEN"	Assume the version of the dataset based on the NESDIS version 3.0 regeneration date.

There are three versions of the SMOPS datasets. According to the use by the 557th Weather Wing:

```
                      version_1.3 <  2016-10-31T12:00:00
2016-10-31T12:00:00 <= version_2.0 <  2017-08-24T12:00:00
                      version_3.0 >= 2017-08-24T12:00:00
```

Also, NESDIS has regenerated SMOPS version 3.0 datasets starting from 2012-08-01.

The value "date-based" will use the dates 2016-10-31 and 2017-08-24 to determine the version of the SMOPS datasets.

The value "NESDIS V3.0 REGEN" will use the date 2012-08-01 to determine the version of the SMOPS datasets.

Should you need to explicitly state the version of the SMOPS datasets, then you may specify their version with either "1.3", "2.0", or "3.0".

Example lis.config entry

```
SMOPS ASCAT soil moisture data directory:       'input'
SMOPS ASCAT model CDF file:                      lsm_cdf.nc
SMOPS ASCAT observation CDF file:                obs_cdf.nc
SMOPS ASCAT CDF read option:                     0
SMOPS ASCAT soil moisture number of bins in the CDF: 100
SMOPS ASCAT use realtime data: 0
SMOPS ASCAT soil moisture use scaled standard deviation model: 1
SMOPS ASCAT naming convention: LIS
SMOPS ASCAT version: 'date-based'
```

9.5.26. SMOS L2 soil moisture assimilation

`SMOS L2 soil moisture data directory:` specifies the directory for the SMOS LS soil moisture data.

`SMOS L2 scale observations:` specifies whether to scale the observations. Acceptable values are:

Value	Description
0	Do not scale
1	Scale

`SMOS L2 use scaled standard deviation model:` specifies whether the observation error standard deviation is to be scaled using model and observation standard deviation.

`SMOS L2 model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology).

`SMOS L2 observation CDF file:` specifies the name of the observation CDF file.

`SMOS L2 soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

Example lis.config entry

```
SMOS L2 soil moisture data directory:
SMOS L2 scale observations:
SMOS L2 use scaled standard deviation model:
SMOS L2 model CDF file:
SMOS L2 observation CDF file:
SMOS L2 soil moisture number of bins in the CDF:
```

9.5.27. ASCAT (TU Wein) soil moisture assimilation

`ASCAT (TUW) soil moisture data directory:` specifies the directory for the ASCAT (TUW) soil moisture data.

`ASCAT (TUW) use scaled standard deviation model:` specifies if the observation error standard deviation is to be scaled using model and observation standard deviation.

`ASCAT (TUW) model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology).

`ASCAT (TUW) observation CDF file:` specifies the name of the observation CDF file.

`ASCAT (TUW) soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

Example lis.config entry

```
ASCAT (TUW) soil moisture data directory:       'input'
ASCAT (TUW) use scaled standard deviation model: 1
ASCAT (TUW) model CDF file:                      lsm_cdf.nc
ASCAT (TUW) observation CDF file:                obs_cdf.nc
ASCAT (TUW) soil moisture number of bins in the CDF: 100
```

9.5.28. MODIS MCD15A2H LAI assimilation

`MCD15A2H LAI data directory:` specifies the location of the data directory containing the MODIS MCD15A2H LAI retrievals.

`MCD15A2H LAI data version:` specifies the version of the MCD15A2H LAI retrievals. The default version is "006".

`MCD15A2H LAI apply temporal smoother between 8-day intervals:` specifies whether to apply temporal smoother between 8-day intervals of the LAI product

`MCD15A2H LAI apply climatological fill values:` specifies whether to fill in climatological LAI values if there are missing values.

`MCD15A2H LAI apply QC flags:` specifies whether to apply quality control flags for LAI retrievals.

Example lis.config entry

```
MCD15A2H LAI data directory:                                ./MCD15A2H.006
MCD15A2H LAI data version:                                  "006"
MCD15A2H LAI apply temporal smoother between 8-day intervals: 1
MCD15A2H LAI apply climatological fill values:              1
MCD15A2H LAI apply QC flags:                                1
```

9.5.29. GLASS LAI assimilation

`GLASS LAI data directory:` specifies the location of the data directory containing the GLASS LAI retrievals.

`GLASS LAI data source:` specifies if the GLASS data source is AVHRR or MODIS.

`GLASS LAI apply temporal smoother between 8-day intervals:` specifies whether to apply temporal smoother between 8-day intervals of the LAI product. Acceptable values are:

Value	Description
0	Do not apply temporal smoother
1	Apply temporal smoother

Example lis.config entry

```
GLASS LAI data directory:                                ./GLASS/LAI
GLASS LAI data source:                                   "AVHRR"
GLASS LAI apply temporal smoother between 8-day intervals: 1
```

9.5.30. GLASS Albedo assimilation

`GLASS Albedo data directory:` specifies the location of the data directory containing the GLASS Albedo retrievals.

`GLASS Albedo data source:` specifies if the GLASS data source is AVHRR or MODIS.

`GLASS Albedo apply QC flags:` specifies whether to apply quality-control flags of the GLASS Albedo data to the assimilation. Acceptable values are:

Value	Description
0	Do not apply QC flags
1	Apply QC flags

Example lis.config entry

```
GLASS Albedo data directory:                             ./GLASS/Albedo
GLASS Albedo data source:                                "AVHRR"
GLASS Albedo apply QC flags:                             1
```

9.5.31. Simulated GRACE

`Simulated GRACE data directory:` specifies the location of the simulated GRACE data.

`Simulated GRACE configuration:` specifies the simulated GRACE configuration. Acceptable values are:

Value	Description
GRACE	GRACE
GRACEFO	GRACE follow-on
GRACE-2	GRACE 2

`Simulated GRACE use reported measurement error values:` specifies whether to use the simulated GRACE reported measurement error values. Acceptable values are:

Value	Description
0	Do not use reported measurement error values
1	Use reported measurement error values

Example lis.config entry

```
Simulated GRACE data directory:
Simulated GRACE configuration:
Simulated GRACE use reported measurement error values:
```

9.5.32. Synthetic Streamflow

`Synthetic streamflow data directory:` specifies the location of the synthetic streamflow data.

Example lis.config entry

```
Synthetic streamflow data directory:
```

9.5.33. ESA CCI soil moisture data assimilation

`ESA CCI soil moisture data directory:` specifies the location of the ESA CCI soil moisture data.

`ESA CCI soil moisture data version:` specifies the version of the ESA CCI soil moisture data.

`ESA CCI soil moisture sensor type:` specifies the sensor type of the ESA CCI soil moisture dataset. Acceptable values are:

Value	Description
“passive”	passive sensor type
“active”	active sensor type
“combined”	combined sensor type

`ESA CCI use scaled standard deviation model:` specifies if the observation error standard deviation is to be scaled using model and observation standard deviation.

`ESA CCI model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology).

`ESA CCI observation CDF file:` specifies the name of the observation CDF file.

`ESA CCI soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

Example lis.config entry

```
ESA CCI soil moisture data directory:
ESA CCI soil moisture data version:
ESA CCI soil moisture sensor type:            combined
ESA CCI use scaled standard deviation model:
ESA CCI model CDF file:
ESA CCI observation CDF file:
ESA CCI soil moisture number of bins in the CDF:
```

9.5.34. AMSR2 (GCOMW) soil moisture data assimilation

`AMSR2(GCOMW) soil moisture data directory:` specifies the AMSR2(GCOMW) soil moisture data directory.

`AMSR2(GCOMW) scale observations:` specifies whether to scale the observations. Acceptable values are:

Value	Description
0	Do not scale
1	Scale

`AMSR2(GCOMW) use scaled standard deviation model:` specifies whether the observation error standard deviation is to be scaled using model and observation standard deviation.

`AMSR2(GCOMW) model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology).

`AMSR2(GCOMW) observation CDF file:` specifies the name of the observation CDF file.

`AMSR2(GCOMW) soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

Example lis.config entry

```
AMSR2(GCOMW) soil moisture data directory:
AMSR2(GCOMW) scale observations:
AMSR2(GCOMW) use scaled standard deviation model:
AMSR2(GCOMW) model CDF file:
AMSR2(GCOMW) observation CDF file:
AMSR2(GCOMW) soil moisture number of bins in the CDF:
```

9.5.35. AMSR2 (GCOMW) snow depth data assimilation

`AMSR2(GCOMW) snow depth data directory:` specifies the directory for the AMSR2(GCOMW) snow depth data.

`AMSR2(GCOMW) snow depth use IMS data for snow detection:` specifies whether to use IMS data for snow detection. Acceptable values are:

Value	Description
0	Do not use IMS data
1	Use IMS data

`AMSR2(GCOMW) snow depth IMS data directory:` specifies the location of the IMS data.

`AMSR2(GCOMW) snow depth use MODIS (MOD10C1) data for snow detection:` specifies whether to use MODIS (MOD10C1) data for snow detection. Acceptable values are:

Value	Description
0	Do not use MODIS (MOD10C1) data
1	Use MODIS (MOD10C1) data

`AMSR2(GCOMW) snow depth MOD10C1 data directory:` specifies the location of the MODIS (MOD10C1) data.

`AMSR2(GCOMW) snow depth use bias corrected version:` specifies whether to use to bias corrected data. Acceptable values are:

Value	Description
0	Do not use bias corrected version
1	Use bias corrected version

`AMSR2(GCOMW) snow depth use input mask:` specifies whether to use an input mask. Acceptable values are:

Value	Description
0	Do not use input mask
1	Use input mask

`AMSR2(GCOMW) snow depth input mask file:` specifies the input mask file.

Example lis.config entry

```
AMSR2(GCOMW) snow depth data directory:
AMSR2(GCOMW) snow depth use IMS data for snow detection:
AMSR2(GCOMW) snow depth IMS data directory:
AMSR2(GCOMW) snow depth use MODIS (MOD10C1) data for snow detection:
AMSR2(GCOMW) snow depth MOD10C1 data directory:
AMSR2(GCOMW) snow depth use bias corrected version:
AMSR2(GCOMW) snow depth use input mask:
AMSR2(GCOMW) snow depth input mask file:
```

9.5.36. SMAP (NASA) soil moisture assimilation

`SMAP(NASA) soil moisture data directory:` specifies the SMAP(NASA) soil moisture data directory.

`SMAP(NASA) soil moisture data designation:` specifies the designation of the SMAP data.

Acceptable values are:

Value	Description
SPL3SMAP	Level 3 active passive SMAP data
SPL3SMP	Level 3 passive SMAP data

`SMAP(NASA) soil moisture Composite Release ID:` specifies the SMAP NASA composite release ID included within the filename (e.g., R16).

`SMAP(NASA) soil moisture use scaled standard deviation model:` specifies whether the observation error standard deviation is to be scaled using model and observation standard deviation.

`SMAP(NASA) model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology). Note: Soil moisture CDF grouped (stratified) by land cover or precipitation climatology or both simultaneously also can be used here.

`SMAP(NASA) observation CDF file:` specifies the name of the observation CDF file. Note: Soil moisture CDF grouped (stratified) by land cover or precipitation climatology or both simultaneously also can be used here.

`SMAP(NASA) soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

`SMAP(NASA) CDF read option:` specifies whether to read all months of or to read month by month from a monthly CDF file.

Acceptable values are:

Value	Description
0	Read all months
1	Read month by month

NOTE Select 0 for yearly CDF data.

Example lis.config entry

```
SMAP(NASA) soil moisture data directory:
SMAP(NASA) soil moisture data designation:
SMAP(NASA) soil moisture Composite Release ID:
SMAP(NASA) soil moisture use scaled standard deviation model:
SMAP(NASA) model CDF file:
SMAP(NASA) observation CDF file:
SMAP(NASA) soil moisture number of bins in the CDF:
SMAP(NASA) CDF read option:
```

9.5.37. SMAP (NRT) soil moisture assimilation

`SMAP(NRT) soil moisture data directory:` specifies the SMAP(NRT) soil moisture data directory

`SMAP(NRT) soil moisture use scaled standard deviation model:` specifies whether the observation error standard deviation is to be scaled using model and observation standard deviation.

`SMAP(NRT) model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology).

`SMAP(NRT) observation CDF file:` specifies the name of the observation CDF file.

`SMAP(NRT) soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

`SMAP(NRT) CDF read option:` specifies whether to read all months of or to read month by month from a monthly CDF file.

Acceptable values are:

Value	Description
0	Read all months
1	Read month by month

NOTE Select 0 for yearly CDF data.

Example lis.config entry

```
SMAP(NRT) soil moisture data directory:
SMAP(NRT) soil moisture use scaled standard deviation model:
SMAP(NRT) model CDF file:
SMAP(NRT) observation CDF file:
SMAP(NRT) soil moisture number of bins in the CDF:
SMAP(NRT) CDF read option:
```

9.5.38. WSF soil moisture assimilation

`WSF soil moisture data directory:` specifies the directory containing the hourly WSF-M soil

moisture retrieval files (ARFS_SM_WSFM_*.nc)

WSF soil moisture use scaled standard deviation model: specifies whether the observation error standard deviation is to be scaled using the model and observation standard deviation.

WSF model CDF file: specifies the name of the model-side CDF file generated by LDT in "DA preprocessing" mode using LIS open-loop output. The observation distribution will be scaled into this model climatology.

WSF observation CDF file: specifies the name of the observation-side CDF file generated by LDT in "DA preprocessing" mode using WSF-M soil moisture retrievals.

WSF soil moisture number of bins in the CDF: specifies the number of bins in the CDF.

WSF CDF read option: specifies whether to read all months at once or month by month from a monthly CDF file.

Value	Description
0	Read all months
1	Read month by month

NOTE Select 0 for yearly CDF data.

Example lis.config entry

```
WSF soil moisture data directory:                          ./wsf_sm_data
WSF model CDF file:                                        ./cdf/noah39_cdf_200obs.nc
WSF observation CDF file:                                  ./cdf/cdf_wsfobs.nc
WSF soil moisture number of bins in the CDF:               100
WSF soil moisture use scaled standard deviation model:     0
WSF CDF read option:                                       1
```

9.5.39. Transfering stratified CDFs from one domain to another

Use CDF transfer for soil moisture data assimilation: specifies whether to use CDF transfer method.

Reference domain model CDF file: specifies the reference domain model CDF name and data directory.

Target domain obs CDF file: specifies the reference domain obs CDF name and data directory.

Number of bins in the soil moisture CDF: specifies the number of bins in the CDF.

Reference domain precipitation climatology data source: specifies the reference domain precipitation climatology generated by LVT.

Target domain precipitation climatology data source: specifies the target domain precipitation climatology generated by LVT.

Example lis.config entry

```
Use CDF transfer for soil moisture data assimilation:
Reference domain model CDF file:
ref_model_cdf_forcing_diff/stratified_cdf_noahmp401.nc
Reference domain obs CDF file: ref_obs_cdf_forcing_diff/stratified_cdf_smapobs.nc
Number of bins in the soil moisture CDF: 100
Reference domain precipitation climatology data source:
Precip.climo.us.nldas2/LVT_MEAN_FINAL.202201010000.d01.nc
Target domain precipitation climatology data source:
Precip.climo.eu.merra/LVT_MEAN_FINAL.202201010000.d01.nc
```

9.5.40. SMAP (NASA) vegetation optical depth assimilation

`SMAP(NASA) vegetation optical depth data directory:` specifies the SMAP(NASA) vegetation optical depth data directory

`SMAP(NASA) vegetation optical depth data designation:` specifies the designation of the SMAP VOD data

Acceptable values are:

Value	Description
SPL2SMP	Level2 passive VOD data
SPL2SMP_E	Level2 oversampled passive VOD data

`SMAP(NASA) vegetation optical depth use scaled standard deviation model:` specifies whether the observation error standard deviation is to be scaled using model and observation standard deviation.

`SMAP(NASA) vegetation optical depth apply SMAP QC flags:` specifies whether to employ the standard SMAP QC flags to screen VOD data

`SMAP(NASA) reference LAI CDF file:` specifies the name of the reference LAI CDF file (observations will be scaled into this climatology).

`SMAP(NASA) vegetation optical depth observation CDF file:` specifies the name of the observation VOD CDF file.

`SMAP(NASA) vegetation optical depth number of bins in the CDF:` specifies the number of bins in the CDF.

Example lis.config entry

```
SMAP(NASA) vegetation optical depth data directory:
SMAP(NASA) vegetation optical depth data designation:
SMAP(NASA) vegetation optical depth use scaled standard deviation model:
SMAP(NASA) vegetation optical depth apply SMAP QC flags:
SMAP(NASA) reference LAI CDF file:
SMAP(NASA) vegetation optical depth observation CDF file:
SMAP(NASA) vegetation optical depth number of bins in the CDF:
```

9.5.41. SMOS (NESDIS) soil moisture assimilation

`SMOS(NESDIS) soil moisture data directory:` specifies the SMOS(NESDIS) soil moisture data directory

`SMOS(NESDIS) soil moisture use scaled standard deviation model:` specifies whether the observation error standard deviation is to be scaled using model and observation standard deviation.

`SMOS(NESDIS) model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology).

`SMOS(NESDIS) observation CDF file:` specifies the name of the observation CDF file.

`SMOS(NESDIS) soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

Example lis.config entry

```
SMOS(NESDIS) soil moisture data directory:
SMOS(NESDIS) soil moisture use scaled standard deviation model:
SMOS(NESDIS) model CDF file:
SMOS(NESDIS) observation CDF file:
SMOS(NESDIS) soil moisture number of bins in the CDF:
```

9.5.42. SMOS NRT NN soil moisture assimilation

`SMOS NRT NN soil moisture data directory:` specifies the SMOS NRT NN soil moisture data directory

`SMOS NRT NN soil moisture use scaled standard deviation model:` specifies whether the observation error standard deviation is to be scaled using model and observation standard deviation.

`SMOS NRT NN model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology).

`SMOS NRT NN observation CDF file:` specifies the name of the observation CDF file.

`SMOS NRT NN soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

`SMOS NRT NN CDF read option:` specifies whether to read all months of or to read month by month from a monthly CDF file.

Acceptable values are:

Value	Description
0	Read all months
1	Read month by month

NOTE Select 0 for yearly CDF data

Example lis.config entry

```
SMOS NRT NN soil moisture data directory: ./SMOS_NRT_NN
SMOS NRT NN soil moisture use scaled standard deviation model: 0
SMOS NRT NN model CDF file:               ../DA_proc_LSM/LDTOUT/noah39_cdf.nc
SMOS NRT NN observation CDF file:         ../DA_proc_SMOS/LDTOUT/SMOS_cdf.nc
SMOS NRT NN soil moisture number of bins in the CDF:          100
SMOS NRT NN CDF read option:       1
```

9.5.43. THySM soil moisture assimilation

`THySM data directory:` specifies the THySM data directory.

`THySM use scaled standard deviation model:` specifies whether the observation error standard deviation is to be scaled using model and observation standard deviation.

`THySM model CDF file:` specifies the name of the model CDF file (observations will be scaled into this climatology).

`THySM observation CDF file:` specifies the name of the observation CDF file.

`THySM soil moisture number of bins in the CDF:` specifies the number of bins in the CDF.

Example lis.config entry

```
THySM data directory:                          ../THySM/
THySM use scaled standard deviation model:     0
THySM model CDF file:                          LSMSM.nc
THySM observation CDF file:                    THySM.nc
THySM soil moisture number of bins in the CDF: 100
```

9.5.44. SNODAS snow depth assimilation

`SNODAS data directory:` specifies the directory for the SNODAS data.

Example lis.config entry

```
SNODAS snow depth data directory:                  ./FORCING/SNODAS
```

9.5.45. SWOT water level assimilation

`SWOT water level data directory:` specifies the SWOT water level data directory.

`SWOT water level map:` specifies the assimilation map file and its associated sequential ID.

`Data assimilation frequency:` specifies the DA frequency: minimum 15mn and maximum 1da.

Example lis.config entry

```
SWOT water level data directory:            ./input/SWOT_obs
SWOT water level map:                       ./SWOT_lis_id.nc
Data assimilation frequency:                "15mn"
```

9.6. Radiative Transfer/Forward Models

This section specifies the choice of radiative transfer or forward modeling tools.

`Radiative transfer model:` specifies which RTM is to be used. Acceptable values are:

Value	Description
CRTM2EM	CRTM2EM
CMEM	CMEM
“Tau Omega”	“Tau Omega”

`RTM invocation frequency:` specifies the invocation frequency of the chosen RTM.

See Section Defining a time interval for a description of how to specify a time interval.

`RTM history output frequency:` specifies the history output frequency of the RTM.

See Section Defining a time interval for a description of how to specify a time interval.

Example lis.config entry

```
Radiative transfer model:     CRTM2EM
RTM invocation frequency:     1hr
RTM history output frequency: 3hr
```

9.6.1. CRTM2EM

This section specifies the specifications to enable a CRTM2EM instance.

`CRTM number of sensors:` specifies the number of sensors to be used.

`CRTM number of layers:` specifies the number of atmospheric layers.

`CRTM number of absorbers:` specifies the number of absorbers.

`CRTM number of clouds:` specifies the number of cloud types.

`CRTM number of aerosols:` specifies the number of aerosol types.

`CRTM sensor id:` specifies the name of sensors to be simulated.

`CRTM coefficient data path:` specifies the location of the files containing the CRTM coefficient data. These data are part of the Subversion checkout that was performed to obtain the CRTM library from JCSDA. The `CRTM coefficient data path:` variable should either explicitly specify the whole path to or symbolically link to *trunk/fix/TauCoeff/ODPS/Big_Endian/* found within the aforementioned checkout.

`CRTM zenith angle:` specifies what?

`RTM input soil moisture correction:` specifies whether to enable input soil moisture correction. Acceptable values are:

Value	Description
0	Do not enable correction
1	Enable correction

`RTM input soil moisture correction src mean file:` specifies the RTM input soil moisture correction src mean file.

`RTM input soil moisture correction src sigma file:` specifies the RTM input soil moisture correction src sigma file.

`RTM input soil moisture correction dst mean file:` specifies the RTM input soil moisture correction dst mean file.

`RTM input soil moisture correction dst sigma file:` specifies the RTM input soil moisture correction dst sigma file.

Example lis.config entry

```
CRTM number of sensors:        1
CRTM number of layers:         64
CRTM number of absorbers:      2
CRTM number of clouds:         0
CRTM number of aerosols:       0
CRTM sensor id:                amsua_n18
CRTM coefficient data path:    ./Coefficient_Data/
CRTM zenith angle:
RTM input soil moisture correction:
RTM input soil moisture correction src mean file:
RTM input soil moisture correction src sigma file:
RTM input soil moisture correction dst mean file:
RTM input soil moisture correction dst sigma file:
```

9.6.2. CMEM3

This section specifies the specifications to enable a CMEM3 instance. For more information regarding CMEM3, please see http://www.ecmwf.int/research/data_assimilation/land_surface/cmem/cmem_index.html.

`CMEM3 sensor id:` specifies the name of sensors to be simulated.

`CMEM3 number of frequencies:` specifies the number of frequencies.

`CMEM3 frequencies file:` specifies the file containing the CMEM3 frequencies data. This is an ASCII file containing two columns of data. The first column specifies frequency in GHz; the second column specifies the incidence angle. A sample file for AMSR-E:

6.925	55.0
10.65	55.0
18.7	55.0
23.8	55.0
36.5	55.0
89.0	55.0

`RTM input soil moisture correction:` specifies whether to enable input soil moisture correction. Acceptable values are:

Value	Description
0	Do not enable correction
1	Enable correction

`RTM input soil moisture correction src mean file:` specifies the RTM input soil moisture correction src mean file.

`RTM input soil moisture correction src sigma file:` specifies the RTM input soil moisture correction src sigma file.

`RTM input soil moisture correction dst mean file:` specifies the RTM input soil moisture correction dst mean file.

`RTM input soil moisture correction dst sigma file:` specifies the RTM input soil moisture correction dst sigma file.

Example lis.config entry

```
CMEM3 sensor id:                  amsre
CMEM3 number of frequencies:      ./amsre-freqs.tx
CMEM3 frequencies file:
RTM input soil moisture correction:
RTM input soil moisture correction src mean file:
RTM input soil moisture correction src sigma file:
RTM input soil moisture correction dst mean file:
RTM input soil moisture correction dst sigma file:
```

9.7. Optimization and Uncertainty Estimation

This section specifies options for carrying out parameter estimation and uncertainty estimation.

`Optimization/Uncertainty Estimation Algorithm:` Specifies which algorithm is to be used for optimization. Acceptable values are:

Value	Description
“none”	no optimization
“Enumerated search”	enumerated search
“Levenberg marquardt”	Levenberg-Marquardt
“Genetic algorithm”	Genetic Algorithm
“Shuffled complex evolution”	SCE-UA Algorithm
“Monte carlo sampling”	MCSIM Algorithm
“Random walk markov chain monte carlo”	MCMC Algorithm
“Differential evolution markov chain”	DEMC Algorithm
“Differential evolution markov chain z”	DEMCz Algorithm

`Optimization/Uncertainty Estimation Set:` specifies the calibration data set, which represents the observation source used in the particular parameter estimation instance. Acceptable values are:

Value	Description
“NONE”	template observations
“No obs”	no observations
“WG PBMR sm”	PBMR soil moisture data for Walnut Gulch
“Synthetic sm1”	synthetic soil moisture data
“Ameriflux obs”	flux data from the Ameriflux data network
“ARM obs”	fluxes, soil moisture, and soil temperature data from the ARM network
“Macon landslide obs”	Macon County landslide observation data

Value	Description
“Global landslide obs”	Global landslide observation data
“CNRS”	CNRS
“AMSRE SR”	AMSR-E (Colorado State Univ.)
“AMSR-E(LPRM) pe soil moisture”	AMSR-E LPRM soil moisture
“Gridded FLUXNET”	FLUXNET
“USDA ARSsm”	USDA ARS soil moisture

`Objective Function Method:` specifies the objective function method. Acceptable values are:

Value	Description
“LM”	Least squares (Levenberg-Marquardt)
“Least squares”	Least squares
“Likelihood”	Maximum likelihood
“Probability”	Maximize probability

`Write PE Observations:` specifies whether to output processed observations for parameter estimation. Acceptable values are:

Value	Description
0	Do not write pe observations
1	Write pe observations

`Number of model types subject to parameter estimation:` specifies the number of model classes used in a parameter estimation instance. E.g.: if LSM and RTM parameters are simultaneously being calibrated then this option will be 2.

`Model types subject to parameter estimation:` specifies the names of the model types to be used in the parameter estimation instance. E.g.: LSM RTM

`Number of model types with observation predictors for parameter estimation:` specifies the number of model types (e.g., LSM, RTM) that will be generating predictions of observations for comparison against real observations when conducting parameter or uncertainty estimation. Acceptable values are either 1 or 2.

`Model types with observation predictors for parameter estimation:` specifies the list of model types (e.g., LSM, RTM) that will be generating predictions of observations for comparison against real observations when conducting parameter or uncertainty estimation. Acceptable values are a combination of LSM and/or RTM.

`Initialize decision space with default values:` specifies whether to use defaults instead of sampled values at the beginning of optimization. Acceptable values are:

Value	Description
0	Use defaults
1	Use sampled values

(Yes, this is backwards from what the label suggests.)

`Calibration period start year:` specifies the starting year of the calibration period.

`Calibration period start month:` specifies the starting month of the calibration period.

`Calibration period start day:` specifies the starting day of the calibration period.

`Calibration period start hour:` specifies the starting hour of the calibration period.

`Calibration period start minutes:` specifies the starting minutes of the calibration period.

`Calibration period start seconds:` specifies the starting seconds of the calibration period.

`LSM Decision space attributes file:` specifies what?

`RTM Decision space attributes file:` specifies what?

9.7.1. Least squares

This section provides specifications of the LS objective function instance

`Least Squares objective function weights file:` specifies the file containing the weights to be applied to each objective function

`Least Squares objective function mode:` specifies which least squares aggregation to use. Acceptable values are:

Value	Description
1	distributed (ie, optimized for each cell independently)

`Least Squares objective function minimum number of obs:` for grid cells with fewer obs than specified, least squares parameter estimation will not be conducted so as to avoid “overfitting” model to the data.

9.7.2. Probability

This section provides specifications of the Probability objective function instance.

`Prior distribution attributes file:` specifies the file containing the prior probability distribution over the parameters

9.7.3. Likelihood

This section provides specifications of the Likelihood objective function instance. There are no additional specifications needed. Unlike the Probability objective function, Likelihood does not factor in prior probability.

9.7.4. Enumerated search

`ES decision space attributes file:` specifies the ES decision space attributes file.

Example lis.config entry

```
ES decision space attributes file:
```

9.7.5. Levenberg Marquardt

`LM start mode:` specifies what?

`LM restart file:` specifies what?

`LM maximum number of observations:` specifies what?

`LM maximum iterations:` specifies what?

`LM mode:` specifies what?

`LM objective function tolerance:` specifies what?

`LM decision space tolerance:` specifies what?

`LM orthogonality tolerance:` specifies what?

`LM step bound factor:` specifies what?

`LM forward difference step length:` specifies what?

Example lis.config entry

```
LM start mode:
LM restart file:
LM maximum number of observations:
LM maximum iterations:
LM mode:
LM objective function tolerance:
LM decision space tolerance:
LM orthogonality tolerance:
LM step bound factor:
LM forward difference step length:
```

9.7.6. Genetic Algorithm

This section provides specifications of the genetic algorithm instance

`GA restart file:` specifies the name of the GA restart file.

`GA number of generations:` specifies the number of generations of GA.

`GA number of children per parent:` specifies how many offsprings are produced by two parent solutions (1 or 2).

`GA crossover scheme:` specifies the type of crossover scheme. Acceptable values are:

Value	Description
1	single point crossover
2	uniform crossover

`GA crossover probability:` threshold to be used for conducting a crossover operation. `GA mutation scheme:` specifies the type of mutation scheme. Acceptable values are:

Value	Description
0	jump mutation
1	creep mutation

`GA creep mutation probability:` specifies the creep mutation max threshold.

`GA jump mutation probability:` specifies the jump mutation max threshold.

`GA use elitism:` specifies whether to enable elitism in the selection of new solutions. Acceptable values are:

Value	Description
0	do not use
1	use

`GA start mode:` specifies the start mode. Acceptable values are:

Value	Description
restart	restart
coldstart	cold start

Example lis.config entry

```
GA restart file:                 ./OUTPUT/EXP999/GA/GA.188.GArst
GA number of generations:                        100
GA number of children per parent:                1
GA crossover scheme:                             2
GA crossover probability:                        0.5
GA use creep mutations:                          0
GA creep mutation probability:                   0.04
GA jump mutation probability:                    0.02
GA use elitism:                                  1
GA start mode:                                   coldstart
```

9.7.7. Shuffled complex evolution

`SCEUA Decision Space Attributes File:` specifies the name of the SCEUA decision space attributes file.

`SCEUA start mode:` specifies the start mode. Acceptable values are:

Value	Description
restart	restart
coldstart	cold start

`SCEUA restart file:` specifies the name of the SCEUA restart file.

`SCEUA Max. Num. of Func. Evals. before Optimization Terminates:` specifies what?

`SCEUA Num. of Shuffles to End Opt. if Crit. less than Min.:` specifies what?

`SCEUA Min. Frac. Crit. Change in Specified Shuffles to Cont. Opt.:` specifies what?

`SCEUA Number of Optimization Complexes:` specifies what?

`SCEUA Seed Value:` specifies what?

`SCEUA Whether to User-specify the Control Parameters:` specifies what?

`SCEUA Number of Points in a Subcomplex:` specifies what?

`SCEUA Num. of Evolution Steps before Shuffle for a Complex:` specifies what?

`SCEUA Whether Include Initial Point in Population:` specifies what?

Example lis.config entry

```
SCEUA Decision Space Attributes File:
SCEUA start mode:
SCEUA restart file:
SCEUA Max. Num. of Func. Evals. before Optimization Terminates:
SCEUA Num. of Shuffles to End Opt. if Crit. less than Min.:
SCEUA Min. Frac. Crit. Change in Specified Shuffles to Cont. Opt.:
SCEUA Number of Optimization Complexes:
SCEUA Seed Value:
SCEUA Whether to User-specify the Control Parameters:
SCEUA Number of Points in a Subcomplex:
SCEUA Num. of Evolution Steps before Shuffle for a Complex:
SCEUA Whether Include Initial Point in Population:
```

9.7.8. Random walk markov chain monte carlo

`RWMCMC decision space attributes file:` specifies the RWMCMC decision space attributes file.

`RWMCMC start mode:` specifies the start mode. Acceptable values are:

Value	Description
restart	restart
coldstart	cold start

`RWMCMC restart file:` specifies the name of the RWMCMC restart file.

`RWMCMC number of iterations:` specifies the number of iterations of RWMCMC.

`RWMCMC perturbation factor:` Applied uniformly to all parameters. The product of this term and the width of the parameter range (ie, max-min) determines the random-walk-like term ('b') in the RWMCMC algorithm.

Example lis.config entry

```
RWMCMC decision space attributes file:
RWMCMC start mode:
RWMCMC restart file:
RWMCMC number of iterations:
RWMCMC perturbation factor:
```

9.7.9. Differential Evolution Markov Chain (DEMC) algorithm

`DEMC decision space attributes file:` specifies the DEMC decision space attributes file.

`DEMC start mode:` specifies the start mode. Acceptable values are:

Value	Description
restart	restart
coldstart	cold start

`DEMC restart file:` specifies the name of the DEMC restart file.

`DEMC number of iterations:` specifies the number of iterations of DEMC.

`DEMC perturbation factor:` Applied uniformly to all parameters. The product of this term and the width of the parameter range (ie, max-min) determines the random-walk-like term ('b') in the DEMC algorithm

`DEMC mode hopping frequency:` At this frequency (f), full jumps between separated regions of high probability may occur (so as to better balance exploration of each region) through the setting of a DEMCz control parameter (gamma=1); at frequency 1-f, the settings are optimized for exploration of the local region of high probability (gamma=2.38)

Example lis.config entry

```
DEMC decision space attributes file:
DEMC start mode:
DEMC restart file:
DEMC number of iterations:
DEMC perturbation factor:
DEMC mode hopping frequency:
```

9.7.10. Differential Evolution Markov Chain (DEMCz) algorithm

This section provides specifications of the DEMCz algorithm instance. DEMCz is an instance of Bayesian analysis (Reference: Gelman et al. (1995)) conducted via Markov chain Monte Carlo (MCMC) (Reference: Brooks et al. (2011)). MCMC enables generation of parameter ensembles for subsequent LIS ensemble runs, where the ensembles reflect user-specified probability distributions as updated with observational datasets. Reference for DEMCz: ter Braak (2006), and ter Braak and Vrugt (2008). DEMCz implements DEMC with the "sampling from the past" of ter Braak and Vrugt (2008)

`DEMCz restart file:` specifies the name of the DEMCz restart file.

`DEMCz number of iterations:` specifies the number of iterations of DEMCz.

`DEMCz GA restart file:` specifies the GA solution that serves as the DEMCz algorithm starting point

`DEMCz perturbation factor:` Applied uniformly to all parameters. The product of this term and the width of the parameter range (ie, max-min) determines the random-walk-like term ('b') in the DEMCz algorithm

`DEMCz mode hopping frequency:` At this frequency (f), full jumps between separated regions of high probability may occur (so as to better balance exploration of each region) through the setting of a DEMCz control parameter (gamma=1); at frequency 1-f, the settings are optimized for exploration

of the local region of high probability (gamma=2.38)

`DEMCz start mode:` specifies the start mode. Acceptable values are:

Value	Description
restart	restart
coldstart	cold start

Example lis.config entry

```
DEMCz restart file:                ./OUTPUT/DEMCz/DEMCz.188.DEMCzrst
DEMCz number of iterations:        100
DEMCz start mode:                  coldstart
DEMCz GA restart file:             ./OUTPUT/GA/GA.188.GArst
DEMCz perturbation factor:        0.001
DEMCz mode hopping frequency:     0.10
```

9.7.11. Monte Carlo simulation

This section provides specifications of the MCSIM algorithm instance. MCSIM randomly samples from user-specified probability distributions to generate parmeter ensembles for subsequent use in LIS ensemble runs. Unlike MCMC algorithms (e.g., DEMCz), the probability distributions being sampled are those given by the user, and not as updated with observational datasets. Algorithm reference: Morgan and Henrion (1990).

`MCSIM number of iterations:` specifies the number of iterations of MCSIM. This typically will be set to 1. Only set to values higher than 1 to accumulate more samples than can be achieved in a single LIS ensemble run.

`MCSIM start mode:` specifies the start mode. The restart option, as just noted, would only be needed if the number of samples that can be achieved in a single LIS ensemble run is limiting.

Acceptable values are:

Value	Description
restart	restart
coldstart	cold start

`MCSIM restart file:` specifies the name of the MCSIM restart file.

Example lis.config entry

```
MCSIM number of iterations:        1
MCSIM start mode:                  coldstart
MCSIM restart file:                none
```

9.7.12. Observations for Parameter Estimation

This section of the config file includes the observation specifications for parameter estimation.

9.7.13. Walnut Gulch PBMR soil moisture data

`WG PBMR soil moisture data directory:` specifies the location of the Walnut Gulch PBMR soil moisture data.

`WG PBMR observations attributes file:` specifies the location of the observation attributes file.

`WG PBMR site index:` specifies the site location of the forcing data.

Example lis.config entry

```
WG PBMR soil moisture data directory:   ../WG_domain/PBMR/
WG PBMR observations attributes file:   ./wgPBMRsm_attribs.txt
WG PBMR site index:                     5
```

9.7.14. Synthetic soil moisture1

`Syn SM data directory:` specifies the location of the synthetic soil moisture data.

`Syn SM observations attributes file:` specifies the synthetic soil moisture observations attributes file.

`Syn SM number of observation types:` specifies the number of synthetic soil moisture observation types.

Example lis.config entry

```
Syn SM data directory:
Syn SM observations attributes file:
Syn SM number of observation types:
```

9.7.15. Ameriflux network observations

`Ameriflux data directory:` specifies what?

`Ameriflux station list file:` specifies what?

`Ameriflux observations attributes file:` specifies what?

Example lis.config entry

```
Ameriflux data directory:
Ameriflux station list file:
Ameriflux observations attributes file:
```

9.7.16. ARM network observations

`ARM data directory:` specifies what?

`ARM site identifier name:` specifies what?

`ARM station list file:` specifies what?

`ARM objective space attributes file:` specifies what?

`ARM number of observation types:` specifies what?

Example lis.config entry

```
ARM data directory:
ARM site identifier name:
ARM station list file:
ARM objective space attributes file:
ARM number of observation types:
```

9.7.17. Macon County landslide observation data

`Macon County Landslide Obs data directory:` specifies the location of the Macon County landslide observation data.

`Macon County Landslide observations attributes file:` specifies the Macon County landslide observation attributes file.

Example lis.config entry

```
Macon County Landslide Obs data directory:
Macon County Landslide observations attributes file:
```

9.7.18. Global landslide observation data

`Global Landslide Obs data directory:` specifies the location of the global landslide observation data.

`Global Landslide observations attributes file:` specifies the global landslide observations attributes file.

Example lis.config entry

```
Global Landslide Obs data directory:
Global Landslide observations attributes file:
```

9.7.19. CNRS

`CNRS Emissivity Obs data directory:` specifies what?

`CNRS Emissivity Obs mask directory:` specifies what?

`CNRS Emissivity observations attributes file:` specifies what?

`Overpass hr descending:` specifies what?

`Overpass hr ascending:` specifies what?

`Mask hr ascending lower:` specifies what?

`Mask hr ascending upper:` specifies what?

`Mask hr descending lower:` specifies what?

`Mask hr descending upper:` specifies what?

`Mask cloud threshold:` specifies what?

Example lis.config entry

```
CNRS Emissivity Obs data directory:
CNRS Emissivity Obs mask directory:
CNRS Emissivity observations attributes file:
Overpass hr descending:
Overpass hr ascending:
Mask hr ascending lower:
Mask hr ascending upper:
Mask hr descending lower:
Mask hr descending upper:
Mask cloud threshold:
```

9.7.20. AMSRE_SR Emissivity

`AMSRE_SR Emissivity Obs data directory:` specifies the location of the AMSR-E emissivity retrievals data.

`AMSRE_SR Emissivity observations attributes file:` specifies the location of the observation attributes file.

`AMSRE_SR number of observations threshold:` specifies how many observations must be behind emissivity average for cell

`Overpass hr descending:` specifies what?

`Overpass hr ascending:` specifies what?

`Mask hr ascending lower:` specifies what?

`Mask hr ascending upper:` specifies what?

`Mask hr descending lower:` specifies what?

`Mask hr descending upper:` specifies what?

Example lis.config entry

```
AMSRE_SR Emissivity Obs data directory: './obs/'
AMSRE_SR Emissivity observations attributes file: './AMSRE_SR_attribs.txt'
AMSRE_SR number of observations threshold: 5
Overpass hr descending:
Overpass hr ascending:
Mask hr ascending lower:
Mask hr ascending upper:
Mask hr descending lower:
Mask hr descending upper:
```

9.7.21. AMSR-E (LPRM) pe soil moisture

`LPRM AMSRE soil moisture data directory:` specifies the location of the AMSR-E LPRM soil moisture data.

`LPRM AMSRE soil moisture observations attributes file:` specifies the location of the observation attributes file.

Example lis.config entry

```
LPRM AMSRE soil moisture data directory: './LPRM.v6'
LPRM AMSRE soil moisture observations attributes file: './LPRM_attribs.txt'
```

9.7.22. USDA ARS soil moisture

`USDA ARS Soilmoisture Obs data directory:` specifies the location of the USDA ARS soil moisture observation data.

`USDA ARS Soilmoisture observations attributes file:` specifies the USDA ARS soil moisture observations attributes file.

`USDA ARS number of observations threshold:` specifies what?

Example lis.config entry

```
USDA ARS Soilmoisture Obs data directory:
USDA ARS Soilmoisture observations attributes file:
USDA ARS number of observations threshold:
```

9.7.23. FLUXNET

`FLUXNET data directory:` specifies what?

`FLUXNET objective space attributes file:` specifies what?

`FLUXNET number of observation types:` specifies what?

Example lis.config entry

```
FLUXNET data directory:
FLUXNET objective space attributes file:
FLUXNET number of observation types:
```

9.7.24. No obs

This PE observation option is used when conducting MCSIM as MCSIM does not factor in observational datasets in the sampling of parameter ensembles. There are no configuration options.

9.8. Parameters

`LIS domain and parameter data file:` specifies the primary input file that contains LIS parameter data.

LIS 7 includes a pre-processing system called the Land Data Toolkit (LDT). It reads the raw parameter data and processes them to the LIS running domain. The `LIS domain and parameter data file:` is the result of the LDT pre-processing. Please read the "Land Data Toolkit (LDT) User's Guide" for more information.

Example lis.config entry

```
LIS domain and parameter data file: ./lis_input.d01.nc
```

9.8.1. Parameter options

`Landmask data source:` specifies the usage of landmask data in the run. Acceptable values are:

Value	Description
none	Do not landmask
LDT	Read landmask from the LDT-generated `LIS domain and parameter data file:`

`Landcover data source:` specifies the usage of landcover data in the run. Acceptable values are:

Value	Description
LDT	Read landcover data from the LDT-generated `LIS domain and parameter data file:`

Example lis.config entry

```
Landmask data source:  LDT
Landcover data source: LDT
```

`Soil texture data source:` specifies the usage of soil texture data in the run. Acceptable values are:

Value	Description
none	Do not read soil texture
LDT	Read soil texture data from the LDT-generated `LIS domain and parameter data file:`

Example lis.config entry

```
Soil texture data source: LDT
```

`Soil fraction data source:` specifies the usage of soil fraction parameters in the run. Acceptable values are:

Value	Description
none	Do not read soil fractions
LDT	Read soil fractions data from the LDT-generated `LIS domain and parameter data file:`

Example lis.config entry

```
Soil fraction data source: none
```

`Soil color data source:` specifies the usage of soil color data in the run. Acceptable values are:

Value	Description
none	Do not read soil color
LDT	Read soil color data from the LDT-generated `LIS domain and parameter data file:`

Example lis.config entry

```
Soil color data source: none
```

`Elevation data source:` specifies the usage of topography data in the run. Acceptable values are:

Value	Description
none	Do not read elevation
LDT	Read elevation data from the LDT-generated `LIS domain and parameter data file:`

Example lis.config entry

```
Elevation data source: LDT
```

`Slope data source:` specifies the usage of slope data in the run. Acceptable values are:

Value	Description
none	Do not read slope
LDT	Read slope data from the LDT-generated `LIS domain and parameter data file:`

Example lis.config entry

```
Slope data source: none
```

`Aspect data source:` specifies the usage of aspect data in the run. Acceptable values are:

Value	Description
none	Do not read aspect
LDT	Read aspect data from the LDT-generated `LIS domain and parameter data file:`

Example lis.config entry

```
Aspect data source: none
```

`Curvature data source:` specifies the usage of curvature data in the run. Acceptable values are:

Value	Description
none	Do not read curvature
LDT	Read curvature data from the LDT-generated `LIS domain and parameter data file:`

Example lis.config entry

```
Curvature data source: none
```

`LAI data source:` specifies the usage of LAI data in the run. Acceptable values are:

Value	Description
none	Do not read LAI
LDT	Read LAI data from the LDT-generated `LIS domain and parameter data file:`
“MODIS real-time”	Read MODIS real-time LAI
ALMIPII	Read ALMIPII real-time LAI

Example lis.config entry

```
LAI data source: none
```

`SAI data source:` specifies the usage of LAI data in the run. Acceptable values are:

Value	Description
none	Do not read SAI
LDT	Read SAI data from the LDT-generated `LIS domain and parameter data file:`
“MODIS real-time”	Read MODIS real-time SAI

Example lis.config entry

```
SAI data source: none
```

`Albedo data source:` specifies the usage of albedo data in the run. Acceptable values are:

Value	Description
none	Do not read albedo
LDT	Read albedo data from the LDT-generated `LIS domain and parameter data file:`
ALMIPII	Read the real-time ALMIP-II albedo data

Example lis.config entry

```
Albedo data source: LDT
```

`Max snow albedo data source:` specifies the usage of the maximum snow albedo in the run. Acceptable values are:

Value	Description
none	Do not read max snow albedo
fixed	Use fixed max snow albedo from the *lis.config* file. This option is only available to the Noah-3.x LSMs.
LDT	Read max snow albedo data from the LDT-generated `LIS domain and parameter data file:`

Example lis.config entry

```
Max snow albedo data source: LDT
```

`Greenness data source:` specifies the usage of greenness fraction data in the run. Acceptable values

are:

Value	Description
none	Do not read greenness fraction
LDT	Read greenness data from the LDT-generated `LIS domain and parameter data file:`
“NESDIS weekly”	Read NESDIS weekly greenness fraction
SPORT	Read SPORT greenness fraction
VIIRS	Read VIIRS greenness fraction
ALMIPII	Read ALMIP-II greenness fraction

Example lis.config entry

```
Greenness data source: LDT
```

`Roughness data source:` specifies the usage of roughness data in the run. Acceptable values are:

Value	Description
none	Do not read roughness
LDT	Read roughness data from the LDT-generated `LIS domain and parameter data file:`
ALMIPII	Read the ALMIPII real-time roughness data

Example lis.config entry

```
Roughness data source: none
```

`Porosity data source:` specifies the usage of soil porosity data in the run. Acceptable values are:

Value	Description
none	Do not read soil porosity
LDT	Read porosity data from the LDT-generated `LIS domain and parameter data file:`

Example lis.config entry

```
Porosity data source: none
```

`Ksat data source:` specifies the usage of hydraulic conductivity data in the run. Acceptable values are:

Value	Description
none	Do not read hydraulic conductivity

Value	Description
LDT	Read hydraulic conductivity data from the LDT-generated `LIS domain and parameter data file:`

Example lis.config entry

```
Ksat data source: none
```

`B parameter data source:` specifies the usage of b parameter data in the run. Acceptable values are:

Value	Description
none	Do not read b parameter
LDT	Read b parameter data from the LDT-generated `LIS domain and parameter data file:`

Example lis.config entry

```
B parameter data source: none
```

`Quartz data source:` specifies the usage of quartz data in the run. Acceptable values are:

Value	Description
none	Do not read quartz
LDT	Read quartz data from the LDT-generated `LIS domain and parameter data file:`

Example lis.config entry

```
Quartz data source: none
```

`Emissivity data source:` specifies the usage of emissivity data in the run. Acceptable values are:

Value	Description
none	Do not read emissivity
LDT	Read emissivity data from the LDT-generated `LIS domain and parameter data file:`
ALMIPII	Read the real-time ALMIPII emissivity data

Example lis.config entry

```
Emissivity data source: none
```

9.8.2. TBOT lag

`TBOT lag skin temperature update option:` specifies whether to adjust deep soil temperature as a weighted average of previous year's annual mean skin temperature and mean of time series of recent daily mean skin temperatures. Acceptable values are:

Value	Description
0	Do not adjust deep soil temperature
1	Adjust deep soil temperature

`TBOT skin temperature lag days:` specifies the number of lag days.

Example lis.config entry

```
TBOT lag skin temperature update option: 0
TBOT skin temperature lag days:          0
```

9.8.3. ALMIPII real-time albedo

`ALMIPII albedo data directory:` specifies the location of the ALMIPII real-time albedo data.

Example lis.config entry

```
ALMIPII albedo data directory:
```

9.8.4. MODIS real-time LAI

`MODIS RT LAI data directory:` specifies the location of the MODIS real-time LAI files.

Example lis.config entry

```
MODIS RT LAI data directory:
```

9.8.5. ALMIPII real-time LAI

`ALMIPII LAI data directory:` specifies the location of the ALMIPII real-time LAI files.

Example lis.config entry

```
ALMIPII LAI data directory:
```

9.8.6. NESDIS weekly greenness fraction

`NESDIS greenness data directory:` specifies the location of the NESDIS weekly greenness files.

Example lis.config entry

```
NESDIS greenness data directory:
```

9.8.7. SPORT greenness fraction

`SPORT greenness data directory:` specifies the location of the SPORT greenness files.

`SPORT GVF use realtime mode:` specifies whether to use the realtime mode. When not using realtime mode, LIS reads the previous and the next GVF bookends for temporal interpolation. When using realtime mode, LIS reads only the next GVF bookend for temporal interpolation. Acceptable values are:

Value	Description
0	Do not use realtime mode
1	Use realtime mode

`SPORT GVF lower left lat:` specifies the lower left latitude of the SPORT GVF domain. (cylindrical latitude/longitude projection)

`SPORT GVF lower left lon:` specifies the lower left longitude of the SPORT GVF domain. (cylindrical latitude/longitude projection)

`SPORT GVF upper right lat:` specifies the upper right latitude of the SPORT GVF domain. (cylindrical latitude/longitude projection)

`SPORT GVF upper right lon:` specifies the upper right longitude of the SPORT GVF domain. (cylindrical latitude/longitude projection)

`SPORT GVF resolution (dx):` specifies the resolution of the SPORT GVF domain along the east-west direction.

`SPORT GVF resolution (dy):` specifies the resolution of the SPORT GVF domain along the north-south direction.

Example lis.config entry

```
SPORT greenness data directory:  ./LISDATA/MODISNDVI/GVF_COMBINED_GLOBAL/gvf_SPORT_3KM
SPORT GVF use realtime mode:      1
SPORT GVF lower left lat:        -59.985
SPORT GVF lower left lon:       -179.985
SPORT GVF upper right lat:        89.985
SPORT GVF upper right lon:       179.985
SPORT GVF resolution (dx):         0.03
SPORT GVF resolution (dy):         0.03
```

9.8.8. VIIRS greenness fraction

`VIIRS GVF use realtime mode:` specifies whether to use the realtime mode. When not using realtime mode, LIS reads the previous and the next GVF bookends for temporal interpolation. When using realtime mode, LIS reads only the next GVF bookend for temporal interpolation. Acceptable values are:

Value	Description
0	Do not use realtime mode
1	Use realtime mode

`VIIRS GVF lower left lat:` specifies the lower left latitude of the VIIRS GVF domain. (cylindrical latitude/longitude projection)

`VIIRS GVF lower left lon:` specifies the lower left longitude of the VIIRS GVF domain. (cylindrical latitude/longitude projection)

`VIIRS GVF upper right lat:` specifies the upper right latitude of the VIIRS GVF domain. (cylindrical latitude/longitude projection)

`VIIRS GVF upper right lon:` specifies the upper right longitude of the VIIRS GVF domain. (cylindrical latitude/longitude projection)

`VIIRS GVF resolution (dx):` specifies the resolution of the VIIRS GVF domain along the east-west direction.

`VIIRS GVF resolution (dy):` specifies the resolution of the VIIRS GVF domain along the north-south direction.

`VIIRS greenness data directory:` specifies the location of the VIIRS greenness files.

Example lis.config entry

```
VIIRS greenness data directory:  ./LISDATA/VIIRSGVF/NESDIS_GVF_LISREAL/gvf_VIIRS_4KM
VIIRS GVF use realtime mode:      1
VIIRS GVF lower left lat:        -89.982
VIIRS GVF lower left lon:       -179.982
VIIRS GVF upper right lat:        89.982
VIIRS GVF upper right lon:       179.982
VIIRS GVF resolution (dx):         0.036
VIIRS GVF resolution (dy):         0.036
```

9.8.9. ALMIPII real-time greenness fraction

`ALMIPII greenness data directory:` specifies the location of the ALMIPII real-time greenness data.

Example lis.config entry

```
ALMIPII greenness data directory:
```

9.8.10. ALMIPII real-time emissivity

`ALMIPII emissivity data directory:` specifies the location of the ALMIPII real-time emissivity data.

Example lis.config entry

```
ALMIPII emissivity data directory:
```

9.8.11. ALMIPII real-time roughness

`ALMIPII roughness data directory:` specifies the location of the ALMIPII real-time roughness data.

Example lis.config entry

```
ALMIPII roughness data directory:
```

9.9. Forcings

9.9.1. GDAS

`GDAS forcing directory:` specifies the location of the GDAS forcing files.

Example lis.config entry

```
GDAS forcing directory:            ./input/FORCING/GDAS/
```

9.9.2. ECMWF

`ECMWF forcing directory:` specifies the location of the ECMWF forcing files.

Example lis.config entry

```
ECMWF forcing directory:       ./input/FORCING/ECMWF/
```

9.9.3. AFWA/AGRMET

`AGRMET forcing directory:` specifies the location of the root directory containing the input files. The AGRMET processing algorithms assumes the following hierarchy under the root directory at each instance. For example, if the root directory for storing the files is “FORCING/AFWA/”, and the current instance is December 1st, 2005, then the files are stored under the “FORCING/AFWA/20051201/” directory. The additional directory names specified here are assumed to be located under this root directory.

`AGRMET first guess source:` specifies the source of the first guess data. Acceptable values are:

Value	Description
GFS	use GFS data
GALWEM	use UK Unified Model (GALWEM) data

`AGRMET GALWEM nominal resolution (km):` specifies the nominal horizontal resolution of the GALWEM GRIB2 data in kilometers. Acceptable values are:

Value	Description
17	17-km (long-time operational resolution at USAF)
10	10-km (proposed operational resolution upgrade for 2020)

`AGRMET GFS filename version:` specifies which filename version convention is used for the GFS GRIB files. Acceptable values are:

Value	Description
1	Example: MT.avn_CY.00_fh.0000_tl.press_gr.0p5deg
2	Example: PS.NCEP_SC.U_DI.A_DC.GRID_GP.GFS_SP.SIMPLE_GR.C0P5DEG_AR.GLOBAL_PA.GFS_DD.20200213_CY.00_FH.000_DF.GR2

`AGRMET analysis directory:` specifies the location where temporary precip analysis fields will be written.

`AGRMET surface fields directory:` specifies the location of the surface fields (*sfc**).

`AGRMET merged precip directory:` specifies the location of the processed precip obs (*presav_**).

`AGRMET cloud data directory:` specifies the location of the WWMCA data (*WWMCA**).

`AGRMET WWMCA GRIB1 read option:` specifies whether to try reading WWMCA GRIB1 files, or try directly to read binary. (*0 = binary, 1 = GRIB1*). Note that if GRIB1 files cannot be found, the code will search for binary as a backup.

`AGRMET GFS data directory:` specifies the location of the GFS data (*MT.avn**).

`AGRMET GALWEM data directory:` specifies the location of the UK Unified Model (GALWEM) data (*PS.557WW_SC.U_DI.F_GP.GALWEM-**).

`AGRMET PPT Background bias correction option:` 0 = no bias correction, 1 = adjust GFS precip towards GALWEM.

`AGRMET SSMI data directory:` specifies the location of the SSM/I data (*ssmira*_).

`AGRMET GEOPRECIP data directory:` specifies the location of the GEOPRECIP files (*prec08** and *rank08**).

`AGRMET JMOBS data directory:` specifies the location of the surface and precip obs (*sfcobs*_* and *preobs*_*).

`AGRMET use timestamp on directories:` specifies whether or not to use a timestamp on directories. Acceptable values are:

Value	Description
0	do not use timestamp
1	use timestamp

`AGRMET use timestamp on gfs:` specifies whether or not to use a timestamp on gfs. Acceptable values are:

Value	Description
0	do not use timestamp
1	use timestamp

`AGRMET latlon mask file:` specifies the location of the 0.1 degree landmask that can be used for processing of respective GEOPRECIP data. Treatment of this is considered “beta”.

`AGRMET 8th polar mask file:` specifies the landmask in 8th mesh polar stereographic projection used by the AGRMET algorithms — useful when different from the basis grid.

`AGRMET 8th polar terrain file:` specifies the terrain in 8th mesh polar stereographic projection used by the AGRMET algorithms — useful when different from basis grid.

`AGRMET 16th polar mask file:` specifies the landmask in 16th mesh polar stereographic projection used by the AGRMET algorithms — useful when different from the basis grid.

`AGRMET 16th polar terrain file:` specifies the terrain in 16th mesh polar stereographic projection used by the AGRMET algorithms — useful when different from basis grid.

`AGRMET 64th polar mask file:` specifies the landmask in 64th mesh polar stereographic projection used by the AGRMET algorithms — useful when different from the basis grid.

`AGRMET 64th polar terrain file:` specifies the terrain in 64th mesh polar stereographic projection used by the AGRMET algorithms — useful when different from basis grid.

`AGRMET native imax:` specifies the native grid dimension x direction which is useful for when precip forcing will come in on different grid from the grid used for cloud and shortwave processing.

Value	Description
512	8th mesh polar stereo

Value	Description
1024	16th mesh polar stereo
(4096)	(64th mesh polar stereo reserved for future use)

`AGRMET native jmax:` specifies the native grid dimension y direction which is useful for when precip forcing will come in on different grid from the grid used for cloud and shortwave processing.

Value	Description
512	8th mesh polar stereo
1024	16th mesh polar stereo
(4096)	(64th mesh polar stereo reserved for future use)

`AGRMET GEOPRECIP imax:` specifies the GEOPRECIP grid dimension x direction which is useful for when precip and native grid differ.

Value	Description
512	8th mesh polar stereo
1024	16th mesh polar stereo
(4096)	(64th mesh polar stereo reserved for future use)
(3600)	(1/10 degree latlon reserved for future use — note this is not grid centered)

`AGRMET GEOPRECIP jmax:` specifies the GEOPRECIP grid dimension y direction which is useful for when precip and native grid differ.

Value	Description
512	8th mesh polar stereo
1024	16th mesh polar stereo
(4096)	(64th mesh polar stereo reserved fro future use)
(1801)	(1/10 degree latlon reserved for future use — note this is not grid centered)

`AGRMET SSMI imax:` specifies the SSMI/S grid dimension x direction which is useful for when precip and native grid differ.

Value	Description
512	8th mesh polar stereo
1024	16th mesh polar stereo
(4096)	(64th mesh polar stereo reserved for future use)
(1440)	(1/4 degree latlon reserved for future use — note this is grid centered)

`AGRMET SSMI jmax:` specifies the SSMI/S grid dimension y direction which is useful for when precip and native grid different

Value	Description
512	8th mesh polar stereo
1024	16th mesh polar stereo
(4096)	(64th mesh polar stereo reserved fro future use)
(720)	(1/4 degree latlon reserved for future use — note this is grid centered)

`AGRMET sfcalc cntm file:` specifies the name of the files with the spreading radii used for the barnes analysis on the GFS and surface obs.

`AGRMET precip climatology:` specifies the path to the precip climatology data.

`AGRMET nogaps wind weight:` specifies the weighting factor for the first guess winds.

`AGRMET minimum wind speed:` specifies the minimum allowable wind speed on the AGRMET grid.

`AGRMET use present/past weather estimate:` specifies whether to use present/past weather estimates. Acceptable values are:

Value	Description
0	do not use estimates
1	use estimates

`AGRMET use precip observations:` specifies whether to use precip observations. Acceptable values are:

Value	Description
0	do not use observations
1	use observations

`AGRMET use SSMI data:` specifies whether to use SSM/I data. Acceptable values are:

Value	Description
0	do not use SSM/I data
1	use SSM/I data

`AGRMET use CDFSII-based estimate:` specifies whether to use a CDFS-II based estimate. Acceptable values are:

Value	Description
0	do not use estimate

Value	Description
1	use estimate

`AGRMET use GEOPRECIP estimate:` specifies whether to use a GEOPRECIP based estimate. Acceptable values are:

Value	Description
0	do not use
1	use the estimate, do not use the rank — assumes that rank of GEOPRECIP is 1; i.e., uses it when it is available
2	use the estimate and use the rank

`AGRMET CDFSII time interval:` specifies the CDFS-II time interval to look for cloud amount. Current value is 6.

`AGRMET use precip climatology:` specifies whether to use precip climatology. Acceptable values are:

Value	Description
0	do not use precip climatology
1	use precip climatology

`AGRMET SSMI zero use switch:` specifies whether to use SSM/I zeros. Acceptable values are:

Value	Description
0	do not use zeros
1	use zeros

`AGRMET snow distribution shape parameter:` specifies the snow distribution shape parameter. (A typical value is 2.6.)

`AGRMET alternate monthly weighting factor:` specifies the alternate monthly weighting factor used in the precip processing.

`AGRMET minimum 3hr climo value:` specifies a minimum 3 hour precip climo value required to generate a non-zero CDFSII total cloud-based precip estimate. A typical value is 0.025.

`AGRMET maximum 3hr climo value:` specifies a maximum 3 hour precip climo value required to generate a non-zero CDFSII total cloud-based precip estimate. A typical value is 0.375.

`AGRMET minimum precip-per-precip day multiplier:` specifies a minimum precip-per-precip day multiplier used to generate a non-zero CDFSII total cloud based precip estimate. A typical value is 0.0.

`AGRMET maximum precip-per-precip day multiplier:` specifies a maximum precip-per-precip day multiplier used to generate a non-zero CDFSII total cloud based precip estimate. A typical value is

1.1.

`AGRMET cloud threshold to generate CDFSII estimate:` specifies the cloud threshold to generate a CDFSII-based estimate. A typical value is 85.0.

`AGRMET median cloud cover percentage1:` specifies the median cloud cover percentage to move to for the CDFSII based precip estimate. A typical value is 15.0.

`AGRMET median cloud cover percentage2:` specifies the median cloud cover percentage to move to for the CDFSII based precip estimate. A typical value is 0.60.

`AGRMET overcast percentage:` specifies the overcast percentage to move to for CDFSII based precipitation estimate. A typical value is 0.30.

`AGRMET 3hr maximum precip ceiling:` specifies the 3 hour maximum precip ceiling value. A typical value is 200.0.

`AGRMET security classification:` E.g., C for confidential, S for secret, T for top secret, U for unclassified. See AFWAMAN_15-3.doc.

`AGRMET distribution classification:` E.g., A for approved for public release. See AFWAMAN_15-3.doc.

`AGRMET data category:` E.g., ANLYS for analysis. See AFWAMAN_15-3.doc.

`AGRMET area of data:` Domain descriptor. E.g., GLOBAL for global theater.

`AGRMET maximum surface obs:` specifies the maximum surface obs. Defaults to 25000.

`AGRMET maximum precip obs:` specifies the maximum precip obs. Defaults to 50000.

`AGRMET retrospective root filename:` specifies the retrospective root filename.

`AGRMET use CMORPH data:` specifies whether to use the CMORPH data. Acceptable values are:

Value	Description
0	do not use CMORPH
1	use CMORPH

`AGRMET CMORPH minimum temperature threshold:` specifies the CMORPH minimum temperature threshold.

`AGRMET CMORPH maximum temperature threshold:` specifies the CMORPH maximum temperature threshold.

`AGRMET GEO_PRECIP minimum temperature threshold:` specifies the GEO_PRECIP minimum temperature threshold.

`AGRMET GEO_PRECIP maximum temperature threshold:` specifies the GEO_PRECIP maximum temperature threshold.

`AGRMET CMORPH data directory:` specifies the location of the CMORPH data.

`AGRMET CMORPH imax:` specifies the CMORPH grid dimension x direction which is useful for when precip and native grid differ.

`AGRMET CMORPH jmax:` specifies the CMORPH grid dimension y direction which is useful for when precip and native grid differ.

`AGRMET CMORPH min lat:` specifies the minimum latitude of the CMORPH data.

`AGRMET CMORPH max lat:` specifies the maximum latitude of the CMORPH data.

`AGRMET CMORPH min lon:` specifies the minimum longitude of the CMORPH data.

`AGRMET CMORPH max lon:` specifies the maximum longitude of the CMORPH data.

`AGRMET CMORPH dx:` specifies the resolution of the CMORPH data along the east-west direction.

`AGRMET CMORPH dy:` specifies the resolution of the CMORPH data along the north-south direction.

`AGRMET use GFS precip:` specifies whether to use the GFS precipitation. (Defaults to 0.) Acceptable values are:

Value	Description
0	do not use GFS precip
1	use GFS precip

`AGRMET use GALWEM precip:` specifies whether to use the GALWEM precipitation. (Defaults to 0.) Acceptable values are:

Value	Description
0	do not use GALWEM precip
1	use GALWEM precip

Note that you may not specify both “AGRMET use GFS precip” and “AGRMET use GALWEM precip” for a given nest.

Note that if you wish to use the first guess precip, then it must match the first guess source.

`AGRMET radiation derived from:` specifies how to compute shortwave and longwave radiation. Acceptable values are:

Value	Description
“cloud types”	use cloud types
“cod properties”	use cloud optical depth properties
“GALWEM_RAD”	use radiation fields from GALWEM

`AGRMET GALWEM radiation data directory:` specifies the location of the GALWEM radiation data files.

`AGRMET number of gauge networks to use:` specifies nonnegative number of gauge networks to use, to be identified in separate config entry.

`AGRMET gauge networks to use::` specifies list of names of gauge networks to be used. (One line of names per domain.)

`AGRMET GALWEM Precip correlation function type:` specifies function for modeling precipitation error correlations. Acceptable values are:

Value	Description
1	use Gaussian function
2	use inverse exponential function

`AGRMET GALWEM T2M correlation function type:` specifies function for modeling 2m temperature error correlations. Acceptable values are:

Value	Description
1	use Gaussian function
2	use inverse exponential function

`AGRMET GALWEM RH2M correlation function type:` specifies function for modeling 2m relative humidity error correlations. Acceptable values are:

Value	Description
1	use Gaussian function
2	use inverse exponential function

`AGRMET GALWEM SPD10M correlation function type:` specifies function for modeling 10m wind speed error correlations. Acceptable values are:

Value	Description
1	use Gaussian function
2	use inverse exponential function

`AGRMET GFS Precip correlation function type:` specifies function for modeling precipitation error correlations. Acceptable values are:

Value	Description
1	use Gaussian function
2	use inverse exponential function

`AGRMET GFS T2M correlation function type:` specifies function for modeling 2m temperature error correlations. Acceptable values are:

Value	Description
1	use Gaussian function
2	use inverse exponential function

`AGRMET GFS RH2M correlation function type:` specifies function for modeling 2m relative humidity error correlations. Acceptable values are:

Value	Description
1	use Gaussian function
2	use inverse exponential function

`AGRMET GFS SPD10M correlation function type:` specifies function for modeling 10m wind speed error correlations. Acceptable values are:

Value	Description
1	use Gaussian function
2	use inverse exponential function

`AGRMET precip obs file format:` specifies preobs file format. Acceptable values are:

Value	Description
1	use legacy files
2	use WIGOS supported files

`AGRMET sfc obs file format:` specifies sfcobs file format. Acceptable values are:

Value	Description
1	use legacy files
2	use WIGOS supported files

`AGRMET GALWEM Precip background error scale length (m):` specifies scale length for GALWEM precipitation error correlation.

`AGRMET GALWEM Precip background error variance:` specifies GALWEM precipitation error variance.

`AGRMET GALWEM Precip Gauge observation error variance:` specifies rain gauge observation precipitation error variance.

`AGRMET GALWEM Precip GEOPRECIP observation error scale length (m):` specifies scale length for GEOPRECIP precipitation error correlation.

`AGRMET GALWEM Precip GEOPRECIP observation error variance:` specifies GEOPRECIP observation precipitation error variance.

`AGRMET GALWEM Precip SSMI observation error scale length (m):` specifies scale length for SSMI

precipitation error correlation.

`AGRMET GALWEM Precip SSMI observation error variance:` specifies SSMI observation precipitation error variance.

`AGRMET GALWEM Precip CMORPH observation error scale length (m):` specifies scale length for CMORPH precipitation error correlation.

`AGRMET GALWEM Precip CMORPH observation error variance:` specifies CMORPH observation precipitation error variance.

`AGRMET GALWEM Precip IMERG observation error scale length (m):` specifies scale length for IMERG precipitation error correlation.

`AGRMET GALWEM Precip IMERG observation error variance:` specifies IMERG observation precipitation error variance.

`AGRMET GALWEM T2M background error scale length (m):` specifies scale length for GALWEM 2m temperature error correlation.

`AGRMET GALWEM T2M background error variance:` specifies GALWEM 2m temperature error variance.

`AGRMET GALWEM T2M station observation error variance:` specifies station observation 2m temperature error variance.

`AGRMET GALWEM RH2M background error scale length (m):` specifies scale length for GALWEM 2m relative humidity error correlation.

`AGRMET GALWEM RH2M background error variance:` specifies GALWEM 2m relative humidity error variance.

`AGRMET GALWEM RH2M station observation error variance:` specifies station observation 2m relative humidity error variance.

`AGRMET GALWEM SPD10M background error scale length (m):` specifies scale length for GALWEM 10m wind speed error correlation.

`AGRMET GALWEM SPD10M background error variance:` specifies GALWEM 10m wind speed error variance.

`AGRMET GALWEM SPD10M station observation error variance:` specifies station observation 10 wind speed error variance.

`AGRMET GFS Precip background error scale length (m):` specifies scale length for GFS precipitation error correlation.

`AGRMET GFS Precip background error variance:` specifies GFS precipitation error variance.

`AGRMET GFS Precip Gauge observation error variance:` specifies rain gauge observation precipitation error variance.

`AGRMET GFS Precip GEOPRECIP observation error scale length (m):` specifies scale length for

GEOPRECIP precipitation error correlation.

`AGRMET GFS Precip GEOPRECIP observation error variance:` specifies GEOPRECIP observation precipitation error variance.

`AGRMET GFS Precip SSMI observation error scale length (m):` specifies scale length for SSMI precipitation error correlation.

`AGRMET GFS Precip SSMI observation error variance:` specifies SSMI observation precipitation error variance.

`AGRMET GFS Precip CMORPH observation error scale length (m):` specifies scale length for CMORPH precipitation error correlation.

`AGRMET GFS Precip CMORPH observation error variance:` specifies CMORPH observation precipitation error variance.

`AGRMET GFS Precip IMERG observation error scale length (m):` specifies scale length for IMERG precipitation error correlation.

`AGRMET GFS Precip IMERG observation error variance:` specifies IMERG observation precipitation error variance.

`AGRMET GFS T2M background error scale length (m):` specifies scale length for GFS 2m temperature error correlation.

`AGRMET GFS T2M background error variance:` specifies GFS 2m temperature error variance.

`AGRMET GFS T2M station observation error variance:` specifies station observation 2m temperature error variance.

`AGRMET GFS RH2M background error scale length (m):` specifies scale length for GFS 2m relative humidity error correlation.

`AGRMET GFS RH2M background error variance:` specifies GFS 2m relative humidity error variance.

`AGRMET GFS RH2M station observation error variance:` specifies station observation 2m relative humidity error variance.

`AGRMET GFS SPD10M background error scale length (m):` specifies scale length for GFS 10m wind speed error correlation.

`AGRMET GFS SPD10M background error variance:` specifies GFS 10m wind speed error variance.

`AGRMET GFS SPD10M station observation error variance:` specifies station observation 10 wind speed error variance.

`AGRMET forcing map projection:` specifies map projection type. Acceptable values are:

Value	Description
latlon	use latitude/longitude projection

`AGRMET forcing domain lower left lat:` specifies southwest latitude corner.

`AGRMET forcing domain lower left lon:` specifies southwest longitude corner.

`AGRMET forcing domain upper right lat:` specifies northeast latitude corner.

`AGRMET forcing domain upper right lon:` specifies northeast longitude corner.

`AGRMET forcing domain resolution (dx):` specifies east-west grid resolution in degrees longitude.

`AGRMET forcing domain resolution (dy):` specifies north-south grid resolution in degrees latitude.

`AGRMET use IMERG data:` specifies whether to use 30-min IMERG data Acceptable values are:

Value	Description
0	Do not assimilate IMERG
1	Assimilate IMERG

`AGRMET IMERG temperature threshold:` temperature threshold (K) below which to reject IMERG retrievals.

`AGRMET IMERG data directory:` top directory to find IMERG files.

`AGRMET IMERG product:` identifies which IMERG run to assimilate. Acceptable values are:

Value	Description
3B-HHR-E	30-min Early Run
3B-HHR-L	30-min Late Run
3B-HHR	30-min Final Run

`AGRMET IMERG version:` text string identifying IMERG version to assimilate. Used to construct file names. V06x and V07x are supported. Acceptable values include:

Value	Description
V06B	Version 06B
V06C	Version 06C
V06D	Version 06D
V07B	Version 07B

`AGRMET IMERG Probability Liquid Precip Threshold:` threshold to reject IMERG if liquid precip likelihood is too low.

`AGRMET output OBA data:` option for writing OBA (observation, background, analysis) files from Bratseth. Acceptable values are:

Value	Description
0	Do not write OBA files
1	Write OBA files
2	Write OBA files w/o actually running Bratseth scheme

`AGRMET skip backQC:` option to disable backQC step. Acceptable values are:

Value	Description
0	Do not skip backQC step
1	Skip backQC step

`AGRMET skip superstatQC:` option to disable superstatQC step. Acceptable values are:

Value	Description
0	Do not skip superstatQC step
1	Skip superstatQC step

`AGRMET 3hr maximum precip ceiling:` set threshold (mm) above which to reject precipitation.

`AGRMET mask file:` path to legacy AGRMET landmask file.

`AGRMET terrain file:` path to legacy AGRMET terrain file.

Example lis.config entry

```
AGRMET forcing directory:               ./FORCING/
AGRMET first guess source:              GFS
AGRMET analysis directory:              ./Analysis
AGRMET surface fields directory:        SFCALC
AGRMET merged precip directory:         PRECIP
AGRMET cloud data directory:            WWMCA
AGRMET WWMCA GRIB1 read option:         0
AGRMET GFS data directory:              GFS
AGRMET GALWEM data directory:           GALWEM
AGRMET SSMI data directory:             SSMI
AGRMET JMOBS data directory:            CDMS
AGRMET use timestamp on directories:    1
AGRMET use timestamp on gfs:            0
AGRMET latlon mask file:                /data/parameters/global_0p25/mask_25KM.1gd4r
AGRMET 8th polar mask file:             /data/parameters/pst_8/point_switches
AGRMET 8th polar terrain file:          /data/parameters/pst_8/terrain
AGRMET 16th polar mask file:            /data/parameters/pst_16/point_switches
AGRMET 16th polar terrain file:         /data/parameters/pst_16/terrain
AGRMET 64th polar mask file:            /data/parameters/pst_16/point_switches
AGRMET 64th polar terrain file:         /data/parameters/pst_16/terrain
AGRMET native imax:                     512  #512 - 8th polar; 1024 - 16th polar; 4096
```

```
- 64th polar (not yet available)
AGRMET native jmax:                    512  #512 - 8th polar; 1024 - 16th polar; 4096
- 64th polar (not yet available)
AGRMET GEOPRECIP imax:                 512  #512 - 8th polar; 1024 - 16th polar; 4096
- 64th polar (not yet available)
AGRMET GEOPRECIP jmax:                 512  #512 - 8th polar; 1024 - 16th polar; 4096
- 64th polar (not yet available)
AGRMET SSMI imax:                      512  #512 - 8th polar; 1024 - 16th polar; 4096
- 64th polar (not yet available)
AGRMET SSMI jmax:                      512  #512 - 8th polar; 1024 - 16th polar; 4096
- 64th polar (not yet available)
AGRMET sfcalc cntm file:               ./STATIC/sfcalc-cntm
AGRMET precip climatology:             ./STATIC/pcp_clim/
AGRMET nogaps wind weight:             0.75
AGRMET minimum wind speed:             0.25
AGRMET use present/past weather estimate: 1
AGRMET use precip observations:        1
AGRMET use SSMI data:                  1
AGRMET use CDFSII-based estimate:      1
AGRMET use GEOPRECIP estimate:         2
AGRMET CDFSII time interval:           6
AGRMET use precip climatology:         1
AGRMET SSMI zero use switch:           1
AGRMET snow distribution shape parameter: 2.6
AGRMET alternate monthly weighting factor: 1.0
AGRMET minimum 3hr climo value:           0.025
AGRMET maximum 3hr climo value:           0.375
AGRMET minimum precip-per-precip day multiplier: 0.0
AGRMET maximum precip-per-precip day multiplier: 1.1
AGRMET cloud threshold to generate CDFSII estimate: 85.0
AGRMET median cloud cover percentage1:             15.0
AGRMET median cloud cover percentage2:             0.60
AGRMET overcast percentage:                        0.30
AGRMET 3hr maximum precip ceiling:                 200.0
AGRMET security classification:           U
AGRMET distribution classification:       C
AGRMET data category:                     ANLYS
AGRMET area of data:                      GLOBAL
AGRMET use CMORPH data:
AGRMET CMORPH minimum temperature threshold:
AGRMET CMORPH maximum temperature threshold:
AGRMET GEO_PRECIP minimum temperature threshold:
AGRMET GEO_PRECIP maximum temperature threshold:
AGRMET CMORPH data directory:
AGRMET CMORPH imax:
AGRMET CMORPH jmax:
AGRMET CMORPH min lat:
AGRMET CMORPH max lat:
AGRMET CMORPH min lon:
AGRMET CMORPH max lon:
AGRMET CMORPH dx:
```

```
AGRMET CMORPH dy:
AGRMET use GFS precip:     1
AGRMET use GALWEM precip:  0
AGRMET radiation derived from: GALWEM_RAD
AGRMET GALWEM radiation data directory: GALWEM_Rad
AGRMET number of gauge networks to use: 7
AGRMET gauge networks to use::
AMIL CANA FAA ICAO WMO HADS NWSLI
::
AGRMET GALWEM Precip correlation function type: 1
AGRMET GALWEM T2M correlation function type: 1
AGRMET GALWEM RH2M correlation function type: 1
AGRMET GALWEM SPD10M correlation function type: 1
AGRMET GFS Precip correlation function type: 1
AGRMET GFS T2M correlation function type: 1
AGRMET GFS RH2M correlation function type: 1
AGRMET GFS SPD10M correlation function type: 1
AGRMET precip obs file format: 1
AGRMET sfc obs file format: 1

AGRMET GALWEM Precip background error scale length (m):         102000.
AGRMET GALWEM Precip background error variance:                      0.83
AGRMET GALWEM Precip Gauge observation error variance:               0.86
AGRMET GALWEM Precip GEOPRECIP observation error scale length (m): 132000.
AGRMET GALWEM Precip GEOPRECIP observation error variance:           1.24
AGRMET GALWEM Precip SSMI observation error scale length (m):   133000.
AGRMET GALWEM Precip SSMI observation error variance:                2.58
AGRMET GALWEM Precip CMORPH observation error scale length (m):  89000.
AGRMET GALWEM Precip CMORPH observation error variance:              1.15
AGRMET GALWEM Precip IMERG observation error scale length (m):  101000.
AGRMET GALWEM Precip IMERG observation error variance:               1.93
AGRMET GALWEM T2M background error scale length (m):            110000.
AGRMET GALWEM T2M background error variance:                         1.48
AGRMET GALWEM T2M station observation error variance:                2.30
AGRMET GALWEM RH2M background error scale length (m):           119000.
AGRMET GALWEM RH2M background error variance:                       30.7
AGRMET GALWEM RH2M station observation error variance:              65.8
AGRMET GALWEM SPD10M background error scale length (m):          53000.
AGRMET GALWEM SPD10M background error variance:                      0.62
AGRMET GALWEM SPD10M station observation error variance:             2.37

AGRMET GFS Precip background error scale length (m):             93000.
AGRMET GFS Precip background error variance:                         0.47
AGRMET GFS Precip Gauge observation error variance:                  0.70
AGRMET GFS Precip GEOPRECIP observation error scale length (m): 131000.
AGRMET GFS Precip GEOPRECIP observation error variance:              1.06
AGRMET GFS Precip SSMI observation error scale length (m):      131000.
AGRMET GFS Precip SSMI observation error variance:                   2.10
AGRMET GFS Precip CMORPH observation error scale length (m):     91000.
AGRMET GFS Precip CMORPH observation error variance:                 0.92
AGRMET GFS Precip IMERG observation error scale length (m):     100000.
```

```
AGRMET GFS Precip IMERG observation error variance:                1.62
AGRMET GFS T2M background error scale length (m):               125000.
AGRMET GFS T2M background error variance:                          1.36
AGRMET GFS T2M station observation error variance:                 2.38
AGRMET GFS RH2M background error scale length (m):              197000.
AGRMET GFS RH2M background error variance:                        51.3
AGRMET GFS RH2M station observation error variance:               66.8
AGRMET GFS SPD10M background error scale length (m):             86000.
AGRMET GFS SPD10M background error variance:                       0.57
AGRMET GFS SPD10M station observation error variance:              2.48

AGRMET forcing map projection:             latlon
AGRMET forcing domain lower left lat:       -89.9531250
AGRMET forcing domain lower left lon:      -179.9296875
AGRMET forcing domain upper right lat:       89.9531250
AGRMET forcing domain upper right lon:      179.9296875
AGRMET forcing domain resolution (dx):        0.1406250
AGRMET forcing domain resolution (dy):        0.0937500

AGRMET use IMERG data:                      1
AGRMET IMERG temperature threshold:        278
AGRMET IMERG data directory:               ./input/IMERG/Early_V07B
AGRMET IMERG product:                      3B-HHR-E        # Early Run
AGRMET IMERG version:                      V07B # Jun 2024
AGRMET IMERG Probability Liquid Precip Threshold: 100

AGRMET output OBA data: 0
AGRMET skip backQC: 0
AGRMET skip superstatQC: 0

AGRMET 3hr maximum precip ceiling: 200.0

AGRMET mask file:                ./input/legacy/all_16/point_switches
AGRMET terrain file:              ./input/legacy/pst_16/terrain
```

9.9.4. PRINCETON

`PRINCETON forcing directory:` specifies the location of the PRINCETON forcing files.

`PRINCETON forcing version:` specifies the processed version level of the Princeton forcing dataset. Acceptable values are:

Value	Description
2	Version 2.0
2.2	Version 2.2

Example lis.config entry

```
PRINCETON forcing directory:    ./input/FORCING/PRINCETON
PRINCETON forcing version:      2.2
```

9.9.5. GSWP2

`GSWP2 landmask file:` specifies the GSWP2 landmask file.

`GSWP2 2m air temperature map:` specifies the GSWP2 2 meter air temperature data.

`GSWP2 2m specific humidity map:` specifies the GSWP2 2 meter specific humidity data.

`GSWP2 wind map:` specifies the GSWP2 wind data.

`GSWP2 surface pressure map:` specifies the GSWP2 surface pressure data.

`GSWP2 convective rainfall rate map:` specifies the GSWP2 convective rainfall rate data.

`GSWP2 rainfall rate map:` specifies the GSWP2 rainfall rate data.

`GSWP2 snowfall rate map:` specifies the GSWP2 snowfall rate data.

`GSWP2 incident shortwave radiation map:` specifies the GSWP2 incident shortwave radiation data.

`GSWP2 incident longwave radiation map:` specifies the GSWP2 incident longwave radiation data.

Example lis.config entry

```
GSWP2 landmask file:                    ./input/gswp2data/Fixed/landmask_gswp.nc
GSWP2 2m air temperature map:           ./input/gswp2data/Tair_cru/Tair_cru
GSWP2 2m specific humidity map:         ./input/gswp2data/Qair_cru/Qair_cru
GSWP2 wind map:                         ./input/gswp2data/Wind_ncep/Wind_ncep
GSWP2 surface pressure map:             ./input/gswp2data/PSurf_ecor/PSurf_ecor
GSWP2 convective rainfall rate map:     ./input/gswp2data/Rainf_C_gswp/Rainf_C_gswp
GSWP2 rainfall rate map:                ./input/gswp2data/Rainf_gswp/Rainf_gswp
GSWP2 snowfall rate map:                ./input/gswp2data/Snowf_gswp/Snowf_gswp
GSWP2 incident shortwave radiation map: ./input/gswp2data/SWdown_srb/SWdown_srb
GSWP2 incident longwave radiation map:  ./input/gswp2data/LWdown_srb/LWdown_srb
```

9.9.6. GMAO GLDAS

`GLDAS forcing directory:` specifies the location of the GMAO GLDAS forcing files.

Example lis.config entry

```
GLDAS forcing directory:         ../FORCING/GLDAS_GMAO/
```

9.9.7. GFS

`GFS forcing directory:` specifies the location of the GFS forcing files.

`GFS domain x-dimension size:` specifies the number of columns of the native domain parameters of the GFS forcing data. The map projection is specified in the driver modules defined for the GFS routines.

`GFS domain y-dimension size:` specifies the number of rows of the native domain parameters of the GFS forcing data. The map projection is specified in the driver modules defined for the GFS routines.

`GFS number of forcing variables:` specifies the number of forcing variables provided by GFS at the model initialization step.

Example lis.config entry

```
GFS forcing directory:            ./input/FORCING/GFS/
GFS domain x-dimension size:      512
GFS domain y-dimension size:      256
GFS number of forcing variables:  10
```

9.9.8. MERRA2

`MERRA2 forcing directory:` specifies the location of the MERRA2 forcing files.

Please note that MERRA2 forcing data are available via NASA's Goddard Earth Sciences Data and Information Services Center (GES DISC; https://disc.gsfc.nasa.gov/). Also, topographic or elevation correction option is now supported with the latest LIS MERRA-2 reader. Please also see the latest LDT notes for updates on how to use this option.

`MERRA2 use lowest model level forcing:` specifies whether to use the lowest model level forcing. Acceptable values are:

Value	Description
0	Do not use the lowest model level forcing.
1	Use the lowest model level forcing.

`MERRA2 use 2m wind fields:` specifies whether to use the 2m diagnosed wind fields. This option will only work if the lowest model level forcing option is turned off. Acceptable values are:

Value	Description
0	Do not use the 2m diagnosed wind speed fields.
1	Use the 2m diagnosed wind speed fields.

`MERRA2 use corrected total precipitation:` specifies whether to use the bias corrected total precipitation. Acceptable values are:

Value	Description
0	Do not use the bias corrected total precipitation.
1	Use the bias corrected total precipitation.

Example lis.config entry

```
MERRA2 forcing directory:              ./MERRA2/
MERRA2 use lowest model level forcing:     1
MERRA2 use 2m wind fields:                 0
MERRA2 use corrected total precipitation:  1
```

9.9.9. GEOS-IT

`GEOS-IT forcing directory:` specifies the location of the GEOS-IT forcing files.

Please note that GEOS-IT is currently in production and is not complete for all calendar years. Also, it is not yet available outside of NASA's NCCS computing platforms. Also, the topographic or elevation correction option is supported through the MERRA-2 geopotential terrain height file. Please also see the latest LDT notes for updates on how to use this option.

`GEOS-IT use lowest model level forcing:` specifies whether to use the lowest model level forcing. Acceptable values are:

Value	Description
0	Do not use the lowest model level forcing.
1	Use the lowest model level forcing.

`GEOS-IT use 2m wind fields:` specifies whether to use the 2m diagnosed wind fields. This option will only work if the lowest model level forcing option is turned off. Acceptable values are:

Value	Description
0	Do not use the 2m diagnosed wind speed fields.
1	Use the 2m diagnosed wind speed fields.

Example lis.config entry

```
GEOS-IT forcing directory:                 ./GEOS-IT
GEOS-IT use lowest model level forcing:    1
GEOS-IT use 2m wind fields:                0
```

9.9.10. ERA5

`ERA5 forcing directory:` specifies the location of the ERA5 forcing files.

`ERA5 forcing tile to grid mapping file:` specifies the file that maps the 1-d forcing to a 2-d format

Example lis.config entry

```
ERA5 forcing directory:              ./ERA5/
ERA5 forcing tile to grid mapping file: ../ERA5/mapping.nc
```

9.9.11. GSWP1

`GSWP1 forcing directory:` specifies the location of the GSWP1 forcing files.

Example lis.config entry

```
GSWP1 forcing directory:       ./input/FORCING/GSWP1
```

9.10. Supplemental forcings

9.10.1. AGRMET radiation (polar stereographic)

`AGRRADPS forcing directory:` specifies the directory containing AGRMET polar stereographic radiation data.

Example lis.config entry

```
AGRRADPS forcing directory:             ./input/FORCING/AGRRADPS
```

9.10.2. CMAP precipitation

`CMAP forcing directory:` specifies the location of the CMAP forcing files.

Example lis.config entry

```
CMAP forcing directory:             ./input/FORCING/CMAP
```

9.10.3. SCAN station data

`SCAN forcing directory:` specifies the location of the SCAN forcing files.

`SCAN metadata file:` specifies the file containing SCAN metadata.

Example lis.config entry

```
SCAN forcing directory:   ./input/FORCING/SCAN
SCAN metadata file:       ./input/FORCING/SCAN/msu_scan.mdata
```

9.10.4. NLDAS2 (grib)

`NLDAS2 forcing directory:` specifies the location of the NLDAS-2 GRIB-1 forcing files.

`NLDAS2 data center source:` specifies the center that produced the NLDAS-2 GRIB-1 files. (This is specified to distinguish the filenames.) Acceptable values are:

Value	Description
"GES-DISC"	NASA GES-DISC
"NCEP"	NCEP

`NLDAS2 use model level data:` specifies whether or not to read in the model level data (instead of 2/10m fields) from the NLDAS-2 forcing dataset (will open up and read "B" files). This data is at the height of the NARR lowest model level.

Note that this will read in "Height of Atmospheric Forcing" and "Surface Exchange Coefficient for Heat". You must make sure that they are included in your forcing variables list file. Acceptable values are:

Value	Description
0	do not use
1	use

`NLDAS2 use model based swdown:` specifies whether or not to read in the un-bias corrected model downward shortwave radiation data (in leiu of the bias corrected data) from the NLDAS-2 forcing dataset (will open up and read "B" files). The data source is the NARR shortwave. Acceptable values are:

Value	Description
0	do not use
1	use

`NLDAS2 use model based precip:` specifies whether or not to read in the model based precipitation data (instead of the observation based precipitation) from the NLDAS-2 forcing dataset (will open up and read "B" files). The data source is the NARR precipitation. Acceptable values are:

Value	Description
0	do not use
1	use

`NLDAS2 use model based pressure:` specifies whether or not to read in the model base pressure data from the NLDAS-2 forcing dataset (will open up and read "B" files). The data source is the pressure at the NARR lowest model level. Acceptable values are:

Value	Description
0	do not use
1	use

Example lis.config entry

```
NLDAS2 forcing directory:               ./input/FORCING/NLDAS2
NLDAS2 data center source:              "GES-DISC"
NLDAS2 use model level data:            0
NLDAS2 use model based swdown:          0
NLDAS2 use model based precip:          0
NLDAS2 use model based pressure:        0
```

9.10.5. NLDAS-2.0 (netcdf)

`NLDAS-2.0 FORA forcing directory:` specifies the location of the NLDAS-2.0 v020 "FORA" netCDF-4 forcing files.

`NLDAS-2.0 FORB forcing directory:` specifies the location of the NLDAS-2.0 v020 "FORB" netCDF-4 forcing files. This config entry is not required unless one of the following FORB data use flags is set to "1".

`NLDAS-2.0 use FORB model level data:` specifies whether or not to read in and use the model level data (instead of 2/10-m fields) from the NLDAS-2 "FORB" forcing dataset. This data is at the height of the NARR lowest model level. The fields that are used are air temperature, air humidity, winds, height of the lowest model level, and the aerodynamic conductance. This config entry is not required, and the default will be to not use this FORB data. However, if the FORB model level data is chosen, you must specify the directory of the FORB data using the "NLDAS-2.0 FORB forcing directory:" config.

Note that this will read in "Height of Atmospheric Forcing" and "Surface Exchange Coefficient for Heat" (aka, aerodynamic conductance). You must make sure that "Forc_Hgt:" and "Ch:" (respectively) are included in your forcing variables list file.

Acceptable values are:

Value	Description
0	do not use
1	use

`NLDAS-2.0 use FORB model-based SWdown:` specifies whether or not to read in and use the un-bias-corrected model downward shortwave radiation data (in leiu of the bias-corrected data) from the NLDAS-2 "FORB" forcing dataset. The data source is the NARR shortwave. This config entry is not required, and the default will be to not use this FORB data. However, if the FORB model-based SWdown is chosen, you must specify the directory of the FORB data using the "NLDAS-2.0 FORB forcing directory:" config. Acceptable values are:

Value	Description
0	do not use
1	use

`NLDAS-2.0 use FORB model-based precip:` specifies whether or not to read in and use the model-based precipitation data (instead of the observation-based precipitation) from the NLDAS-2 "FORB" forcing dataset. The data source is the NARR precipitation. This config entry is not required, and the default will be to not use this FORB data. However, if the FORB model-based precip is chosen, you must specify the directory of the FORB data using the "NLDAS-2.0 FORB forcing directory:" config. Acceptable values are:

Value	Description
0	do not use
1	use

`NLDAS-2.0 use FORB model-based pressure:` specifies whether or not to read in and use the pressure data from the NLDAS-2 "FORB" forcing dataset. This data is at the height of the NARR lowest model level. This config entry is not required, and the default will be to not use this FORB data. However, if the FORB model-based pressure is chosen, you must specify the directory of the FORB data using the "NLDAS-2.0 FORB forcing directory:" config. Acceptable values are:

Acceptable values are:

Value	Description
0	do not use
1	use

Example lis.config entry

```
NLDAS-2.0 FORA forcing directory:               ./input/NLDAS2/FORA
NLDAS-2.0 FORB forcing directory:               ./input/NLDAS2/FORB
NLDAS-2.0 use FORB model level data:            0
NLDAS-2.0 use FORB model-based SWdown:          0
NLDAS-2.0 use FORB model-based precip:          0
NLDAS-2.0 use FORB model-based pressure:        0
```

9.10.6. COAMPS

`COAMPS output forcing directory:` specifies the location of the COAMPS forcing files.

`COAMPS nest id:` specifies the nest id COAMPS forcing usually provides forcing for 2 nests. The first nest is 15km resolution and the second nest is a smaller sub-domain with a resolution of 5km. Acceptable values are:

Value	Description
0	do not use
1	use

Example lis.config entry

```
COAMPS output forcing directory:      ./input/FORCING/COAMPS
COAMPS nest id: 1
```

9.10.7. TRMM 3B42RT precipitation

`TRMM 3B42RT forcing directory:` specifies the location of the TRMM 3B42RT forcing files.

Example lis.config entry

```
TRMM 3B42RT forcing directory:     ./input/FORCING/3B42RT/
```

`TRMM 3B42RTV7 forcing directory:` specifies the location of the TRMM 3B42RT Version 7 forcing files.

Example lis.config entry

```
TRMM 3B42RTV7 forcing directory:  ../MET_FORCING/3B42RT-V7/
```

9.10.8. TRMM 3B42V6 precipitation

`TRMM 3B42V6 forcing directory:` specifies the location of the TRMM 3B42V6 forcing files.

Example lis.config entry

```
TRMM 3B42V6 forcing directory:       ./input/FORCING/3B42V6/
```

9.10.9. TRMM 3B42V7 precipitation

`TRMM 3B42V7 forcing directory:` specifies the location of the TRMM 3B42V7 forcing files.

Example lis.config entry

```
TRMM 3B42V7 forcing directory:       ./input/FORCING/3B42V7/
```

9.10.10. CMORPH precipitation

`CMORPH forcing directory:` specifies the location of the CMORPH precipitation forcing files.

Example lis.config entry

```
CMORPH forcing directory:     ./input/FORCING/CMORPH/
```

9.10.11. IMERG precipitation

`IMERG forcing directory:` specifies the location of the GPM IMERG precipitation forcing files.

`IMERG product:` specifies the product of the GPM IMERG precipitation forcing files. The valid options are: early, late, and final. If no version is specified, the reader will default to the "final" product of GPM IMERG.

`IMERG version:` specifies the version of the GPM IMERG precipitation forcing files. If no version is specified, the reader will default to "V06B".

The supported versions of GPM IMERG are:

Version	Product
V06B	early, late, final
V06C	early, late, final
V06D	early, late, final
V07A	preliminary support for final

Example lis.config entry

```
IMERG forcing directory:     ./FORCING/IMERG
IMERG product: 'final'
IMERG version: 'V06B'
```

9.10.12. Stage II precipitation

`STAGE2 forcing directory:` specifies the location of the STAGE2 forcing files.

Example lis.config entry

```
STAGE2 forcing directory:       ./input/FORCING/STII
```

9.10.13. Stage IV precipitation

`STAGE4 forcing directory:` specifies the location of the STAGE4 forcing files.

Example lis.config entry

```
STAGE4 forcing directory:       ./input/FORCING/STIV
```

9.10.14. NARR

`NARR forcing directory:` specifies the location of the NARR forcing files.

`NARR domain x-dimension size:` specifies the number of columns of the native domain parameters of the NARR forcing data.

`NARR domain y-dimension size:` specifies the number of rows of the native domain parameters of the NARR forcing data.

`NARR domain y-dimension size:` specifies the number of rows of the native domain parameters of the NARR forcing data.

`NARR domain z-dimension size:` specifies the number of atmospheric profiles in the NARR forcing data.

Example lis.config entry

```
NARR forcing directory:            ./input/Code/NARR/
NARR domain x-dimension size:      768
NARR domain y-dimension size:      386
NARR domain z-dimension size:      30
```

9.10.15. RFE2Daily

`RFE2Daily forcing directory:` specifies the location of the RFE2Daily forcing files.

`RFE2Daily time offset:` specifies the time offset for the RFE2Daily forcing data, in hours. This adjusts when LIS will read the RFE2Daily precipitation data. For general use, the data should be read at hour 6z, but for use by GeoWRSI, the data should be read at hour 0z.

Example lis.config entry

```
RFE2Daily forcing directory:    ./input/MET_FORCING/RFE2.0_CPC/Africa/
RFE2Daily time offset:          0 # for use by GeoWRSI
```

9.10.16. CHIRPS2

`CHIRPS2.0 forcing directory:` specifies the location of the UCSB CHIRPS v2.0 precipitation forcing file directory. User must specify first part of CHIRPS filename, which allows the user to either run with the CHIRPS- or the CHIRP-based (without station data) datasets.

`CHIRPS2.0 forcing resolution:` specifies the spatial resolution of CHIRPS v2.0 forcing dataset. Two options include 0.05 or 0.25 (deg).

Example lis.config entry

```
CHIRPS2.0 forcing directory:   ./CHIRPSv2/daily_p05/chirps-v2.0
CHIRPS2.0 forcing resolution:     0.05
```

9.10.17. PET_USGS

`USGS PET forcing directory:` specifies the location of the PET USGS forcing files.

`USGS PET forcing type:` specifies the choice for PET forcing data type. Acceptable values are:

Value	Description
current	Retrospective or current time-based PET files

Value	Description
climatology	Climatology-based PET files

Example lis.config entry

```
USGS PET forcing directory:       ./PET_USGS
```

9.10.18. RFE2 data bias corrected to GDAS

`RFE2gdas forcing directory:` specifies the location of the RFE2gdas forcing files.

Example lis.config entry

```
RFE2gdas forcing directory:
```

9.10.19. NAM242

`NAM242 forcing directory:` specifies the location of the "NAM 242 AWIPS Grid -- Over Alaska" forcing files

Example lis.config entry

```
NAM242 forcing directory: ./input/MET_FORCING/NAM242
```

9.10.20. WRFout

`WRF output forcing directory:` specifies the location of the WRF output data files.

`WRF nest id:` specifies the nest id of the WRF output data files.

Example lis.config entry

```
WRF output forcing directory: ./input/wrfout/
WRF nest id:                          1
```

9.10.21. WRFoutv2

`WRF output v2 forcing directory:` specifies the location of the "NCAR-WRF 4km metforcing output" forcing files

Example lis.config entry

```
WRF output v2 forcing directory: ./input/MET_FORCING/conus_wrf
```

9.10.22. WRF AK domain

`WRF AK forcing directory:` specifies the location of the "NCAR-WRF Alaska domain 4km metforcing output" files

Example lis.config entry

```
WRF AK forcing directory: ./input/MET_FORCING/AK_wrf
```

9.10.23. GEOS5 Forecast

`GEOS5 forecast forcing directory:` specifies the location of the GEOS5 forecast forcing files.

`GEOS5 forecast forcing number of ensemble members:` specifies the number of ensemble members desired for the GEOS-5 forecast dataset.

Example lis.config entry

```
GEOS5 forecast forcing directory:     ./MET_FORCING/GEOS5/
GEOS5 forecast forcing number of ensemble members:   11
```

9.10.24. GEFS Forecast

`GEFS forecast directory:` specifies the location of the GEFS forecast forcing files.

`GEFS forecast type:` specifies the GEFS forecast product type, which can either be Reforecast2 or Operational.

`GEFS forecast run mode:` specifies the run mode related to the GEFS dataset, which can either be forecast or analysis run mode. Currently, only the forecast mode is supported.

`GEFS forecast grid projection:` specifies the GEFS forecast product grid projection, which can either be latlon or gaussian. Currently only latlon is supported.

`GEFS pressure level field:` specifies the GEFS pressure level field, which can either be surface (default setting in LIS) or mean sea level (msl) can be selected (which is not supported yet).

`GEFS forecast number of ensemble members:` specifies the number of GEFS ensemble members being read in. Reforecast2 currently supports up to a 11 members.

`GEFS forecast grid resolution:` specifies the grid resolution in degrees of the GEFS forecast data. The current resolutions supported are:

GEFS forecast type	Resolutions
`Reforecast2`	`0.25` and `1.0`
`Operational`	`0.25` and `0.50`

Example lis.config entry

```
GEFS forecast directory:        ./MET_FORCING/GEFS/Reforecast/
GEFS forecast type:              Reforecast2      # Reforecast2 | Operational
GEFS forecast run mode:          forecast         # forecast | analysis
GEFS forecast grid projection:   latlon           # latlon | gaussian
GEFS pressure level field:       surface          # surface | msl
GEFS forecast number of ensemble members:  11
GEFS forecast grid resolution:   0.25
```

9.10.25. Generic Ensemble Forecast Reader

`Generic ensemble forecast directory:` specifies the location of the user-generated ensemble forecast forcing files.

`Generic ensemble forecast number of ensemble members:` specifies the number of ensemble members desired for the user-generated ensemble forecast dataset.

`Name of base forecast model:` specifies the base forecast model used in the generated ensemble-based forecast forcing files being read in. Default setting is GEOS5, but options include GEOS5 and CFSv2.

`Generic ensemble forecast initial date:` specifies the initial forecast date, such as YYYYMMDD. This option enables the user to be able to run from restart conditions if a forecast run stops or times out during runtime. This is an optional entry.

Example lis.config entry

```
Generic ensemble forecast directory:     ./GEOS5_BiasCorrected/
Generic ensemble forecast number of ensemble members:  11
Name of base forecast model:               GEOS5
Generic ensemble forecast initial date:    20200501
```

9.10.26. Precipitation-only Ensemble Forecast Reader

`Precipitation ensemble forecast directory:` specifies the location of the user-generated ensemble precipitation forecast forcing files.

`Precipitation ensemble forecast number of ensemble members:` specifies the number of ensemble members desired for the user-generated precipitation ensemble forecast dataset.

`Name of base forecast model:` specifies the base forecast model used in the generated ensemble-based forecast forcing files being read in. Default setting is GEOS5, but options include GEOS5 and CFSv2.

`Precipitation ensemble forecast initial date:` specifies the initial forecast date, such as YYYYMMDD. This option enables the user to be able to run from restart conditions if a forecast run stops or times out during runtime. This is an optional entry.

Example lis.config entry

```
Precipitation ensemble forecast directory:    ./GEOS5_BiasCorrected/
Precipitation ensemble forecast number of ensemble members:  11
Name of base forecast model:                   GEOS5
Precipitation ensemble forecast initial date:  20200501
```

9.10.27. Bondville

`Bondville forcing file:` specifies the location of the Bondville forcing file.

`Bondville Noah-MP-4.0.1 forcing:` specifies the version of the Bondville forcing to be used. This option sets the formatting read statements for the ASCII forcing file. Acceptable values are:

Value	Description
0	Use the Noah-3.X version of the Bondville forcing
1	Use the Noah-MP-4.0.1 version of the Bondville forcing from HRLDAS

Example lis.config entry

```
Bondville forcing file:              ./bondville.dat
Bondville Noah-MP-4.0.1 forcing:     1
```

9.10.28. SNOTEL

`SNOTEL forcing directory:` specifies the location of the SNOTEL forcing files.

`SNOTEL metadata file:` specifies the location of the SNOTEL metadata file.

`SNOTEL coord file:` specifies the location of the SNOTEL coordinates file.

Example lis.config entry

```
SNOTEL forcing directory:
SNOTEL metadata file:
SNOTEL coord file:
```

9.10.29. VIC processed forcing

This is used by the LIS development team to support debugging VIC within LIS. One must first run stand-alone VIC, configured to output its forcing data. Then one must grid the output forcing data into a format understood by LIS.

`VIC forcing directory:` specifies the location of the VIC processed forcing files.

`VIC forcing interval:` specifies the frequency of the VIC processed forcing data, in seconds.

`VIC forcing domain lower left lat:` specifies the lower left latitude of the VIC processed forcing data. (cylindrical latitude/longitude projection)

`VIC forcing domain lower left lon:` specifies the lower left longitude of the VIC processed forcing data. (cylindrical latitude/longitude projection)

`VIC forcing domain upper right lat:` specifies the upper right latitude of the VIC processed forcing data. (cylindrical latitude/longitude projection)

`VIC forcing domain upper right lon:` specifies the upper right longitude of the VIC processed forcing data. (cylindrical latitude/longitude projection)

`VIC forcing domain resolution (dx):` specifies the resolution of the of the VIC processed forcing data along the east-west direction.

`VIC forcing domain resolution (dy):` specifies the resolution of the of the VIC processed forcing data along the north-south direction.

`VIC NC:` specifies the number of columns of the VIC processed forcing data.

`VIC NR:` specifies the number of rows of the VIC processed forcing data.

Example lis.config entry

```
VIC forcing directory:
VIC forcing interval:
VIC forcing domain lower left lat:
VIC forcing domain lower left lon:
VIC forcing domain upper right lat:
VIC forcing domain upper right lon:
VIC forcing domain resolution (dx):
VIC forcing domain resolution (dy):
VIC NC:
VIC NR:
```

9.10.30. PALS station

`PALS met forcing directory:` specifies the location of the PALS station forcing files.

`PALS met forcing station name:` specifies the name of the PALS station.

`PALS met forcing data start year:` specifies the starting year of the PALS station data.

`PALS met forcing data start month:` specifies the starting month of the PALS station data.

`PALS met forcing data start day:` specifies the starting day of the PALS station data.

`PALS met forcing data start hour:` specifies the starting hour of the PALS station data.

`PALS met forcing data start minute:` specifies the starting minute of the PALS station data.

`PALS met forcing data start second:` specifies the starting second of the PALS station data.

Example lis.config entry

```
PALS met forcing directory:
PALS met forcing station name:
PALS met forcing data start year:
PALS met forcing data start month:
PALS met forcing data start day:
PALS met forcing data start hour:
PALS met forcing data start minute:
PALS met forcing data start second:
```

9.10.31. LDT-generated

`Generated metforcing directory:` specifies the location of the LDT generated meteorological forcing files. Files generated in LDT are in netCDF format, and they are automatically loaded and handled by the LIS reader.

Example lis.config entry

```
Generated metforcing directory:   ./LDT_OUTPUT/
```

9.10.32. CLIM-Standard

`Metforcing climatology directory:` specifies the location of the LDT generated forcing climatologies files. Files generated in LDT are in netCDF format, and they are automatically loaded and handled by this selected reader in LIS.

Example lis.config entry

```
Metforcing climatology directory:   ./Forcing_Climatology/MERRA2Clim/
```

9.10.33. Generic ensemble forecast

`Generic ensemble forecast directory:` specifies the location of the generic ensemble forecast data.

`Generic ensemble forecast number of ensemble members:` specifies the number of ensemble members.

Example lis.config entry

```
Generic ensemble forecast directory:
Generic ensemble forecast number of ensemble members:
```

9.10.34. AWAP

`AWAP forcing directory:` specifies the location of the AWAP precipitation forcing data.

Example lis.config entry

```
AWAP forcing directory:
```

9.10.35. GDAS T1534

`GDAS T1534 forcing directory:` specifies the location of the GDAS T1534 metforcing data.

Example lis.config entry

```
`GDAS T1534 forcing directory:`
```

9.10.36. MRMS

`MRMS forcing directory:` specifies the location of the MRMS metforcing data.

`MRMS masking:` specifies whether to use a monthly-varying mask for where MRMS data are considered acceptable to the user. (1=Yes 0=No)

`MRMS mask threshold:` specifies Radar Quality Index value (on scale of 0-100) above which to use MRMS data and below which to use a different forcing.

`MRMS mask directory:` specifies the location of the MRMS mask files.

Example lis.config entry

```
MRMS forcing directory:
MRMS masking: 1
MRMS mask threshold: 60.0
MRMS mask directory: ./input/MASKS/
```

9.10.37. AWRA-L 6.0.0

`AWRAL forcing directory:` specifies the location of the AWRA-L metforcing data.

`AWRAL domain x-dimension size:` specifies the number of columns of the native domain parameters of the AWRA-L forcing data.

`AWRAL domain y-dimension size:` specifies the number of rows of the native domain parameters of the AWRA-L forcing data.

Example lis.config entry

```
AWRAL forcing directory:               ./INPUT/AWRAL.FORCING
AWRAL domain x-dimension size:         841
AWRAL domain y-dimension size:         681
```

9.10.38. PLUMBER2

`PLUMBER2 forcing file:` specifies the location of the PLUMBER2 forcing file.

`PLUMBER2 Station ID:` specifies the station ID of the PLUMBER2 forcing file.

`PLUMBER2 Time Delta:` specifies the PLUMBER2 site-specific forcing time step (in seconds).

Example lis.config entry

```
PLUMBER2 forcing file: ./input/PLUMBER2/AU-Cow_2010-2015_OzFlux_Met.nc
PLUMBER2 Station ID: AU-Cow
PLUMBER2 Time Delta: 1800
```

9.10.39. GDDP

`GDDP forcing file:` specifies the location of the GDDP metforcing data.

`GDDP forcing scenario:` specifies the GDDP forcing scenario. Currently only `historical` is supported.

`GDDP reference daily climatology directory:` specifies the location of the GDDP reference daily climatology data.

`GDDP reference hourly climatology directory:` specifies the location of the GDDP reference hourly climatology data.

Example lis.config entry

```
GDDP forcing directory:                     ./input/MET_FORCING/NEX-GDDP-CMIP6/
GDDP forcing scenario:                     historical
GDDP reference daily climatology directory:  ./input/MET_FORCING/M2CLIMO/DAILY/
GDDP reference hourly climatology directory: ./input/MET_FORCING/M2CLIMO/HOURLY/
```

9.10.40. GALWEM Forecast

`GALWEM forecast forcing directory:` specifies the location of the GALWEM forecast forcing files.

`GALWEM forecast resolution:` specifies the resolution of the GALWEM forecast data. The current resolutions supported are: 17(=17km) or 25(=0.25deg)

`GALWEM forecast run mode:` specifies the run mode related to the GALWEM dataset, which can either be forecast or analysis run mode. Currently, only the forecast mode is supported.

Example lis.config entry

```
GALWEM forecast forcing directory: ./GALWEM_17km
GALWEM forecast grid resolution:   17          # 17(=17km) or 25(=0.25 deg)
GALWEM forecast run mode:          forecast    # forecast | analysis
```

9.10.41. GALWEM-GE Forecast

`GALWEM-GE forecast forcing directory:` specifies the location of the GALWEM-GE forecast forcing files.

`GALWEM-GE forecast run mode:` specifies the run mode related to the GALWEM-GE dataset, which can either be forecast or analysis run mode. Currently, only the forecast mode is supported.

`GALWEM-GE forecast number of ensemble members:` specifies the number of ensembles of the GALWEM-GE forecast forcing data.

`Apply GALWEM-GE precipitation bias correction:` specifies whether to enable the precipitation bias correction. Acceptable values are:

Value	Description
0	Do not enable
1	Enable

`GALWEM-GE model CDF directory:` specifies the location of the GALWEM-GE model CDF files.

Example lis.config entry

```
GALWEM-GE forecast forcing directory:          ./input/GALWEM_GE
GALWEM-GE forecast run mode:                   forecast
GALWEM-GE forecast number of ensemble members: 10
Apply GALWEM-GE precipitation bias correction: 1 #enter 1 - use; or 0
GALWEM-GE model CDF directory:                 ./input/cdf/
```

9.10.42. MOGREPS-G Forecast

`MOGREPS-G forecast forcing directory:` specifies the location of the MOGREPS-G forecast forcing files.

`MOGREPS-G forecast run mode:` specifies the run mode related to the MOGREPS-G dataset, which can either be forecast or analysis run mode. Currently, only the forecast mode is supported.

`MOGREPS-G forecast number of ensemble members:` specifies the number of ensembles of the MOGREPS-G forecast forcing data.

`Apply MOGREPS-G precipitation bias correction:` specifies whether to enable the precipitation bias correction. Acceptable values are:

Value	Description
0	Do not enable
1	Enable

`MOGREPS-G model CDF file:` specifies the location of the MOGREPS-G model CDF file.

Example lis.config entry

```
MOGREPS-G forecast forcing directory:          ./MOGREPS-G
MOGREPS-G forecast run mode:                   forecast    # forecast | analysis
MOGREPS-G forecast number of ensemble members: 18
Apply MOGREPS-G precipitation bias correction: 1 #enter 1 - use; or 0
MOGREPS-G model CDF file:
./input/cdf/MOGREPS_G_leadtime_cdf_10km.nc
```

9.11. Land surface models

9.11.1. Forcing only — Template

`TEMPLATE model timestep:` specifies the timestep for the run. The template LSM is not a model; rather, it is a placeholder for a model. It demonstrates the hooks that are needed to add a land surface model into LIS. This "LSM" is also used to run LIS with the purpose of only processing and writing forcing data.

See Section Defining a time interval for a description of how to specify a time interval.

Example lis.config entry

```
TEMPLATE model timestep: 1hr
```

9.11.2. NCEP's Noah-2.7.1

`Noah.2.7.1 model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

For a nested domain, the timesteps for each nest should be specified with white spaces as the delimiter. If two domains (one subnest) are employed, the first one using 900 seconds and the second one using 3600 seconds as the timestep, the model timesteps are specified as:

E.g.: `Noah.2.7.1 model timestep: 15mn 60mn`

`Noah.2.7.1 restart output interval:` defines the restart writing interval for Noah-2.7.1. The typical value used in the LIS runs is 24 hours (1da).

See Section Defining a time interval for a description of how to specify a time interval.

`Noah.2.7.1 restart file:` specifies the Noah-2.7.1 active restart file.

`Noah.2.7.1 vegetation parameter table:` specifies the Noah-2.7.1 static vegetation parameter table file.

`Noah.2.7.1 soil parameter table:` specifies the Noah-2.7.1 soil parameter file.

`Noah.2.7.1 use PTF for mapping soil properties:` specifies if pedotransfer functions are to be used

for mapping soil properties (0-do not use, 1-use).

`Noah.2.7.1 number of vegetation parameters:` specifies the number of static vegetation parameters specified for each veg type.

`Noah.2.7.1 soils scheme:` specifies the soil mapping scheme used. Acceptable values are:

Value	Description
1	Zobler
2	STATSGO

`Noah.2.7.1 number of soil classes:` specifies the number of soil classes in the above mapping scheme. Acceptable values are:

Value	Description
9	Zobler
19	STATSGO

`Noah.2.7.1 number of soil layers:` specifies the number of soil layers. The typical value used in Noah-2.7.1 is 4.

`Noah.2.7.1 layer thicknesses:` specifies the thickness (in meters) of each of the Noah-2.7.1 soil layers (top layer to bottom layer). If the number of soil layers and thicknesses change from the typical 4 layers with thicknesses of 0.1, 0.3, 0.6, and 1.0 meters, users should change the values of NROOT for each vegetation type to map the number of layers with roots for transpiration in their own custom noah.vegparms parameter file.

`Noah.2.7.1 initial skin temperature:` specifies the initial skin temperature in Kelvin used in the cold start runs.

`Noah.2.7.1 initial soil temperatures:` specifies the initial soil temperature (for all layers, top to bottom) in Kelvin used in the cold start runs.

`Noah.2.7.1 initial total soil moistures:` specifies the initial total volumetric soil moistures (for all layers, top to bottom) used in the cold start runs. (units $\frac{m^3}{m^3}$)

`Noah.2.7.1 initial liquid soil moistures:` specifies the initial liquid volumetric soil moistures (for all layers, top to bottom) used in the cold start runs. (units $\frac{m^3}{m^3}$)

`Noah.2.7.1 initial canopy water:` specifies the initial canopy water (m).

`Noah.2.7.1 initial snow depth:` specifies the initial snow depth (m).

`Noah.2.7.1 initial snow equivalent:` specifies the initial snow water equivalent (m).

`Noah.2.7.1 reference height for forcing T and q:` specifies the height in meters of air temperature and specific humidity forcings.

`Noah.2.7.1 reference height for forcing u and v:` specifies the height in meters of u and v wind

forcings.

`Noah.2.7.1 reinitialize parameters from OPTUE output:` specifies whether to reinitialize parameters from OPTUE output. Defaults to 0.

`Noah.2.7.1 parameter restart file (from OPTUE):` specifies the restart file to use to reinitialize parameters. Only used when `Noah.2.7.1 reinitialize parameters from OPTUE output:` is set to 1.

Example lis.config entry

```
Noah.2.7.1 model timestep:                  15mn
Noah.2.7.1 restart output interval:         1mo
Noah.2.7.1 restart file:                    ./LIS.E111.200401210000.d01.Noah271rst
Noah.2.7.1 vegetation parameter table:      ../../noah271_parms/noah.vegparms_UMD.txt
Noah.2.7.1 soil parameter table:
../../noah271_parms/noah.soilparms_STATSGO-FAO.txt
Noah.2.7.1 use PTF for mapping soil properties: 0
Noah.2.7.1 number of vegetation parameters: 7
Noah.2.7.1 soils scheme:                    2      # 1-Zobler; 2-STATSGO
Noah.2.7.1 number of soil classes:          16     # 9 for Zobler
Noah.2.7.1 number of soil layers:           4
Noah.2.7.1 layer thicknesses:               0.1  0.3  0.6  1.0
Noah.2.7.1 initial skin temperature:        290.0000                                  #
Kelvin
Noah.2.7.1 initial soil temperatures:       290.0000  290.0000  290.0000  290.0000   #
Kelvin
Noah.2.7.1 initial total soil moistures:    0.2000000 0.2000000 0.2000000 0.2000000  #
volumetric (m3 m-3)
Noah.2.7.1 initial liquid soil moistures:   0.2000000 0.2000000 0.2000000 0.2000000  #
volumetric (m3 m-3)
Noah.2.7.1 initial canopy water:            0.0                                       #
depth (m)
Noah.2.7.1 initial snow depth:              0.0                                       #
depth (m)
Noah.2.7.1 initial snow equivalent:         0.0                                       #
SWE depth (m)
Noah.2.7.1 reference height for forcing T and q:  20.0
Noah.2.7.1 reference height for forcing u and v:  20.0
```

9.11.3. NCAR's Noah-3.2

`Noah.3.2 model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

For a nested domain, the timesteps for each nest should be specified with white spaces as the delimiter. If two domains (one subnest) are employed, the first one using 900 seconds and the second one using 3600 seconds as the timestep, the model timesteps are specified as:

E.g.: `Noah.3.2 model timestep: 15mn 60mn`

`Noah.3.2 restart output interval:` defines the restart writing interval for Noah-3.2. The typical value used in the LIS runs is 24 hours (1da).

See Section Defining a time interval for a description of how to specify a time interval.

`Noah.3.2 restart file:` specifies the Noah-3.2 active restart file.

`Noah.3.2 vegetation parameter table:` specifies the Noah-3.2 static vegetation parameter table file.

`Noah.3.2 soil parameter table:` specifies the Noah-3.2 soil parameter file.

`Noah.3.2 general parameter table:` specifies the Noah-3.2 general parameter file.

`Noah.3.2 use PTF for mapping soil properties:` specifies if pedotransfer functions are to be used for mapping soil properties (0-do not use, 1-use).

`Noah.3.2 soils scheme:` specifies the soil mapping scheme used. Acceptable values are:

Value	Description
1	Zobler
2	STATSGO

`Noah.3.2 number of soil layers:` specifies the number of soil layers. The typical value used in Noah is 4.

`Noah.3.2 layer thicknesses:` specifies the thickness (in meters) of each of the Noah-3.2 soil layers (top layer to bottom layer). If the number of soil layers and thicknesses change from the typical 4 layers with thicknesses of 0.1, 0.3, 0.6, and 1.0 meters, users should change the values of NROOT for each vegetation type to map the number of layers with roots for transpiration in their own custom VEGPARM.TBL parameter file.

`Noah.3.2 use distributed soil depth map:` specifies whether to use a distributed soil depth map. Defaults to 0.

`Noah.3.2 use distributed root depth map:` specifies whether to use a distributed root depth map. Defaults to 0.

`Noah.3.2 initial skin temperature:` specifies the initial skin temperature in Kelvin used in the cold start runs.

`Noah.3.2 initial soil temperatures:` specifies the initial soil temperature (for all layers, top to bottom) in Kelvin used in the cold start runs.

`Noah.3.2 initial total soil moistures:` specifies the initial total volumetric soil moistures (for all layers, top to bottom) used in the cold start runs. (units $\frac{m^3}{m^3}$)

`Noah.3.2 initial liquid soil moistures:` specifies the initial liquid volumetric soil moistures (for all layers, top to bottom) used in the cold start runs. (units $\frac{m^3}{m^3}$)

`Noah.3.2 initial canopy water:` specifies the initial canopy water (m).

`Noah.3.2 initial snow depth:` specifies the initial snow depth (m).

`Noah.3.2 initial snow equivalent:` specifies the initial snow water equivalent (m).

`Noah.3.2 fixed max snow albedo:` specifies a fixed maximum snow albedo (fraction, 0.0 to 1.0) for all grid points. This value will only be used if "fixed" is chosen for `Max snow albedo data source`.

`Noah.3.2 fixed deep soil temperature:` specifies a fixed deep soil temperature (Kelvin) for all grid points. Entering a value of 0.0 will have the code use the deep soil temperature from the LDT-generated `LIS domain and parameter data file`.

`Noah.3.2 fixed vegetation type:` specifies a fixed vegetation type index for all grid points. Entering a value of 0 will not fix the vegetation types, and the code will use the `Landcover data source` information instead.

`Noah.3.2 fixed soil type:` specifies a fixed soil type index for all grid points. Entering a value of 0 will not fix the soil types, and the code will use the `Soil texture data source` information instead.

`Noah.3.2 fixed slope type:` specifies a fixed slope type index for all grid points. Entering a value of 0 will not fix the slope index types, and the code will use the `Slope data source` information instead.

`Noah.3.2 sfcdif option:` specifies whether to use the updated SFCDIF routine in Noah-3.2, or to use the previous SFCDIF routine. The typical option is to use the updated SFCDIF routine (option = 1).

`Noah.3.2 z0 veg-type dependence option:` specifies whether to use the vegetation type dependent roughness height option on the CZIL parameter in the SFCDIF routine. The typical option in Noah-3.2 is not use this dependence (option = 0).

`Noah.3.2 greenness fraction:` specifies a monthly (January to December) greenness vegetation fraction for all grid points. These values are used only if the `Greenness data source` option is set to "none".

`Noah.3.2 background albedo:` specifies a monthly background (snow-free) albedo for all grid points. These values are only used for an initial condition calculation, and only if the `Albedo data source` option is set to "none". After the first timestep, these values are not used.

`Noah.3.2 background roughness length:` specifies a monthly background (snow-free) roughness length. These values are used only for an initial condition calculation and are not used after the first timestep.

`Noah.3.2 reference height for forcing T and q:` specifies the height in meters of air temperature and specific humidity forcings.

`Noah.3.2 reference height for forcing u and v:` specifies the height in meters of u and v wind forcings.

Example lis.config entry

```
Noah.3.2 model timestep:                  15mn
Noah.3.2 restart output interval:         1mo
Noah.3.2 restart file:                    LIS.E111.200805140000.d01.Noah32rst
```

```
Noah.3.2 vegetation parameter table:      ../../noah32_parms/VEGPARM.TBL
Noah.3.2 soil parameter table:            ../../noah32_parms/SOILPARM.TBL
Noah.3.2 general parameter table:         ../../noah32_parms/GENPARM.TBL
Noah.3.2 use PTF for mapping soil properties: 0
Noah.3.2 soils scheme:                    2      # 1-Zobler; 2-STATSGO
Noah.3.2 number of soil layers:           4
Noah.3.2 layer thicknesses:               0.1  0.3  0.6  1.0
Noah.3.2 use distributed soil depth map:  0      # 0 - do not use; 1 - use map
Noah.3.2 use distributed root depth map:  0      # 0 - do not use; 1 - use map
Noah.3.2 initial skin temperature:        290.0000                                  #
Kelvin
Noah.3.2 initial soil temperatures:       290.0000  290.0000  290.0000  290.0000   #
Kelvin
Noah.3.2 initial total soil moistures:    0.2000000 0.2000000 0.2000000 0.2000000  #
volumetric (m3 m-3)
Noah.3.2 initial liquid soil moistures:   0.2000000 0.2000000 0.2000000 0.2000000  #
volumetric (m3 m-3)
Noah.3.2 initial canopy water:            0.0                                       #
depth (m)
Noah.3.2 initial snow depth:              0.0                                       #
depth (m)
Noah.3.2 initial snow equivalent:         0.0                                       #
SWE depth (m)
Noah.3.2 fixed max snow albedo:           0.0    # fraction; 0.0 - do not fix
Noah.3.2 fixed deep soil temperature:     0.0    # Kelvin; 0.0 - do not fix
Noah.3.2 fixed vegetation type:           0      # 0 - do not fix
Noah.3.2 fixed soil type:                 0      # 0 - do not fix
Noah.3.2 fixed slope type:                0      # 0 - do not fix
Noah.3.2 sfcdif option:                   1      # 0 - previous SFCDIF; 1 - updated
SFCDIF
Noah.3.2 z0 veg-type dependence option:   0      # 0 - off; 1 - on; dependence of CZIL
in SFCDIF
# Green vegetation fraction - by month
#  - used only if "Greenness data source" above is zero
Noah.3.2 greenness fraction:  0.01  0.02  0.07  0.17  0.27  0.58  0.93  0.96  0.65
0.24  0.11  0.02
# Background (i.e., snow-free) albedo - by month
#  - used only for first timestep; subsequent timesteps use
#    the values as computed in the previous call to "SFLX"
Noah.3.2 background albedo:   0.18  0.17  0.16  0.15  0.15  0.15  0.15  0.16  0.16
0.17  0.17  0.18
# Background (i.e., snow-free) roughness length (m) - by month
#  - used only for first timestep; subsequent timesteps use
#    the values as computed in the previous call to "SFLX"
Noah.3.2 background roughness length: 0.020 0.020 0.025 0.030 0.035 0.036 0.035 0.030
0.027 0.025 0.020 0.020
Noah.3.2 reference height for forcing T and q:  20.0      # (m) - negative=use height
from forcing data
Noah.3.2 reference height for forcing u and v:  20.0      # (m) - negative=use height
from forcing data
```

9.11.4. NCAR's Noah-3.3

`Noah.3.3 model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

For a nested domain, the timesteps for each nest should be specified with white spaces as the delimiter. If two domains (one subnest) are employed, the first one using 900 seconds and the second one using 3600 seconds as the timestep, the model timesteps are specified as:

E.g.: `Noah.3.3 model timestep: 15mn 60mn`

`Noah.3.3 restart output interval:` defines the restart writing interval for Noah-3.3. The typical value used in the LIS runs is 24 hours (1da).

See Section Defining a time interval for a description of how to specify a time interval.

`Noah.3.3 restart file:` specifies the Noah-3.3 active restart file.

`Noah.3.3 vegetation parameter table:` specifies the Noah-3.3 static vegetation parameter table file.

`Noah.3.3 soil parameter table:` specifies the Noah-3.3 soil parameter file.

`Noah.3.3 general parameter table:` specifies the Noah-3.3 general parameter file.

`Noah.3.3 use PTF for mapping soil properties:` specifies if pedotransfer functions are to be used for mapping soil properties (0-do not use, 1-use).

`Noah.3.3 soils scheme:` specifies the soil mapping scheme used. Acceptable values are:

Value	Description
1	Zobler
2	STATSGO

`Noah.3.3 number of soil layers:` specifies the number of soil layers. The typical value used in Noah is 4.

`Noah.3.3 layer thicknesses:` specifies the thickness (in meters) of each of the Noah-3.3 soil layers (top layer to bottom layer). If the number of soil layers and thicknesses change from the typical 4 layers with thicknesses of 0.1, 0.3, 0.6, and 1.0 meters, users should change the values of NROOT for each vegetation type to map the number of layers with roots for transpiration in their own custom VEGPARM.TBL parameter file.

`Noah.3.3 use distributed soil depth map:` specifies whether to use a distributed soil depth map. Defaults to 0.

`Noah.3.3 use distributed root depth map:` specifies whether to use a distributed root depth map. Defaults to 0.

`Noah.3.3 initial skin temperature:` specifies the initial skin temperature in Kelvin used in the cold start runs.

`Noah.3.3 initial soil temperatures:` specifies the initial soil temperature (for all layers, top to bottom) in Kelvin used in the cold start runs.

`Noah.3.3 initial total soil moistures:` specifies the initial total volumetric soil moistures (for all layers, top to bottom) used in the cold start runs. (units $\frac{m^3}{m^3}$)

`Noah.3.3 initial liquid soil moistures:` specifies the initial liquid volumetric soil moistures (for all layers, top to bottom) used in the cold start runs. (units $\frac{m^3}{m^3}$)

`Noah.3.3 initial canopy water:` specifies the initial canopy water (m).

`Noah.3.3 initial snow depth:` specifies the initial snow depth (m).

`Noah.3.3 initial snow equivalent:` specifies the initial snow water equivalent (m).

`Noah.3.3 fixed max snow albedo:` specifies a fixed maximum snow albedo (fraction, 0.0 to 1.0) for all grid points. This value will only be used if "fixed" is chosen for `Max snow albedo data source`.

`Noah.3.3 fixed deep soil temperature:` specifies a fixed deep soil temperature (Kelvin) for all grid points. Entering a value of 0.0 will have the code use the deep soil temperature from the LDT-generated `LIS domain and parameter data file`.

`Noah.3.3 fixed vegetation type:` specifies a fixed vegetation type index for all grid points. Entering a value of 0 will not fix the vegetation types, and the code will use the `Landcover data source` information instead.

`Noah.3.3 fixed soil type:` specifies a fixed soil type index for all grid points. Entering a value of 0 will not fix the soil types, and the code will use the `Soil texture data source` information instead.

`Noah.3.3 fixed slope type:` specifies a fixed slope type index for all grid points. Entering a value of 0 will not fix the slope index types, and the code will use the `Slope data source` information instead.

`Noah.3.3 sfcdif option:` specifies whether to use the updated SFCDIF routine in Noah-3.3, or to use the previous SFCDIF routine. The typical option is to use the updated SFCDIF routine (option = 1).

`Noah.3.3 z0 veg-type dependence option:` specifies whether to use the vegetation type dependent roughness height option on the CZIL parameter in the SFCDIF routine. The typical option in Noah-3.3 is not use this dependence (option = 0).

`Noah.3.3 greenness fraction:` specifies a monthly (January to December) greenness vegetation fraction for all grid points. These values are used only if the `Greenness data source` option is set to "none".

`Noah.3.3 background albedo:` specifies a monthly background (snow-free) albedo for all grid points. These values are only used for an initial condition calculation, and only if the `Albedo data source` option is set to "none". After the first timestep, these values are not used.

`Noah.3.3 background roughness length:` specifies a monthly background (snow-free) roughness length. These values are used only for an initial condition calculation and are not used after the first timestep.

`Noah.3.3 reference height for forcing T and q:` specifies the height in meters of air temperature and specific humidity forcings.

`Noah.3.3 reference height for forcing u and v:` specifies the height in meters of u and v wind forcings.

`Noah.3.3 soil moisture CDF file:` specifies the Noah 3.3 soil moisture CDF file.

Example lis.config entry

```
Noah.3.3 model timestep:                  15mn
Noah.3.3 restart output interval:         1mo
Noah.3.3 restart file:                    LIS.E111.200805140000.d01.Noah33rst
Noah.3.3 vegetation parameter table:      ../../noah33_parms/VEGPARM.TBL
Noah.3.3 soil parameter table:            ../../noah33_parms/SOILPARM.TBL
Noah.3.3 general parameter table:         ../../noah33_parms/GENPARM.TBL
Noah.3.3 use PTF for mapping soil properties: 0
Noah.3.3 soils scheme:                    2      # 1-Zobler; 2-STATSGO
Noah.3.3 number of soil layers:           4
Noah.3.3 layer thicknesses:               0.1  0.3  0.6  1.0
Noah.3.3 use distributed soil depth map:  0      # 0 - do not use; 1 - use map
Noah.3.3 use distributed root depth map:  0      # 0 - do not use; 1 - use map
Noah.3.3 initial skin temperature:        290.0000                                  #
Kelvin
Noah.3.3 initial soil temperatures:       290.0000  290.0000  290.0000  290.0000   #
Kelvin
Noah.3.3 initial total soil moistures:    0.2000000 0.2000000 0.2000000 0.2000000  #
volumetric (m3 m-3)
Noah.3.3 initial liquid soil moistures:   0.2000000 0.2000000 0.2000000 0.2000000  #
volumetric (m3 m-3)
Noah.3.3 initial canopy water:            0.0                                       #
depth (m)
Noah.3.3 initial snow depth:              0.0                                       #
depth (m)
Noah.3.3 initial snow equivalent:         0.0                                       #
SWE depth (m)
Noah.3.3 fixed max snow albedo:           0.0    # fraction; 0.0 - do not fix
Noah.3.3 fixed deep soil temperature:     0.0    # Kelvin; 0.0 - do not fix
Noah.3.3 fixed vegetation type:           0      # 0 - do not fix
Noah.3.3 fixed soil type:                 0      # 0 - do not fix
Noah.3.3 fixed slope type:                0      # 0 - do not fix
Noah.3.3 sfcdif option:                   1      # 0 - previous SFCDIF; 1 - updated
SFCDIF
Noah.3.3 z0 veg-type dependence option:   0      # 0 - off; 1 - on; dependence of CZIL
in SFCDIF
# Green vegetation fraction - by month
#  - used only if "Greenness data source" above is zero
Noah.3.3 greenness fraction:  0.01  0.02  0.07  0.17  0.27  0.58  0.93  0.96  0.65
0.24  0.11  0.02
# Background (i.e., snow-free) albedo - by month
#  - used only for first timestep; subsequent timesteps use
```

```
#    the values as computed in the previous call to "SFLX"
Noah.3.3 background albedo:   0.18  0.17  0.16  0.15  0.15  0.15  0.15  0.16  0.16
0.17  0.17  0.18
# Background (i.e., snow-free) roughness length (m) - by month
#  - used only for first timestep; subsequent timesteps use
#    the values as computed in the previous call to "SFLX"
Noah.3.3 background roughness length: 0.020 0.020 0.025 0.030 0.035 0.036 0.035 0.030
0.027 0.025 0.020 0.020
Noah.3.3 reference height for forcing T and q:   2.0      # (m) - negative=use height
from forcing data
Noah.3.3 reference height for forcing u and v:  10.0      # (m) - negative=use height
from forcing data
Noah.3.3 soil moisture CDF file:
```

9.11.5. NCAR's Noah-3.6

`Noah.3.6 model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

For a nested domain, the timesteps for each nest should be specified with white spaces as the delimiter. If two domains (one subnest) are employed, the first one using 900 seconds and the second one using 3600 seconds as the timestep, the model timesteps are specified as:

E.g.: `Noah.3.6 model timestep: 15mn 60mn`

`Noah.3.6 restart output interval:` defines the restart writing interval for Noah-3.6. The typical value used in the LIS runs is 24 hours (1da).

See Section Defining a time interval for a description of how to specify a time interval.

`Noah.3.6 restart file:` specifies the Noah-3.6 active restart file.

`Noah.3.6 vegetation parameter table:` specifies the Noah-3.6 static vegetation parameter table file.

`Noah.3.6 soil parameter table:` specifies the Noah-3.6 soil parameter file.

`Noah.3.6 general parameter table:` specifies the Noah-3.6 general parameter file.

`Noah.3.6 use PTF for mapping soil properties:` specifies if pedotransfer functions are to be used for mapping soil properties (0-do not use, 1-use).

`Noah.3.6 soils scheme:` specifies the soil mapping scheme used. Acceptable values are:

Value	Description
1	Zobler
2	STATSGO

`Noah.3.6 number of soil layers:` specifies the number of soil layers. The typical value used in Noah is 4.

`Noah.3.6 layer thicknesses:` specifies the thickness (in meters) of each of the Noah-3.6 soil layers (top layer to bottom layer). If the number of soil layers and thicknesses change from the typical 4 layers with thicknesses of 0.1, 0.3, 0.6, and 1.0 meters, users should change the values of NROOT for each vegetation type to map the number of layers with roots for transpiration in their own custom VEGPARM.TBL parameter file.

`Noah.3.6 use distributed soil depth map:` specifies whether to use a distributed soil depth map. Defaults to 0.

`Noah.3.6 use distributed root depth map:` specifies whether to use a distributed root depth map. Defaults to 0.

`Noah.3.6 initial skin temperature:` specifies the initial skin temperature in Kelvin used in the cold start runs.

`Noah.3.6 initial soil temperatures:` specifies the initial soil temperature (for all layers, top to bottom) in Kelvin used in the cold start runs.

`Noah.3.6 initial total soil moistures:` specifies the initial total volumetric soil moistures (for all layers, top to bottom) used in the cold start runs. (units $\frac{m^3}{m^3}$)

`Noah.3.6 initial liquid soil moistures:` specifies the initial liquid volumetric soil moistures (for all layers, top to bottom) used in the cold start runs. (units $\frac{m^3}{m^3}$)

`Noah.3.6 initial canopy water:` specifies the initial canopy water (m).

`Noah.3.6 initial snow depth:` specifies the initial snow depth (m).

`Noah.3.6 initial snow equivalent:` specifies the initial snow water equivalent (m).

`Noah.3.6 fixed max snow albedo:` specifies a fixed maximum snow albedo (fraction, 0.0 to 1.0) for all grid points. This value will only be used if “fixed” is chosen for `Max snow albedo data source`.

`Noah.3.6 fixed deep soil temperature:` specifies a fixed deep soil temperature (Kelvin) for all grid points. Entering a value of 0.0 will have the code use the deep soil temperature from the LDT-generated `LIS domain and parameter data file`.

`Noah.3.6 fixed vegetation type:` specifies a fixed vegetation type index for all grid points. Entering a value of 0 will not fix the vegetation types, and the code will use the `Landcover data source` information instead.

`Noah.3.6 fixed soil type:` specifies a fixed soil type index for all grid points. Entering a value of 0 will not fix the soil types, and the code will use the `Soil texture data source` information instead.

`Noah.3.6 fixed slope type:` specifies a fixed slope type index for all grid points. Entering a value of 0 will not fix the slope index types, and the code will use the `Slope data source` information instead.

`Noah.3.6 sfcdif option:` specifies whether to use the updated SFCDIF routine in Noah-3.6, or to use the previous SFCDIF routine. The typical option is to use the updated SFCDIF routine (option = 1).

`Noah.3.6 z0 veg-type dependence option:` specifies whether to use the vegetation type dependent

roughness height option on the CZIL parameter in the SFCDIF routine. The typical option in Noah-3.6 is not use this dependence (option = 0).

`Noah.3.6 Run UA snow-physics option:` specifies whether to run the University of Arizona (UA) snow-physics option. Either `.true.` or `.false.` should be selected. If `.true.` is given, then the UA snow-physics will be run. If `.false.` is given, then the standard Noah snow-physics will be run instead.

`Noah.3.6 greenness fraction:` specifies a monthly (January to December) greenness vegetation fraction for all grid points. These values are used only if the `Greenness data source` option is set to "none".

`Noah.3.6 background albedo:` specifies a monthly background (snow-free) albedo for all grid points. These values are only used for an initial condition calculation, and only if the `Albedo data source` option is set to "none". After the first timestep, these values are not used.

`Noah.3.6 background roughness length:` specifies a monthly background (snow-free) roughness length. These values are used only for an initial condition calculation and are not used after the first timestep.

`Noah.3.6 reference height for forcing T and q:` specifies the height in meters of air temperature and specific humidity observations.

`Noah.3.6 reference height for forcing u and v:` specifies the height in meters of u and v wind forcings.

`Noah.3.6 removal of residual snow fix:` specifies whether or not a snow fix is used (1 - fix is active, 0 - inactive). The land-surface model was found to keep very small amounts of snow in rare cases. This fix zeros out snow values that are under a predetermined threshold.

Example lis.config entry

```
Noah.3.6 model timestep:                  15mn
Noah.3.6 restart output interval:         1mo
Noah.3.6 restart file:                    LIS.E111.200805140000.d01.Noah36rst
Noah.3.6 vegetation parameter table:      ../../noah36_parms/VEGPARM.TBL
Noah.3.6 soil parameter table:            ../../noah36_parms/SOILPARM.TBL
Noah.3.6 general parameter table:         ../../noah36_parms/GENPARM.TBL
Noah.3.6 use PTF for mapping soil properties: 0
Noah.3.6 soils scheme:                    2      # 1-Zobler; 2-STATSGO
Noah.3.6 number of soil layers:           4
Noah.3.6 layer thicknesses:               0.1  0.3  0.6  1.0
Noah.3.6 use distributed soil depth map:  0      # 0 - do not use; 1 - use map
Noah.3.6 use distributed root depth map:  0      # 0 - do not use; 1 - use map
Noah.3.6 initial skin temperature:        290.0000                              #
Kelvin
Noah.3.6 initial soil temperatures:       290.0000  290.0000  290.0000  290.0000   #
Kelvin
Noah.3.6 initial total soil moistures:    0.2000000 0.2000000 0.2000000 0.2000000  #
volumetric (m3 m-3)
Noah.3.6 initial liquid soil moistures:   0.2000000 0.2000000 0.2000000 0.2000000  #
```

```
volumetric (m3 m-3)
Noah.3.6 initial canopy water:            0.0                                    #
depth (m)
Noah.3.6 initial snow depth:              0.0                                    #
depth (m)
Noah.3.6 initial snow equivalent:         0.0                                    #
SWE depth (m)
Noah.3.6 fixed max snow albedo:           0.0    # fraction; 0.0 - do not fix
Noah.3.6 fixed deep soil temperature:     0.0    # Kelvin; 0.0 - do not fix
Noah.3.6 fixed vegetation type:           0      # 0 - do not fix
Noah.3.6 fixed soil type:                 0      # 0 - do not fix
Noah.3.6 fixed slope type:                0      # 0 - do not fix
Noah.3.6 sfcdif option:                   1      # 0 - previous SFCDIF; 1 - updated
SFCDIF
Noah.3.6 z0 veg-type dependence option:   0      # 0 - off; 1 - on; dependence of CZIL
in SFCDIF
Noah.3.6 Run UA snow-physics option:     .false. # ".true." or ".false"
# Green vegetation fraction - by month
#  - used only if "Greenness data source" above is zero
Noah.3.6 greenness fraction:  0.01  0.02  0.07  0.17  0.27  0.58  0.93  0.96  0.65
0.24  0.11  0.02
# Background (i.e., snow-free) albedo - by month
#  - used only for first timestep; subsequent timesteps use
#    the values as computed in the previous call to "SFLX"
Noah.3.6 background albedo:   0.18  0.17  0.16  0.15  0.15  0.15  0.15  0.16  0.16
0.17  0.17  0.18
# Background (i.e., snow-free) roughness length (m) - by month
#  - used only for first timestep; subsequent timesteps use
#    the values as computed in the previous call to "SFLX"
Noah.3.6 background roughness length: 0.020 0.020 0.025 0.030 0.035 0.036 0.035 0.030
0.027 0.025 0.020 0.020
Noah.3.6 reference height for forcing T and q:   2.0      # (m) - negative=use height
from forcing data
Noah.3.6 reference height for forcing u and v:  10.0      # (m) - negative=use height
from forcing data
Noah.3.6 removal of residual snow fix: 0
```

9.11.6. NCAR's Noah-3.9

`Noah.3.9 model timestep:` specifies the timestep for the run.

`Noah.3.9 restart output interval:` defines the restart writing interval for Noah-3.9. The typical value used in the LIS runs is 24 hours (1da).

See Section Defining a time interval for a description of how to specify a time interval.

`Noah.3.9 restart file:` specifies the Noah-3.9 active restart file.

`Noah.3.9 restart file format:` specifies the Noah-3.9 active restart file format (default = netcdf).

`Noah.3.9 vegetation parameter table:` specifies the Noah-3.9 static vegetation parameter table file.

`Noah.3.9 soil parameter table:` specifies the Noah-3.9 soil parameter file.

`Noah.3.9 general parameter table:` specifies the Noah-3.9 general parameter file.

`Noah.3.9 use PTF for mapping soil properties:` specifies if pedotransfer functions are to be used for mapping soil properties (0-do not use, 1-use).

`Noah.3.9 soils scheme:` specifies the soil mapping scheme used. Acceptable values are:

Value	Description
1	Zobler
2	STATSGO

`Noah.3.9 number of soil layers:` specifies the number of soil layers. The typical value used in Noah is 4.

`Noah.3.9 layer thicknesses:` specifies the thickness (in meters) of each of the Noah-3.9 soil layers (top layer to bottom layer). If the number of soil layers and thicknesses change from the typical 4 layers with thicknesses of 0.1, 0.3, 0.6, and 1.0 meters, users should change the values of NROOT for each vegetation type to map the number of layers with roots for transpiration in their own custom VEGPARM.TBL parameter file.

`Noah.3.9 use distributed soil depth map:` specifies whether to use a distributed soil depth map. Defaults to 0.

`Noah.3.9 use distributed root depth map:` specifies whether to use a distributed root depth map. Defaults to 0.

`Noah.3.9 initial skin temperature:` specifies the initial skin temperature in Kelvin used in the cold start runs.

`Noah.3.9 initial soil temperatures:` specifies the initial soil temperature (for all layers, top to bottom) in Kelvin used in the cold start runs.

`Noah.3.9 initial total soil moistures:` specifies the initial total volumetric soil moistures (for all layers, top to bottom) used in the cold start runs. (units $\frac{m^3}{m^3}$)

`Noah.3.9 initial liquid soil moistures:` specifies the initial liquid volumetric soil moistures (for all layers, top to bottom) used in the cold start runs. (units $\frac{m^3}{m^3}$)

`Noah.3.9 initial canopy water:` specifies the initial canopy water (m).

`Noah.3.9 initial snow depth:` specifies the initial snow depth (m).

`Noah.3.9 initial snow equivalent:` specifies the initial snow water equivalent (m).

`Noah.3.9 fixed max snow albedo:` specifies a fixed maximum snow albedo (fraction, 0.0 to 1.0) for all grid points. This value will only be used if “fixed” is chosen for `Max snow albedo data source`.

`Noah.3.9 fixed deep soil temperature:` specifies a fixed deep soil temperature (Kelvin) for all grid

points. Entering a value of 0.0 will have the code use the deep soil temperature from the LDT-generated `LIS domain and parameter data file`.

`Noah.3.9 fixed vegetation type:` specifies a fixed vegetation type index for all grid points. Entering a value of 0 will not fix the vegetation types, and the code will use the `Landcover data source` information instead.

`Noah.3.9 fixed soil type:` specifies a fixed soil type index for all grid points. Entering a value of 0 will not fix the soil types, and the code will use the `Soil texture data source` information instead.

`Noah.3.9 fixed slope type:` specifies a fixed slope type index for all grid points. Entering a value of 0 will not fix the slope index types, and the code will use the `Slope data source` information instead.

`Noah.3.9 sfcdif option:` specifies whether to use the updated SFCDIF routine in Noah-3.9, or to use the previous SFCDIF routine. The typical option is to use the updated SFCDIF routine (option = 1).

`Noah.3.9 z0 veg-type dependence option:` specifies whether to use the vegetation type dependent roughness height option on the CZIL parameter in the SFCDIF routine. The typical option in Noah-3.9 is not use this dependence (option = 0).

`Noah.3.9 Run UA snow-physics option:` specifies whether to run the University of Arizona (UA) snow-physics option. Either `.true.` or `.false.` should be selected. If `.true.` is given, then the UA snow-physics will be run. If `.false.` is given, then the standard Noah snow-physics will be run instead.

`Noah.3.9 greenness fraction:` specifies a monthly (January to December) greenness vegetation fraction for all grid points. These values are used only if the `Greenness data source` option is set to "none".

`Noah.3.9 background albedo:` specifies a monthly background (snow-free) albedo for all grid points. These values are only used for an initial condition calculation, and only if the `Albedo data source` option is set to "none". After the first timestep, these values are not used.

`Noah.3.9 background roughness length:` specifies a monthly background (snow-free) roughness length. These values are used only for an initial condition calculation and are not used after the first timestep.

`Noah.3.9 reference height for forcing T and q:` specifies the height in meters of air temperature and specific humidity observations.

`Noah.3.9 reference height for forcing u and v:` specifies the height in meters of u and v wind forcings.

`Noah.3.9 thermal conductivity option:` specifies the option for the soil thermal conductivity calculation metho for soil type 3 (sandy loam) and for soil type 4 (silt loam). This option was added based on the results in Massey et al. (2014, JAMC). 1 = original calculation; 2 = new calculation, but only for soil texture classes 3 and 4; all other texture classes still use the original calculation.

`Noah.3.9 FASDAS option (0 or 1):` specifies the FASDAS (Flux Adjusting Surface Data Assimilation System) option. 0 = do not use; 1 = use. Option 1 is not currently supported in LIS.

Example lis.config entry

```
Noah.3.9 model timestep:                  15mn
Noah.3.9 restart output interval:         1da
Noah.3.9 restart file:                    none
Noah.3.9 restart file format:             netcdf
Noah.3.9 vegetation parameter table:
./input/LS_PARAMETERS/noah36_parms/VEGPARM.TBL
Noah.3.9 soil parameter table:
./input/LS_PARAMETERS/noah36_parms/SOILPARM.orig
Noah.3.9 general parameter table:
./input/LS_PARAMETERS/noah36_parms/GENPARM.TBL
Noah.3.9 use PTF for mapping soil properties: 0
Noah.3.9 soils scheme:                    1      # 1-Zobler; 2-STATSGO
Noah.3.9 number of soil layers:           4
Noah.3.9 layer thicknesses:               0.1  0.3  0.6  1.0
Noah.3.9 use distributed soil depth map:  0
Noah.3.9 use distributed root depth map:  0
Noah.3.9 initial skin temperature:        290.0000                              #
Kelvin
Noah.3.9 initial soil temperatures:       290.0000  290.0000  290.0000  290.0000   #
Kelvin
Noah.3.9 initial total soil moistures:    0.2000000 0.2000000 0.2000000 0.2000000  #
volumetric (m3 m-3)
Noah.3.9 initial liquid soil moistures:   0.2000000 0.2000000 0.2000000 0.2000000  #
volumetric (m3 m-3)
Noah.3.9 initial canopy water:            0.0                                   #
depth (m)
Noah.3.9 initial snow depth:              0.0                                   #
depth (m)
Noah.3.9 initial snow equivalent:         0.0                                   #
also known swe - depth (m)
Noah.3.9 fixed max snow albedo:           0.0                                   #
fraction; 0.0 - do not fix
Noah.3.9 fixed deep soil temperature:     0.0                                   #
Kelvin; 0.0 - do not fix
Noah.3.9 fixed vegetation type:           0                                     # 0
- do not fix
Noah.3.9 fixed soil type:                 0                                     # 0
- do not fix
Noah.3.9 fixed slope type:                0                                     # 0
- do not fix
Noah.3.9 sfcdif option:                   1      # 0 - previous SFCDIF; 1 - updated
SFCDIF
Noah.3.9 z0 veg-type dependence option:   0      # 0 - off; 1 - on; dependence of CZIL
in SFCDIF
Noah.3.9 Run UA snow-physics option:   .false.   # ".true." or ".false"
Noah.3.9 greenness fraction:  0.01  0.02  0.07  0.17  0.27  0.58  0.93  0.96  0.65
0.24  0.11  0.02
Noah.3.9 background albedo:   0.18  0.17  0.16  0.15  0.15  0.15  0.15  0.16  0.16
0.17  0.17  0.18
```

```
Noah.3.9 background roughness length: 0.020 0.020 0.025 0.030 0.035 0.036 0.035 0.030
0.027 0.025 0.020 0.020
Noah.3.9 reference height for forcing T and q:   20.0      # (m) - negative=use height
from forcing data
Noah.3.9 reference height for forcing u and v:   20.0      # (m) - negative=use height
from forcing data
Noah.3.9 thermal conductivity option:     1
Noah.3.9 FASDAS option (0 or 1):          0
```

9.11.7. Noah-MP 3.6

`Noah-MP.3.6 model timestep:` specifies the timestep for the Noah-MP-3.6 LSM.

See Section Defining a time interval for a description of how to specify a time interval.

`Noah-MP.3.6 restart output interval:` specifies the restart output interval for the Noah-MP-3.6 LSM.

See Section Defining a time interval for a description of how to specify a time interval.

`Noah-MP.3.6 restart file:` specifies the Noah-MP-3.6 LSM restart file.

`Noah-MP.3.6 restart file format:` specifies the Noah-MP-3.6 restart file format (default = netcdf).

`Noah-MP.3.6 landuse parameter table:` specifies the filename of the Noah-MP-3.6 vegetation parameter table.

`Noah-MP.3.6 soil parameter table:` specifies the filename of the Noah-MP-3.6 soil parameter table.

`Noah-MP.3.6 general parameter table:` specifies the filename of the Noah-MP-3.6 general parameter table.

`Noah-MP.3.6 MP parameter table:` specifies the filename of the Noah-MP-3.6 multi-physics parameter table.

`Noah-MP.3.6 number of soil layers:` specifies the number of soil layers for Noah-MP-3.6 soil moisture/temperature.

`Noah-MP.3.6 soil layer thickness:` specifies the thicknesses of the individual Noah-MP-3.6 LSM layers. The first number is the thickness of the top soil layer, and the following numbers are the thicknesses of each soil layer going down. If the number of soil layers and thicknesses change from the typical 4 layers with thicknesses of 0.1, 0.3, 0.6, and 1.0 meters, users should change the values of NROOT for each vegetation type to map the number of layers with roots for transpiration in their own custom VEGPARM.TBL parameter file.

`Noah-MP.3.6 number of snow layers:` specifies the maximum number of snow layers for the Noah-MP-3.6 LSM snow physics.

`Noah-MP.3.6 vegetation model option:` specifies the dynamic vegetation model option for Noah-MP-3.6 LSM. Acceptable values are:

Value	Description
1	off (use table LAI; use FVEG = SHDFAC from input)
2	on (dynamic vegetation)
3	off (use table LAI; calculate FVEG)
4	off (use table LAI; use maximum vegetation fraction)

`Noah-MP.3.6 canopy stomatal resistance option:` specifies the canopy stomatal resistance option for Noah-MP-3.6 LSM. Acceptable values are:

Value	Description
1	Ball-Berry
2	Jarvis

`Noah-MP.3.6 soil moisture factor for stomatal resistance option:` specifies the soil moisture factor for stomatal resistance option for Noah-MP-3.6 LSM. Acceptable values are:

Value	Description
1	Noah (soil moisture)
2	CLM (matric potential)
3	SSiB (matric potential)

`Noah-MP.3.6 runoff and groundwater option:` specifies the runoff and groundwater option for Noah-MP-3.6 LSM. Acceptable values are:

Value	Description
1	SIMGM: TOPMODEL with groundwater (Niu et al. 2007 JGR)
2	SIMTOP: TOPMODEL with an equilibrium water table (Niu et al. 2005 JGR)
3	Noah original surface and subsurface runoff (free drainage) (Schaake 1996)
4	BATS surface and subsurface runoff (free drainage)

`Noah-MP.3.6 surface layer drag coefficient option:` specifies the surface layer drag coefficient option for Noah-MP-3.6 LSM. Acceptable values are:

Value	Description
1	Monin-Obukhov
2	original Noah (Chen 1997)

`Noah-MP.3.6 supercooled liquid water option:` specifies the supercooled liquid water option for Noah-MP-3.6 LSM. Acceptable values are:

Value	Description
1	no iteration (Niu and Yang, 2006 JHM)
2	Koren's iteration (1999)

`Noah-MP.3.6 frozen soil permeability option:` specifies the frozen soil permeability option for Noah-MP-3.6 LSM. Acceptable values are:

Value	Description
1	linear effects, more permeable (Niu and Yang, 2006, JHM)
2	nonlinear effects, less permeable (Koren 1999)

`Noah-MP.3.6 radiation transfer option:` specifies the radiation transfer option for Noah-MP-3.6 LSM. Acceptable values are:

Value	Description
1	modified two-stream (gap = F(solar angle, 3D structure ...)<1-FVEG)
2	two-stream applied to grid-cell (gap = 0)
3	two-stream applied to vegetated fraction (gap=1-FVEG)

`Noah-MP.3.6 snow surface albedo option:` specifies the snow surface albedo option for Noah-MP-3.6 LSM. Acceptable values are:

Value	Description
1	BATS
2	CLASS

`Noah-MP.3.6 rainfall and snowfall option:` specifies the option for partitioning precipitation into rainfall and snowfall for Noah-MP-3.6 LSM. Acceptable values are:

Value	Description
1	Jordan (1991)
2	BATS: when SFCTMP<TFRZ+2.2
3	Noah: when SFCTMP<TFRZ

`Noah-MP.3.6 lower boundary of soil temperature option:` specifies the lower boundary condition of soil temperature option for Noah-MP-3.6 LSM. Acceptable values are:

Value	Description
1	zero heat flux from bottom (ZBOT and TBOT not used)
2	TBOT at ZBOT (8m) read from a file (original Noah)

`Noah-MP.3.6 snow and soil temperature time scheme:` specifies the snow and soil temperature time scheme for Noah-MP-3.6 LSM. Acceptable values are:

Value	Description
1	semi-implicit
2	fully implicit (original Noah)

`Noah-MP.3.6 soil color index:` specifies the Noah-MP-3.6 LSM soil color type, an integer index from 1 to 8. Defaults to 4.

`Noah-MP.3.6 CZIL option (iz0tlnd):` specifies whether to use the Chen adjustment of CZIL in the Noah-MP-LSM. Defaults to 0. Acceptable values are:

Value	Description
0	do not use
1	use

`Noah-MP.3.6 initial value of snow albedo at the last timestep:` specifies the Noah-MP-3.6 LSM initial albold (albedo of previous timestep).

`Noah-MP.3.6 initial value of snow mass at the last timestep:` specifies the Noah-MP-3.6 LSM initial snow mass at the last timestep (mm).

`Noah-MP.3.6 initial soil temperatures:` specifies the Noah-MP-3.6 LSM initial soil temperatures, one for each layer, with the first value for the top soil layer, then going down.

`Noah-MP.3.6 initial total soil moistures:` specifies the Noah-MP-3.6 LSM initial total soil moistures, one for each layer, with the first value for the top soil layer, then going down.

`Noah-MP.3.6 initial liquid soil moistures:` specifies the Noah-MP-3.6 LSM initial liquid soil moisture, one for each layer, with the first value for the top soil layer, then going down.

`Noah-MP.3.6 initial canopy air temperature:` specifies the Noah-MP-3.6 LSM initial canopy air temperature (K).

`Noah-MP.3.6 initial canopy air vapor pressure:` specifies the Noah-MP-3.6 LSM initial canopy air vapor pressure (Pa).

`Noah-MP.3.6 initial wetted or snowed fraction of canopy:` specifies the Noah-MP-3.6 LSM initial wetted or snowed fraction of canopy.

`Noah-MP.3.6 initial intercepted liquid water:` specifies the Noah-MP-3.6 LSM initial intercepted liquid water (mm).

`Noah-MP.3.6 initial intercepted ice mass:` specifies the Noah-MP-3.6 LSM initial intercepted ice mass (mm).

`Noah-MP.3.6 initial vegetation temperature:` specifies the Noah-MP-3.6 LSM initial vegetation temperature (K).

`Noah-MP.3.6 initial ground temperature:` specifies the Noah-MP-3.6 LSM initial ground temperature (skin temperature) (K).

`Noah-MP.3.6 initial snowfall on the ground:` specifies the Noah-MP-3.6 LSM initial snowfall on the ground (mm/s).

`Noah-MP.3.6 initial snow height:` specifies the Noah-MP-3.6 LSM initial snow depth (m).

`Noah-MP.3.6 initial snow water equivalent:` specifies the Noah-MP-3.6 LSM initial snow water equivalent (mm).

`Noah-MP.3.6 initial depth to water table:` specifies the Noah-MP-3.6 LSM initial depth to water table (m).

`Noah-MP.3.6 initial water storage in aquifer:` specifies the Noah-MP-3.6 LSM initial water storage in the aquifer (mm).

`Noah-MP.3.6 initial water in aquifer and saturated soil:` specifies the Noah-MP-3.6 LSM initial water in the aquifer and in the saturated soil (mm).

`Noah-MP.3.6 initial lake water storage:` specifies the Noah-MP-3.6 LSM initial lake water storage (mm).

`Noah-MP.3.6 initial leaf mass:` specifies the Noah-MP-3.6 LSM initial leaf mass (used only for dynamic vegetation) (g/m2).

`Noah-MP.3.6 initial mass of fine roots:` specifies the Noah-MP-3.6 LSM initial mass of fine roots (used only for dynamic vegetation) (g/m2).

`Noah-MP.3.6 initial stem mass:` specifies the Noah-MP-3.6 LSM initial stem mass (used only for dynamic vegetation) (g/m2).

`Noah-MP.3.6 initial mass of wood including woody roots:` specifies the Noah-MP-3.6 LSM initial mass of wood (including woody roots) (used only for dynamic vegetation) (g/m2).

`Noah-MP.3.6 initial stable carbon in deep soil:` specifies the Noah-MP-3.6 LSM initial stable carbon in deep soil (used only for dynamic vegetation) (g/m2).

`Noah-MP.3.6 initial short-lived carbon in shallow soil:` specifies the Noah-MP-3.6 LSM initial short-lived carbon in shallow soil (used only for dynamic vegetation) (g/m2).

`Noah-MP.3.6 initial LAI:` specifies the Noah-MP-3.6 LSM initial leaf area index.

`Noah-MP.3.6 initial SAI:` specifies the Noah-MP-3.6 LSM initial stem area index.

`Noah-MP.3.6 initial momentum drag coefficient:` specifies the Noah-MP-3.6 LSM initial momentum drag coefficient (s/m).

`Noah-MP.3.6 initial sensible heat exchange coefficient:` specifies the Noah-MP-3.6 LSM initial sensible heat exchange coefficient (s/m).

`Noah-MP.3.6 initial snow aging term:` specifies the Noah-MP-3.6 LSM initial snow aging term.

`Noah-MP.3.6 initial soil water content between bottom of the soil and water table:` specifies the Noah-MP-3.6 LSM initial soil water content between the bottom of the soil and water table (m3/m3).

`Noah-MP.3.6 initial recharge to or from the water table when deep:` specifies the Noah-MP-3.6 LSM initial recharge to or from the water table when deep (m).

`Noah-MP.3.6 initial recharge to or from the water table when shallow:` specifies the Noah-MP-3.6 LSM initial recharge to or from the water table when shallow (m).

`Noah-MP.3.6 initial reference height of temperature and humidity:` specifies the Noah-MP-3.6 LSM initial reference height (in meters) of the forcing temperature, humidity, and winds. If the reference heights are different, best to choose the height of the winds.

`Noah-MP.3.6 soil moisture CDF file:` specifies the Noah-MP-3.6 LSM soil moisture CDF file.

Note that the below example include the default WRF configuration options (from the vegetation model to the snow and soil temperature time scheme).

Example lis.config entry

```
Noah-MP.3.6 model timestep:               15mn
Noah-MP.3.6 restart output interval:      1mo
Noah-MP.3.6 restart file:
./OUTPUT/opt_dveg_4/SURFACEMODEL/201212/LIS_RST_NOAHMP36_201212312100.d01.nc
Noah-MP.3.6 restart file format:          netcdf
Noah-MP.3.6 landuse parameter table:      "./input/noahmp_params/VEGPARM.TBL"
Noah-MP.3.6 soil parameter table:         "./input/noahmp_params/SOILPARM.TBL"
Noah-MP.3.6 general parameter table:      "./input/noahmp_params/GENPARM.TBL"
Noah-MP.3.6 MP parameter table:           "./input/noahmp_params/MPTABLE.TBL"
Noah-MP.3.6 number of soil layers:        4
Noah-MP.3.6 soil layer thickness:         0.1  0.3  0.6  1.0
Noah-MP.3.6 number of snow layers:        3
Noah-MP.3.6 vegetation model option:                  4  # 1=prescribed; 2=dynamic;
3=calculate; 4=maximum
Noah-MP.3.6 canopy stomatal resistance option:        1  # 1=Ball-Berry; 2=Jarvis
Noah-MP.3.6 soil moisture factor for stomatal resistance option:  1  # 1=Noah; 2=CLM;
3=SSiB
Noah-MP.3.6 runoff and groundwater option:            1  # 1=SIMGM; 2=SIMTOP;
3=Schaake96; 4=BATS
Noah-MP.3.6 surface layer drag coefficient option:    1  # 1=M-O; 2=Chen97
Noah-MP.3.6 supercooled liquid water option:          1  # 1=NY06; 2=Koren99
Noah-MP.3.6 frozen soil permeability option:          1  # 1=NY06; 2=Koren99
```

```
Noah-MP.3.6 radiation transfer option:                 1  # 1=gap=F(3D;cosz);
2=gap=0; 3=gap=1-Fveg
Noah-MP.3.6 snow surface albedo option:                2  # 1=BATS; 2=CLASS
Noah-MP.3.6 rainfall and snowfall option:              1  # 1=Jordan91; 2=BATS;
3=Noah
Noah-MP.3.6 lower boundary of soil temperature option:  2  # 1=zero-flux; 2=Noah
Noah-MP.3.6 snow and soil temperature time scheme:      1  # 1=semi-implicit; 2=fully
implicit
Noah-MP.3.6 soil color index:                          4
Noah-MP.3.6 CZIL option (iz0tlnd):                     0
Noah-MP.3.6 initial value of snow albedo at the last timestep:  0.2
Noah-MP.3.6 initial value of snow mass at the last timestep:    0.0
Noah-MP.3.6 initial soil temperatures:                     288.0  288.0  288.0  288.0
Noah-MP.3.6 initial total soil moistures:                    0.20   0.20   0.20   0.20
Noah-MP.3.6 initial liquid soil moistures:                   0.20   0.20   0.20   0.20
Noah-MP.3.6 initial canopy air temperature:                288.0
Noah-MP.3.6 initial canopy air vapor pressure:             261.68518
Noah-MP.3.6 initial wetted or snowed fraction of canopy:     0.0
Noah-MP.3.6 initial intercepted liquid water:                0.0
Noah-MP.3.6 initial intercepted ice mass:                    0.0
Noah-MP.3.6 initial vegetation temperature:                288.0
Noah-MP.3.6 initial ground temperature:                    288.0
Noah-MP.3.6 initial snowfall on the ground:                  0.0
Noah-MP.3.6 initial snow height:                             0.0
Noah-MP.3.6 initial snow water equivalent:                   0.0
Noah-MP.3.6 initial depth to water table:                    2.5
Noah-MP.3.6 initial water storage in aquifer:             4900.0
Noah-MP.3.6 initial water in aquifer and saturated soil:  4900.0
Noah-MP.3.6 initial lake water storage:                      0.0
Noah-MP.3.6 initial leaf mass:                               9.0
Noah-MP.3.6 initial mass of fine roots:                    500.0
Noah-MP.3.6 initial stem mass:                               3.33
Noah-MP.3.6 initial mass of wood including woody roots:    500.0
Noah-MP.3.6 initial stable carbon in deep soil:           1000.0
Noah-MP.3.6 initial short-lived carbon in shallow soil:   1000.0
Noah-MP.3.6 initial LAI:                                     0.5
Noah-MP.3.6 initial SAI:                                     0.1
Noah-MP.3.6 initial momentum drag coefficient:               0.0
Noah-MP.3.6 initial sensible heat exchange coefficient:      0.0
Noah-MP.3.6 initial snow aging term:                         0.0
Noah-MP.3.6 initial soil water content between bottom of the soil and water table:
0.0
Noah-MP.3.6 initial recharge to or from the water table when deep:
0.0
Noah-MP.3.6 initial recharge to or from the water table when shallow:
0.0
Noah-MP.3.6 initial reference height of temperature and humidity:
10.0
Noah-MP.3.6 soil moisture CDF file:
```

9.11.8. Noah-MP-4.0.1

`Noah-MP.4.0.1 model timestep:` specifies the timestep for the Noah-MP-4.0.1 LSM.

See Section Defining a time interval for a description of how to specify a time interval.

`Noah-MP.4.0.1 restart output interval:` specifies the restart output interval for the Noah-MP-4.0.1 LSM.

See Section Defining a time interval for a description of how to specify a time interval.

`Noah-MP.4.0.1 restart file:` specifies the Noah-MP-4.0.1 LSM restart file.

`Noah-MP.4.0.1 restart file format:` specifies the Noah-MP-4.0.1 restart file format (default = netcdf).

`Noah-MP.4.0.1 soil parameter table:` specifies the filename of the Noah-MP-4.0.1 soil parameter table.

`Noah-MP.4.0.1 general parameter table:` specifies the filename of the Noah-MP-4.0.1 general parameter table.

`Noah-MP.4.0.1 MP parameter table:` specifies the filename of the Noah-MP-4.0.1 multi-physics parameter table.

`Noah-MP.4.0.1 number of soil layers:` specifies the number of soil layers for Noah-MP-4.0.1 soil moisture/temperature.

`Noah-MP.4.0.1 thickness of soil layers:` specifies the thicknesses of the individual Noah-MP-4.0.1 LSM layers. The first number is the thickness of the top soil layer, and the following numbers are the thicknesses of each soil layer going down. If the number of soil layers and thicknesses change from the typical 4 layers with thicknesses of 0.1, 0.3, 0.6, and 1.0 meters, users should change the values of NROOT for each vegetation type to map the number of layers with roots for transpiration in their own custom MPTABLE.TBL parameter file.

`Noah-MP.4.0.1 dynamic vegetation option:` specifies the dynamic vegetation model option for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Options not yet supported in the LIS implementation are indicated with [NS]. Acceptable values are:

Value	Note	Description
1		off (use table LAI/SAI; use input GVF)
2		on (dynamic vegetation; GVF is a function of LAI/SAI)
3		off (use table LAI/SAI; GVF is a function of LAI/SAI)
4	**	off (use table LAI/SAI; GVF is the maximum value)

Value	Note	Description
5	**	on (dynamic vegetation; GVF is the maximum value)
6		on (dynamic vegetation; use input GVF)
7		off (use input LAI/SAI; use input GVF)
8		off (use input LAI/SAI; GVF is a function of LAI/SAI)
9		off (use input LAI/SAI; GVF is the maximum value)
10	NS	crop model on (use maximum vegetation fraction)

When using options 1 through 6, users should set `LAI data source:` to "none". For options 1, 3, or 4, the LAI value will be read from the `Noah-MP.4.0.1 MP parameter table:` file (typically, "MPTABLE.TBL") based on the vegetation class of the tile and the current month. For options 2, 5, or 6, the LAI is a prognostic variable as a function of the LeafMass calculated from the dynamic vegetation scheme. When using options 7 through 9, users should set `LAI data source:` to "LDT", after running LDT to include an LAI dataset as one of the parameters in the `LIS domain and parameter data file:`.

When using options 1 through 6, users should set `SAI data source:` to "none". For options 1, 3, or 4, the SAI value will be read from the `Noah-MP.4.0.1 MP parameter table:` file (typically, "MPTABLE.TBL") based on the vegetation class of the tile and the current month. For options 2, 5, or 6, the SAI is a prognostic variable as a function of the StemMass calculated from the dynamic vegetation scheme. When using options 7 through 9, users can set `SAI data source:` to "LDT", after running LDT to include an SAI dataset as one of the parameters in the `LIS domain and parameter data file:`. Alternatively, for these options (7, 8, or 9), users can choose to not use an input SAI dataset by setting `SAI data source:` to "none", in which case the SAI value will be set from the `Noah-MP.4.0.1 MP parameter table:` file.

When using options 1, 4, 5, 6, 7, or 9, users should set `Greenness data source:` to "LDT", after running LDT to include a greenness dataset as one of the parameters in the `LIS domain and parameter data file:`. The greenness parameter variable name can be referred to as GVF (greenness vegetation fraction), FVEG, or SHDFAC in the Noah-MP.4.0.1 physics code. When using options 1, 6, or 7, the greenness value is set to the monthly climatology value for each tile (unless "CONSTANT" was chosen when LDT was run for the `Greenness data source:`). When using options 4, 5, or 9, the greenness value for each tile is set to the maximum value of all months from the monthly climatology at that tile. When using options 2, 3, or 8, the greenness is a function of LAI and SAI at each tile for each timestep.

Note that when using dynamic vegetation option 2, 5, or 6, the Ball-Berry canopy stomatal resistance option must be selected for the following config.

`Noah-MP.4.0.1 canopy stomatal resistance option:` specifies the canopy stomatal resistance option

for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Acceptable values are:

Value	Note	Description
1	**	Ball-Berry
2		Jarvis

`Noah-MP.4.0.1 soil moisture factor for stomatal resistance:` specifies the soil moisture factor for stomatal resistance option for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Acceptable values are:

Value	Note	Description
1	**	Noah (soil moisture)
2		CLM (matric potential)
3		SSiB (matric potential)

`Noah-MP.4.0.1 runoff and groundwater option:` specifies the runoff and groundwater option for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Options not yet supported in the LIS implementation are indicated with [NS]. Acceptable values are:

Value	Note	Description
1	**	SIMGM: TOPMODEL with groundwater (Niu et al. 2007 JGR)
2		SIMTOP: TOPMODEL with an equilibrium water table (Niu et al. 2005 JGR)
3		Noah original surface and subsurface runoff (free drainage) (Schaake 1996)
4		BATS surface and subsurface runoff (free drainage)
5	NS	Miguez-Macho&Fan groundwater scheme (Miguez-Macho et al. 2007 JGR; Fan et al. 2007 JGR)

`Noah-MP.4.0.1 surface layer drag coefficient option:` specifies the surface layer drag coefficient option for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Acceptable values are:

Value	Note	Description
1	**	Monin-Obukhov

Value	Note	Description
2	**	original Noah (Chen 1997)

`Noah-MP.4.0.1 supercooled liquid water option:` specifies the supercooled liquid water option for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Acceptable values are:

Value	Note	Description
1	**	no iteration (Niu and Yang, 2006 JHM)
2		Koren's iteration (1999)

`Noah-MP.4.0.1 frozen soil permeability option:` specifies the frozen soil permeability option for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Acceptable values are:

Value	Note	Description
1	**	linear effects, more permeable (Niu and Yang, 2006, JHM)
2		nonlinear effects, less permeable (Koren 1999)

`Noah-MP.4.0.1 radiation transfer option:` specifies the radiation transfer option for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Acceptable values are:

Value	Note	Description
1		modified two-stream (gap = F(solar angle, 3D structure ...)<1-FVEG)
2		two-stream applied to grid-cell (gap = 0)
3	**	two-stream applied to vegetated fraction (gap=1-FVEG)

`Noah-MP.4.0.1 snow surface albedo option:` specifies the snow surface albedo option for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Acceptable values are:

Value	Note	Description
1		BATS
2	**	CLASS

`Noah-MP.4.0.1 rainfall & snowfall option:` specifies the option for partitioning precipitation into

rainfall and snowfall for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Options not yet supported in the LIS implementation are indicated with [NS]. Acceptable values are:

Value	Note	Description
1	**	Jordan (1991)
2		BATS: when SFCTMP<TFRZ+2.2
3		Noah: when SFCTMP<TFRZ
4	NS	Use WRF microphysics output

`Noah-MP.4.0.1 lower boundary of soil temperature option:` specifies the lower boundary condition of soil temperature option for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Acceptable values are:

Value	Note	Description
1		zero heat flux from bottom (ZBOT and TBOT not used)
2	**	TBOT at ZBOT (8m) read from a file (original Noah)

`Noah-MP.4.0.1 snow&soil temperature time scheme option:` specifies the snow and soil temperature time scheme for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Acceptable values are:

Value	Note	Description
1	**	semi-implicit; flux top boundary condition
2		fully implicit (original Noah); temperature top boundary condition
3		same as 1, but FSNO for TS calculation (generally improves snow; v3.7)

`Noah-MP.4.0.1 glacier option:` specifies the glacier model option for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Acceptable values are:

Value	Note	Description
1	**	include phase change of ice
2		simple (ice treatment more like original Noah)

`Noah-MP.4.0.1 surface resistance option:` specifies the surface resistance option for Noah-MP-4.0.1

LSM. Options generally recommended for use by the model developers are indicated with [**]. Acceptable values are:

Value	Note	Description
1	**	Sakaguchi and Zeng, 2009
2		Sellers (1992)
3		adjusted Sellers to decrease RSURF for wet soil
4		option 1 for non-snow; rsurf = rsurf_snow for snow (set in MPTABLE); AD v3.8

`Noah-MP.4.0.1 soil configuration option:` specifies soil configuration option for defining soil properties for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Options not yet supported in the LIS implementation are indicated with [NS]. Acceptable values are:

Value	Note	Description
1	**	input dominant soil texture
2	NS	input soil texture varies that varies with depth
3	NS	use soil composition (sand, clay, orgm) and pedotransfer functions (OPT_PEDO)
4	NS	use input soil properties (BEXP_3D, SMCMAX_3D, etc.)

`Noah-MP.4.0.1 soil pedotransfer function option:` specifies the soil pedotransfer function option for Noah-MP-4.0.1 LSM. This option is only activated when the soil configuration option is set to 3. Acceptable values are:

Value	Note	Description
1	**	Saxton and Rawls (2006)

`Noah-MP.4.0.1 crop model option:` specifies the crop model option for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Options not yet supported in the LIS implementation are indicated with [NS]. Accepted values are:

Value	Note	Description
0	**	No crop model
1	NS	Liu et al. 2016
2	NS	Gecros crop model; Yin and van Laar, 2005

`Noah-MP.4.0.1 urban physics option:` specifies the urban physics option for Noah-MP-4.0.1 LSM. Options generally recommended for use by the model developers are indicated with [**]. Accepted values are:

Value	Note	Description
0	**	No urban scheme
1	NS	Single-layer
2	NS	Multi-layer BEP scheme
3	NS	Multi-layer BEM scheme

`Noah-MP.4.0.1 reference height of temperature and humidity:` specifies the Noah-MP-4.0.1 LSM reference height (in meters) of the forcing temperature, humidity, and winds. If the reference heights are different, best to choose the height of the winds.

`Noah-MP.4.0.1 initial surface skin temperature:` specifies the Noah-MP-4.0.1 LSM initial surface skin temperature (K).

`Noah-MP.4.0.1 initial snow water equivalent:` specifies the Noah-MP-4.0.1 LSM initial snow water equivalent (mm).

`Noah-MP.4.0.1 initial snow depth:` specifies the Noah-MP-4.0.1 LSM initial snow depth (m).

`Noah-MP.4.0.1 initial total canopy surface water:` specifies the Noah-MP-4.0.1 LSM initial total canopy surface water (mm).

`Noah-MP.4.0.1 initial soil temperatures:` specifies the Noah-MP-4.0.1 LSM initial soil temperatures, one for each layer, with the first value for the top soil layer, then going down.

`Noah-MP.4.0.1 initial total soil moistures:` specifies the Noah-MP-4.0.1 LSM initial total soil moistures, one for each layer, with the first value for the top soil layer, then going down.

`Noah-MP.4.0.1 initial leaf area index:` specifies the Noah-MP-4.0.1 LSM initial leaf area index.

`Noah-MP.4.0.1 initial water table depth:` specifies the Noah-MP-4.0.1 LSM initial depth to water table (m).

`Noah-MP.4.0.1 initial water in the aquifer:` specifies the Noah-MP-4.0.1 LSM initial water storage in the aquifer (mm).

`Noah-MP.4.0.1 initial water in aquifer and saturated soil:` specifies the Noah-MP-4.0.1 LSM initial water in the aquifer and in the saturated soil (mm).

`Noah-MP.4.0.1 snow depth glacier model option:` specifies the maximum snow water equivalent that is used in the Noah-MP-4.0.1 glacier model (mm). This config entry is optional; if is not in the *lis.config* file, the default value of 2000.0 mm is used. This maximum only applies to tiles identified as glacier in the landcover classification.

Example lis.config entry

```
Noah-MP.4.0.1 model timestep:                15mn
Noah-MP.4.0.1 restart output interval:       1mo
Noah-MP.4.0.1 restart file:                  none
Noah-MP.4.0.1 restart file format:           netcdf
Noah-MP.4.0.1 soil parameter table:          ./WRF-4.0.1/run/SOILPARM.TBL
Noah-MP.4.0.1 general parameter table:       ./WRF-4.0.1/run/GENPARM.TBL
Noah-MP.4.0.1 MP parameter table:            ./WRF-4.0.1/run/MPTABLE.TBL
Noah-MP.4.0.1 number of soil layers:         4
Noah-MP.4.0.1 thickness of soil layers:      0.1  0.3  0.6  1.0
Noah-MP.4.0.1 dynamic vegetation option:                     4  # Up to 10 different
options
Noah-MP.4.0.1 canopy stomatal resistance option:             1  # 1=Ball-Berry;
2=Jarvis
Noah-MP.4.0.1 soil moisture factor for stomatal resistance:   1  # 1=Noah; 2=CLM;
3=SSiB
Noah-MP.4.0.1 runoff and groundwater option:                 3  # 1=SIMGM; 2=SIMTOP;
3=Schaake96; 4=BATS; 5=Miguez-Macho&Fan
Noah-MP.4.0.1 surface layer drag coefficient option:         1  # 1=M-O; 2=Chen97
Noah-MP.4.0.1 supercooled liquid water option:               1  # 1=NY06; 2=Koren99
Noah-MP.4.0.1 frozen soil permeability option:               1  # 1=NY06; 2=Koren99
Noah-MP.4.0.1 radiation transfer option:                     3  # 1=gap=F(3D;cosz);
2=gap=0; 3=gap=1-Fveg
Noah-MP.4.0.1 snow surface albedo option:                    2  # 1=BATS; 2=CLASS
Noah-MP.4.0.1 rainfall & snowfall option:                    1  # 1=Jordan91; 2=BATS;
3=Noah
Noah-MP.4.0.1 lower boundary of soil temperature option:     2  # 1=zero-flux; 2=Noah
Noah-MP.4.0.1 snow&soil temperature time scheme option:      1  # 1=semi-implicit;
2=fully implicit; 3=FSNO for TS
Noah-MP.4.0.1 glacier option:                                1  # 1=include phase
change; 2=slab ice (Noah)
Noah-MP.4.0.1 surface resistance option:                     1  # 1=Sakaguchi and
Zeng 2009; 2=Sellers (1992); 3=adjusted Sellers; 4=option1 for non-snow and rsurf_snow
for snow
Noah-MP.4.0.1 soil configuration option:                     1  # 1=input dominant
soil texture; 2=input soil texture varies that varies with depth; 3=soil composition
and pedotransfer; 4=input soil properties
Noah-MP.4.0.1 soil pedotransfer function option:             1  # 1=Saxton and Rawls
(2006) (used when soil_opt=3)
Noah-MP.4.0.1 crop model option:                             0  # 0=No crop model;
1=Liu et al. 2016; 2=Gecros
Noah-MP.4.0.1 urban physics option:                          0  # 0=No; 1=Single-
layer; 2=Multi-layer BEP scheme; 3=Multi-layer BEM scheme
Noah-MP.4.0.1 reference height of temperature and humidity: 6.0
Noah-MP.4.0.1 initial surface skin temperature:          263.7
Noah-MP.4.0.1 initial snow water equivalent:               1.0
Noah-MP.4.0.1 initial snow depth:                         0.01
Noah-MP.4.0.1 initial total canopy surface water:         0.01
Noah-MP.4.0.1 initial soil temperatures:                266.1  274.0  276.9  279.9
Noah-MP.4.0.1 initial total soil moistures:             0.298  0.294  0.271  0.307
Noah-MP.4.0.1 initial leaf area index:                    2.0
Noah-MP.4.0.1 initial water table depth:                  2.5
```

```
Noah-MP.4.0.1 initial water in the aquifer:                 4900.0
Noah-MP.4.0.1 initial water in aquifer and saturated soil:  4900.0
Noah-MP.4.0.1 snow depth glacier model option:              2000
```

9.11.9. RUC 3.7

`RUC37 model timestep:` specifies the timestep for RUC.

See Section Defining a time interval for a description of how to specify a time interval.

`RUC37 restart output interval:` specifies the restart output interval for RUC.

`RUC37 number of soil levels:` number of soil levels.

`RUC37 soil level depth:` thicknesses of each soil level (m)

`RUC37 zlvl:` reference height of temperature and humidity (m)

`RUC37 zlvl_wind:` reference height of wind (m)

`RUC37 use local parameters: .true.` to use table values for albbck, shdfac, and z0brd; `.false.` to use values for albbck, shdfac, and z0brd as set in this driver routine.

`RUC37 use 2D LAI map:` if rdlai2d == `.true.`, then the xlai value that we pass to lsmruc will be used. if rdlai2d == `.false.`, then xlai will be computed within lsmruc, from table minimum and maximum values in vegparm.tbl, and the current green vegetation fraction.

`RUC37 use monthly albedo map:` if usemonalb == `.true.`, then the alb value passed to lsmruc will be used as the background snow-free albedo term. if usemonalb == `.false.`, then alb will be computed within lsmruc from minimum and maximum values in vegparm.tbl, and the current green vegetation fraction.

`RUC37 option_iz0tlnd:` option to turn on (iz0tlnd=1) or off (iz0tlnd=0) the vegetation-category-dependent calculation of the zilitinkivich coefficient czil in the sfcdif subroutines.

`RUC37 option_sfcdif:` option to use previous (sfcdif_option=0) or updated (sfcdif_option=1) version of sfcdif subroutine.

`RUC37 landuse_tbl_name:` noah model landuse parameter table

`RUC37 soil_tbl_name:` noah model soil parameter table

`RUC37 gen_tbl_name:` "./input/GENPARM.TBL"

`RUC37 landuse_scheme_name:` landuse classification scheme

`RUC37 soil_scheme_name:` soil classification scheme

`RUC37 water_class_num:` number of water category in landuse classification

`RUC37 ice_class_num:` number of ice category in landuse classification

`RUC37 urban_class_num:` number of urban category in landuse classification

`RUC37 restart file:` restart file name

`RUC37 restart file format:` format of restart file, netcdf or binary

`RUC37 initial emiss:` surface emissivity (0.0 - 1.0).

`RUC37 initial ch:` exchange coefficient for head and moisture (m s-1).

`RUC37 initial cm:` exchange coefficient for momentum (m s-1).

`RUC37 initial sneqv:` water equivalent of accumulated snow depth (m).

`RUC37 initial snowh:` physical snow depth (m).

`RUC37 initial canwat:` canopy moisture content (kg m-2)

`RUC37 initial alb:` surface albedo including possible snow-cover effect. This is set in lsmruc.

`RUC37 initial smc:` total soil moisture content (m3 m-3)

`RUC37 initial sho:` liquid soil moisture content (m3 m-3)

`RUC37 initial stc:` soil temperature (k)

`RUC37 initial tskin:` skin temperature (k)

`RUC37 initial qvg:` effective mixing ratio at the surface (kg kg{-1})

`RUC37 initial qcg:` effective cloud water mixing ratio at the surface (kg kg{-1})

`RUC37 initial qsg:` surface water vapor mixing ratio at saturation (kg/kg)

`RUC37 initial snt75cm:` snow temperature at 7.5 cm depth (k)

`RUC37 initial tsnav:` average snow temperature in k

`RUC37 initial soilm:` total soil column moisture content, frozen and unfrozen (m)

`RUC37 initial smroot:` available soil moisture in the root zone (fraction [smcwlt-smcmax])

`RUC37 initial smfr:` soil ice content

`RUC37 initial keepfr:` frozen soil glag

`RUC37 initial qsfc:` effective mixing ratio at the surface (kg kg{-1})

Example lis.config entry

```
RUC37 model timestep: 15mn
RUC37 restart output interval: 1mo
RUC37 number of soil levels:  9                         # nsoil: number of soil
levels.
```

```
RUC37 soil level depth:   0.      0.01      0.04     0.1      0.3      0.6      1.0
1.6      3.0     # soil_layer_thickness: thicknesses of each soil level (m)
RUC37 zlvl:      3   # reference height of temperature and humidity (m)
RUC37 zlvl_wind: 6   # reference height of wind (m)
RUC37 use local parameters:  .true.          # use_local_param: .true. to use table
values for albbck, shdfac, and z0brd; .false. to use values for albbck, shdfac, and
z0brd as set in this driver routine
RUC37 use 2D LAI map:   .false.         # use_2d_lai_map: if rdlai2d == .true., then
the xlai value that we pass to lsmruc will be used. if rdlai2d == .false., then xlai
will be computed within lsmruc, from table minimum and maximum values in vegparm.tbl,
and the current green vegetation fraction.
RUC37 use monthly albedo map: .false.   # use_monthly_albedo_map: if usemonalb ==
.true., then the alb value passed to lsmruc will be used as the background snow-free
albedo term.  if usemonalb == .false., then alb will be computed within lsmruc from
minimum and maximum values in vegparm.tbl, and the current green vegetation fraction.
RUC37 option_iz0tlnd:      0            # option_iz0tlnd: option to turn on
(iz0tlnd=1) or off (iz0tlnd=0) the vegetation-category-dependent calculation of the
zilitinkivich coefficient czil in the sfcdif subroutines.
RUC37 option_sfcdif:       1            # option_sfcdif: option to use previous
(sfcdif_option=0) or updated (sfcdif_option=1) version of sfcdif subroutine.
RUC37 landuse_tbl_name: "./input/VEGPARM.TBL"  # landuse_tbl_name: noah model landuse
parameter table
RUC37 soil_tbl_name:    "./input/SOILPARM.TBL"  # soil_tbl_name: noah model soil
parameter table
RUC37 gen_tbl_name:     "./input/GENPARM.TBL"
RUC37 landuse_scheme_name:  "USGS-RUC"  # landuse_scheme_name: landuse classification
scheme
RUC37 soil_scheme_name:     "STAS-RUC"  # soil_scheme_name: soil classification scheme
RUC37 water_class_num:   16             # water_class_num: number of water category in
landuse classification
RUC37 ice_class_num:     24             # ice_class_num: number of ice category in
landuse classification
RUC37 urban_class_num:   1
RUC37 restart file:
RUC37 restart file format: "netcdf"
RUC37 initial emiss:    0.96  # emiss: surface emissivity (0.0 - 1.0).
RUC37 initial ch:      1.E-4  # ch: exchange coefficient for head and moisture (m s-
1).
RUC37 initial cm:      1.E-4  # cm: exchange coefficient for momentum (m s-1).
RUC37 initial sneqv:  0.0     # sneqv: water equivalent of accumulated snow depth (m).
RUC37 initial snowh:  0.0     # snowh: physical snow depth (m).
RUC37 initial canwat: 0.0     # canwat: canopy moisture content (kg m-2)
RUC37 initial alb:    0.18    # alb: surface albedo including possible snow-cover
effect.  this is set in lsmruc,
RUC37 initial smc: 0.30505  0.30367  0.29954  0.29747  0.29471  0.28456  0.27310
0.29457  0.34467    # smc: total soil moisture content (m3 m-3)
RUC37 initial sho: 0.16489  0.16398  0.16175  0.26640  0.26524  0.28456  0.27310
0.29457  0.34467    # sho: liquid soil moisture content (m3 m-3)
RUC37 initial stc: 263.6909 264.1726 265.6178 267.4237 272.7203 275.2323 277.0464
278.8583 285.0      # stc: soil temperature (k)
RUC37 initial tskin: 263.6909              # tskin: skin temperature (k)
```

```
RUC37 initial qvg:  0.0016286864          # qvg: effective mixing ratio at the
surface ( kg kg{-1} )
RUC37 initial qcg:  0.0                   # qcg: effective cloud water mixing ratio
at the surface ( kg kg{-1} )
RUC37 initial qsg:  0.0                   # qsg: surface water vapor mixing ratio at
satration (kg/kg)
RUC37 initial snt75cm: 263.69089          # snt75cm: snow temperature at 7.5 cm depth
(k)
RUC37 initial tsnav: 263.85               # tsnav: average snow temperature in k
RUC37 initial soilm:  -9.9999996e+35      # soilm: total soil column moisture
content, frozen and unfrozen ( m )
RUC37 initial smroot: -9.9999996e+35      # smroot: available soil moisture in the
root zone ( fraction [smcwlt-smcmax]
RUC37 initial smfr: 0.1557333 0.1552111 0.1531000 0.034522217 0.032744441 0.  0.  0.
0.    # smfr: soil ice content
RUC37 initial keepfr: 0.     0.       0.       0.       0.       0.       0.      0.
0.    # keepfr: frozen soil glag
RUC37 initial qsfc: 1.6260381E-03         # qsfc: effective mixing ratio at the
surface ( kg kg{-1} )
```

9.11.10. CLM 2.0

`CLM model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

`CLM restart output interval:` defines the restart writing interval for CLM. The typical value used in the LIS runs is 24 hours (1da).

See Section Defining a time interval for a description of how to specify a time interval.

`CLM restart file:` specifies the CLM active restart file.

`CLM vegetation parameter table:` specifies vegetation type parameters look-up table.

`CLM canopy height table:` specifies the canopy top and bottom heights (for each vegetation type) look-up table.

`CLM initial soil moisture:` specifies the initial volumetric soil moisture wetness used in the cold start runs.

`CLM initial soil temperature:` specifies the initial soil temperature in Kelvin used in the cold start runs.

`CLM initial snow mass:` specifies the initial snow mass used in the cold start runs.

Example lis.config entry

```
CLM model timestep:                   15mn
CLM restart output interval:          1da
CLM restart file:                     ./clm.rst
CLM vegetation parameter table:       ./input/clm_parms/umdvegparam.txt
CLM canopy height table:              ./input/clm_parms/clm2_ptcanhts.txt
CLM initial soil moisture:            0.45
CLM initial soil temperature:         290.0
CLM initial snow mass:                0.0
```

9.11.11. VIC 4.1.1

`VIC411 model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

`VIC411 model step interval:` defines the model step interval for VIC, in seconds.

VIC uses two timestep variables to control its execution. `VIC411 model step interval:` corresponds to VIC's `TIME_STEP` variable. VIC's `VIC411 model timestep:` corresponds to VIC's `SNOW_STEP` variable.

For water balance mode, `VIC411 model step interval:` must be set to 86400.

For energy balance mode, `VIC411 model step interval:` must be set to VIC's `VIC411 model timestep:`.

Note that for both energy balance mode and water balance mode, VIC's `VIC411 model timestep:`, in seconds, must be both a multiple of 3600 and a factor of 86400. Simply stated VIC's `VIC411 model timestep:` must correspond to 1, 2, 3, 4, 6, 12, or 24 hours.

`VIC411 restart output interval:` defines the restart writing interval for VIC. The typical value used in the LIS runs is 24 hours (1da).

See Section Defining a time interval for a description of how to specify a time interval.

`VIC411 veg tiling scheme:` specifies whether VIC or LIS will perform vegetation-based sub-grid tiling.

For LIS sub-grid tiling, tiling is based on vegetation fractions from the `landcover file:` file.

For VIC sub-grid tiling, tiling is based on vegetation fractions from the `VEGPARAM` file. Acceptable values are:

Value	Description
0	VIC tiling
1	LIS tiling

`VIC411 global parameter file:` This is VIC's configuration file. Please see VIC's documentation at: https://vic.readthedocs.io/en/vic.4.2.d/Development/VersionSummaries/ for more information.

`VIC411 total number of veg types:` specifies the number of vegetation classes in VIC's landcover dataset (`VEGPARAM`).

`VIC411 convert units:` Used for testing; set this to 1.

Example lis.config entry

```
VIC411 model timestep:             1hr
VIC411 model step interval:        3600
VIC411 restart output interval:    1da
VIC411 veg tiling scheme:          1
VIC411 global parameter file:      ./input/vic411_global_file_nldas2_testcase
VIC411 total number of veg types:  13
VIC411 convert units:              1
```

9.11.12. VIC 4.1.2

`VIC412 model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

`VIC412 model step interval:` defines the model step interval for VIC, in seconds.

VIC uses two timestep variables to control its execution. `VIC412 model step interval:` corresponds to VIC's `TIME_STEP` variable. VIC's `VIC412 model timestep:` corresponds to VIC's `SNOW_STEP` variable.

For water balance mode, `VIC412 model step interval:` must be set to 86400.

For energy balance mode, `VIC412 model step interval:` must be set to VIC's `VIC412 model timestep:`.

Note that for both energy balance mode and water balance mode, VIC's `VIC412 model timestep:`, in seconds, must be both a multiple of 3600 and a factor of 86400. Simply stated VIC's `VIC412 model timestep:` must correspond to 1, 2, 3, 4, 6, 12, or 24 hours.

`VIC412 restart output interval:` defines the restart writing interval for VIC. The typical value used in the LIS runs is 24 hours (1da).

See Section Defining a time interval for a description of how to specify a time interval.

`VIC412 restart file:` specifies the VIC 4.1.2 active restart file.

`VIC412 restart file format:` specifies the format for the VIC 4.1.2 restart file. Acceptable values are:

Value	Description
binary	binary format
netcdf	netCDF format

`VIC412 veg tiling scheme:` specifies whether VIC or LIS will perform vegetation-based sub-grid tiling.

For LIS sub-grid tiling, tiling is based on vegetation fractions from the `landcover file:` file.

For VIC sub-grid tiling, tiling is based on vegetation fractions from the `VEGPARAM` file. Acceptable values are:

Value	Description
0	VIC tiling
1	LIS tiling

`VIC412 total number of veg types:` specifies the number of vegetation classes in VIC's landcover dataset (`VEGPARAM`).

`VIC412 convert units:` Used for testing; set this to 1.

The VIC global parameter file is no longer needed. All configuration settings are in *lis.config* for VIC. Specifications are the same as the global parameter file of standalone VIC except option names come with a prefix "VIC412_", in which 412 is the version number of the VIC model. For example, the number of VIC soil layers is specified as the following:

```
VIC412_NLAYER: 3
```

See VIC's documentation at: https://vic.readthedocs.io/en/vic.4.2.d/Development/VersionSummaries/ for more information about configuring VIC.

Example lis.config entry

```
VIC412 model timestep:             1hr
VIC412 model step interval:        3600
VIC412 restart file:               ./vic412.rst
VIC412 restart file format:        "binary"
VIC412 restart output interval:    1da
VIC412 veg tiling scheme:          1
VIC412 total number of veg types:  13
VIC412 convert units:              1
```

9.11.13. JULES 5.0

`JULES.5.0 model timestep:` specifies the timestep for the run.

`JULES.5.0 restart file:` specifies the JULES.5.0 active restart file.

`JULES.5.0 namelist directory:` directory containing JULES.5.0 configuration name lists

`JULES.5.0 restart output interval:` JULES.5.0 restart time interval

`JULES.5.0 reference height for forcing T and q:` reference height for air temperature and humidity

`JULES.5.0 reference height for forcing u and v:` reference height for wind speed

Example lis.config entry

```
JULES.5.0 model timestep:                  15mn
JULES.5.0 restart file:
JULES.5.0 namelist directory:              ./
JULES.5.0 restart output interval:         1mo
JULES.5.0 reference height for forcing T and q: 2
JULES.5.0 reference height for forcing u and v: 10
```

9.11.14. Mosaic

`Mosaic model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

`Mosaic restart output interval:` defines the restart writing interval for Mosaic. The typical value used in the LIS runs is 24 hours (1da).

See Section Defining a time interval for a description of how to specify a time interval.

`Mosaic restart file:` specifies the Mosaic active restart file.

`Mosaic vegetation parameter table:` specifies the vegetation parameters look-up table.

`Mosaic monthly vegetation parameter table:` specifies the monthly vegetation parameters look-up table.

`Mosaic soil parameter table:` specifies the soil parameters look-up table.

`Mosaic number of soil classes:` specifies the number of soil classes. Acceptable values are:

Value	Description
11	FAO

`Mosaic Depth of Layer 1 (m):` specifies the depth in meters of layer 1.

`Mosaic Depth of Layer 2 (m):` specifies the depth in meters of layer 2.

`Mosaic Depth of Layer 3 (m):` specifies the depth in meters of layer 3.

`Mosaic initial soil moisture:` specifies the initial soil moisture.

`Mosaic initial soil temperature:` specifies the initial soil temperature in Kelvin.

`Mosaic use forcing data observation height:` specifies whether to use observation height from the forcing dataset.

Acceptable values are:

Value	Description
0	Do not use observation height from forcing
1	Use observation height from forcing

`Mosaic use forcing data aerodynamic conductance:` specifies whether to use aerodynamic conductance field from the forcing dataset.

Acceptable values are:

Value	Description
0	Do not use aerodynamic conductance from forcing data
1	Use aerodynamic conductance from forcing dataset

`Mosaic use distributed soil depth map:` specifies whether to use a distributed soil depth map.

Acceptable values are:

Value	Description
0	Do not use distributed soil depth map
1	Use distributed soil depth map

Example lis.config entry

```
Mosaic model timestep:                      15mn
Mosaic restart output interval:             1da
Mosaic restart file:                        ./mosaic.rst
Mosaic vegetation parameter table:          ./input/mos_parms/mosaic_vegparms_umd.txt
Mosaic monthly vegetation parameter table:
./input/mos_parms/mosaic_monthlyvegparms_umd.txt
Mosaic soil parameter table:                ./input/mos_parms/mosaic_soilparms_fao.txt
Mosaic number of soil classes:              11
Mosaic Depth of Layer 1 (m):                0.02
Mosaic Depth of Layer 2 (m):                1.48
Mosaic Depth of Layer 3 (m):                2.00
Mosaic initial soil moisture:               0.3
Mosaic initial soil temperature:            290
Mosaic use forcing data observation height:       0
Mosaic use forcing data aerodynamic conductance:  0
Mosaic use distributed soil depth map:            0
```

9.11.15. HySSiB

`HYSSIB model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

`HYSSIB restart output interval:` defines the restart writing interval for Hy-SSiB. The typical value used in the LIS runs is 24 hours (1da).

See Section Defining a time interval for a description of how to specify a time interval.

`HYSSIB restart file:` specifies the Hy-SSiB active restart file.

`HYSSIB vegetation parameter table:` specifies the Hy-SSiB static vegetation parameter table file.

`HYSSIB albedo parameter table:` specifies the Hy-SSiB static albedo parameter table file.

`HYSSIB topography stand dev file:` specifies the Hy-SSiB topography standard deviation file.

`HYSSIB number of vegetation parameters:` specifies the number of vegetation parameters.

`HYSSIB number of monthly veg parameters:` specifies the number of monthly vegetation parameters.

`HYSSIB reference height for forcing T and q:` specifies the height of the forcing T and q variables used from the forcing; specifying a negative value will use the height from the forcing data, provided it is available.

`HYSSIB reference height for forcing u and v:` specifies the height of the forcing u and v variables used from the forcing; specifying a negative value will use the height from the forcing data, provided it is available.

`HYSSIB initial soil moisture:` specifies the initial soil moisture.

`HYSSIB initial soil temperature:` specifies the initial soil temperature in Kelvin.

Example lis.config entry

```
HYSSIB model timestep:                          15mn
HYSSIB restart output interval:                 1mo
HYSSIB restart file:                            ./hyssib.rst
HYSSIB vegetation parameter table:              ./input/hyssib_parms/hyssib_vegparms.bin
HYSSIB albedo parameter table:                  ./input/hyssib_parms/hyssib_albedo.bin
HYSSIB topography stand dev file:               ./input/UMD-25KM/topo_std.1gd4r
HYSSIB number of vegetation parameters:         20
HYSSIB number of monthly veg parameters:        11
HYSSIB reference height for forcing T and q:  -1.0      # (m) - negative=use height
from forcing data
HYSSIB reference height for forcing u and v:  -1.0      # (m) - negative=use height
from forcing data
HYSSIB initial soil moisture:                   0.30
HYSSIB initial soil temperature:                290.0
```

9.11.16. Catchment Fortuna-2_5

`CLSM F2.5 model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

`CLSM F2.5 restart output interval:` defines the restart writing interval for Catchment Fortuna-2_5. The typical value used in the LIS runs is 24 hours (1da).

See Section Defining a time interval for a description of how to specify a time interval.

`CLSM F2.5 restart file:` specifies the Catchment active restart file.

`CLSM F2.5 top soil layer depth:` specifies the top soil layer depth.

`CLSM F2.5 initial soil moisture:` specifies the initial volumetric soil moisture. (units $\frac{m^3}{m^3}$)

`CLSM F2.5 initial soil temperature:` specifies the initial soil temperature in Kelvin.

`CLSM F2.5 fixed reference height:` specifies the fixed reference height. The default value used for this height by the GMAO is 10.0 meters. This fixed value will only be used if a forcing height field is not used in LIS. If a forcing height field is not used, and the height at which the wind is observed is known, then the wind height should be used for this value. There is not a separate term available for the height of the temperature or humidity forcing.

`CLSM F2.5 turbulence scheme:` specifies the turbulence scheme.

`CLSM F2.5 use MODIS albedo flag:` specifies whether to use the MODIS scale factor albedo. Acceptable values are:

Value	Description
0	Do not use the MODIS albedo
1	Use the MODIS albedo

Example lis.config entry

```
CLSM F2.5 model timestep:             30mn
CLSM F2.5 restart output interval:    1da
CLSM F2.5 restart file:               ./clmsf25.rst
CLSM F2.5 top soil layer depth:       0.02
CLSM F2.5 initial soil moisture:      0.30
CLSM F2.5 initial soil temperature:   290.0
CLSM F2.5 fixed reference height:     10.0
CLSM F2.5 turbulence scheme:          0
CLSM F2.5 use MODIS albedo flag:      1
```

9.11.17. GeoWRSI 2.0

`WRSI CalcSOS model run mode:` specifies which model run mode to run the model in, either “SOS” or “WRSI”.

`WRSI user input settings file:` specifies the path for the WRSI model file to select user-specific WRSI and SOS settings.

`WRSI crop parameter directory:` specifies the path for the crop-type parameter files.

`WRSI initial dekad of season:` The crop growing season initial timestep (in dekads).

`WRSI final dekad of season:` The crop growing season final timestep (in dekads).

`WRSI initial growing season year:` Initial year of the first growing season for the LIS-GeoWRSI model run. For now, should match the first year in the *lis.config* file `Starting year:`.

`WRSI final growing season year:` Final year of the last growing season for the LIS-GeoWRSI model run. For now, should match the final year in the *lis.config* file `Ending year:`.

`WRSI number of growing seasons:` Set the number of growing seasons to have GeoWRSI run over (default value is 1).

`WRSI model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

`WRSI restart output interval:` defines the restart writing interval for WRSI. The typical value used in the LIS-WRSI runs is 10-day, or 1-dekad.

See Section Defining a time interval for a description of how to specify a time interval.

`WRSI restart file:` specifies the WRSI active restart file.

Example lis.config entry

```
WRSI CalcSOS model run mode:        SOS
WRSI user input settings file:      ./wrsi_inputs/EA_Oct2Feb/GeoWRSI_userSettings.txt
WRSI crop parameter directory:      ./wrsi_inputs/crops
WRSI initial dekad of season:       25
WRSI final dekad of season:         6
WRSI initial growing season year:   2009
WRSI final growing season year:     2010
WRSI number of growing seasons:     1
WRSI model timestep:                "1da"
WRSI restart output interval:       "1da"
WRSI restart file:                  "none"
```

9.11.18. Australia's CABLE-1.4b

`CABLE model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

`CABLE restart output interval:` defines the restart writing interval for CABLE-1.4b. The typical value used in the LIS runs is 24 hours (1da).

See Section Defining a time interval for a description of how to specify a time interval.

`CABLE restart file:` specifies the CABLE-1.4b restart file.

`CABLE vegetation parameter table:` specifies the CABLE-1.4b vegetation parameter file.

`CABLE canopy structure flag:` specifies the CABLE-1.4b flag to select which canopy structure will be used; options are default, hawkesbury, and canopy_vh.

`CABLE photosynthesis structure flag:` specifies the CABLE-1.4b flag to select which photosynthesis structure will be used; options are default and hawkesbury.

`CABLE soil structure flag:` specifies the CABLE-1.4b flag to select which soil structure will be used; options are soilsnow and sli.

`CABLE sli soils litter structure flag:` specifies the CABLE-1.4b flag to select which litter structure will be used when using the sli soil structure; options are default, on, off, and resistance.

`CABLE sli soils isotope structure flag:` specifies the CABLE-1.4b flag to select which isotope structure will be used when using the sli soil structure; options are default, off, HDO, H2180, and spatial.

`CABLE sli soils coupled structure flag:` specifies the CABLE-1.4b flag to select which coupled structure will be used when using the sli soil structure; options are coupled and uncoupled.

`CABLE soil parameter table:` specifies the CABLE-1.4b soil parameter file.

`CABLE fixed vegetation type:` specifies a fixed vegetation type index for all grid points. Entering a value of 0 will not fix the vegetation types, and the code will use the `Landcover data source` information instead.

`CABLE fixed soil type:` specifies a fixed soil type index for all grid points. Entering a value of 0 will not fix the soil types, and the code will use the `Soil texture data source` information instead.

`CABLE fixed snow-free soil albedo:` specifies the snow-free soil albedo for all grid points.

`CABLE fixed CO2 concentration:` specifies the CO2 concentration of the near-surface air for all grid points, in ppmv.

`CABLE reference height:` specifies the height in meters of the forcing variables.

`CABLE maximum verbosity:` set to `.true.` to print to the log details of variables during calculation of the tile.

`CABLE tile to print:` specifies the tile number to print to the log; setting this value to 0 will print details of all tiles.

Example lis.config entry

```
CABLE model timestep:                    30mn
CABLE restart output interval:           1da
CABLE restart file:                      cable.rst
CABLE vegetation parameter table:        ./inpul/cable_parms/def_veg_params_igbp.txt
CABLE canopy structure flag:             default     # default; hawkesbury; canopy_vh
CABLE photosynthesis structure flag:     default     # default; hawkesbury
CABLE soil structure flag:               soilsnow    # soilsnow; sli
CABLE sli soils litter structure flag:   resistance  # default; on; off; resistance
CABLE sli soils isotope structure flag:  off         # default; off; HDO; H218O;
spatial
CABLE sli soils coupled structure flag:  coupled     # coupled; uncoupled
CABLE soil parameter table:              ./inpul/cable_parms/def_soil_params.txt
CABLE fixed vegetation type:             0
CABLE fixed soil type:                   0
CABLE fixed snow-free soil albedo:       0.1
CABLE fixed CO2 concentration:           350.0    # in ppmv
CABLE reference height:                  40.0     # in meters
CABLE maximum verbosity:                 .true.   # write detail of every grid cell
init and params to log?
CABLE tile to print:                     26784    # tile number to print (0 = print
all tiles)
```

9.11.19. RDHM 3.5.6

`RDHM356 model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

`RDHM356 restart output interval:` defines the restart writing interval for RDHM356.

See Section Defining a time interval for a description of how to specify a time interval.

`RDHM356 TempHeight:` specifies the observation height of the temperature and humidity fields, in meters.

`RDHM356 WindHeight:` specifies the observation height of the wind field, in meters.

`RDHM356 DT_SAC_SNOW17:` specifies the timestep of SAC-HTET and SNOW-17 in seconds. This must be `RDHM356 model timestep:` specified in seconds.

`RDHM356 DT_FRZ:` specifies the timestep of the frozen soil model, in seconds.

`RDHM356 FRZ_VER_OPT:` specifies the version number of the frozen soil model. Acceptable values are:

Value	Description
1	Old version
2	New version

Note, if set to 1, zero snow depth causes problems.

`RDHM356 SNOW17_OPT:` SNOW-17 option. Acceptable values are:

Value	Description
1	Use Snow-17
else	Do not use Snow-17

`RDHM356 SACHTET_OPT:` SAC-HTET option. Acceptable values are:

Value	Description
1	Use Sac-HTET
else	Do not use Sac-HTET

`RDHM356 NSTYP:` specifies the number of soil types.

`RDHM356 NVTYP:` specifies the number of vegetation types.

`RDHM356 NDINTW:` specifies the number of desired soil layers for total and liquid soil moisture.

`RDHM356 NDSINT:` specifies the number of desired soil layers for soil temperature.

`RDHM356 NORMALIZE:` specifies whether to normalize total and liquid soil moisture output. Acceptable values are:

Value	Description
0	Do not normalize
1	Normalize

`RDHM356 DSINTW:` specifies the thickness of the desired soil layers for liquid and total soil moisture.

`RDHM356 DSINT:` specifies the thickness of the desired soil layers for soil temperature.

`RDHM356 PETADJ_MON:` specifies the adjustment of potential evapotranspiration for 12 months.

`RDHM356 CZIL:` specifies the Zilitinkevich parameter, range: [0.0, 1.0].

`RDHM356 FXEXP:` specifies the bare soil evaporation exponential non-linear parameter.

`RDHM356 vegRCMAX:` specifies the maximum stomatal resistance, in s/m.

`RDHM356 PC:` specifies the plant coefficient.

`RDHM356 PET_OPT:` specifies the potential evapotranspiration scheme. Acceptable values are:

Value	Description
<0	Use energy-based Penman
0	Use non-Penman-based ETP

Value	Description
>0	Use empirical Penman equation

`RDHM356 TOPT:` specifies the optimum air temperature, in Kelvin.

`RDHM356 RDST:` specifies the tension water redistribution scheme. Acceptable values are:

Value	Description
0	Use OHD version of SRT (uses reference gradient instead of actual)
1	Use Noah version of SRT

`RDHM356 thresholdRCMIN:` constant for alternating RCMIN (0.5) (s/m).

`RDHM356 SFCREF:` specifies the reference wind speed for potential evapotranspiration adjustment, in m/s.

`RDHM356 BAREADJ:` specifies the Ek-Chen evaporation threshold switch.

`RDHM356 SNOW17_SWITCH:` specifies liquid water freezing version. Acceptable values are:

Value	Description
0	Victor's version
1	Eric's version

`RDHM356 restart file:` specifies the RDHM 3.5.6 active restart file.

`RDHM356 restart file format:` specifies the format of the RDHM 3.5.6 restart file. Acceptable values are:

Value	Description
binary	read/write binary restart files
netcdf	read/write netCDF restart files

`RDHM356 tmxmn directory:` specifies the directory containing the NetCDF file of daily maximum and minimum temperature (F).

`RDHM356 initial UZTWC (ratio):` specifies the initial upper zone tension water storage content.

`RDHM356 initial UZFWC (ratio):` specifies the initial upper zone free water storage content.

`RDHM356 initial LZTWC (ratio):` specifies the initial lower zone tension water storage content.

`RDHM356 initial LZFSC (ratio):` specifies the initial lower zone supplemental free water storage content.

`RDHM356 initial LZFPC (ratio):` specifies the initial lower zone primary free water storage content.

`RDHM356 initial ADIMC (ratio):` specifies the initial additional impervious area content.

`RDHM356 initial TS0:` specifies the initial first soil layer temperature, in Celsius.

`RDHM356 initial UZTWH (ratio):` specifies the initial unfrozen upper zone tension water.

`RDHM356 initial UZFWH (ratio):` specifies the initial unfrozen upper zone free water.

`RDHM356 initial LZTWH (ratio):` specifies the initial unfrozen lower zone tension water.

`RDHM356 initial LZFSH (ratio):` specifies the initial unfrozen lower zone supplemental free water.

`RDHM356 initial LZFPH (ratio):` specifies the initial unfrozen lower zone primary free water.

`RDHM356 initial SMC:` specifies the initial volumetric content of total soil moisture for each layer.

`RDHM356 initial SH2O:` specifies the initial volumetric content of liquid soil moisture for each layer.

`RDHM356 initial WE:` specifies the initial snow water equivalent without liquid water, in mm.

`RDHM356 initial LIQW:` specifies the initial liquid water in snow.

`RDHM356 initial NEGHS:` specifies the initial negative snow heat, in mm.

`RDHM356 initial TINDEX:` specifies the initial antecedent temperature index.

`RDHM356 initial ACCMAX:` specifies the initial accumulated snow water temperature, including liquid, in Celsius.

`RDHM356 initial SNDPT:` specifies the initial snow depth, in cm.

`RDHM356 initial SNTMP:` specifies the initial average snow temperature.

`RDHM356 initial SB:` specifies the last highest snow water equivalent before any snow fall, in mm.

`RDHM356 initial SBAESC:` specifies the initial extent of snow cover during melt and new snow fall.

`RDHM356 initial SBWS:` specifies the initial snow water storage during melt and new snow fall, in mm.

`RDHM356 initial STORAGE:` specifies the initial snow liquid water attenuation storage, in mm.

`RDHM356 initial AEADJ:` specifies the initial adjusted areal snow cover fraction [0, 1].

`RDHM356 initial EXLAG:` specifies the initial array of lagged liquid water values.

`RDHM356 initial NEXLAG:` specifies the number of coordinates in the lagged liquid water array.

`RDHM356 initial TA_PREV:` specifies the air temperature of previous timestep, in Celsius.

Example lis.config entry

```
RDHM356 model timestep:          "1hr"
RDHM356 restart output interval: "1hr"
```

```
RDHM356 TempHeight:              2.0
RDHM356 WindHeight:             10.0
RDHM356 DT_SAC_SNOW17:          3600
RDHM356 DT_FRZ:                 1800
RDHM356 FRZ_VER_OPT:            1
RDHM356 SNOW17_OPT:             1
RDHM356 SACHTET_OPT:            1
RDHM356 NSTYP:                  12
RDHM356 NVTYP:                  14
RDHM356 NDINTW:                 5
RDHM356 NDSINT:                 5
RDHM356 NORMALIZE:              1
RDHM356 DSINTW:                 0.05 0.25 0.60 0.75 1.00
RDHM356 DSINT:                  0.05 0.25 0.60 0.75 1.00
RDHM356 PETADJ_MON:             1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
RDHM356 CZIL:                   0.12
RDHM356 FXEXP:                  2.0
RDHM356 vegRCMAX:               5000
RDHM356 PC:                     -1
RDHM356 PET_OPT:                -1
RDHM356 TOPT:                   298
RDHM356 RDST:                   1
RDHM356 thresholdRCMIN:         0.5
RDHM356 SFCREF:                 4.0
RDHM356 BAREADJ:                0.230000004
RDHM356 SNOW17_SWITCH:          1
RDHM356 restart file:           "none"
RDHM356 restart file format:    "netcdf"
RDHM356 tmxmn directory:        "none"
RDHM356 initial UZTWC (ratio):  0.55
RDHM356 initial UZFWC (ratio):  0.14
RDHM356 initial LZTWC (ratio):  0.56
RDHM356 initial LZFSC (ratio):  0.11
RDHM356 initial LZFPC (ratio):  0.46
RDHM356 initial ADIMC (ratio):  1.0
RDHM356 initial TS0:            4.0
RDHM356 initial UZTWH (ratio):  0.1
RDHM356 initial UZFWH (ratio):  0.1
RDHM356 initial LZTWH (ratio):  0.1
RDHM356 initial LZFSH (ratio):  0.1
RDHM356 initial LZFPH (ratio):  0.1
RDHM356 initial SMC:            0.35 0.35 0.35 0.35 0.35 0.35
RDHM356 initial SH2O:           0.35 0.35 0.35 0.35 0.35 0.35
RDHM356 initial WE:             0
RDHM356 initial LIQW:           0
RDHM356 initial NEGHS:          0
RDHM356 initial TINDEX:         0
RDHM356 initial ACCMAX:         0
RDHM356 initial SNDPT:          0
RDHM356 initial SNTMP:          0
RDHM356 initial SB:             0
```

```
RDHM356 initial SBAESC:          0
RDHM356 initial SBWS:            0
RDHM356 initial STORAGE:         0
RDHM356 initial AEADJ:           0
RDHM356 initial EXLAG:           0 0 0 0 0 0 0
RDHM356 initial NEXLAG:          7
RDHM356 initial TA_PREV:         0
```

9.11.20. AWRA-L 6.0.0

`AWRAL600 model timestep:` specifies the model timestep for the AWRA-L 6.0.0 LSM.

See Section Defining a time interval for a description of how to specify a time interval.

`AWRAL600 restart output interval:` specifies the model timestep for the AWRA-L 6.0.0 LSM.

See Section Defining a time interval for a description of how to specify a time interval.

`AWRAL600 restart file:` specifies the AWRA-L 6.0.0 restart file.

`AWRAL600 restart file format:` specifies the AWRA-L 6.0.0 restart file format, netcdf or binary (default=netcdf).

`AWRAL600 nhru:` specifies the number of hydrological response units (HRUs).

`AWRAL600 nhypsbins:` specifies the number of hypsometric curve distribution percentile bins.

`AWRAL600 slope_coeff:` specifies the scaling factor for slope.

`AWRAL600 pair:` specifies the air pressure.

`AWRAL600 kr_coeff:` specifies the scaling factor for ratio of saturated hydraulic conductivity.

`AWRAL600 hypsperc:` specifies the hypsometric curve distribution percentile bins.

The following constant parameter options accept values for each HRU specified in `AWRAL600 nhru` above, from shallow to deep.

`AWRAL600 alb_dry:` specifies the dry soil albedo for each HRU.

`AWRAL600 alb_wet:` specifies the wet soil albedo for each HRU.

`AWRAL600 cgsmax:` specifies the coefficient relating vegetation photosynthetic capacity to maximum stomatal conductance for each HRU.

`AWRAL600 er_frac_ref:` specifies the specific ratio of the mean evaporation rate and the mean rainfall intensity during storms for each HRU.

`AWRAL600 fsoilemax:` specifies the soil evaporation scaling factor corresponding to unlimited soil water supply for each HRU.

`AWRAL600 lairef:` specifies the reference leaf area index (at which fv = 0.63) for each HRU.

`AWRAL600 rd:` specifies the rooting depth for each HRU.

`AWRAL600 s_sls:` specifies the specific canopy rainfall storage per unit leaf area for each HRU.

`AWRAL600 sla:` specifies the specific leaf area for each HRU.

`AWRAL600 tgrow:` specifies the characteristic time scale for vegetation growth towards equilibrium for each HRU.

`AWRAL600 tsenc:` specifies the characteristic time scale for vegetation senescence towards equilibrium for each HRU.

`AWRAL600 ud0:` specifies the maximum possible root water uptake from the deep soil store for each HRU.

`AWRAL600 us0:` specifies the maximum possible root water uptake from the shallow soil store for each HRU.

`AWRAL600 vc:` specifies the vegetation photosynthetic capacity index per unit canopy cover for each HRU.

`AWRAL600 w0lime:` specifies the limiting the value of the relative soil moisture content of the top soil layer at which evaporation is reduced for each HRU.

`AWRAL600 w0ref_alb:` specifies the reference value of w0 that determines the rate of albedo decrease with wetness for each HRU.

`AWRAL600 wdlimu:` specifies the water-limiting relative water content of the deep soil store for each HRU.

`AWRAL600 wslimu:` specifies the water-limiting relative water content of the shallow soil store for each HRU.

`AWRAL600 timesteps:` specifies the number of daily timesteps.

`AWRAL600 initial sr:` specifies the volume of water in the surface water store.

`AWRAL600 initial sg:` specifies the groundwater storage in the unconfined aquifer.

`AWRAL600 initial s0:` specifies the water storage in the surface soil layer for each HRU.

`AWRAL600 initial ss:` specifies the water content of the shallow soil store for each HRU.

`AWRAL600 initial sd:` specifies the water content of the deep soil store for each HRU.

`AWRAL600 initial mleaf:` specifies the leaf biomass.

Example lis.config entry:

```
AWRAL600 model timestep:          1da
AWRAL600 restart output interval: 1mo
AWRAL600 restart file:            none
AWRAL600 restart file format: "netcdf"

AWRAL600 nhru:          2
AWRAL600 nhypsbins:     20
AWRAL600 slope_coeff:   0.43879647
AWRAL600 pair:          97500.0
AWRAL600 kr_coeff:      0.66159026
AWRAL600 hypsperc:      0.0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1 0.15 0.2
0.3 0.4 0.5 0.6 0.75 0.9 1.0

# hru params (1st = shallow, 2nd = deep)
AWRAL600 alb_dry:       0.26 0.26
AWRAL600 alb_wet:       0.16 0.16
AWRAL600 cgsmax:        0.03209419 0.02124781
AWRAL600 er_frac_ref:   0.032129 0.06425805
AWRAL600 fsoilemax:     0.58500527 0.99960822
AWRAL600 lairef:        1.4 2.5
AWRAL600 rd:            1.0 6.0
AWRAL600 s_sls:         0.29277 0.067438
AWRAL600 sla:           10.0 3.0
AWRAL600 tgrow:         150.0 1000.0
AWRAL600 tsenc:         10.0 60.0
AWRAL600 ud0:           0.0 11.56989
AWRAL600 us0:           6.0 6.0
AWRAL600 vc:            0.65 0.35
AWRAL600 w0lime:        0.85 0.85
AWRAL600 w0ref_alb:     0.3 0.3
AWRAL600 wdlimu:        0.3 0.3
AWRAL600 wslimu:        0.3 0.3
AWRAL600 timesteps:     1

# hru params (1st = shallow, 2nd = deep)
AWRAL600 initial sr: 0.0
AWRAL600 initial sg: 100.0
AWRAL600 initial s0: 0.5 0.5
AWRAL600 initial ss: 0.5 0.5
AWRAL600 initial sd: 0.5 0.5
### 2/sla
AWRAL600 initial mleaf: 0.67 0.2
```

`AquaCrop.7.2 soil parameter table:` specifies the soil AquaCrop.7.2 soil parameter file.

`AquaCrop.7.2 model timestep:` specifies the model timestep for AquaCrop.7.2. This option should be set to `"1da"` because of the fixed daily model timestep of AquaCrop.

`AquaCrop.7.2 restart output interval:` specifies the restart writing interval for AquaCrop.7.2 The typical value is 1 month (1mo).

`AquaCrop.7.2 restart file:` specifies the AquaCrop.7.2 restart file.

`AquaCrop.7.2 restart file format:` specifies the restart file format for AquaCrop.7.2.

`AquaCrop.7.2 reference height for forcing T and q:` specifies the height in meters of air temperature and specific humidity forcings.

`AquaCrop.7.2 reference height for forcing u and v:` specifies the height in meters of u and v wind forcings.

`AquaCrop.7.2 initial liquid soil moistures:` specifies the initial liquid volumetric soil moistures (for each layer defined in LDT, from top to bottom) used in the cold start runs. (units $\frac{m^3}{m^3}$)

`AquaCrop.7.2 input path:` specifies the directory containing the native AquaCrop files.

`AquaCrop.7.2 CO2_Filename:` specifies the file name of the CO2 file (.CO2) used by AquaCrop.7.2 stored in the "input path" directory.

`AquaCrop.7.2 crop library directory:` specifies the location of the crop library directory containing the AC_Crop.Inventory file and the AC_Crop.List directory containing the crop files.

`AquaCrop.7.2 Management_Filename:` specifies the management file (.MAN) used by AquaCrop.7.2 stored in the "input path" directory. If not specified, AquaCrop.7.2 will run without management file (set to "(None)").

`AquaCrop.7.2 Irrigation_Filename:` specifies the management file (.IRR) used by AquaCrop.7.2 stored in the "input path" directory. If not specified, AquaCrop.7.2 will run without irrigation file (set to "(None)").

`AquaCrop.7.2 starting day of sim period:` specifies the starting day of the AquaCrop simulation period (same for each year given that the length of the AquaCrop simulation period is hardcoded to 1 calendar year).

`AquaCrop.7.2 starting month of sim period:` specifies the starting month of the AquaCrop simulation period (same for each year given that the length of the AquaCrop simulation period is hardcoded to 1 calendar year).

`AquaCrop.7.2 starting day of crop period:` specifies the starting day of the AquaCrop cropping period (planting/sowing). Currently, only one cropping period is possible within an AquaCrop simulation period (= 1 calendar year).

`AquaCrop.7.2 starting month of crop period:` specifies the starting month of the AquaCrop cropping period (planting/sowing). Currently, only one cropping period is possible within an AquaCrop simulation period (= 1 calendar year).

Example lis.config entry:

```
AquaCrop.7.2 soil parameter table: ./SOILPARM_AC72.TBL
AquaCrop.7.2 model timestep: "1da"
AquaCrop.7.2 restart output interval: "1mo"
AquaCrop.7.2 restart file: none
AquaCrop.7.2 restart file format: netcdf
AquaCrop.7.2 reference height of T and q: 2.0
AquaCrop.7.2 reference height of u and v: 10.0
AquaCrop.7.2 initial liquid soil moistures: 0.33 0.33
AquaCrop.7.2 input path: "./AC_INPUT_dir/"
AquaCrop.7.2 CO2_Filename: "file.CO2"
AquaCrop.7.2 crop library directory: "./crop_params_dir/"
AquaCrop.7.2 Management_Filename: "file.MAN"
AquaCrop.7.2 Irrigation_Filename: "file.IRR"

##Simulation and crop period
AquaCrop.7.2 starting day of sim period: 1
AquaCrop.7.2 starting month of sim period: 1
AquaCrop.7.2 starting day of crop period: 22
AquaCrop.7.2 starting month of crop period: 3
```

9.12. Sublevel land surface models

9.12.1. SnowModel, Liston

`SnowModel model timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

`SnowModel restart output interval:` defines the restart writing interval for Glen Liston's SnowModel model. The typical value used in the LIS runs is 24 hours (1da).

See Section Defining a time interval for a description of how to specify a time interval.

`SnowModel restart file:` specifies the SnowModel active restart file.

`SnowModel restart file format:` specifies the restart file format for SnowModel.

`SnowModel parameter file:` specifies the main SnowModel-specific input and option parameter configuration file, which is needed to run SnowModel.

`SnowModel parameters source option:` specifies if SnowModel will read in its native binary parameter files from within the SnowModel code or what is preprocessed in LDT. LDT option supports parallel runs Acceptable values are:

Value	Description
SnowModel	Use SnowModel built-in routines to read in

Value	Description
LDT	Use the LIS SnowModel main driver to load parameters from LDT.

`SnowModel MicroMet input source:` specifies if SnowModel will read in its own specifically formatted binary or ASCII table forcing files, or if LIS meteorological forcing fields will be passed in, with the option to turn on MicroMet topographic-downscaling options on the LIS metforcing layer side. To turn on "micromet" option in LIS, set Topographic correction method (met forcing) to micromet. Acceptable values are:

Value	Description
SnowModel	Readin specific SnowModel forcing files
LIS	LIS-based meteorological forcing fields

`SnowModel preprocess code option:` specifies the turning on of the SnowModel built-in preprocess code module, which performs initial preprocessing of gridded data for running the model. Currently, only option supported is 1 (on).

`Write out SnowModel forcing file fields:` specifies if you want to write out SnowModel forcing fields generated by reading in SnowModel-specific forcing files. This option is mainly used when SnowModel MicroMet input source is set to SnowModel and you run SnowModel in offline subLSM mode (no other LSMs or models run with this submodel). Selecting 1 activates this option, and 0 indicates off.

`SnowModel number of snow layers:` specifies the number of snow layers that would be allowed to build within the SnowModel runtime. This option is currently set to 1 within LIS, and must also be activated and increased by setting the multiple layer snow model scheme in the SnowModel option parameter file (snowmodel.par).

`SnowModel initial snow water equivalent:` specifies the initial snow water equivalent (SWE) value. This is currently set to default values found in the coldstart mode for model restart reads, based on a SnowModel initialization approach.

Example lis.config entry

```
SnowModel model timestep:                1hr
SnowModel restart file:                ./none
SnowModel restart output interval:       1mo
SnowModel restart file format:          "netcdf"
SnowModel parameter file:              ./snowmodel.par
SnowModel parameters source option:       LDT
SnowModel MicroMet input source:          LIS
Write out SnowModel forcing file fields:  1
SnowModel preprocess code option:         1
SnowModel number of snow layers:          1
SnowModel initial snow water equivalent:  0.0
```

9.13. Lake models

9.13.1. FLAKE.1.0

`FLAKE1 model timestep:` specifies the timestep for FLAKE1.

See Section Defining a time interval for a description of how to specify a time interval.

`FLAKE1 restart interval:` specifies the restart output interval for FLAKE1.

See Section Defining a time interval for a description of how to specify a time interval.

`FLAKE1 height where wind speed is measured:` specifies the height where wind speed is measured. [m]

`FLAKE1 height where temperature and humidity are measured:` specifies the height where temperature and humidity are measured. [m]

`FLAKE1 restart file:` specifies the FLAKE1 active restart file.

`FLAKE1 initial temperature at the air-snow interface:` specifies the initial temperature at the air-snow interface. [K]

`FLAKE1 initial temperature at the snow-ice interface:` specifies the initial temperature at the snow-ice interface. [K]

`FLAKE1 initial mean temperature of the water column:` specifies the initial mean temperature of the water column. [K]

`FLAKE1 initial temperature of mixed layer:` specifies the initial temperature of the mixed layer. [K]

`FLAKE1 initial temperature at the water-bottom sediment interface:` specifies the initial temperature at the water-bottom sediment interface. [K]

`FLAKE1 initial temperature at the bottom of the upper layer of the sediments:` specifies the initial temperature at the bottom of the upper layer of the sediments. [K]

`FLAKE1 initial thermocline shape factor:` specifies the initial thermocline shape factor. [fraction]

`FLAKE1 initial snow thickness:` specifies the initial snow thickness. [m]

`FLAKE1 initial ice thickness:` specifies the initial ice thickness. [m]

`FLAKE1 initial thickness of mixed layer:` specifies the initial thickness of the mixed layer. [m]

`FLAKE1 initial thickness of the upper layer of bottom sediments:` specifies the initial thickness of the upper layer of bottom sediments.

`FLAKE1 initial surface temperature:` specifies the initial surface temperature. [K]

`FLAKE1 initial water surface albedo with respect to solar radiation:` specifies the initial water surface albedo with respect to solar radiation. [fraction]

`FLAKE1 initial ice surface albedo with respect to the solar radiation:` specifies the initial ice surface albedo with respect to the solar radiation. [fraction]

`FLAKE1 initial snow surface albedo with respect to the solar radiation:` specifies the initial snow surface albedo with respect to the solar radiation. [fraction]

Example lis.config entry

```
FLAKE1 model timestep:
FLAKE1 restart interval:
FLAKE1 height where wind speed is measured:
FLAKE1 height where temperature and humidity are measured:
FLAKE1 restart file:
FLAKE1 initial temperature at the air-snow interface:
FLAKE1 initial temperature at the snow-ice interface:
FLAKE1 initial mean temperature of the water column:
FLAKE1 initial temperature of mixed layer:
FLAKE1 initial temperature at the water-bottom sediment interface:
FLAKE1 initial temperature at the bottom of the upper layer of the sediments:
FLAKE1 initial thermocline shape factor:
FLAKE1 initial snow thickness:
FLAKE1 initial ice thickness:
FLAKE1 initial thickness of mixed layer:
FLAKE1 initial thickness of the upper layer of bottom sediments:
FLAKE1 initial surface temperature:
FLAKE1 initial water surface albedo with respect to solar radiation:
FLAKE1 initial ice surface albedo with respect to the solar radiation:
FLAKE1 initial snow surface albedo with respect to the solar radiation:
```

9.14. Open water models

9.14.1. template open water

`Template open water timestep:` specifies the timestep for the run.

See Section Defining a time interval for a description of how to specify a time interval.

Example lis.config entry

```
Template open water timestep:
```

9.15. Land slide models

9.15.1. GLS

`GLS susceptibility index map:` specifies what?

`GLS susceptibility index threshold:` specifies what?

`GLS slope value:` specifies what?

`GLS y-intercept value:` specifies what?

`GLS rainfall accumulation interval1:` specifies what?

`GLS rainfall accumulation interval2:` specifies what?

`GLS rainfall accumulation interval3:` specifies what?

`GLS rainfall threshold for interval1:` specifies what?

`GLS rainfall threshold for interval2:` specifies what?

`GLS rainfall threshold for interval3:` specifies what?

`GLS model timestep:` specifies what?

`GLS output format:` specifies what?

`GLS output interval:` specifies what?

Example lis.config entry

```
GLS susceptibility index map:
GLS susceptibility index threshold:
GLS slope value:
GLS y-intercept value:
GLS rainfall accumulation interval1:
GLS rainfall accumulation interval2:
GLS rainfall accumulation interval3:
GLS rainfall threshold for interval1:
GLS rainfall threshold for interval2:
GLS rainfall threshold for interval3:
GLS model timestep:
GLS output format:
GLS output interval:
```

9.15.2. TRIGRS

`TRIGRS initialization file:` specifies what?

`TRIGRS app timestep:` specifies what?

`TRIGRS rain input source style:` specifies what?

Example lis.config entry

```
TRIGRS initialization file:
TRIGRS app timestep:
TRIGRS rain input source style:
```

9.16. Irrigation

`Irrigation scheme:` specifies the name of the irrigation scheme to use. Acceptable values are:

Value	Description
none	No irrigation scheme
Sprinkler	Demand sprinkler scheme
Flood	Demand flood scheme

`Irrigation output interval:` defines the output writing interval for irrigation.

See Section Defining a time interval for a description of how to specify a time interval.

`Irrigation threshold:` defines the irrigation trigger threshold for the flood and sprinkler irrigation schemes.

`Irrigation max soil layer depth:` specifies the maximum soil layer depth. Defaults to 1 layer.

`Sprinkler irrigation max root depth file:` specifies the location of the max root depth file for sprinkler irrigation.

`Flood irrigation max root depth file:` specifies the location of the max root depth file for flood irrigation.

`Drip irrigation max root depth file:` specifies the location of the max root depth file for drip irrigation.

`Irrigation GVF parameter 1:` specifies growing season for irrigation in Noah-MP [set to 0.40 for Ozdogan et al. (2010) irrigation]

`Irrigation GVF parameter 2:` specifies growing season for irrigation in Noah-MP [set to 0.00 for Ozdogan et al. (2010) irrigation]

In the original GVF threshold in the sprinkler irrigation scheme by Ozdogan et al. (2010), a fraction of 0.4 was applied as part of the max-min seasonality in GVF. Nie et al. (2018) added a dyanmic option. These two parameters and the GVF range allow the user to adjust the percentage of the irrigation cut-off so that areas of greater GVF range will have a higher percentage cut-off and areas of lower GVF range will have a lower cut-off. In the code, the irrigation threhold contains the term (GVFparam1 + GVFparam2*(shdmax-shdmin)) instead of a static value of 0.4. By using this equation, the user may adjust the cut-off percentage as a function of GVF range (shdmax-shdmin).

`Irrigation scheduling based on dynamic vegetation:` specifies whether to schedule irrigation based on GVF simulated by the DVEG module in Noah-MP. This option works together with `Noah-MP.4.0.1 dynamic vegetation option` = 2. Acceptable values are:

Value	Description
0	No
1	Yes

Defaults to 0.

`Groundwater abstraction for irrigation:` specifies whether to withdraw water used for irrigation from the groundwater in Noah-MP. Acceptable values are:

Value	Description
0	No
1	Yes

Defaults to 0.

`Irrigation source water partition:` specifies whether to withdraw water used for irrigation from groundwater based on the groundwater irrigation ratio dataset. This option works only when the irrigation groundwater ratio is set up in the `LIS domain and parameter data file`. Now only supports the CONUS domain. Acceptable values are:

Value	Description
0	No
1	Yes

Defaults to 0.

Example lis.config entry

```
Irrigation scheme:            "none"
Irrigation output interval:   "1da"
Irrigation threshold:          0.50
Irrigation max soil layer depth: 1
Sprinkler irrigation max root depth file:
Flood irrigation max root depth file:
Drip irrigation max root depth file:
Irrigation GVF parameter 1: 0.40
Irrigation GVF parameter 2: 0.00
Irrigation scheduling based on dynamic vegetation: 0
Groundwater abstraction for irrigation: 0
Irrigation source water partition: 0
```

9.17. Routing

9.17.1. HYMAP routing

`HYMAP routing model time step:` specifies the timestep for the HyMAP router.

See Section Defining a time interval for a description of how to specify a time interval.

`HYMAP routing model output interval:` defines the output writing interval for the HyMAP router.

See Section Defining a time interval for a description of how to specify a time interval.

`HYMAP run in ensemble mode:` specifies whether to run the HyMAP router in ensemble mode. Acceptable values are:

Value	Description
0	Do not run in ensemble mode
1	Run in ensemble mode

`HYMAP routing method:` specifies the HyMAP routing method to use. Acceptable values are:

Value	Description
kinematic	use kinematic method
diffusive	use diffusive method

`HYMAP routing model linear reservoir flag:` specifies whether to use linear reservoirs in the HyMAP router. Acceptable values are:

Value	Description
1	Use
2	Do not use

`HYMAP routing model evaporation option:` specifies whether to compute evaporation in flood plains in the HyMAP router. Note that the ability to calculate this evaporation is currently disabled in the HyMAP router code. Acceptable values are:

Value	Description
1	Compute evaporation in flood plains
2	Do not compute evaporation in flood plains

`HYMAP routing model start mode:` specifies the restart mode to be used for the HyMAP router. Acceptable values are:

Value	Description
restart	A restart mode is being used; read a HyMAP restart file
coldstart	A cold start mode is being used; no restart file read

`HYMAP routing model restart interval:` defines the restart writing interval for the HyMAP router.

See Section Defining a time interval for a description of how to specify a time interval.

`HYMAP routing model restart file:` specifies the HyMAP router active restart file.

Example lis.config entry

```
HYMAP routing model time step: "30mn"
HYMAP routing model output interval: "1da"
HYMAP run in ensemble mode: 0
HYMAP routing method: "kinematic"
HYMAP routing model linear reservoir flag: 1
HYMAP routing model evaporation option: 2
HYMAP routing model start mode: "coldstart"
HYMAP routing model restart interval: "1mo"
HYMAP routing model restart file:
"./OL/ROUTING/200001/LIS_RST_HYMAP_router_200001312345.d01.bin"
```

9.17.2. HYMAP2 routing

`HYMAP2 routing model time step:` specifies the timestep for the HyMAP2 router.

See Section Defining a time interval for a description of how to specify a time interval.

`HYMAP2 routing model output interval:` defines the output writing interval for the HyMAP2 router.

See Section Defining a time interval for a description of how to specify a time interval.

`HYMAP2 run in ensemble mode:` specifies whether to run the HyMAP2 router in ensemble mode. Acceptable values are:

Value	Description
0	Do not run in ensemble mode
1	Run in ensemble mode

`HYMAP2 routing method:` specifies the HyMAP2 routing method to use. Acceptable values are:

Value	Description
kinematic	use kinematic method
diffusive	use diffusive method
“local inertia”	use local inertia method
hybrid	use hybrid method (requires a river flow map from LDT)

`HYMAP2 routing model time step method:` specifies the HyMAP2 routing model time step method to use. Acceptable values are:

Value	Description
constant	use constant timestep
adaptive	use adaptive (time-varying) timesteps (must provide an alfa coefficient value)

`HYMAP2 routing model adaptive time step alfa coefficient:` specifies the adaptive time step alfa coefficent (a real number) for the HyMAP2 router. This coefficient is not needed if using the `constant` time step method.

`HYMAP2 floodplain dynamics:` specifies whether simulate floodplain dynamics in the HyMAP2 router. Acceptable values are:

Value	Description
0	Do not use
1	Use

`HYMAP2 reservoir operation option:` specifies whether to use reservoir operations in the HyMAP2 router. This option is still in development in the HyMAP2 router within LIS. Acceptable values are:

Value	Description
0	Do not use
1	Use (additional *lis.config* entries required)

`HYMAP2 number of reservoirs:` specifies the number of reservoirs to use with the HyMAP2 router. This config entry is only used when `HYMAP2 reservoir operation option:` is set to 1. The number of reservoirs should be an integer.

`HYMAP2 reservoir operation input time series size:` specifies the time series length (or number of time steps in the inputs files) when using reservoir operations with the HyMAP2 router. This config entry is only used when `HYMAP2 reservoir operation option:` is set to 1. The time series size should be an integer.

`HYMAP2 reservoir operation input directory:` specifies the input directory for the reservoir operation files to be used when using reservoir operations with the HyMAP2 router. This config entry is only used when `HYMAP2 reservoir operation option:` is set to 1.

`HYMAP2 reservoir operation header filename:` specifies the filename header for the reservoir operation files to be used when using reservoir operations with the HyMAP2 router. This config entry is only used when `HYMAP2 reservoir operation option:` is set to 1.

`HYMAP2 reservoir operation input data type:` specifies the input data type for the reservoir operation files to be used when using reservoir operations with the HyMAP2 router. This config entry is only used when `HYMAP2 reservoir operation option:` is set to 1.

Value	Description
“water level”	Use water level data
streamflow	Use streamflow data

`HYMAP2 routing model linear reservoir flag:` specifies whether to use linear reservoirs in the HyMAP2 router. Acceptable values are:

Value	Description
0	Do not use
1	Use

`HYMAP2 routing model evaporation option:` specifies whether to compute evaporation in flood plains in the HyMAP2 router. Acceptable values are:

Value	Description
none	Do not compute evaporation in flood plains
penman	Compute evaporation in flood plains using Penman method

`HYMAP2 routing model dwi flag:` specifies whether to use DWI maps from LDT in the HyMAP2 router. Acceptable values are:

Value	Description
0	Do not use DWI maps
1	Use DWI maps (requires two DWI fields from LDT)

`HYMAP2 routing model start mode:` specifies the restart mode to be used for the HyMAP2 router. Acceptable values are:

Value	Description
restart	A restart mode is being used; read a HyMAP2 restart file
coldstart	A cold start mode is being used; no restart file read

`HYMAP2 routing model restart interval:` defines the restart writing interval for the HyMAP2 router.

See Section Defining a time interval for a description of how to specify a time interval.

`HYMAP2 routing model restart file:` specifies the HyMAP2 router active restart file.

`HYMAP2 enable 2-way coupling:` specifies whether to enable 2-way coupling.

Value	Description
0	Do not use
1	Use

`HYMAP2 2-way coupling flooded fraction threshold:` specifies the flooded fraction threshold used in the 2-way coupling mode.

`HYMAP2 use localization update in DA:` specifies whether to enable the localization scheme for DA.

Acceptable values are:

Value	Description
0	Do not use localization
1	Use localization for DA

`HYMAP2 localization update window size:` specifies localization update window size.

`HYMAP2 localization weight map:` specifies the file location of the localization weight map.

Example lis.config entry

```
HYMAP2 routing model time step: "30mn"
HYMAP2 routing model output interval: "1da"
HYMAP2 run in ensemble mode: 0
HYMAP2 routing method: "kinematic"
HYMAP2 routing model time step method: "constant"
HYMAP2 routing model adaptive time step alfa coefficient: 0.7
HYMAP2 floodplain dynamics: 1
HYMAP2 reservoir operation option: 0
HYMAP2 number of reservoirs: 0
HYMAP2 reservoir operation input time series size: 1
HYMAP2 reservoir operation input directory: "./reservoir_data"
HYMAP2 reservoir operation header filename: "RESDATA"
HYMAP2 reservoir operation input data type: "streamflow"
HYMAP2 routing model linear reservoir flag: 1
HYMAP2 routing model evaporation option: "none"
HYMAP2 routing model dwi flag: 0
HYMAP2 routing model start mode: "coldstart"
HYMAP2 routing model restart interval: "1mo"
HYMAP2 routing model restart file:
"./OL/ROUTING/197901/LIS_RST_HYMAP2_router_197901030000.d01.nc

HYMAP2 enable 2-way coupling: 0
HYMAP2 2-way coupling flooded fraction threshold: 0.1

HYMAP2 use localization update in DA: 0
HYMAP2 localization update window size: 10
HYMAP2 localization weight map: ./input/localization_map/distance_map_full_ohio_010.nc
```

9.17.3. HYMAP3 routing

`HYMAP3 routing model time step:` specifies the timestep for the HyMAP3 router.

See Section Defining a time interval for a description of how to specify a time interval.

`HYMAP3 routing model output interval:` defines the output writing interval for the HyMAP3 router.

See Section Defining a time interval for a description of how to specify a time interval.

`HYMAP3 run in ensemble mode:` specifies whether to run the HyMAP3 router in ensemble mode.

Acceptable values are:

Value	Description
0	Do not run in ensemble mode
1	Run in ensemble mode

`HYMAP3 routing method:` specifies the HyMAP3 routing method to use.

Acceptable values are:

Value	Description
kinematic	use kinematic method
diffusive	use diffusive method
“local inertia”	use local inertia method
hybrid	use hybrid method (requires a river flow map from LDT)
urban	use urban hydrology method (requires river flow and urban drainage outlet maps from LDT, and an additional lis.config_ entry)

`HYMAP3 urban drainage parameter file:` specifies the text file name containing gutter and drainage network parameters. This config entry is only used when ` HYMAP3 routing method:` is set to `urban`.

`HYMAP3 routing model time step method:` specifies the HyMAP3 routing model time step method to use. This option is elective. If not defined, HYMAP3 adopts `adaptive` by default.

Acceptable values are:

Value	Description
constant	use constant timestep
adaptive	use adaptive (time-varying) timesteps (must provide an alfa coefficient value)

`HYMAP3 routing model adaptive time step alfa coefficient:` specifies the adaptive time step alfa coefficient (a real number) for the HyMAP3 router. This option is elective. If not defined, HYMAP3 adopts 0.5 by default. This coefficient is not needed if using the `constant` time step method.

`HYMAP3 floodplain dynamics:` specifies whether simulate floodplain dynamics in the HyMAP3 router.

Acceptable values are:

Value	Description
0	Do not use
1	Use

`HYMAP3 reservoir operation option:` specifies whether to use reservoir operations in the HyMAP3 router. This option is elective. If not defined, HYMAP3 does not use reservoir operation.

Acceptable values are:

Value	Description
0	Do not use
1	Use data-driven model (additional *lis.config* entries required)
2	Use parameter-based model (additional *lis.config* entries required)
3	Use beaver dam module (additional *lis.config* entries required)

additional *lis.config* entries for data-driven model

`HYMAP3 reservoir operation input directory:` specifies the input directory for the reservoir operation files to be used when using reservoir operations with the HyMAP3 router. This config entry is only used when `HYMAP3 reservoir operation option:` is set to 1.

`HYMAP3 reservoir operation header filename:` specifies the filename header for the reservoir operation files to be used when using reservoir operations with the HyMAP3 router. This config entry is only used when `HYMAP3 reservoir operation option:` is set to 1.

additional *lis.config* entries for parameter-based model `HYMAP3 reservoir operation input file:` specifies NetCDF file containing reservoir parameters. This config entry is only used when `HYMAP3 reservoir operation option:` is set to 2.

`HYMAP3 reservoir list:` specifies text file containing the list of reservoirs. This config entry is only used when `HYMAP3 reservoir operation option:` is set to 2.

`HYMAP3 levee:` specifies whether to account for levees. This option is elective. If not defined, HYMAP3 does not account for levees.

Acceptable values are:

Value	Description
0	Do not use
1	Use (requires a levee map from LDT)

`HYMAP3 sea level:` specifies whether to account for sea levels as downstream boundary condition. This option is elective. If not defined, HYMAP3 does not account for sea levels.

Acceptable values are:

Value	Description
0	Do not use
1	Use (requires additional lis.config_ entries)

`HYMAP3 sea level input directory:` specifies the directory where data is found when using sea levels as downstream boundary condition with the HyMAP3 router. This config entry is only used when `HYMAP3 sea level:` is set to 1.

`HYMAP3 sea level header filename:` specifies the filename header for the sea level files to be used when using sea levels as downstream boundary condition with the HyMAP3 router. This config entry is only used when `HYMAP3 sea level:` is set to 1.

`HYMAP3 sea level outlet list:` specifies the text filename listing the outlet grid cells using sea level data as downstream boundary conditions with the HyMAP3 router. This config entry is only used when `HYMAP3 sea level:` is set to 1.

`HYMAP3 routing model start mode:` specifies the restart mode to be used for the HyMAP3 router.

Acceptable values are:

Value	Description
restart	A restart mode is being used; read a HyMAP3 restart file
coldstart	A cold start mode is being used; no restart file read

`HYMAP3 routing model restart interval:` defines the restart writing interval for the HyMAP3 router.

See Section Defining a time interval for a description of how to specify a time interval.

`HYMAP3 routing model restart file:` specifies the HyMAP3 router active restart file.

`HYMAP3 enable 2-way coupling:` specifies whether to enable 2-way coupling.

Value	Description
0	Do not use
1	Use

`HYMAP3 2-way coupling flooded fraction threshold:` specifies the flooded fraction threshold used in the 2-way coupling mode.

`HYMAP3 runoff bias correction:` specifies whether to account for a runoff bias correction. This option is elective and, if not defined, HYMAP3 does not account for runoff bias correction. This option requires a runoff bias correction field provided in the LIS domain and parameter data file (HYMAP_runoff_bias_correction).

Acceptable values are:

Value	Description
0	Do not use
1	Use

Example lis.config entry

```
HYMAP3 routing model time step: "30mn"
HYMAP3 routing model output interval: "1da"
HYMAP3 run in ensemble mode: 0
HYMAP3 routing method: "kinematic"
HYMAP3 routing model time step method: "constant"
HYMAP3 routing model adaptive time step alfa coefficient: 0.7
HYMAP3 floodplain dynamics: 1
HYMAP3 reservoir operation option: 1
HYMAP3 reservoir operation input directory: "./reservoir_data"
HYMAP3 reservoir operation header filename: "RESDATA"
HYMAP3 levees: 1
HYMAP3 sea level: 1
HYMAP3 sea level input directory: ./sea_level_data
HYMAP3 sea level header filename: SEALEVDATA_
HYMAP3 sea level outlet list: OUTLETLIST
HYMAP3 routing model start mode: "coldstart"
HYMAP3 routing model restart interval: "1mo"
HYMAP3 routing model restart file:
"./OL/ROUTING/197901/LIS_RST_HYMAP3_router_197901030000.d01.nc
HYMAP3 enable 2-way coupling: 0
HYMAP3 2-way coupling flooded fraction threshold: 0.1
HYMAP3 runoff bias correction: 1
```

9.17.4. NLDAS routing

`NLDAS routing model output interval:` defines the output writing interval for the NLDAS router.

See Section Defining a time interval for a description of how to specify a time interval.

`NLDAS routing model restart interval:` defines the restart writing interval for the NLDAS router.

See Section Defining a time interval for a description of how to specify a time interval.

`NLDAS routing internal unit hydrograph file:` specifies the internal unit hydrograph file.

`NLDAS routing transport unit hydrograph file:` specifies the transport unit hydrograph file.

`NLDAS routing coordinates order file:` specifies the coordinates order file.

`NLDAS routing initial condition for runoff:` specifies the initial condition for runoff file.

`NLDAS routing initial condition for transport:` specifies the initial condition for transport file.

`NLDAS routing model start mode:` specifies if a restart mode is being used. Acceptable values are:

Value	Description
restart	A restart mode is being used
coldstart	A cold start mode is being used, no restart file read

`NLDAS routing model restart file:` specifies the NLDAS router active restart file.

Example lis.config entry

```
NLDAS routing model output interval:
NLDAS routing model restart interval:
NLDAS routing internal unit hydrograph file:
NLDAS routing transport unit hydrograph file:
NLDAS routing coordinates order file:
NLDAS routing initial condition for runoff:
NLDAS routing initial condition for transport:
NLDAS routing model start mode:
NLDAS routing model restart file:
```

9.17.5. RAPID routing

`RAPID routing model time step:` specifies the timestep for the RAPID router.

See Section Defining a time interval for a description of how to specify a time interval.

`RAPID river routing time step:` specifies the timestep for RAPID river routing precedure.

`RAPID routing model output interval:` defines the output writing interval for the RAPID router.

See Section Defining a time interval for a description of how to specify a time interval.

`RAPID routing model restart interval:` defines the restart output writing interval for the RAPID router.

See Section Defining a time interval for a description of how to specify a time interval.

`RAPID routing model start mode:` specifies the restart mode to be used for the RAPID router. Acceptable values are:

Value	Description
restart	A restart mode is being used; read a RAPID restart file
coldstart	A cold start mode is being used; no restart file read

`RAPID run in ensemble mode:` specifies whether to run the RAPID router in ensemble mode.

Acceptable values are:

Value	Description
0	Do not run in ensemble mode
1	Run in ensemble mean mode
2	Run in ensemble mode

`RAPID run option:` is set to 1 for a regular run. The other options are not supported yet.

`RAPID routing option:` is set to 1 for applying matrix-based Mukingum algorithm. The other options are not supported yet.

`RAPID cost function phi option:` is set to 1 for phi1. The other options are not supported yet.

`RAPID initial flow:` use initial instantaneous flow file. This option is not supported. Set to `.false.`.

`RAPID write final flow:` save final instantaneous flow file. This option is not supported. Set to `.false.`.

`RAPID compute volume:` compute flow volume. This option is not supported. Set to `.false.`.

`RAPID human-induced flow:` apply human-induced flow. This option is not supported. Set to `.false.`.

`RAPID upstream forcing:` use upstrem forcing. This option is not supported. Set to `.false.`.

`RAPID dam model used:` use dam model. This option is not supported. Set to `.false.`.

`RAPID output influence:` use output influence. This option is not supported. Set to `.false.`.

`RAPID uncertainty quantification:` use uncertainty quantification. This option is not supported. Set to `.false.`.

`RAPID river connectivity file:` specifies river connectivity file.

`RAPID max number of upstream reaches:` specifies maximum number of upstream reaches.

`RAPID river weight table:` specifies river weight table file.

`RAPID river basin ID file:` specifies river basin ID file.

`RAPID Muskingum parameter k file:` specifies Muskingum parameter k file.

`RAPID Muskingum parameter x file:` specifies Muskingum parameter x file.

`RAPID namelist file:` specifies namelist file.

Example lis.config entry

```
RAPID routing model time step: "1da"
RAPID river routing time step: "15mn"
RAPID routing model output interval: "1da"
RAPID routing model restart interval: "1mo"
RAPID routing model start mode: restart
RAPID routing model restart file:
./output/ol/ROUTING/200801/LIS_RST_RAPID_router_200801150000.d01.nc
RAPID run in ensemble mode: 0
RAPID run option: 1
RAPID routing option: 1
RAPID cost function phi option: 1
RAPID initial flow: .false.
RAPID write final flow: .false.
RAPID compute volume: .false.
RAPID human-induced flow: .false.
RAPID upstream forcing: .false.
RAPID dam model used: .false.
RAPID output influence: .false.
RAPID uncertainty quantification: .false.
RAPID river connectivity file: ./rapid_params/rapid_connect.csv
RAPID max number of upstream reaches:   3
RAPID river weight table: ./rapid_params/weight_lis.csv
RAPID river basin ID file: ./rapid_params/riv_bas_id.csv
RAPID Muskingum parameter k file: ./rapid_params/k.csv
RAPID Muskingum parameter x file: ./rapid_params/x.csv
RAPID namelist file: ./rapid_params/rapid_namelist
```

9.17.6. Crocus8.1

`CROCUS81 model timestep:` specifies the timestep for the run.

`CROCUS81 restart output interval:` defines the restart writing interval for Crocus8.1. The typical value is 1 month (1mo).

`CROCUS81 nsnow:` specifies the total number of snow layers.

`CROCUS81 nimpur:` specifies the number of impurity types Note: this option is not activated in the current version.

`CROCUS81 SNOWRES_opt:` specifies the turbulant exchange option. Acceptable values are:

Value	Description
DEF	Default: Louis (ISBA: Noilhan and Mahfouf 1996)
RIL	Limit Richarson number under very stable conditions (currently testing)

Value	Description
M98	Martin et Lejeune 1998: older computation for turbulent fluxes coefficents in Crocus

`CROCUS81 OMEB_BOOL:` Acceptable values are:

Value	Description
.true.	Coupled to MEB. This means surface fluxes ae IMPOSED as an upper boundary condition to the explicit snow schemes.
.false.	Then energy budget and fluxes are computed herein.

`CROCUS81 HIMPLICIT_WIND_opt:` specifies the wind implicitation option. Acceptable values are:

Value	Description
OLD	direct
NEW	Taylor series, order 1

`CROCUS81 PTSTEP:` must set to 900s because it has been used to compute the amount of snowfall to triger the CALL_MODEL.

`CROCUS81 UREF:` specifies the reference height of the wind.

`CROCUS81 ZREF:` specifies the reference height of the first atmospheric level.

`CROCUS81 Z0NAT:` specifies the grid box average roughness length.

`CROCUS81 Z0EFF:` specifies the roughness length for momentum.

`CROCUS81 Z0HNAT:` specifies the grid box average roughness length for heat.

`CROCUS81 D_G:` specifies the assumed first soil layer thickness (m).

`CROCUS81 SNOWDRIFT_opt:` Acceptable values are:

Value	Description
NONE	No snowdrift scheme
DFLT	falling snow falls as purely dendritic
GA01	Gallee et al 2001
VI13	Vionnet et al 2013

`CROCUS81 SNOWDRIFT_SUBLIM_BOOL:` activate sublimation during drift.

`CROCUS81 SNOW_ABS_ZENITH_BOOL:` activate parametrization of solar absorption for polar regions.

`CROCUS81 SNOWMETAMO_opt:` specifies the metamorphism scheme. Acceptable values are:

Value	Description
B92	Brun et al 1992
C13	Carmagnola et al 2014
T07	Taillandier et al 2007
F06	Flanner et al 2006

`CROCUS81 SNOWRAD_opt:` specifies the radiative transfer scheme. Acceptable values are:

Value	Description
B92	Brun et al 1992
T17	(Tuzet et al. 2017) (Libois et al. 2013)
TARTES	with impurities content scheme (Currently not available)

`CROCUS81 ATMORAD_BOOL:` activate atmotartes scheme.

`CROCUS81 IMPWET:` specifies the wet deposit impurity coefficient.

`CROCUS81 IMPDRY:` specifies the dry deposit impurity coefficient.

`CROCUS81 SNOWFALL_opt:` specifies the falling snow scheme. Acceptable values are:

Value	Description
V12	Vionnet et al. 2012 from Brun et al. 1989
A76	Anderson et al. 1976
S02	Lehning el al. 2002
P75	Pahaut 1975
NZE	Constant density 200 kg/m3 (who knows ?)

`CROCUS81 SNOWCOND_opt:` specifies the thermal conductivity scheme. Acceptable values are:

Value	Description
Y81	default Crocus from Yen et al. 1981
I02	ISBA_ES snow conductivity parametrization (Boone et al. 2002)
C11	Calonne et al. 2011 snow conductivity parametrization

`CROCUS81 SNOWHOLD_opt:` specifies the liquid water content scheme. Acceptable values are:

Value	Description
B92	default Crocus from Brun et al. 1992 or Vionnet et al. 2012
B02	ISBA_ES parametrization (Boone et al. 2002)
O04	CLM parametrization (Oleson et al 2004)
S02	SNOWPACK aprametrization (Lehning et al 2002)

`CROCUS81 SNOWCOMP_opt:` specifies the compaction option. Acceptable values are:

Value	Description
B92	snow compaction basis version
B93	for slightly different parameters

`CROCUS81 SNOWZREF_opt:` specifies the reference height is constant or variable from the snow surface. Acceptable values are:

Value	Description
CST	constant reference height from the snow surface
VAR	variable reference height from the snow surface (i.e. constant from the ground)

`CROCUS81 SNOWCOMPACT_BOOL:` activate snow comapction.

`CROCUS81 SNOWMAK_BOOL:` activate snowmaking.

`CROCUS81 SNOWTILLER_BOOL:` activate Tilling.

`CROCUS81 SELF_PROD_BOOL:` snow management option.

`CROCUS81 SNOWMAK_PROP_BOOL:` Additionnal boolean to use modified properties of machine made snow (MMS) or not.

`CROCUS81 PRODSNOWMAK_BOOL:` activate snowmaking daytime.

`CROCUS81 GLACIER_BOOL:` Acceptable values are:

Value	Description
.true.	Over permanent snow and ice, initialise WGI=WSAT, Hsnow>=10m and allow 0.8<SNOALB<0.85
.false.	No specific treatment

`CROCUS81 TG:` specifies the surface soil temperature (effective temperature the of layer lying below snow).

`CROCUS81 use monthly albedo map:` Acceptable values are:

Value	Description
.true.	use monthly climatology albedo
.false.	use constant value of 0.2

`CROCUS81 boolean option to partition total precip:` Acceptable values are:

Value	Description
.true.	forcing only provides total precip
.false.	forcing contains snowfall and rainfall

`CROCUS81 restart file:` specifies the Crocus restart file.

`CROCUS81 restart file format:` specifies the format for the Crocus8.1 restart file.

`CROCUS81 initial SNOWSWE:` specifies the initial snow SWE (kg/m2).

`CROCUS81 initial SNOWRHO:` specifies the initial snow layer(s) density (kg/m3).

`CROCUS81 initial SNOWHEAT:` specifies the initial snow layer(s) heat content (J/m2).

`CROCUS81 initial SNOWALB:` specifies the initial surface albedo.

`CROCUS81 initial SNOWGRAN1:` specifies the initial Snow layer(s) grain parameter 1.

`CROCUS81 initial SNOWGRAN2:` specifies the initial Snow layer(s) grain parameter 1.

`CROCUS81 initial SNOWHIST:` specifies the initial Snow layer(s) Historical parameter (-) in [0-5].

`CROCUS81 initial SNOWLIQ:` specifies the initial Snow layer(s) liquid water content (m).

`ROCUS81 initial SNOWTEMP: specifies the initial Snow layer(s) temperature (K).

`CROCUS81 initial SNOWDZ:` specifies the initial Snow layer(s) thickness (m).

`CROCUS81 initial GRNDFLUX:` specifies the initial Soil/snow interface heat flux (W/m2).

`CROCUS81 initial SNDRIFT:` specifies the initial Blowing snow sublimation (kg/m2/s). Note: Snow compaction and metamorphism due to drift, Mass is unchanged.

`CROCUS81 initial RI_n:` specifies the initial Richardson number.

`ROCUS81 initial CDSNOW:` specifies the initial drag coefficient for momentum over snow.

`CROCUS81 initial USTARSNOW:` specifies the initial Friction velocity over snow (m/s).

`CROCUS81 initial CHSNOW:` specifies the initial Drag coefficient for heat over snow (-).

`CROCUS81 initial SNOWMAK_dz:` specifies the initial depth from snow making process.

Example lis.config entry

```
CROCUS81 model timestep:                   15mn
CROCUS81 restart output interval:          1mo
CROCUS81 nsnow:                            50
CROCUS81 nimpur:                           2
CROCUS81 SNOWRES_opt:                      "DEF"
CROCUS81 OMEB_BOOL:                       .FALSE.
CROCUS81 HIMPLICIT_WIND_opt:              "NEW"
CROCUS81 PTSTEP:                           900
CROCUS81 UREF:                             10
CROCUS81 ZREF:                             1.5
CROCUS81 Z0NAT:                            0.005
CROCUS81 Z0EFF:                            0.001
CROCUS81 Z0HNAT:                           0.0005
CROCUS81 D_G:                              0.01
CROCUS81 SNOWDRIFT_opt:                    "NONE"
CROCUS81 SNOWDRIFT_SUBLIM_BOOL:            .FALSE.
CROCUS81 SNOW_ABS_ZENITH_BOOL:             .FALSE.
CROCUS81 SNOWMETAMO_opt:                   "C13"
CROCUS81 SNOWRAD_opt:                      "B92"
CROCUS81 ATMORAD_BOOL:                     .FALSE.
CROCUS81 IMPWET:                           0.0 0.0
CROCUS81 IMPDRY:                           0.0 0.0
CROCUS81 SNOWFALL_opt:                     "V12"
CROCUS81 SNOWCOND_opt:                     "Y81"
CROCUS81 SNOWHOLD_opt:                     "B92"
CROCUS81 SNOWCOMP_opt:                     "B92"
CROCUS81 SNOWZREF_opt:                     "CST"
CROCUS81 SNOWCOMPACT_BOOL:                 .FALSE.
CROCUS81 SNOWMAK_BOOL:                     .FALSE.
CROCUS81 SNOWTILLER_BOOL:                  .FALSE.
CROCUS81 SELF_PROD_BOOL:                   .FALSE.
CROCUS81 SNOWMAK_PROP_BOOL:                .FALSE.
CROCUS81 PRODSNOWMAK_BOOL:                 .FALSE.
CROCUS81 GLACIER_BOOL:                     .FALSE.
CROCUS81 TG:                               273.15
CROCUS81 use monthly albedo map:           .TRUE.
CROCUS81 boolean option to partition total precip:
CROCUS81 restart file:
output/SURFACEMODEL/201708/LIS_RST_CROCUS81_201708312345.d01.nc
CROCUS81 restart file format:              netcdf
CROCUS81 initial SNOWSWE: 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
CROCUS81 initial SNOWRHO: 10000000000 10000000000 10000000000 10000000000 10000000000
10000000000 10000000000 10000000000 10000000000 10000000000 10000000000 10000000000
10000000000 10000000000 10000000000 10000000000 10000000000 10000000000 10000000000
10000000000 10000000000 10000000000 10000000000 10000000000 10000000000 10000000000
10000000000 10000000000 10000000000 10000000000 10000000000 10000000000 10000000000
10000000000 10000000000 10000000000 10000000000 10000000000 10000000000 10000000000
```

```
10000000000 10000000000 10000000000 10000000000 10000000000 10000000000 10000000000
10000000000 10000000000 10000000000
CROCUS81 initial SNOWHEAT: 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
CROCUS81 initial SNOWALB: 0.0
CROCUS81 initial SNOWGRAN1: 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
CROCUS81 initial SNOWGRAN2: 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
CROCUS81 initial SNOWHIST: 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
CROCUS81 initial SNOWAGE: 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
CROCUS81 initial SNOWLIQ: 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
CROCUS81 initial SNOWTEMP: 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
CROCUS81 initial SNOWDZ: 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0  0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0
CROCUS81 initial GRNDFLUX: 0.0
CROCUS81 initial SNDRIFT: 0.0
CROCUS81 initial RI_n: 0.0
CROCUS81 initial CDSNOW: 0.0
CROCUS81 initial USTARSNOW: 0.0
CROCUS81 initial CHSNOW: 0.0
CROCUS81 initial SNOWMAK_dz: 0.0
```

9.18. Runoff

9.18.1. ERA interim land runoff

`ERA interim land runoff data output directory:` specifies directory where ERA interim outputs are located.

`ERA interim land runoff data output interval:` specifies ERA interim output time step

Example lis.config entry

```
ERA interim land runoff data output directory: ./ERAI_OUTPUT/
ERA interim land runoff data output interval: "1da"
```

9.18.2. GLDAS1 runoff

`GLDAS1 runoff data output directory:` specifies directory where GLDAS1 outputs are located.

`GLDAS1 runoff data model name:` specifies GLDAS1 land surface model name.

`GLDAS1 runoff data spatial resolution (degree):` specifies GLDAS1 output spatial resolution

`GLDAS1 runoff data output interval:` specifies GLDAS1 output time step

Example lis.config entry

```
GLDAS1 runoff data output directory: ./GLDAS1_OUTPUT/
GLDAS1 runoff data model name:  VIC
GLDAS1 runoff data spatial resolution (degree): 0.25
GLDAS1 runoff data output interval: "1da"
```

9.18.3. GLDAS2 runoff

`GLDAS2 runoff data output directory:` specifies directory where GLDAS2 outputs are located.

`GLDAS2 runoff data model name:` specifies GLDAS2 land surface model name.

`GLDAS2 runoff data spatial resolution (degree):` specifies GLDAS2 output spatial resolution

`GLDAS2 runoff data output interval:` specifies GLDAS2 output time step

Example lis.config entry

```
GLDAS2 runoff data output directory: ./GLDAS2_OUTPUT/
GLDAS2 runoff data model name:  VIC
GLDAS2 runoff data spatial resolution (degree): 0.25
GLDAS2 runoff data output interval: "1da"
```

9.18.4. GWBMIP runoff

`GWBMIP runoff data output directory:` specifies directory where GWBMIP outputs are located.

`GWBMIP runoff data model name prefix:` specifies GWBMIP land surface model used.

`GWBMIP runoff data output interval:` specifies GWBMIP output time step

Example lis.config entry

```
GWBMIP runoff data output directory: ./GWBMIP_OUTPUT/
GWBMIP runoff data model name prefix: NOAH33
GWBMIP runoff data output interval: "1da"
```

9.18.5. LIS runoff

`LIS runoff output directory:` specifies directory where LIS outputs are located.

`LIS runoff output interval:` specifies LIS output time step

`LIS runoff output domain file:` specifies location of the LIS runoff output domain file.

Example lis.config entry

```
LIS runoff output directory: ./LIS_OUTPUT/
LIS runoff output interval: "1da"
LIS runoff output domain file: ./LIS_OUTPUT/lis_input_010_hybrid.nc
```

9.18.6. MERRA2 runoff

`MERRA2 runoff data output directory:` specifies directory where MERRA2 outputs are located.

`MERRA2 runoff data output interval:` specifies MERRA2 output time step

Example lis.config entry

```
MERRA2 runoff data output directory: ./MERRA2_OUTPUT/
MERRA2 runoff data output interval: "1da"
```

9.18.7. NLDAS2 runoff

`NLDAS2 runoff data output directory:` specifies directory where NLDAS2 outputs are located.

`NLDAS2 runoff data model name:` specifies NLDAS2 land surface model used.

`NLDAS2 runoff data output interval:` specifies NLDAS2 output time step

Example lis.config entry

```
NLDAS2 runoff data output directory: ./NLDAS2_OUTPUT/
NLDAS2 runoff data model name:  NOAH
NLDAS2 runoff data output interval: "1da"
```

9.19. Model output configuration

The output start time is used to define when to begin writing model output. Any value not defined will default to the corresponding LIS start time. The output start time does not affect restart writing. Restart files are written according to the LIS start time and the model restart output interval value.

The output start time is specified in the following format:

Variable	Value	Description
`Output start year:`	integer 2001 – present	specifying output start year
`Output start month:`	integer 1 – 12	specifying output start month
`Output start day:`	integer 1 – 31	specifying output start day
`Output start hour:`	integer 0 – 23	specifying output start hour
`Output start minutes:`	integer 0 – 59	specifying output start minute
`Output start seconds:`	integer 0 – 59	specifying output start second

Writing output may be restricted to a specified time with respect to any year. To restrict output to a specified time, you must set `Output at specific time only:` to 1, and then you must specify the specific output writing time. If you choose not to restrict output writing to a specified time, then you do not have to set the specific output writing time variables.

`Output at specific time only:` specifies whether to write output only at a specified time. Defaults to 0. Acceptable values are:

Value	Description
0	Do not restrict output to a specified time
1	Restrict output to a specified time

The specific output writing time is specified in the following format:

Variable	Value	Description
`Specific output writing time (month):`	integer 1 – 12	specifying output month
`Specific output writing time (day):`	integer 1 – 31	specifying output day
`Specific output writing time (hour):`	integer 0 – 23	specifying output hour
`Specific output writing time (minute):`	integer 0 – 59	specifying output minute
`Specific output writing time (second):`	integer 0 – 59	specifying output second

Example lis.config entry

```
Output start year:
Output start month:
Output start day:
Output start hour:
Output start minutes:
Output start seconds:
Output at specific time only:
Specific output writing time (month):
Specific output writing time (day):
Specific output writing time (hour):
Specific output writing time (minute):
Specific output writing time (second):
```

`Model output attributes file:` specifies the attributes to be used for a customizable model output. Please refer to the sample MODEL_OUTPUT_LIST.TBL file for the complete specification.

Example lis.config entry

```
Model output attributes file: './MODEL_OUTPUT_LIST.TBL'
```

9.20. Defining a time interval

Time interval values must be entered in a format where the timestep value is followed by 2 character string indicating the time units.

Examples include: 60ss, 30mn, 2hr, 0.5da

Acceptable values for the timestep units are:

Value	Description
ss	seconds
mn	minutes
hr	hours
da	days
mo	months
yr	years

Units of months assumes a 30-day month.

Units of years assumes a 365-day year.

Chapter 10. Specification of Input Forcing Variables

This section defines the specification of the input forcing variables for LIS. This file is specified in a space delimited column format. Each row consists of the following entries:

`Short Name` short name of the forcing variable.

`Use option` determines whether to include this the variable for use within LIS Acceptable values are:

Value	Description
0	do not include the variable
1	include the variable

`Number of vertical levels` The number of vertical levels corresponding to the variable.

`Units` specified unit of the variable.

Note that this is a full list of input forcing variables. Not all models use all these variables.

Note that being listed in the *forcing_variables.txt* file does not guarantee that the field will be available within LIS. Availablity depends on the support provided by the base forcing and supplemental forcing schemes selected in the *lis.config* run-time configuration file.

```
#short name  select  vlevels  units
Tair:       1  1  K       # Near surface air temperature
Qair:       1  1  kg/kg   # Near surface specific humidity
SWdown:     1  1  W/m2    # Incident shortwave radiation (total)
SWdirect:   0  1  W/m2    # Incident shortwave radiation (direct)
SWdiffuse:  0  1  W/m2    # Incident shortwave radiation (diffuse)
LWdown:     1  1  W/m2    # Incident longwave radiation
Wind_E:     1  1  m/s     # Eastward wind
Wind_N:     1  1  m/s     # Northward wind
Psurf:      1  1  Pa      # Surface pressure
Rainf:      1  1  kg/m2s  # Rainfall rate
Snowf:      0  1  kg/m2s  # Snowfall rate
CRainf:     1  1  kg/m2s  # Convective rainfall rate
Forc_Hgt:   0  1  m       # Height of forcing variables
Ch:         0  1  -       # Surface exchange coefficient for heat
Cm:         0  1  -       # Surface exchange coefficient for momentum
Q2sat:      0  1  -       # Saturated mixing ratio
Emiss:      0  1  -       # Surface emissivity
Cosz:       0  1  -       # Cosine of zenith angle
Albedo:     0  1  -       # Surface albedo
PARDR:      0  1  -       # Photosynthetically Active Direct Radiation
PARDF:      0  1  -       # Photosynthetically Active Diffuse Radiation
SWnet:      0  1  -       # Net Shortwave Radiation at the Surface
PET:        0  1  kg/m2s  # Potential ET
RefET:      0  1  kg/m2s  # Reference ET
CAPE:       0  1  J/kg    # Convective Available Potential Energy
LPressure:  0  1  Pa      # Level pressure
O3:         0  1  -       # Ozone concentration
Xice:       0  1  -       # Sea ice mask
QSFC:       0  1  kg/kg   # Surface specific humidity
CHS2:       0  1  -       # 2m Surface Exchange Coefficient for Heat
CQS2:       0  1  -       # 2m Surface Exchange Coefficient for Moisture
T2:         0  1  K       # 2m Air Temperature
Q2:         0  1  kg/kg   # 2m Specific Humidity
TH2:        0  1  K       # 2m Potential Temperature
TMN:        0  1  K       # Soil Temperature at Lower Boundary
Snowflag:   0  1  -       # Snowflag
Density:    0  1  kg/m3   # Atmospheric Density
VaporPress: 0  1  Pa      # Vapor Pressure
VaporPressDeficit: 0 1 Pa # Vapor Pressure Deficit
Wind:       0  1  m/s     # Wind Speed
```

Chapter 11. Model Output Specifications

This section defines the specification of the model output from LIS. This file is specified in a space delimited column format. Each row consists of the following entries:

`Short Name` specifies the ALMA compliant short name of the variable.

`Use option` specifies whether to write the variable. Acceptable values are:

Value	Description
0	do not write the variable
1	write the variable

`Units:` specifies the desired units of the output variable. You must check the source code to determine all the units that are available for each output variable.

`Sign Convention:` specifies the direction in which the variable is considered to have positive values. Note that the land models in LIS employ the "traditional approach" where all variables are considered positive in their dominant direction. i.e. precipitation and radiation are positive towards the surface (downward), evaporation, sensible heat and runoff are positive away from the surface.

Acceptable values are:

Value		Description
-		No sign
UP	DN	Up or Down (Used for fluxes, Precip)
IN	OUT	In or Out of the grid cell (Used for runoff, baseflow)
INC	DEC	Increase or Decrease (Used for change in storager terms)
S2L	L2S	Solid to Liquid and Liquid to Solid (for phase change terms)
S2V	V2S	Solid to Vapor and Vapor to Solid (for phase change terms)
E	N	Eastward and Northward (used for Wind components)

`Time Average option` determines how temporally process the variable. Acceptable values are:

Value	Description
0	Instantaneous output
1	Time averaged output
2	Instantaneous and Time averaged output
3	Accumulated output

`Min/Max option` determines whether to record minimum and maximum values for the variable. For a given grid-cell, the minimum and maximum values correspond to the minimum and maximum found for all subgrid tiles and ensembles contained in the grid-cell during that output interval. Acceptable values are:

Value	Description
0	Do not compute minimum and maximum values
1	Do compute minimum and maximum values

`Standard Deviation option` determines whether to record the standard deviation of the values for the variable. For a given grid-cell, the standard deviation is a measure of the spread of the subgrid tiles and ensembles contained within the grid-cell from the grid-cell's mean. Acceptable values are:

Value	Description
0	Do not compute standard deviation
1	Do compute standard deviation

`Number of vertical levels` specifies the number of vertical levels corresponding to the variable.

`grib ID` specifies the grib ID to be used for the variable when output is written in grib1 format.

`grib scale factor` specifies the grib scale factor to be used for the variable when output is written in grib1 format.

Note that this is a full list of output variables. Not all models support all these variables. You must check the source code to verify that the model you want to run supports the variables that you want to write. \footnotesize

```
#short_name select? units signconv timeavg? min/max? std? vert.levels grib_id
grib_scalefactor longname

#Energy balance components
Swnet:        1  W/m2    DN   1 0 0 1 111 10      # Net shortwave radiation (W/m2)
Lwnet:        1  W/m2    DN   1 0 0 1 112 10      # Net longwave radiation (W/m2)
Qle:          1  W/m2    UP   1 0 0 1 121 10      # Latent heat flux (W/m2)
Qh:           1  W/m2    UP   1 0 0 1 122 10      # Sensible heat flux (W/m2)
Qg:           1  W/m2    DN   1 0 0 1 155 10      # Ground heat flux (W/m2)
Qf:           0  W/m2    S2L  1 0 0 1 229 10      # Energy of fusion (W/m2)
Qv:           0  W/m2    S2V  1 0 0 1 198 10      # Energy of sublimation (W/m2)
Qa:           0  W/m2    DN   1 0 0 1 136 10      # Advective energy (W/m2)
```

```
Qtau:         0  N/m2    DN   1 0 0 1 172 10      # Momentum flux (N/m2)
DelSurfHeat:  0  J/m2    INC  1 0 0 1 137 10      # Change in surface heat storage
(J/m2)
DelColdCont:  0  J/m2    INC  1 0 0 1 138 10      # Change in snow cold content (J/m2)
BR:           0  -       -    1 0 1 1 256 10      # Bowen ratio
EF:           0  -       -    1 0 1 1 256 10      # Evaporative fraction
Rnet:         0  W/m2    DN   1 0 1 1 256 10      # Total net radiation

#Water balance components
Snowf:        1  kg/m2s  DN   1 0 0 1 161 10000   # Snowfall rate (kg/m2s)
Rainf:        1  kg/m2s  DN   1 0 0 1 162 10000   # Rainfall rate (kg/m2s)
RainfConv:    1  kg/m2s  DN   1 0 0 1  63 10000   # Convective rainfall rate (kg/m2s)
TotalPrecip:  1  kg/m2s  DN   1 0 0 1  61 10000   # Total precipitation rate (kg/m2s)
Evap:         1  kg/m2s  UP   1 0 0 1  57 10000   # Total evapotranspiration (kg/m2s)
Qs:           1  kg/m2s  OUT  1 0 0 1 235 10000   # Surface runoff (kg/m2s)
Qrec:         0  kg/m2s  IN   1 0 0 1 163 10000   # Recharge (kg/m2s)
Qsb:          1  kg/m2s  OUT  1 0 0 1 234 10000   # Subsurface runoff (kg/m2s)
Qtot:         1  kg/m2s  OUT  1 0 0 1 235 10000   # Total runoff or discharge to
stream (kg/m2s)
Qsm:          0  kg/m2s  S2L  1 0 0 1  99 10000   # Snowmelt (kg/m2s)
Qfz:          0  kg/m2s  L2S  1 0 0 1 130 10000   # Refreezing of water in the
snowpack (kg/m2s)
Qst:          0  kg/m2s  -    1 0 0 1 131 10000   # Snow throughfall (kg/m2s)
DelSoilMoist: 0  kg/m2   INC  1 0 0 1 132 10000   # Change in soil moisture (kg/m2)
DelSWE:       0  kg/m2   INC  1 0 0 1 133 1000    # Change in snow water equivalent
(kg/m2)
DelSurfStor:  0  kg/m2   INC  1 0 0 1 134 1000    # Change in surface water storage
(kg/m2)
DelIntercept: 0  kg/m2   INC  1 0 0 1 135 1000    # Change in interception storage
(kg/m2)
RHMin:        0  -       -    1 0 0 1  52 10      # Minimum 2-meter relative humidity
(-)
Ch:           0  m/s     -    1 0 0 1 208 10      # Surface exchange coefficient for
heat
Cm:           0  m/s     -    1 0 0 1 252 10      # Surface exchange coefficient for
momentum

#Surface state variables
SnowT:        0  K       -    1 0 0 1 165 10      # Snow surface temperature (K)
VegT:         0  K       -    1 0 0 1 146 10      # Vegetation canopy temperature (K)
BareSoilT:    0  K       -    1 0 0 1 147 10      # Temperature of bare soil (K)
AvgSurfT:     1  K       -    1 0 0 1 148 10      # Average surface temperature (K)
RadT:         0  K       -    1 0 0 1 149 10      # Surface radiative temperature (K)
Albedo:       1  -       -    0 0 0 1  84 100     # Surface albedo (-)
SWE:          1  kg/m2   -    0 0 0 1  65 1000    # Snow Water Equivalent (kg/m2)
SWEVeg:       0  kg/m2   -    1 0 0 1 139 1000    # SWE intercepted by vegetation
(kg/m2)
SurfStor:     0  kg/m2   -    1 0 0 1 150 1000    # Surface water storage (kg/m2)

#Subsurface state variables
SoilMoist:    1  kg/m2   -    0 0 0 4  86 1000    # Average layer soil moisture
```

```
(kg/m2)
SoilTemp:     1  K       -    0 0 0 4  85 1000    # Average layer soil temperature (K)
SmLiqFrac:    0  -       -    0 0 0 4 160 100     # Average layer fraction of liquid
moisture (-)
SmFrozFrac:   0  -       -    0 0 0 4 140 100     # Average layer fraction of frozen
moisture (-)
SoilWet:      0  -       -    0 0 0 1 144 100     # Total soil wetness (-)
RelSMC:       0  m3/m3   -    0 0 0 4 141 1000    # Relative soil moisture
RootTemp:     0  K       -    0 0 0 1 142 1000    # Rootzone temperature (K)

#Evaporation components
PotEvap:      0  kg/m2s  UP   1 0 0 1 145 1       # Potential evapotranspiration
(kg/m2s)
ECanop:       0  kg/m2s  UP   1 0 0 1 200 1       # Interception evaporation (kg/m2s)
TVeg:         0  kg/m2s  UP   1 0 0 1 210 1       # Vegetation transpiration (kg/m2s)
ESoil:        0  kg/m2s  UP   1 0 0 1 199 1       # Bare soil evaporation (kg/m2s)
EWater:       0  kg/m2s  UP   1 0 0 1 197 1       # Open water evaporation (kg/m2s)
RootMoist:    0  kg/m2   -    0 0 0 1 171 1       # Root zone soil moisture (kg/m2)
CanopInt:     0  kg/m2   -    0 0 0 1 223 1000    # Total canopy water storage (kg/m2)
EvapSnow:     0  kg/m2s  -    1 0 0 1 173 1000    # Snow evaporation (kg/m2s)
SubSnow:      0  kg/m2s  -    1 0 0 1 198 1000    # Snow sublimation (kg/m2s)
SubSurf:      0  kg/m2s  -    1 0 0 1 143 1000    # Sublimation of the snow free area
(kg/m2s)
ACond:        0  m/s     -    1 0 0 1 179 100000  # Aerodynamic conductance
CCond:        0  m/s     -    1 0 0 1 181 100000  # Canopy conductance
SoilET:       0  kg/m2   -    1 0 0 1 256 1       # Soil evaporation
AResist:      0  s/m     -    1 0 0 1 256 1       # Aerodynamic resistance

#Other hydrologic variables
WaterTableD:  0  m       -    0 0 0 1 174 1       # Water table depth (m)
TWS:          0  mm      -    0 0 0 1 175 1       # Terrestrial water storage (mm)
GWS:          0  mm      -    0 0 0 1 176 1       # Ground water storage (mm)

#Cold season processes
Snowcover:    0  -       -    0 0 0 1 238 100     # Snow cover (-)
SAlbedo:      0  -       -    0 0 0 1 184 1000    # Albedo of the snow-covered area (-
)
SnowTProf:    0  K       -    0 0 0 1 239 1000    # Temperature of the snow pack (K)
SnowDepth:    0  m       -    0 0 0 1  66 1000    # Snow depth (m)
SLiqFrac:     0  -       -    0 0 0 1 185 1000    # Fraction of SWE in the liquid
phase
SnowThresh:   0  -       -    0 0 0 1  66 1000    # Snow depth threshold (m)

#Variables to compared against remote sensed data
LWup:         0  W/m2    UP   1 0 0 1 212 1       # Longwave radiation up from the
surface (W/m2)

#Carbon variables
GPP:          0  kg/m2s2 DN   1 0 0 1 256 1       # Gross Primary Production
NPP:          0  kg/m2s2 DN   1 0 0 1 256 1       # Net Primary Production
NEE:          0  kg/m2s2 UP   1 0 0 1 256 1       # Net Ecosystem Exchange
```

```
AutoResp:     0  kg/m2s2 UP   1 0 0 1 256 1      # Autotrophic respiration
HeteroResp:   0  kg/m2s2 UP   1 0 0 1 256 1      # Heterotrophic respiration
LeafResp:     0  kg/m2s2 UP   1 0 0 1 256 1      # Leaf respiration
TotSoilCarb:  0  kg/m2   -    1 0 0 1 256 1      # Total soil carbon
TotLivBiom:   0  kg/m2   -    1 0 0 1 256 1      # Total living biomass

#Forcings
Wind_f:       1  m/s     -    1 0 0 1  32 10     # Near surface wind (m/s)
Rainf_f:      1  kg/m2s  DN   1 0 0 1 162 1000   # Average rainfall rate
Snowf_f:      0  kg/m2s  DN   1 0 0 1 161 1000   # Average snowfall rate
CRainf_f:     1  kg/m2   DN   1 0 0 1  63 1000   # Average convective rainfall rate
Tair_f:       1  K       -    1 0 0 1  11 10     # Near surface air temperature
Qair_f:       1  kg/kg   -    1 0 0 1  51 1000   # Near surface specific humidity
Psurf_f:      1  Pa      -    1 0 0 1   1 10     # Surface pressure
SWdown_f:     1  W/m2    DN   1 0 0 1 204 10     # Surface incident shortwave
radiation
LWdown_f:     1  W/m2    DN   1 0 0 1 205 10     # Surface incident longwave
radiation
PARDR_f:      0  W/m2    DN   1 0 0 1 256 10     # Surface incident PAR direct
PARDF_f:      0  W/m2    DN   1 0 0 1 256 10     # Surface incident PAR diffuse

#Additional forcings
DirectSW_f:   0  W/m2    -    1 0 0 1 166 10     # Surface direct incident shortwave
radiation
DiffuseSW_f:  0  W/m2    -    1 0 0 1 167 10     # Surface diffuse incident shortwave
radiation
NWind_f:      0  m/s     N    1 0 0 1  34 10     # Northward wind
EWind_f:      0  m/s     E    1 0 0 1  33 10     # Eastward wind
FHeight_f:    0  m       -    1 0 0 1 256 10     # Height of forcing variables
Ch_f:         0  m/s     -    1 0 0 1 208 10     # Surface exchange coefficient for
heat
Cm_f:         0  m/s     -    1 0 0 1 252 10     # Surface exchange coefficient for
momentum
Emiss_f:      0  -       -    1 0 0 1 256 10     # Surface emissivity
MixRatio_f:   0  kg/kg   -    1 0 0 1  53 10     # Surface mixing ratio
CosZenith_f:  0  -       -    1 0 0 1 256 10     # Cosine of zenith angle
Albedo_f:     0  -       -    1 0 0 1  84 10     # Surface albedo
CAPE_f:       0  J/kg    -    1 0 0 1 157 10     # Convective Available Potential
Energy
Z0brd:        0  m       -    1 0 0 1 256 1      # Z0brd
T2diag:       0  K       -    1 0 0 1 256 1      # Diagnostic t2
Q2diag:       0  kg/kg   -    1 0 0 1 256 1      # Diagnostic q2
Snowflag_f:   0  -       -    1 0 0 1 256 1      # Snowflag
Density_f:    0  kg/m3   -    1 0 0 1 256 1      # Atmospheric density
VaporPress_f: 0  -       -    1 0 0 1 256 1      # Vapor pressure
VaporPressDeficit_f: 0  -  -  1 0 0 1 256 1      # Vapor pressure deficit

#Additional FEWSNET Forcings
PET_f:         0 kg/m2s  -    0 0 0 1 228 1000   # Average PET rate
RefET_f:       0 kg/m2s  -    0 0 0 1 256 1000   # Average RefET rate
TotalPrecip_f: 0 kg/m2   DN   0 0 0 1 256 1000   # Total precipitation
```

```
#Parameters
Landmask:     0  -       -    0 0 0 1  81 1       # Land mask (0 - Water, 1 - Land)
Landcover:    0  -       -    0 0 0 1 225 1       # Land cover
Soiltype:     0  -       -    0 0 0 1 224 1       # Soil type
SandFrac:     0  -       -    0 0 0 1 256 1       # Sand fraction
ClayFrac:     0  -       -    0 0 0 1 256 1       # Clay fraction
SiltFrac:     0  -       -    0 0 0 1 256 1       # Silt fraction
Porosity:     0  -       -    0 0 0 1 240 1       # Porosity
Soilcolor:    0  -       -    0 0 0 1 256 1       # Soil color
Elevation:    0  m       -    0 0 0 1 196 10      # Elevation
Slope:        0  -       -    0 0 0 1 222 10      # Slope
LAI:          0  -       -    0 0 0 1 182 100     # LAI
SAI:          0  -       -    0 0 0 1 256 100     # SAI
Snfralbedo:   0  -       -    0 0 0 1 184 100     # Snow fraction albedo
Mxsnalbedo:   0  -       -    0 0 0 1 159 100     # Maximum snow albedo
Greenness:    0  -       -    0 0 0 1  87 100     # Greenness
Roughness:    0  m       -    0 0 0 1  83 10      # Roughness
Tempbot:      0  K       -    0 0 0 1 256 10      # Bottom soil temperature

#Routing
Streamflow:   0  m3/s    -    1 0 0 1 256 10      # Streamflow

#VIC PET output
vic_pet_satsoil:  0  kg/m2s  -    1 0 0 1 166 1   # Potential evap from saturated bare
soil
vic_pet_h2osurf:  0  kg/m2s  -    1 0 0 1 166 1   # Potential evap from open water
vic_pet_short:    0  kg/m2s  -    1 0 0 1 166 1   # Potential evap (transpiration
only) from short reference crop (grass)
vic_pet_tall:     0  kg/m2s  -    1 0 0 1 166 1   # Potential evap (transpiration
only) from tall reference crop (alfalfa)
vic_pet_natveg:   0  kg/m2s  -    1 0 0 1 166 1   # Potential evap (transpiration
only) from current vegetation and current canopy resistance
vic_pet_vegnocr:  0  kg/m2s  -    1 0 0 1 166 1   # Potential evap (transpiration
only) from current vegetation and 0 canopy resistance

#FLDAS-WRSI components
SOS:                      0      - - 0 0 0 1 0 10 # Start-of-season [in dekads]
WRSI:                     0      - - 0 0 0 1 0 10 # Water requirement satisfaction
index [ratio]
KF2:                      0      % - 0 0 0 1 0 10 # Percent of Season [%]
SumWR:                    0  kg/m2 - 0 0 0 1 0 10 # Sum of Water Requirement [mm]
SumET:                    0  kg/m2 - 0 0 0 1 0 10 # Sum of Evapotranspiration [mm]
SWI:                      0      % - 0 0 0 1 0 10 # Soil Water Index [%]
SOSa:                     0      - - 0 0 0 1 0 10 # Start-of-season Anomaly [in
dekads]
TotalSurplusWater:        0  kg/m2 - 0 0 0 1 0 10 # Total surplus water [mm]
MaxSurplusWater:          0  kg/m2 - 0 0 0 1 0 10 # Max surplus water experienced in 1
dekad [mm]
TotalWaterDeficit:        0  kg/m2 - 0 0 0 1 0 10 # Total water deficit [mm]
MaxWaterDeficit:          0  kg/m2 - 0 0 0 1 0 10 # Max water deficit experienced in 1
```

```
dekad [mm]
TotalAETInitial:          0  kg/m2 - 0 0 0 1 0 10 # Actual evapotranspiration ~
Initial stage [mm]
TotalWRInitial:           0  kg/m2 - 0 0 0 1 0 10 # Water requirement ~ Initial stage
[mm]
TotalSurplusWaterInitial: 0  kg/m2 - 0 0 0 1 0 10 # Surplus water ~ Initial stage [mm]
TotalWaterDeficitInitial: 0  kg/m2 - 0 0 0 1 0 10 # Water deficit ~ Initial stage [mm]
TotalAETVeg:              0  kg/m2 - 0 0 0 1 0 10 # Actual evapotranspiration ~
Vegetative stage [mm]
TotalWRVeg:               0  kg/m2 - 0 0 0 1 0 10 # Water requirement ~ Vegetative
stage [mm]
TotalSurplusWaterVeg:     0  kg/m2 - 0 0 0 1 0 10 # Surplus water ~ Vegetative stage
[mm]
TotalWaterDeficitVeg:     0  kg/m2 - 0 0 0 1 0 10 # Water deficit ~ Vegetative stage
[mm]
TotalAETFlower:           0  kg/m2 - 0 0 0 1 0 10 # Actual evapotranspiration ~
Flowering stage [mm]
TotalWRFlower:            0  kg/m2 - 0 0 0 1 0 10 # Water requirement ~ Flowering
stage [mm]
TotalSurplusWaterFlower:  0  kg/m2 - 0 0 0 1 0 10 # Surplus water ~ Flowering stage
[mm]
TotalWaterDeficitFlower:  0  kg/m2 - 0 0 0 1 0 10 # Water deficit ~ Flowering stage
[mm]
TotalAETRipe:             0  kg/m2 - 0 0 0 1 0 10 # Actual evapotranspiration ~
Ripening stage [mm]
TotalWRRipe:              0  kg/m2 - 0 0 0 1 0 10 # Water requirement ~ Ripening stage
[mm]
TotalSurplusWaterRipe:    0  kg/m2 - 0 0 0 1 0 10 # Surplus water ~ Ripening stage
[mm]
TotalWaterDeficitRipe:    0  kg/m2 - 0 0 0 1 0 10 # Water deficit ~ Ripening stage
[mm]
PermWiltDate:             0      - - 0 0 0 1 0 10 # Permanent wilting date [dekad]
Wilting1:                 0      - - 0 0 0 1 0 10 # First wilting date [dekad]
Wilting2:                 0      - - 0 0 0 1 0 10 # Second wilting date [dekad]
WRSIa:                    0      - - 0 0 0 1 0 10 # WRSI anomaly [-]
growing_season:           0      - - 0 0 0 1 0 10 # Growing season [season-year]
WHC:                      0  kg/m2 - 0 0 0 1 0 10 # Water holding capacity; parameter
[mm]
LGP:                      0      - - 0 0 0 1 0 10 # Length of growing period;
parameter [dekad]
WR_TimeStep:              0  kg/m2 - 0 0 0 1 0 10 # Water requirement per
timestep(dekad) [mm]
AET_TimeStep:             0  kg/m2 - 0 0 0 1 0 10 # Actual ET per timestep [mm]
WRSI_TimeStep:            0      - - 0 0 0 1 0 10 # WRSI per timestep [-]
SurplusWater_TimeStep:    0  kg/m2 - 0 0 0 1 0 10 # Surplus water per timestep [mm]

#SacHTET specific output
sac_tsint:       0  K        -   0 0 0 1 256 10  # Soil temperature of inteneded layer
sac_swint:       0  m3/m3    -   0 0 0 1 256 10  # Total volumetric soil moisture
content of intended layer
sac_swhint:      0  m3/m3    -   0 0 0 1 256 10  # Liquid volumetric soil moisture
```

```
content of intended layer
sac_frost:       0  -        -   0 0 0 1 256 10  # Frost
sac_uztwc:       0  mm       -   0 0 0 1 256 10  # UZTWC
sac_uzfwc:       0  mm       -   0 0 0 1 256 10  # UZFWC
sac_lztwc:       0  mm       -   0 0 0 1 256 10  # LZTWC
sac_lzfsc:       0  mm       -   0 0 0 1 256 10  # LZFSC
sac_lzfpc:       0  mm       -   0 0 0 1 256 10  # LZFPC
sac_adimpc:      0  mm       -   0 0 0 1 256 10  # ADIMPC
sac_uztwh:       0  mm       -   0 0 0 1 256 10  # UZTWH
sac_uzfwh:       0  mm       -   0 0 0 1 256 10  # UZFWH
sac_lztwh:       0  mm       -   0 0 0 1 256 10  # LZTWH
sac_lzfsh:       0  mm       -   0 0 0 1 256 10  # LZFSH
sac_lzfph:       0  mm       -   0 0 0 1 256 10  # LZFPH

#Snow17 specific output
snow17_swe:      0  kg/m2    -   0 0 0 1 256 10  # SWE
snow17_aeadj:    0  mm       -   0 0 0 1 256 10  # AEADJ
snow17_neghs:    0  mm       -   0 0 0 1 256 10  # NEGHS
snow17_liqw:     0  kg/m2    -   0 0 0 1 256 10  # LIQW
snow17_accmax:   0  mm       -   0 0 0 1 256 10  # ACCMAX
snow17_rmlt:     0  kg/m2    -   0 0 0 1 256 10  # RMLT

#Lake output
Lake_Tsnow:      0  K        -   0 0 0 1 256 10  # Lake temperature at the air snow
interface
Lake_Tice:       0  K        -   0 0 0 1 256 10  # Lake temperature at the snow snow
interface
Lake_Tmnw:       0  K        -   0 0 0 1 256 10  # Mean temperature of the water
column
Lake_Twml:       0  K        -   0 0 0 1 256 10  # Lake temperature of the mixed layer
Lake_Tbot:       0  K        -   0 0 0 1 256 10  # Lake temperature at the water
bottom
Lake_Tb1:        0  K        -   0 0 0 1 256 10  # Temperature at the bottom of upper
layer of sediments
Lake_CT:         0  -        -   0 0 0 1 256 10  # Thermocline shape factor of lake
Lake_Hice:       0  -        -   0 0 0 1 256 10  # Ice thickness above lake
Lake_Hml:        0  -        -   0 0 0 1 256 10  # Thickness of mixed layer of lake
Lake_Hb1:        0  -        -   0 0 0 1 256 10  # Thickness of upper layer of bottom
sediments
Lake_Walbedo:    0  -        -   0 0 0 1 256 10  # Water surface albedo over lake
Lake_IceAlbedo:  0  -        -   0 0 0 1 256 10  # Ice surface albedo over lake
Lake_SnowAlbedo: 0 -         -   0 0 0 1 256 10  # Snow surface albedo over lake
Lake_UFRa:       0  -        -   0 0 0 1 256 10  # Lake friction velocity in air
Lake_UFRw:       0  -        -   0 0 0 1 256 10  # Lake friction velocity in surface
water
Lake_WConv:      0  -        -   0 0 0 1 256 10  # Lake convective velocity scale
Lake_IW:         0  -        -   0 0 0 1 256 10  # Lake radiation flux at the
interface
Lake_Qbot:       0  -        -   0 0 0 1 256 10  # Lake heat flux across water
sediment boundary
```

```
#HyMAP routing output
RiverStor:       0  m3       -   0 0 0 1 256 10  # River water storage
RiverDepth:      0  m        -   0 0 0 1 256 10  # River depth
RiverVelocity:   0  m/s      -   0 0 0 1 256 10  # River flow velocity
FloodQ:          0  m3/s     -   0 0 0 1 256 10  # Floodplain water discharge
FloodEvap:       0  kg/m2s   -   0 0 0 1 256 10  # Floodplain evaporation
FloodStor:       0  m3       -   0 0 0 1 256 10  # Floodplain water storage
FloodDepth:      0  m        -   0 0 0 1 256 10  # Floodplain depth
FloodVelocity:   0  m/s      -   0 0 0 1 256 10  # Floodplain flow velocity
FloodedFrac:     0  -        -   0 0 0 1 256 10  # Flooded fraction
FloodedArea:     0  m2       -   0 0 0 1 256 10  # Flooded area
SurfElev:        0  m        -   0 0 0 1 256 10  # Surface water elevation
RunoffStor:      0  mm       -   0 0 0 1 256 10  # Runoff reservoir storage
BaseflowStor:    0  mm       -   0 0 0 1 256 10  # Baseflow reservoir storage
RunoffDWI:       0  mm       -   0 0 0 1 256 10  # Runoff deep water infiltration
BaseflowDWI:     0  mm       -   0 0 0 1 256 10  # Baseflow deep water infiltration
SWS:             0  mm       -   0 0 0 1 256 10  # Surface water storage
EvapWater:       0  kg/m2s   -   0 0 0 1 256 10  # Potential evaporation from open
water
EvapDif:         0  kg/m2s   -   0 0 0 1 256 10  # Differential evaporation (potential
evaporation - actual evapotranspiration)

#RTM output
RTM emissivity:  0  -        -   0 0 0 1 256 10  # RTM emissivity
RTM Tb:          0  K        -   0 0 0 1 256 10  # RTM brightness temperature
RTM SoilMoist:   0  m3/m3    -   0 0 0 1 256 10  # RTM soil moisture

#Irrigation output
Irrigated water: 0  kg/m2s   -   0 0 0 1 256 10  # Irrigated water amount

#AWRAL600 output
e0:           1  mm      -    0 0 0 1 0 1 # potential evaporation
etot:         1  mm      -    0 0 0 1 0 1 # actual evapotranspiration
Qtot:         1  mm      -    0 0 0 1 0 1 # total discharge to stream
sr:           1  mm      -    0 0 0 1 0 1 # volume of water in the surface water store
sg:           1  mm      -    0 0 0 1 0 1 # groundwater storage in the unconfined
aquifer
dd:           1  mm      -    0 0 0 1 0 1 # vertical drainage from the bottom of the
deep soil layer
s0:           1  mm      -    0 0 0 2 0 1 # water storage in the surface soil layer
for each hru
ss:           1  mm      -    0 0 0 2 0 1 # water content of the shallow soil store
for each hru
sd:           1  mm      -    0 0 0 2 0 1 # water content of the deep soil store for
each hru
mleaf:        1  kg/m2   -    0 0 0 2 0 1 # leaf biomass for each hru
s0_avg:       1  mm      -    0 0 0 1 0 1 # water storage in the surface soil layer
ss_avg:       1  mm      -    0 0 0 1 0 1 # water content of the shallow soil store
sd_avg:       1  mm      -    0 0 0 1 0 1 # water content of the deep soil store

# SnowModel-specific fields:
```

```
SM_SWE:          1  m       -    0 0 0 1  65 1000    # Snow Water Equivalent (kg/m2)
SM_SnowDepth:    1  m       -    0 0 0 1  66 1000    # Snow depth (m)
SM_SnowDensity:  1  kg/m3   -    0 0 0 1 900 10      # Snow density (kg/m3)
SM_Snowcover:    0  -       -    0 0 0 1 238 100     # Snow cover (-)
SM_SLiqFrac:     0  -       -    0 0 0 1 185 1000    # Fraction of SWE in the liquid
phase
SM_SWEVeg:       0  kg/m2   -    1 0 0 1 139 1000    # SWE intercepted by vegetation
(kg/m2)
SM_Albedo:       1  -       -    1 0 0 1  84 100     # Surface albedo (-)
SM_SAlbedo:      0  -       -    0 0 0 1 184 1000    # Albedo of the snow-covered area
(-)
# Other fields -- summed output:
SM_Qs:           0  m       OUT  3 0 0 1 235 10000   # Surface runoff from snowpack /
top-soil (m/timestep)
SM_Qsm:          0  m       S2L  3 0 0 1  99 10000   # Snowmelt (kg/m2s)
SM_SubSnow:      0  m       -    3 0 0 1 198 1000    # Snow sublimation (m)
SM_Snowf:        1  m       DN   3 0 0 1 161 10000   # Snowfall rate (m/timestep)
SM_Rainf:        1  m       DN   3 0 0 1 162 10000   # Rainfall rate (m/timestep)
SM_TotalPrecip:  1  m       DN   3 0 0 1  61 10000   # Total precipitation rate
(m/timestep)
# SnowModel-modified forcings:
SM_SWdown:    1  W/m2    DN   1 0 0 1 204 10         # SnowModel-modified SWdown
SM_LWdown:    1  W/m2    DN   1 0 0 1 205 10         # SnowModel-modified LWdown
SM_NWind:     1  m/s     N    1 0 0 1  34 10         # SnowModel-modified NWind
SM_EWind:     1  m/s     E    1 0 0 1  33 10         # SnowModel-modified EWind

#AquaCrop output
AC_Biomass:            1  t/ha  -  1 0 0 1 223 1000 # cummulative biomass (ton/ha)
AC_RootZoneWC_Actual:  1  mm    -  1 0 0 1 153 1000 # actual rootzone WC (mm)
AC_RootZoneWC_WP:      1  mm    -  1 0 0 1 153 1000 # rootzone WC at wilting point
(mm)
AC_RootZoneWC_FC:      1  mm    -  1 0 0 1 153 1000 # rootzone WC at field capacity
(mm)
AC_Tact:               1  mm    -  1 0 0 1 153 1000 # actual plant transpiration (mm)
AC_Eact:               1  mm    -  1 0 0 1 153 1000 # actual soil evaporation (mm)
AC_ETo:                1  mm    -  1 0 0 1 153 1000 # reference ET Penman-Monteith
(mm)
AC_Rain:               1  mm    -  1 0 0 1 153 1000 # daily rainfall (mm)
AC_Irrigation:         1  mm    -  1 0 0 1 153 1000 # irrigation (mm)
AC_RootingDepth:       1  m     -  1 0 0 1 151 1000 # rooting depth (m)
AC_CCiActual:          1  -     -  1 0 0 1 151 1000 # canopy Cover (-)
AC_Tmin:               1  degC  -  1 0 0 1 153 1000 # daily minimum temperature (degC)
AC_Tmax:               1  degC  -  1 0 0 1 153 1000 # daily maximum temperature (degC)
AC_Yield:              1  t/ha  -  1 0 0 1 153 1000 # yield (ton/ha)
AC_StExp:              1  %     -  1 0 0 1 153 1000 # expansion stress (%)
AC_StSen:              1  %     -  1 0 0 1 153 1000 # senescence stress (%)
AC_cycle_complete:     1  -     -  1 0 0 1 153 1000 # Flag cycle completed within sim
```

Chapter 12. User Support

This section describes how to request help from and provide feedback to the LISF development team.

12.1. Requesting Help

To request help from the LISF development team, please visit the Discussions tab of our GitHub repository at https://github.com/NASA-LIS/LISF/discussions. Please review the existing posts; your question may already be answered. If it is not, then please open a "New discussion" to post your question there.

NOTE	Posting a question requires a GitHub account. Register at https://github.com/signup.

12.2. Bug Reports

Please review our Contribution Guidelines to learn how to report a bug or error.

When reporting a bug or an error running LIS, please provide a description of the problem, including any error messages printed to the screen. Attach a copy of the *lislog.0000* file. Also attach a copy of any relevant supporting files such as:

For LIS:

- *lis.config*
- *lislog.0000*
- *MODEL_OUTPUT_LIST.TBL*
- *configure.lis* (in your make directory)

For LDT:

- *ldt.config*
- *ldtlog.0000*
- *configure.ldt* (in your make directory)

For LVT:

- *lvt.config*
- *lvtlog.0000*
- *configure.lvt* (in your make directory)

Please note that the LISF development team does not receive funding to provide community support. Your questions and issues are important to us, but we can address them only when time permits.

IMPORTANT

Due to U.S. federal law, we are not allowed to respond to anyone from a designated country (see https://www.nasa.gov/oiir/export-control). By policy, we will not respond to messages from either non-institutional or non-organizational email addresses; e.g., we will not respond to email messages from gmail.

Appendix A: Frequently Asked Questions

This section provides a description of common error messages and a possible few options on how to address them.

1. *Routine to diagnose error (variable)*

```
Error:<var> field is not defined
for diagnostic output ..
Please exclude it from the model output attributes table
Program stopping..
```

   This error occurs because the variable specified in the model output attributes file is not among the ones supported for output from the particular model. Either exclude the variable (turn it off) from the model output attributes file or implement the routine within the model to support it.

2. *Routine to diagnose error (units)*

```
Error:<units> for field <var> is not defined
for diagnostic output ..
supported unit types: <list>
Program stopping..
```

   This error occurs because the units of the variable specified in the model output attributes file is not among the supported types. Either change the incorrect unit specification or run the model simulation with a unit type that is supported by LIS.

3. *Routine to diagnose error (direction)*

```
Error:<direction> for field <var> is not defined
for diagnostic output ..
supported direction types: <list>
Program stopping..
```

   This error occurs because the direction of the variable specified in the model output attributes file is not among the supported types. Either change the incorrect direction specification or run the model simulation with a direction type that is supported by LIS.

Appendix B: LIS Binary File Convention

(Draft, 4/23/2003)

B.1. Introduction

The majority of LIS data is saved in Fortran binary files, with various formats. This note defines the official LIS file scheme, to facilitate unified and consistent access to LIS data by LIS code, user programs and GDS client-server system.

B.2. Byte order

LIS data, by default, are saved in binary files as big endian numbers.

B.3. Storage organization

For a specific spatial resolution, the spatial grid space has NC columns and NR rows. In addition, a vectorized land space will often be used, with NL land points.

The minimum storage unit is a 2-D array of NC X NR, or a 1-D array of NL elements. Two dimensional grid space data and 1-D land space data are always saved in separate files.

B.4. Missing/undefined values

Data type	Missing/Undefined value
character*1	CHAR(255)
integer*1	-128
integer*4	-9999 (?)
real*4	(?)

B.5. File name extension convention and access code samples

A LIS binary file name extention has 4 fields. The first field is one or more numeric characters, indicating the total number of storage units the file has. The second field is the lower-case character “g” or “l”, indicating grid space or land space, respectively. The third field is the lower-case character “s” or “d”, indicating sequential or direct access. The last field, has 2 character width, with the first character indicating the number of bytes each number in the file takes, and the second character, as “c”, “i”, or “r”, indicating the type of data as character, integer or real, respectively.

Example1: *datafile1.2gs4r*

Sample Fortran code segment to read this file:

```
      Real*4 v1(NC, NR), v2(NC, NR)
      Open(12, file="datafile1.2gs4r", form="unformatted")
      read(12)v1
      read(12)v2
      Close(12)
```

Example2: *datafile2.15gd4i*

Sample Fortran code segment to read this file:

```
      Integer*4 v1(NC, NR), v10(NC, NR)
      Open(12, file="datafile2.15gd4i", form="unformatted", &
      access="direct", recl=NC*NR*4)
      read(12, rec=1)v1
      read(12, rec=10)v10
      Close(12)
```

Example3: *soilcolor.1ls1c*

Sample Fortran code segment to read this file:

```
      Character*1 color(NL)
      Open(12, file="soilcolor.1ls1c", form="unformatted")
      read(12)color
      Close(12)
```

Appendix C: LIS source tree

- *LICENSES*

  Directory the NASA Open Source license for LIS along with the licenses of other included components

- *RESTRICTED*
- *apps*

  Directory containing applications built on LIS

- *arch*

  Directory containing the configurable options for building the LIS executable

- *configs*

  Directory containing some sample LIS configuration files

- *core*

  Directory containing core routines in LIS

- *dataassim*

  Top level directory for data assimilation support, which includes the following subcomponents

  - *algorithm*

    Directory containing the following data assimilation algorithm implementations:

    - *di*

      Direct insertion algorithm for data assimilation

    - *ekf*

      NASA GMAO's extended Kalman filter algorithm for data assimilation

    - *enkf*

      NASA GMAO's Ensemble Kalman Filter algorithm for data assimilation

    - *enkfgrace*

      GRACE Ensemble Kalman Filter algorithm for data assimilation

    - *ensrf*

      specifies what?

- *pf*

  Particle filter algorithm for data assimilation

- *biasEstimation*

  Directory containing the following dynamic bias estimation algorithms:

  - *gmaoBE*

    NASA GMAO's dynamic bias estimation algorithm

- *obs*

  Directory containing the following observation handlers for data assimilation:

  - *AMRE_swe*

    AMSRE snow water equivalent retrievals in HDF4/HDFEOS format

  - *ANSA_SCF*

    Blended snow cover fraction from the AFWA NASA snow algorithm

  - *ANSA_SNWD*

    Snow depth retrievals from the AFWA NASA snow algorithm

  - *ANSA_SWE*

    Snow water equivalent retrievals from the AFWA NASA snow algorithm

  - *ASCAT_TUW*

    ASCAT (TU Wein) soil moisture

  - *ASO_SWE*

    specifies what?

  - *CDFS_GVF*

    CDFS green vegetation fraction

  - *CDF_Transfer_NASA_SMAPsm*

    specifies what?

  - *ESACCI_sm*

    ESACCI Essential Climate Variable product

  - *GCOMW_AMSR2L3SND*

AMSR2 snow depth retrievals

- *GCOMW_AMSR2L3sm*

  AMSR2 soil moisture retrievals

- *GLASS_Albedo*

  GLASS Albedo retrievals

- *GLASS_LAI*

  GLASS LAI retrievals

- *GRACE*

  GRACE soil moisture

- *IMS_sca*

  IMS snow cover area

- *ISCCP_Tskin*

  ISCCP skin temperature product in binary format

- *LPRM_AMSREsm*

  Soil moisture retrievals from AMSRE derived using the land parameter retrieval model (LPRM) from University of Amsterdam

- *MCD15A2H_LAI*

  specifies what?

- *MODIS_SPORT_LAI*

  specifies what?

- *MODISsca*

  MODIS snow cover area product in HDF4/HDFEOS format

- *NASA_AMSREsm*

  NASA AMSRE soil moisture data in binary format

- *NASA_SMAPsm*

  NASA SMAP soil moisture retrievals

- *NASA_SMAPvod*

  NASA SMAP vegetation optical depth retrievals

- *PMW_snow*

  PMW snow

- *SMAP_E_OPLsm*

  Operation Enhanced (9-km) SMAP soil moisture

- *SMAP_NRTsm*

  SMAP near-real time soil moisture retrievals

- *SMMR_SNWD*

  SMMR snow depth

- *SMOPS_AMSR2sm*

  SMOPS AMSR2 real time soil moisture

- *SMOPS_ASCATsm*

  SMOPS ASCAT A and B real time soil moisture

- *SMOPS_SMAPsm*

  SMOPS SMAP real time soil moisture

- *SMOPS_SMOSsm*

  SMOPS SMOS real time soil moisture

- *SMOS_L2sm*

  SMOS L2 soil moisture

- *SMOS_NESDIS*

  SMOS NESDIS soil moisture retrievals

- *SMOS_NRTNN_L2sm*

  SMOS near-real-time neural-network L2 soil moisture (SMOS NRT NN L2 SM)

- *SNIP*

  Snow and Ice Products (SNIP) analysis

- *SNODAS*

  Snow Data Assimilation System (SNODAS)

- *SNODEP*

AFWA snowdepth data in Grib1 format

- *SSMI_SNWD*

  SSMI snow depth

- *SWOT_WL*

  Surface Water and Ocean Topography (SWOT) water level observations

- *SYN_LBAND_TB*

  Synthetic L-band brightness temperature

- *THySM*

  Thermal hydraulic disaggregation of soil moisture (THySM)

- *USAFSI*

  USAF Snow and Ice Analysis

- *VIIRS_GVF*

  VIIRS green vegetation fraction

- *WUS_UCLAsnow*

  Margulis Western US Snow Reanalysis dataset

- *WindSat_Cband_sm*

  C-band soil moisture retrievals from WindSat

- *WindSat_sm*

  X-band soil moisture retrievals from WindSat

- *hydrowebWL*

  hydroweb water level

- *pildas*

  PILDAS soil moisture observations (such as one generated from a previous LIS LSM run)

- *simGRACE_JPL*

  Synthetic soil moisture retrievals from GRACE

- This directory also includes the following synthetic data handler examples:
- *multisynsmobs*

Synthetic soil moisture data with multiple observation types

- *syntheticSnowTb*

  specifies what?

- *syntheticlst*

  Synthetic land surface temperature data handler

- *syntheticsf*

  Synthetic streamflow data handler

- *syntheticsm*

  Synthetic soil moisture data handler (produced from a LIS LSM run)

- *syntheticsnd*

  Synthetic snow depth data handler

- *syntheticswe*

  Synthetic snow water equivalent data handler

- *syntheticwl*

  specifies what?

◦ *perturb*

Directory containing the following perturbation algorithm implementations

- *gmaopert*

  NASA GMAO's perturbation algorithm

- *uniform*

  specifies what?

• *forecast*

Top level directory for forecasting support, which includes the following subcomponents

◦ algorithm

Directory containing the following forecasting algorithm implementations

- ESPboot

  Boot ensemble streamflow prediction

        - ESPconv

          Conventional ensemble streamflow prediction

- *interp*

  Generic spatial and temporal interpolation routines

- *irrigation*

  Directory containing the following irrigation schemes

    - *drip*

      Drip irrigation scheme

    - *flood*

      Flood irrigation scheme

    - *sprinkler*

      Demand sprinkler irrigation scheme

- *lib*

  Directory contains the following RTM-related libraries

    - lis-cmem3
    - lis-crtm
    - lis-crtm-profile-utility

- *make*

  Directory containing Makefile and needed header files for building LIS executable

- *metforcing*

  Top level directory for base meteorological forcing methods, which includes the following implementations

    - *3B42RT*

      TRMM 3B42RT precipitation product

    - *3B42RTV7*

      TRMM 3B42RTV7 precipitation product

    - *3B42V6*

      TRMM 3B42V6 precipitation product

- *3B42V7*

  TRMM 3B42V7 precipitation product

- *AWAP*

  AWAP precipitation product

- *AWRAL*

  Australian Water Resource Assessment Landscape (AWRA-L) metforcing data

- *Bondville*

  Bondville forcing products

- *COAMPSout*

  Metforcing extracted from COAMPS output (COAMPSout)

- *HiMAT_GMU*

  Downscaled MERRA2 precipitation data over the High Mountain Asia domain from GMU (HiMAT_GMU)

- *Loobos*

  specifies what?

- *PALSmetdata*

  PALS station data

- *RFE2Daily*

  RFE2 precipitation product from FEWSNET (diurnally non-disaggregated)

- *RFE2gdas*

  RFE2 precipitation product from FEWSNET bias corrected against GDAS data

- *WRFAKdom*

  Metforcing extracted from WRF output over Alaska domain (WRFAKdom)

- *WRFout*

  Metforcing extracted from WRF output (WRFout)

- *WRFoutv2*

  Metforcing extracted from WRF output (WRFoutv2)

- *agrradps*

AGRMET radiation product (polar stereographic prjection)

- *chirps2*

  UCSB CHIRPS v2.0 satellite-gage merged precipitation product

- *climatology*

  LDT-generated forcing climatologies

- *cmap*

  CMAP precipitation product

- *cmorph*

  CMORPH precipitation product

- *ecmwf*

  ECMWF meteorological forcing data

- *era5*

  specifies what?

- *galwem*

  GALWEM 17km or 0.25deg deterministic forecast reader

- *galwem_ge*

  GALWEM-GE forecast reader

- *gdas*

  NCEP GDAS meteorological forcing data

- *gdasT1534*

  NCEP GDAS GFS T1534 meteorological forcing data

- *gddp*

  NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP)

- *gefs*

  specifies what?

- *genEnsFcst*

  User-derived ensemble forecast data

- *genMetForc*

  LDT-generated meteorological forcing data

- *geos5fcst*

  NASA GEOS 5 meteorological forecast forcing data

- *geos_it*

  GEOS-IT

- *gfs*

  NCEP GFS meteorological forcing data

- *gldas*

  NASA GMAO GLDAS meteorological forcing data

- *gswp1*

  Global Soil Wetness Project-1 meteorological forcing data

- *gswp2*

  Global Soil Wetness Project-2 meteorological forcing data

- *imerg*

  GPM L3 precipitation product

- *merra2*

  GMAO Modern Era Retrospective-Analysis for Research and Applications data

- *mogreps_g*

  Met Office Global and Regional Ensemble Prediction System - global ensemble (MOGREPS-G) forecasts

- *mrms*

  National Center for Environmental Prediction (NCEP) Multi-Radar/Multi-Sensor (MRMS) Doppler Radar+gage product.

- *nam242*

  North American Mesoscale Forecast System (NAM) 242 AWIPS Grid -- Over Alaska product

- *narr*

  North American Regional Reanalysis (3d) data

- *nldas2*

  North American Land Data Assimilation System 2 forcing product

- *pet_usgs*

  Daily potential evapotranspiration data from the USGS FAO-PET method, using GDAS forcing fields as inputs

- *plumber2*

  PLUMBER2 station data

- *pptEnsFcst*

  specifies what?

- *princeton*

  Renalaysis product from Princeton University ([sheffield_etal_2006])

- *scan*

  Soil Climate Analysis Network precipitation product

- *snotel*

  SNOTEL meteorological forcing data

- *stg2*

  NCEP Stage IV QPE precipitation product

- *stg4*

  NCEP Stage II precipitation product

- *templateMetForc*

  An empty template for meteorological forcing data implementations

- *usaf*

  Routines for generating meteorological forcing data in the “AGRMET ops” running mode and for handling said data when running in the “retrospective” runmode

- *vicforcing*

  VIC 4.1.1 pre-processed meteorological forcing data

- *vicforcing.4.1.2*

  VIC 4.1.2 pre-processed meteorological forcing data

- *offline*

  Directory containing the main program for the offline mode of operation

- *optUE*

  Top level directory for optimization support, which includes the following subcomponents

  - *algorithm*

    Directory containing the following optimization algorithm implementations

    - *DEMC*

      Differential evolution Monte Carlo algorithm

    - *DEMCz*

      Differential evolution Monte Carlo Z algorithm

    - *ES*

      Enumerated search

    - *GA*

      Single objective Genetic Algorithm

    - *LM*

      Levenberg-Marquardt gradient search algorithm

    - *MCSIM*

      Monte Carlo simple propagation scheme

    - *RWMCMC*

      Random walk Markov chain monte carlo algorithm

    - *SCE-UA*

      Shuffled Complex Evolutionary Algorithm

  - *type*

    - *paramestim*

      Directory for parameter estimation support

      The directory for parameter estimation support *paramestim* includes the following subcomponents

      - *objfunc*

Directory containing the following objective function evaluation methods

- *LL*

  Maximum likelihood

- *LM*

  Objective function definition for LM algorithm

- *LS*

  Least squares based objective function

- *P*

  Prior function definition

- *obs*

  Directory containing the following observation handlers for parameter estimation

  - *AMSRE_SR*
  - *ARM*

    specifies what?

  - *ARSsm*

    specifies what?

  - *Ameriflux*

    In-situ observations from Ameriflux

  - *CNRS*

    specifies what?

  - *EmptyObs*
  - *FLUXNET*

    specifies what?

  - *Global_LS_data*

    Global landslide observational data

  - *ISCCP_Tskin*

    ISCCP land surface temperature observations

  - *ISMNsm*

specifies what?

- *LPRM_AMSREsm*

  Soil moisture retrievals from AMSRE derived using the land parameter retrieval model (LPRM) from University of Amsterdam

- *Macon_LS_data*

  Macon County North Carolina landslide observational data

- *SMAPsm*

  SMAP soil moisture observational data

- *UAsnow*

  University of Arizona (UA) swe/snow depth observations

- *USDA_ARSsm*

  USDA Agricultural Research Service soil mositure retrievals

- *pesynsm1*

  Synthetic soil moisture observations

- *template*
- *wgPBMRsm*

  PBMR soil moisture data for the Walnut Gulch watershed

- *params*

  Directory containing implementations of the following land surface model parameters

  - *albedo*

    Routines for handling albedo data products

  - *emissivity*

    Routines for handling emissivity data products

  - *gfrac*

    Routines for handling green vegetation fraction data products

  - *lai*

    Routines for handling Leaf/Stem area index data products

  - *roughness*

Routines for handling roughness data products

- *plugins*

  Directory containing modules defining the function table registry of extensible functionalities

- *routing*

  Directory containing routing models

  - *HYMAP_router*
  - *HYMAP2_router*
  - *HYMAP3_router*
  - *NLDAS_router*
  - *RAPID_router*

- *rtms*

  Directory containing coupling routines to the following radiative transfer models

  - *CRTM*

    Routines to handle coupling to the JCSDA Community Radiative Transfer Model

  - *CRTM2*

    Routines to handle coupling to the JCSDA Community Radiative Transfer Model, version 2

  - *CRTM2EM*

    Routines to handle coupling to the JCSDA Community Radiative Transfer Model Emissions model

  - *LIS_CMEM3*

    Community Microwave Emission Model from ECMWF

  - *TauOmegaRTM*

    Routines to handle coupling to the Tau Omega Radiative Transfer Model

- *runmodes*

  Directory containing the following running modes in LIS

  - *RTMforward*

    Routines to manage the program flow when a forward model integration using a radiative transfer model is employed

  - *agrmetmode*

Routines to manage the program flow in the AFWA operational mode

- *forecast*

  Routines to manage the forecast simulation mode

- *gce_cpl_mode*

  Routines to manage the program flow in the coupled LIS-GCE mode

- *landslide_optUE*

  Routines to manage the program flow in combined use of landslide modeling simulations and optimization

- *nuopc_cpl_mode*

  National Unified Operational Prediction Capability (NUOPC) coupled runmode

- *paramEstimation*

  Routines to manage the program flow in the parameter estimation mode

- *retrospective*

  Routines to manage the program flow in the retrospective analysis mode

- *smootherDA*

  Routines to manage the program flow in the smoother da analysis mode

- *wrf_cpl_mode*

  Routines to manage the program flow in the coupled LIS-WRF mode not using ESMF

- *surfacemodels*

  Top level directory for surface model support, which includes the following subcomponents

  - *glacier*

    Directory containing implementations of the following glacier surface models

    - *noahmp.3.9.1.1*

      NCAR Noah multiphysics land surface model version 3.9.1.1

    - *template*

      An empty template for glacire surface model implementations

  - *lake*

    Directory containing implementations of the following lake surface models

- *FLake.1.0*

  FLake, version 1.0. For internal use only.

- *land*

Directory containing implementations of the following land surface models

- *ac.7.2*

  KU Leuven AquaCrop, version 7.2

- *awral.6.0.0*

  Australian Water Resource Assessment Landscape (AWRA-L) land surface model, version 6.0.0

- *cable*

  CSIRO Atmosphere Biosphere Land Exchange model, version 1.4b

- *clm2*

  NCAR community land model, version 2.0

- *clsm.f2.5*

  NASA GMAO Catchment land surface model version Fortuna 2.5

- *geowrsi.2*

  GeoWRSI version 2

- *hyssib*

  NASA HySSIB land surface model

- *jules.5.0*

  Support for UK Met Office's JULES 5.0 land surface model

- *jules.5.1*

  Support for UK Met Office's JULES 5.1 land surface model

- *jules.5.2*

  Support for UK Met Office's JULES 5.2 land surface model

- *jules.5.3*

  Support for UK Met Office's JULES 5.3 land surface model

- *jules.5.4*

Support for UK Met Office's JULES 5.4 land surface model

- *jules.5.x*

  Support for UK Met Office's JULES 5.5 (and higher) land surface model

- *mosaic*

  NASA Mosaic land surface model

- *noah.2.7.1*

  NCEP Noah land surface model version 2.7.1

- *noah.3.2*

  NCAR Noah land surface model version 3.2

- *noah.3.3*

  NCAR Noah land surface model version 3.3

- *noah.3.6*

  NCAR Noah land surface model version 3.6

- *noah.3.9*

  NCAR Noah land surface model version 3.9

- *noahmp.3.6*

  NCAR Noah multiphysics land surface model version 3.6

- *noahmp.4.0.1*

  NCAR Noah multiphysics land surface model version 4.0.1

- *rdhm.3.5.6*

  NOAA OHD Research Distributed Hydrologic Model version 3.5.6

- *ruc.3.7*

  NOAA Rapid Update Cycle model version 3.7.1

- *summa.1.0*

  First attempt to incorporate the Structure for Unifying Multiple Modeling Alternatives (SUMMA) into LIS. For internal use only.

- *template*

  An empty template for land surface model implementations

        - *vic.4.1.1*

          Variable Infiltration Capacity model from University of Washington, version 4.1.1

        - *vic.4.1.2.l*

          Variable Infiltration Capacity model from University of Washington, version 4.1.2.l

        - *subLSM*

          Directory containing implementations of sub land surface modeling processes.

          - *crocus.8.1*

            Crocus 8.1 snow model

          - *snowmodel*

            CSU/Glen Liston snowmodel, April 2021

    - *openwater*

      Directory containing implementations of the following open water surface models

      - *template*

        An empty template for open water surface model implementations

- *testcases*

  testcases for verifying various functionalities

- *utils*

  Miscellaneous helpful utilities

NOTE

Each of the LSM directories under *surfacemodels/land* contain specific plugin interfaces related to

(1) coupling to WRF and GCE models, (2) Data assimilation instances, (3) Irrigation instances, (4) Parameter estimation instances, (5) Routing instances, and (6) Radiative transfer instances.

These routines defined for Noah land surface model version 3.3 are shown below. Note that similar routines are implemented in other LSMs.

(1) Coupling interfaces:

- *cpl_wrf_noesmf*

  Routines for coupling Noah with WRF without ESMF

(2) Data assimilation interfaces:

- *da_snodep*

  Noah routines related to the assimilation of AFWA SNODEP observations

- *da_snow*

  Noah routines related to the assimilation of snow water equivalent observations

- *da_soilm*

  Noah routines related to the assimilation of soil moisture observations

(3) Irrigation interfaces:

- *irrigation*

  Noah routines related to interacting with the irrigation scheme

(4) Parameter estimation interfaces:

- *pe*

  Noah routines related to the estimation of soil properties through parameter estimation

(5) Routing interfaces:

- *routing*

  Noah routines related to interacting with the routing schemes

(6) Radiative transfer model interfaces:

- *sfc_cmem3*
- *sfc_crtm*
- *sfc_tauomega*

Appendix D: What's New (continued)

NOTE	There were no public releases for versions 7.6 or 7.7.

D.1. Version 7.5

1. Supports additional metforcing datasets
    - GALWEM 17km or 0.25deg deterministic forecast reader (galwem)
    - GALWEM-GE forecast reader (galwem_ge)
    - GEOS-IT (geos_it)
2. Supports additional data assimilation observation datasets
    - CDFS green vegetation fraction (CDFS_GVF)
    - CDF_Transfer_NASA_SMAPsm
    - Operation Enhanced (9-km) SMAP soil moisture (SMAP_E_OPLsm)
    - VIIRS green vegetation fraction (VIIRS_GVF)
    - Margulis Western US Snow Reanalysis dataset (WUS_UCLAsnow)
3. Includes RAPID router

D.2. Version 7.4

1. Includes new runmodes
    - National Unified Operational Prediction Capability (NUOPC) coupled runmode
2. Includes additional surface models
    - Crocus 8.1 snow model
3. Supports additional metforcing datasets
    - metforcing extracted from COAMPS output (COAMPSout)
    - metforcing extracted from WRF output over Alaska domain (WRFAKdom)
    - metforcing extracted from WRF output (WRFoutv2)
    - NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP)
    - PLUMBER2 station data
4. Supports additional data assimilation observation datasets
    - MCD15A2H LAI
    - SMOS near-real-time neural-network L2 soil moisture (SMOS NRT NN L2 SM)
    - Snow Data Assimilation System (SNODAS)
    - Thermal hydraulic disaggregation of soil moisture (THySM)
    - hydroweb water level

5. Removes the following metforcing datasets
    - AGRMET radiation (latlon)
    - AMMA land surface model intercomparision project phase 2 (ALMIPII)
    - Walnut Gulch meteorological station data (ARMS)
    - Canadian Precipitation analysis (CaPA)
    - CEOP
    - COOP
    - ECMWF reanalysis
    - Single-point FASST product (FASSTsingle)
    - GDAS(3d)
    - GDAS profile data from the PMM land surface working group (GDAS(LSWG))
    - GEOS
    - GMAO Modern Era Retrospective-Analysis for Research and Applications data (MERRA-Land)
    - North American Land Data Assimilation System forcing product (NLDAS1)
    - PILDAS
    - NOAA OHD RDHM 3.5.6 forcing data (RDHM 3.5.6)
    - Rhone AGG
6. Disables the following external runoff data sources
    - GLDAS1 runoff data
    - GLDAS2 runoff data
    - NLDAS2 runoff data
    - MERRA2 runoff data
    - ERA interim land runoff data
    - GWB MIP runoff data
7. Disables the following parameters
    - MODIS near-real time LAI

D.3. LIS 7.3

1. Includes new runmodes
    - RTMforward runmode
    - AGRMET ops runmode
    - GCE-coupled runmode
    - landslide optUE runmode
2. Includes additional surface models

    - NoahMP 3.9.1.1 glacier model
    - template glacier model
    - FLake 1.0 lake model
    - AWRA-L 6.0.0 land model
    - Jules 5.0 land model
    - Noah 3.9 land model
    - NoahMP 4.0.1 model
3. Includes HYMAP2 router
4. Includes ESPboot forecasting algorithm
5. Includes GLS landslide application
6. Includes TRIGRS landslide application
7. Includes additional data assimilation algorithms
    - extended Kalman filter algorithm
    - ensrf algorithm
    - particle filter algorithm
8. Includes additional optimization and uncertainty alogrithms
    - Enumerated Search algorithm
    - Shuffled Complex Evolution - University of Arizona (SCEUA) algorithm
9. Includes Levenberg-Marquadt (LM) parameter estimation objective function
10. Supports additional real-time parameters
    - albedo parameters
    - emissivity parameters
    - roughness parameters
11. Supports additional metforcing datasets
    - AMMA land surface model intercomparision project phase 2 (ALMIPII) metforcing data
    - Australian Water Resource Assessment Landscape (AWRA-L) metforcing data
    - Canadian Precipitation Analysis (CaPA) data
    - FASSTsingle metforcing data
    - downscaled MERRA2 precipitation data over the High Mountain Asia domain from GMU (HiMAT_GMU)
    - Loobos metforcing data
    - arms metforcing data
    - era5 metforcing data
    - gdas3d metforcing data
    - gefs metforcing data

- mrms metforcing data
- pptEnsFcst metforcing data
- usaf metforcing data

12. Supports additional data assimilation observation datasets
    - simGRACE_JPL observations
    - syntheticSnowTb observations
    - syntheticlst observations
    - syntheticsf observations
    - syntheticsm observations
    - syntheticsnd observations
    - syntheticswe observations
    - syntheticwl observations
    - AMSRE SWE observations
    - AFWA NASA snow algorithm (ANSA) SWE retrievals
    - ASCAT_TUW observations
    - ASO_SWE observations
    - GLASS Albedo observations
    - GLASS LAI observations
    - IMS_sca observations
    - International Satellite Cloud Climatology Project (ISCCP) skin temperature observations
    - MODIS SPoRT LAI observations
    - NASA SMAP vegetation optical depth retrievals
    - SMAP near-real time (NRT) soil moisture observations
    - SMOPS AMSR2 soil moisture observations
    - SMOPS ASCAT soil moisture observations
    - SMOPS SMAP soil moisture observations
    - SMOPS SMOS soil moisture observations
    - SNODEP observations
    - SYN_LBAND_TB observations
    - USAFSI observations
    - WindSat_Cband_sm observations
    - multisynsmobs observations
13. Supports additional parameter estimation observation datasets
    - Walnut Gulch (WG) PBMR soil moisture observations
    - ARM observations

- ARSsm observations
- Ameriflux observations
- CNRS observations
- FLUXNET observations
- Global_LS_data observations
- ISCCP_Tskin observations
- ISMNsm observations
- Macon_LS_data observations
- SMAP soil moisture observations
- University of Arizona (UA) swe/snow depth observations
- USDA ARS soil moisture observations
- pesynsm1 observations

D.4. LIS 7.2

1. Includes the NOAA Rapid Update Cycle (RUC) 3.7.1 land surface model
2. Includes the ensemble streamflow prediction (ESP) conventional forecasting runmode
3. Includes additional parameter and uncertainty estimation support
   - Differential evolution Markov chain (DEMC)
   - Levenberg-Marquardt
   - Random walk Markov chain monte carlo
4. Includes additional radiative transfer model support
   - Tau Omega
5. Data assimilation is performed on the observation grid
6. Supports HYMAP runoff data
7. Supports ANSA snow depth observations
8. Supports GCOMW AMSR2 L3 soil moisture observations
9. Supports GCOMW AMSR2 L3 snow depth observations
10. Supports NASA SMAP soil moisture observations
11. Supports PILDAS soil moisture observations
12. Supports SMMR snow depth observations
13. Supports SMOS L2 soil moisture observations
14. Supports SMOS NESDIS soil moisture observations
15. Supports SSMI snow depth observations
16. Supports AWAP precipitation data

17. Supports LDT generated met forcing climatology data
18. Supports generic ensemble forecast met forcing data
19. Supports GRIB 2 formatted output

D.5. LIS 7.1

1. Includes Noah 3.6
2. Includes NoahMP 3.6
3. Includes CABLE 1.4b
4. Includes Flake 1.0 — internal use only! (available only in development branch)
5. Includes flood irrigation
6. Includes drip irrigation
7. Supports SMOS L2 soil moisture observations (available only in development branch)
8. Supports simulated GRACE products (available only in development branch)
9. Supports GCOMW AMSR2 L3 soil moisture observations (available only in development branch)
10. Supports VIIRS Daily GVF data
11. Supports TRMM 3B42 V7 real time precipitation
12. Supports Gaussian T1534 GFS met forcing data
13. Supports MERRA-2 met forcing data — these data are not currently available to external users; they should become available in July 2015
14. Supports LDT-generated met forcing data (available only in development branch)
15. Supports downscaling precipitation (PRISM) (NLDAS-2 only)

D.6. LIS 7.0

1. Requires companion Land Data Toolkit (LDT) input data and parameter preprocessor
2. Includes VIC 4.1.2.l
3. Includes RDHM 3.5.6 (SacHTET and Snow17)
4. Includes demand sprinkler irrigation
5. Includes HYMAP routing
6. Includes NLDAS routing
7. Includes radiative transfer model support
    - LIS-CRTM2EM — LIS' implementation of JCSDA's CRTM2 with emissivity support

      See http://ftp.emc.ncep.noaa.gov/jcsda/CRTM/

    - LIS-CMEM3 — LIS' implementation of ECMWF's CMEM 3.0

      See http://old.ecmwf.int/research/data_assimilation/land_surface/cmem/cmem_source.html

for the original code.

8. Includes parameter and uncertainty estimation support
    - Genetic algorithm (GA)
    - Monte Carlo sampling (MCSIM)
    - Differential evolution Markov chain z (DEMCz)
9. Supports ensemble of met forcing sources
10. Supports GEOS 5 forecast met forcing data
11. Supports PALS met forcing data
12. Supports PILDAS met forcing data
13. Supports ECV soil moisture data assimilation
14. Supports GRACE data assimilation
15. Supports PMW snow data assimilation
16. Supports SMOPS soil moisture data assimilation

Note that the notion of a base forcing and a supplemental forcing have been replaced with the notion of a meteorological forcing. Thus the support in *baseforcing* and in *suppforcing* have been combined into *metforcing*.

Note that LIS is developing support for surface types other than land. Thus all the land surface models contained in *lsms* have been moved into *surfacemodels/land*.

Note that the companion program LDT is now required to process input parameters. Thus the support for static and climatological parameters have been removed from *params* and placed into LDT.

D.7. LIS 6.2

1. Includes VIC 4.1.1.
2. Includes CABLE 1.4b — restricted distribution.
3. Includes Catchment F2.5.
4. Includes Noah 3.3.
5. Includes SiB2.
6. Includes WRSI.
7. Support for North American Mesoscale Forecast System (NAM) “242 AWIPS Grid -- Over Alaska” product.
8. Support for USGS potential evapotranspiration (PET) data (for use in WRSI).
9. Support for Climate Prediction Center’s (CPC) Rainfall Estimates version 2 (RFE2) daily precipition (for use in WRSI).
10. Support to apply lapse-rate correction to bottom temperature field (for use in Noah).

D.8. LIS 6.1

1. Includes Noah 3.1.
2. Includes Noah 3.2.
3. Support for SPoRT Daily GVF data.
4. Support for North American Regional Reanalysis (3d) (NARR) data.
5. Support for NCEP's modified IGBP MODIS landcover data.
6. Support to specify direction for output variables.
7. Support for assimilation of ANSA snow depth products, MODIS snowcover, and LPRM retrievals of AMSRE soil moisture.

D.9. LIS 6.0

1. Modules have been restructured to streamline public and private interfaces
2. Restructured AGRMET processing — parallel support, lat/lon support.
3. This version now uses ESMF 3.1.0rp3.
4. Support for computational halos.
5. Allows mosaicing of different forcings concurrently (e.g. GDAS global + NLDAS over CONUS+SALDAS over south america, etc.)
6. Allows multiple overlays of different supplemental forcings (e.g. GDAS overlaid with NLDAS, AGRMET, STAGEIV)
7. Allows concurrent instances of data assimilation
8. Includes a highly configurable I/O interface (Allows unit conversions, temporal averaging, model-independent support for binary, Grib1 and NETCDF)
9. Includes support for 3d forcing (that includes the atmospheric profile) and a configurable specification of the forcing inputs
10. A dynamic bias estimation component (from NASA GMAO) has been added to the data assimilation subsystem.
11. Generic support for parameter estimation/optimization with the implmentation of a heuristic approach using Genetic Algorithms.
12. New sources for data assimilation (using NASA and NESDIS retrievals of AMSRE soil moisture)
13. Support for real time GVF data from NESDIS and MODIS
14. A suite of upscaling algorithms to complement the existing spatial downscaling algorithms.
15. Support for new map projections — UTM
16. Support for forward modeling using radiative transfer models, and support for radiance based assimilation

D.10. LIS 5.0

1. This version includes the infrastructure for performing data assimilation using a number of different algorithms from simple approaches such as direct insertion to the more sophisticated ensemble kalman filtering.
2. More streamlined support for different architectures: A configuration based specification for the LIS makefile.
3. The data assimilation infrastructure utilizes the Earth System Modeling Framework (ESMF) structures. The LIS configuration utility has been replaced with the corresponding ESMF utility.

D.11. LIS 4.2

1. Completed implementation of AGRMET processing algorithms
2. Ability to run on polar stereographic, mercator, lambert conformal, and lat/lon projections
3. Updated spatial interpolation tools to support the transformations to/from the above grid projections
4. Switched to a highly interactive configurations management from the fortran namelist-based lis.crd style.
5. Streamlined error and diagnostic logging, in both sequential and parallel processing environments.
6. extended grib support; included the UCAR-based read-grib library
7. Support for new supplemental forcing analyses — Huffman, CMORPH

D.12. LIS 4.1

1. Preliminary AFWA support
2. Ability to run on a defined layout of processors.
3. Updates to plugins, preliminary implementation of alarms.
4. Definition of LIS specfic environment variables.

D.13. LIS 4.0.2

1. GSWP-2 support — LIS can now run GSWP-2 experiments. Currently only CLM and Noah models have full support.
2. Updates to the 1km running mode.
3. Updates to the GDS running mode.

D.14. LIS 4.0

1. VIC 4.0.5 — LIS' implementation of VIC has been reinstated.

D.15. LIS 3.1

1. New domain-plugin support — facilitates creating new domains.
2. New domain definition support — facilitates defining running domains. Sub-domain selection now works for both MPI-based and non MPI-based runs.
3. New parameter-plugin support — facilitates adding new input parameter data-sets.
4. New LIS version of ipolates — facilitates creating new domains and base forcing data-sets.
5. Compile-time MPI support — MPI libraries are no longer required to compile LIS.
6. Compile-time netCDF support — netCDF libraries are no longer required to compile LIS.
7. New LIS time manager support — ESMF time manager was removed. ESMF libraries are not required in this version of LIS.

D.16. LIS 3.0

1. Running Modes — Now there is more than one way to run LIS. In addition to the standard MPI running mode, there are the GDS running mode and the 1 km running mode.
2. Sub-domain Selection — Now you are no longer limited to global simulations. You may choose any sub-set of the global domain to run over. See Section LIS config File for more details. (This is currently only available for the MPI-based running mode.)
3. Plug-ins — Now it is easy to add new LSM and forcing data-sets into the LIS driver. See LIS' Developer's Guide for more details.

Appendix E: Revision history

Revision	Summary of Changes	Date
7.0	LISF Public 7.8.0 release	Jun 5, 2026
6.0	LISF 557WW 7.8.0 release	Apr 20, 2026
5.0	LISF 557WW 7.7.0 release	Jan 16, 2026
4.1	LISF 557WW 7.6.1 release	Nov 21, 2025
3.1	LISF Public 7.5.3 release	Apr 29, 2025
4.0	LISF 557WW 7.6.0 release	Nov 12, 2024
2.6	LISF 557WW 7.5.15 release	Jun 14, 2024
3.0	LISF Public 7.5.0 release	Jan 11, 2024
2.5	LISF 557WW 7.5.9 release	Jul 05, 2023
2.4	LISF 557WW 7.5.8 release	Jun 30, 2023
2.3	LISF 557WW 7.5.5 release	Jun 20, 2023
2.2	LISF 557WW 7.5.4 release	May 5, 2023
2.1	LISF 557WW 7.5.0 release	Nov 30, 2022
2.0	LISF Public 7.4.0 release	Jun 22, 2022
1.19	LISF Public 7.3.4 release	May 27, 2022
1.18	LISF Public 7.3.2 release	Dec 06, 2021
1.17	Updates for LISF 557WW 7.4.6 release	Nov 17, 2021
1.16	LISF Public 7.3.1 release	Mar 31, 2021
1.15	Updates for LISF 557WW 7.4.0 release	Mar 4, 2021
1.14	Updates for LIS 557WW 7.3.3 release	Jan 25, 2021
1.13	LISF Public 7.3.0 release	Dec 21, 2020
1.12	LIS 557WW 7.3.0 release	Aug 24, 2020
1.11	LIS 557WW 7.3 release candidate 4	Aug 28, 2019
1.10	LIS 7.2 557WW release	Feb 2, 2018
1.9	LIS 7.2 AFWA Beta release	Nov 24, 2017
1.8	Updates regarding public release vs repository	Aug 7, 2017
1.7	Updates for LIS 7.2r Public Release	May 5, 2017

Revision	Summary of Changes	Date
1.6	Updates for LIS 7.1 AFWA Release	August 29, 2016
1.5	Updates for LIS 7.1rp7 Public Release	August 4, 2016
1.4	LIS 7.1 AFWA FY15 Deliverable	July 28, 2016
1.3	LIS 7.1rp1 Public Release	December 15, 2015
1.2	Note unavailability of MERRA2 forcing data	May 29, 2015
1.1	LIS 7.1 Public Release	May 27, 2015
1.0	LIS 7.1 Initial AFWA Release	April 13, 2015

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