LVT OL and DA Experiment Comparison

Step-7

In this presentation ...

- Overview of the Land Verification Toolkit (LVT) and case setup.
- LVT config file options;
- Running LVT for the open-loop (OL) and and data assimilation (DA) cases;
- Comparing the OL and DA output.

Running LVT: Our Testcase Overview

- Next, we compare the output from our *open-loop (Step 2) and data assimilation (Step 6)* runs, using the Land Verification Toolkit (LVT), which is part of the LISF software.
- We will read in to LVT the model output files generated in Steps 2 and 6 and compare the two experiments, along with the SMAP DA observations.
- Since LVT is a verification and validation software, you will need to plot the output with a visualization software, such as Python, Matlab, GrADS.
- Several features and options exist in LVT, so we greatly recommend users to review our online documentation found at:

  http://lis.gsfc.nasa.gov

  http://modelingguru.nasa.gov

Download necessary files to run this step …

1) Download the "*Step 3*" tarred-gzipped file from the LIS testcases webpage ("*testcase7_lvt_expcomp.tgz*").

2) Unpack the testcase files into your working directory, `$WORKING_DIR`

3) Once unpacked, you will see the following directories and files:

- `lvt.config.ol.da` ➔ LVT config file for the OL and DA model output
- `lvt.config_smapDAobs` ➔ LVT config file for the DA observations used in the DA run
- `METRICS.TBL` ➔ This LVT text file provides the statistical metric 'select' options
- `TS_LOCATIONS.TXT` ➔ This file specifies areal or single point locations for time-series
- **`target_STATS.ol.da`** ➔ `Directory containing processed LIS OL and DA output`
- **`target_STATS.smapDAobs`** ➔ `Directory containing processed SMAP DA obs`
- Target LVT log files ➔ two log files that were previously produced and provided

OL vs. SMAP DA Run Comparison

Step 1: Data comparison – Open Loop vs. SMAP-DA run, (lvt.config.ol.da)

```
#Overall driver options
LVT running mode:                    "Data intercomparison"
Map projection of the LVT analysis:    latlon
LVT output format:                      netcdf
LVT output methodology:              "2d gridspace"

Analysis data sources:              "LIS output"  "LIS output"
…

#     Datastream 1          |          Datastream 2
LVT datastream attributes table::
SoilMoist    1 1  m3/m3   - 1 4   SoilMoist   1 1  m3/m3  - 1 4
RootMoist  1 1  m3/m3   - 1 1  RootMoist  1 1  m3/m3  - 1 1
::
```

Step 2: Process DA observations, for same time period, same region/stations (lvt.config.smapDAobs)

```
#Overall driver options
LVT running mode:                    "Data intercomparison"
Map projection of the LVT analysis:    latlon
LVT output format:                      netcdf
LVT output methodology:              "2d gridspace"

Analysis data sources:              "LIS DAOBS"  "none"
## DATA STREAM INPUTS ....

#Observation
LIS DAOBS output directory:  ./SMAPDA_OUTPUT/DAOBS
LIS DAOBS domain file:       ../INPUT/lis_input.nldas.noah36.d01.nc
LIS DAOBS instance index:      1
LIS DAOBS use scaled obs:      1
LIS DAOBS output interval:     "15mn"
LIS DAOBS observation type:   "soil moisture"
```

Running LVT for our two cases

- First, run LVT to process and look at the OL vs. DA soil moisture output:

  `./LVT lvt.config.ol.da`

- Was the run successful?
  - **Yes** ⇒ *Great job!*
  - **No** ⇒ *look at the error message and lvtlog_ol_da.0000 file*
- The output will be found in the directory: `STATS.ol.da`
- The processed files should include point data for "Fort Cobb" and "Little Washita", which were specified in the `TS_LOCATIONS.txt` file.
- You can compare the output files with those found in the "target" directories: `target_STATS.ol.da`

Running LVT for our two cases

- Next run LVT to process the SMAP DA observations to be easily compared with our model output:

  `./LVT lvt.config.smapDAobs`

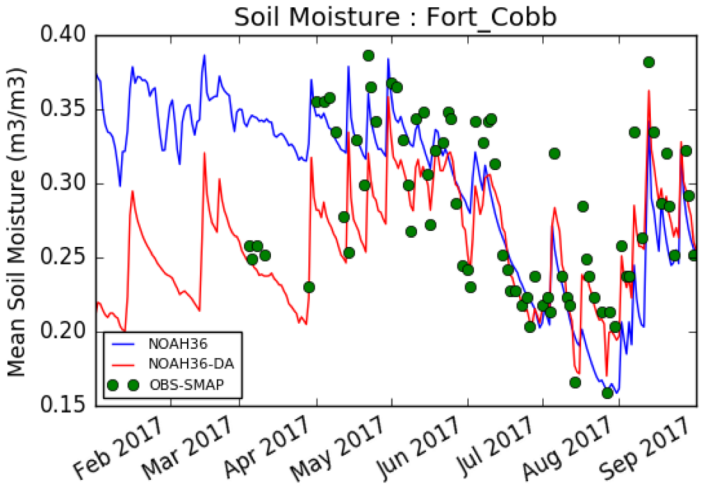
- Was the run successful?
  - **Yes** ⇒ *Great job!*
  - **No** ⇒ *look at the error message and lvtlog_ol_da.0000 file*
- The output will be found in the directory: **`STATS.smapDAobs`**
- You can compare the output files with those found in the "target" directories: **`target_STATS.smapDAobs`**

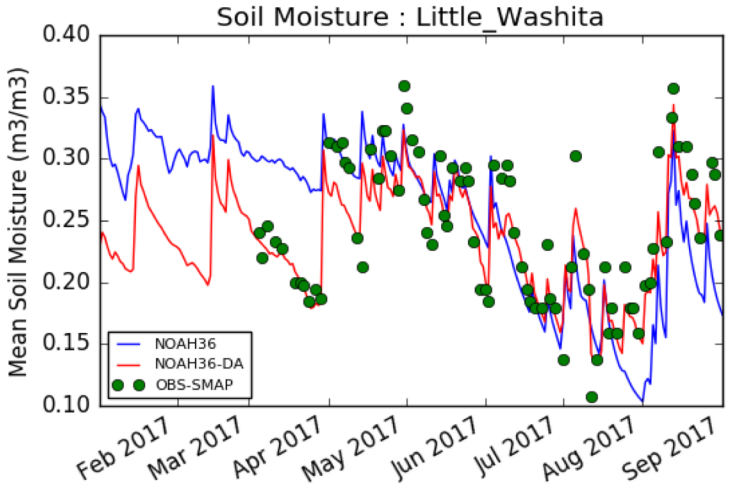
OL vs. SMAP: SMAP Assimilation Plots

To plot the output files, you can use almost any visualization package or software, e.g., Python, Matlab, GrADS, IDL, NCL.

Two sample scripts are provided for plotting in Matlab (plot_TS.m) and gnuplot (plot_noah36_smapda_littlewashita.plt).

Below, two example figures are shown, which were plotted with Python.





Examine LVT output

```
discover35> more MEAN_SUMMARY_STATS.dat
 ------------------------------------------------------
 VAR: soil_moisture_content_v_soil_moisture_content
 ------------------------------------------------------
     ALL:    0.20605E+00 +/-    0.34978E-02   0.99531E+02
Little_Was   0.20483E+00 +/-       -          0.99531E+02
Fort_Cobb:   0.22596E+00 +/-       -          0.99531E+02
 ------------------------------------------------------
 VAR: DS2_soil_moisture_content_v_soil_moisture_content
 ------------------------------------------------------
     ALL:    0.18673E+00 +/-    0.20791E-01   0.99531E+02
Little_Was   0.18190E+00 +/-       -          0.99531E+02
Fort_Cobb:   0.19157E+00 +/-       -          0.99531E+02
```

This file contains mean over regions or stations from model and from observations.

Columns 1 to 4 represent the location name, average value for that location, confidence interval, number of points contributing to the average

ASCII time series file

First 5 columns represent the time information (year, month, day, hour, minute)

```
discover34> more MEAN_Little_Washita.dat
2017 01 02 00 00  0.167289E+00 -0.999900E+04  0.167289E+00  0.167289E+00  0.000000E+00 -0.999900E+04
0.154833E+00 -0.999900E+04  0.154833E+00  0.154833E+00 -0.999900E+04 -0.999900E+04
2017 01 03 00 00   0.175021E+00 -0.999900E+04  0.175021E+00  0.175021E+00  0.000000E+00 -0.999900E+04
0.168958E+00 -0.999900E+04  0.168958E+00  0.168958E+00 -0.999900E+04 -0.999900E+04
2017 01 04 00 00   0.178459E+00 -0.999900E+04  0.178459E+00  0.178459E+00  0.000000E+00 -0.999900E+04
0.165292E+00 -0.999900E+04  0.165292E+00  0.165292E+00 -0.999900E+04 -0.999900E+04
```

For each variable, 6 columns for datastream1, 6 columns for data stream 2

Columns 6-11 represent the soil moisture values from LIS output, 12-17 represent soil moisture values from ARS data

- ☑ mean value
- ☑ standard deviation
- ☑ minimum
- ☑ maximum
- ☑ ensemble standard deviation
- ☑ confidence interval

If more variables are included in the analysis, additional columns will be included for each variable

Note that for comparison metrics, there will be no columns for observation values

Additional Background on the LVT Configuration File

- Next, we provide some additional explanations of the lvt.config file options and features.
- **Additional details can be found in the LVT user's guides, which can be found at the LIS website and on ModelingGuru.**

LVT configuration file

- For the text entries, case/exactness of the string is important!
- For entries with spaces, use double quotes. Otherwise quotes are not necessary
- Comments can be inserted with a # prefix

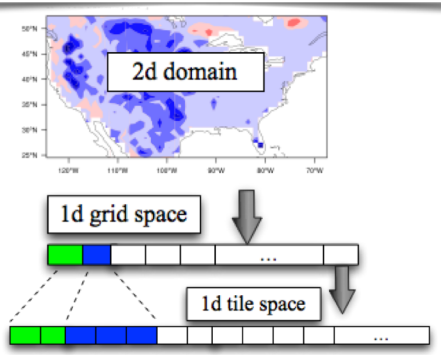
```
#------------------------------------------------------------------------------
# README
#
# This LVT configuration shows an example of comparing variables from a
# LIS output (from Noah.3.3 LSM) against the in-situ USDA ARS soil moisture
# measurements
#
# The model output from Noah.3.3 output is produced over CONUS at 0.125 deg
# spatial resolution (at daily intervals). The LVT analysis is conducted
# over a CONUS domain at 0.5 deg spatial resolution.
#
# The following variables are compared: surface soil moisture
#
# The following metrics are used: Mean and Anomaly correlation
#
#------------------------------------------------------------------------------

LVT running mode:                   "Data intercomparison"
Map projection of the LVT analysis: "latlon"
LVT output format:                  "netcdf"
LVT output methodology:             "2d gridspace"
Analysis data sources:              "LIS output" "USDA ARS soil moisture"
```

`LVT running mode:` specifies the running mode to be used Acceptable values are:

Value	Description
"Data intercomparison"	standard analysis mode where a particular data is compared against another
"Benchmarking"	A benchmarking output is generated based on the input training datasets
"DA statistics processing"	data assimilation diagnostics analysis
"DA observation processing"	data assimilation observation analysis
"OPTUE output processing"	parameter estimation/uncertainty output analysis
"RTM output processing"	radiative transfer model output analysis

`LVT output methodology:` specifies the output methodology used in LVT. The LVT output is written 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
"1d tilespace"	LVT output in a 1-D tile domain
"2d gridspace"	LVT output in a 2-D grid domain
"1d gridspace"	LVT output in a 1-D grid domain



Configuration: Time specification

```
Start mode:                          coldstart
LVT restart output interval:         "1mo"
LVT restart filename:                none
Starting year:                       2006
Starting month:                      5
Starting day:                        1
Starting hour:                       0
Starting minute:                     0
Starting second:                     0
Ending year:                         2006
Ending month:                        8
Ending day:                          31
Ending hour:                         0
Ending minute:                       0
Ending second:                       0
LVT clock timestep:                  "1da"
Undefined value:                     -9999
LVT diagnostic file:                 lvtlog
```

`LVT restart output interval:` specifies the frequency at which the restart files must be written during a LVT analysis. The time interval is specified with a number followed by a 2 character suffix that indicates the units. For example, a restart interval of 1 hour can be specified as "1hr", "60mn", or "3600ss".

Acceptable values for the 2 character suffix are:

Value	Description
ss	second
mn	minute
hr	hour
da	day
mo	month
yr	year

LVT recomputes the clock timestep based on the data intervals of each data stream. The minimum tilmestep value is chosen.

LVT clock timestep = min (timestep set in the config file, timestep of datastream 1, timestep of datastream 2)

Configuration: Analysis domain

```
Input domain and mask data file:  ./lis_input.nldas.nc
#LVT analysis domain
Run domain lower left lat:                25.75
Run domain lower left lon:              -124.75
Run domain upper right lat:               50.75
Run domain upper right lon:             -67.75
Run domain resolution (dx):               0.5
Run domain resolution (dy):               0.5
```

- Specifies the extents of the LVT analysis domain
- The config entries are dependent on the chosen LVT map projection
- The LVT analysis domain can be a subset of the domain specified in the 'Input domain and mask data file'
- The spatial resolution of the LVT analysis domain can be different from the spatial resolution of the 'Input domain and mask data file'
- LVT will generate the landmask for the analysis domain by interpolating/upscaling the 'LANDMASK' field

The input NetCDF file used to create the gridspace in LVT

Should contain a field called "LANDMASK" with a 0/1 landmask representation

The global attributes/dimensions of this file should contain relevant map projection and domain extent information

```
netcdf lis_input.nldas {
dimensions:
        east_west = 464 ;
        north_south = 224 ;
```

```
variables:
        float time(time) ;
        float LANDMASK(north_south, east_west) ;
                LANDMASK:standard_name = "LANDMASK" ;
                LANDMASK:units = "" ;
                LANDMASK:scale_factor = 1.f ;
                LANDMASK:add_offset = 0.f ;
                LANDMASK:missing_value = -9999.f ;
                LANDMASK:vmin = 0.f ;
                LANDMASK:vmax = 0.f ;
                LANDMASK:num_bins = 1 ;
```

```
// global attributes:
                :MAP_PROJECTION = "EQUIDISTANT CYLINDRICAL" ;
                :SOUTH_WEST_CORNER_LAT = 25.0625f ;
                :SOUTH_WEST_CORNER_LON = -124.9375f ;
                :DX = 0.125f ;
                :DY = 0.125f ;
```

Configuration: Data sources

```
#------------------------------------------------------------------------------
# README
#
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# LIS output (from Noah.3.3 LSM) against the in-situ USDA ARS soil moisture
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#
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# spatial resolution (at daily intervals). The LVT analysis is conducted
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#
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#
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#
#------------------------------------------------------------------------------

LVT running mode:                    "Data intercomparison"
Map projection of the LVT analysis: "latlon"
LVT output format:                  "netcdf"
LVT output methodology:             "2d gridspace"
Analysis data sources:              "LIS output" "USDA ARS soil moisture"
```

`Analysis data sources:` specifies the two sources of data to be used in an LVT comparison. The user must always choose two sources specified in adjacent columns. The second column entry will be taken as the reference data and the first column will be used as the data being evaluated (against the reference data). If the comparison LIS output against a non-LIS data, it is recommended to specify the first source as "LIS output" and then the other data as the second data source.

Value	Description
"none"	template
"LIS output"	output from another LIS run
"LIS DAOBS"	processed observations from a LIS DA run
"ISCCP LST"	ISCCP skin temperature observations
"MODIS LST"	MODIS (Terra/Aqua) land surface temperature observations
"SCAN"	SCAN soil moisture station observations
"NASMD"	North American Soil Moisture Database soil moisture station observ
"ISMN"	ISMN soil moisture station observations
"SURFRAD"	SURFRAD observations
"SNOTEL"	SNOTEL snow water equivalent observations
"LSWG Tb"	Tb brightness temperature observations at the LSWG sites
"FMI SWE"	Finnish Meteorological Institute (FMI) snow course data
"CMC"	Canadian Meteorological Center (CMC) snow depth analysis
"SNODAS"	NOHRSC SNow Data Assimilation (SNODAS) product
"AMSR-E NASA soil moisture"	NASA (NSIDC) retrival of AMSR-E soil moisture
"AMSR-E LPRM soil moisture"	LPRM (VU) retrival of AMSR-E soil moisture
"AMMA"	AMMA station observations
"Ameriflux"	Ameriflux station observations
"ARM"	ARM station observations
"SMOSREX"	SMOSREX station observations
"AGRMET"	AGRMET land surface analysis
"Globsnow"	GlobSnow SWE analysis
"SNODEP metobs"	WMO snow depth station observations
"MOD10A1"	MOD10A1 fractional snow cover data from MODIS
"ANSA snowdepth"	ANSA snow depth retrievals
"ANSA SWE"	ANSA SWE retrievals
"CPC precipitation"	CPC unified precipitation product
"USGS streamflow"	USGS streamflow observations
"Naturalized streamflow"	Naturalized streamflow estimates
"FLUXNET"	Gridded FLUXNET data from MPI
"MOD16A2"	MOD16A2 ET products from MODIS
"UW ET"	University of Washington ET products from MODIS
"ALEXI"	ALEXI model ET estimates from USDA
"USDA ARS soil moisture"	soil moisture measurements from USDA ARS watersheds
"GHCN"	Global Historical Climatology Network data
"ALEXI"	Atmosphere Land Exchange Inverse model outputs of ET
"NLDAS2"	North American Land Data Assimilation System Phase-2 data
"GRACE"	processed GRACE data used in a LIS-DA instance
"PBO H2O"	plate boundary observatory data
"USGS ground water well data"	USGS ground water well data
"SMOS L2 soil moisture"	SMOS level 2 soil moisture
"SMOS L1 TB"	SMOS level 1 brightness temperature
"GCOMW AMSR2 L3 soil moisture"	GCOMW AMSR2 level 3 soil moisture
"SMOPS soil moisture"	Soil Moisture Operational Product System data
"ESA CCI soil moisture"	ESA CCI soil moisture
"GIMMS NDVI"	GIMMS NDVI data
"GIMMS AVHRR NDVI"	GIMMS AVHRR NDVI data
"GIMMS MODIS NDVI"	GIMMS MODIS NDVI data
"GLDAS2"	NASA Global Land Data Assimilation System version 2 data
"MERRA2"	MERRA version 2 data
"ERA interim land"	ERA Interim Land data
"SSEB"	USGS SSEB operational ET and ET anomaly data
"GRDC"	Global Runoff Data Center data
"GLERL hydro data"	Great Lakes hydrology data
"GL6 JULES data"	GL6 JULES data
"GLEAM"	GLEAM data
"FLUXNET2015 dataset"	Measurements from FLUXNET2015 dataset
"USCRN soil moisture"	USCRN soil moisture data

- Two data sources must always be specified, separated by spaces

"LIS output" "LIS output"

"LIS output" "none"

"LIS output" "NLDAS2"

"NLDAS2" "CMC"

"NLDAS2" "GDAS2"

Configuration: Datastream attributes table

```
LVT datastream attributes table::
SoilMoist  1 1  m3/m3   - 1 4 SoilMoist  1 1  m3/m3   - 1 1
::
```

Variable from datastream 1 | Variable from datastream 2

- Variable name
- Starting number of selected levels (0=>not selected)
- Ending number of selected levels
- Units
- Direction type
- Time averaging option (0-instantaneous, 1- time averaged)
- Number of total vertical levels

```
LVT datastream attributes table::
Qle  1 1 W/m2   UP 1 1 SoilMoist   1 1 m3/m3 - 1 4
Qle  1 1 W/m2   UP 1 1 TotalPrecip 1 1 kg/m2 - 1 1
Qle  1 1 W/m2   UP 1 1 Rnet       1 1 W/m2  - 1 1
RadT 0 0 K      - 1 1 RadT        0 0 K     - 1 1
::
```

- Specifies the variables being analyzed from the datastreams
- Each line represents variable specification from datastream 1 and datastream 2
- Specification for each variable consists of 6 columns; variable names follow ALMA convention
- Any variable from datastream 1 can be compared to any variable from datastream 2 (as long as the metric of comparison is meaningful!)

- Qle being compared against surface soil moisture, total precipitation, Net radiation
- Qle from datastream 1 is used for multiple comparisons against variables from datastream 2
- Radiative temperature comparison is turned off

Configuration: Vertical averaging, external masking

```
LVT surface soil layer thickness:  0.10
LVT root zone soil layer thickness:  1.0
```

- Specifies the thickness (m) of the surface and root zone soil layers used in the analysis
- LVT will vertically average the individual soil layers (of the datastreams) to the thickness used in analysis
- The averaging will be weighted by the thicknesses

```
Apply external mask:                    0
External mask directory:                none
Temporal (monthly) mask flags:          0 0 0 0 1 1 1 0 0 0 0 0
```

- 0 - no masking
- 1- external temporally varying mask
- 2 - external fixed static mask
- 3 - temporal monthly mask

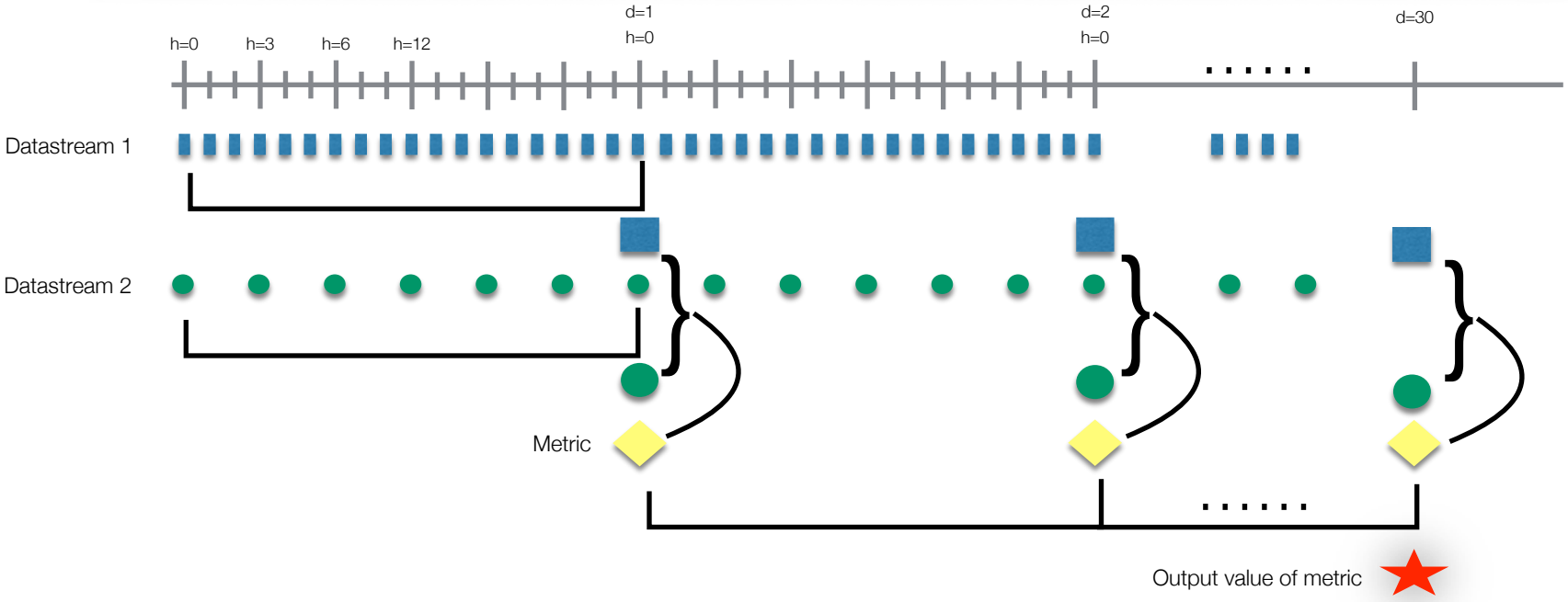
- Apply monthly mask (0/1) in the analysis (restricts the analysis to JJA in the above case)

External mask directory: Specifies the name of the data mask file/directory. If the mask varies temporally, then this option specifies the top-level directory containing data mask. Note that the mask files are expected to be in binary, sequential access format.

Configuration: Output frequency

```
Observation count threshold:                    0
Metrics computation frequency:                  "1da"
Metrics output frequency:                       "1mo"
Starting month if a shifted year definition is used in temporal averaging: 1
```

- Observation count threshold - computations are excluded over those grid points where the specified minimum count is not met
- Metrics computation frequency - the individual datastream values are averaged upto this interval and then the metric is computed
- Metrics output frequency - the metric values are averaged upto the stats output interval



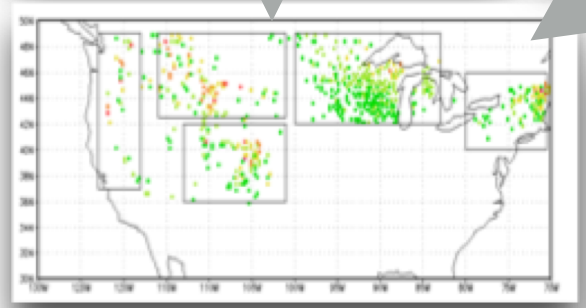
Configuration: Time series output

- Specifies the name of the file that lists the locations and regions in the domain where ASCII time series data (for each metric) are to be derived
- Five different styles of specifying the locations/regions

```
Time series location file:                    ./TS_LOCATIONS.TXT
```

Style 1: Specify lat/lon bounding boxes

```
#Number of locations
2
#Location style (1-lat/lon, 2-col/row, 3-tile)
1
#Location name, (next line) SW-lat, SW-lon, NE-lat, NE-lon,
min number of grid points
WEST_US
40 -130 50 -110 5
HIGH_PLAINS_US
43 -110 49 -100 2
 .....
 .....
```



Style 2: Specify column/row bounding indices

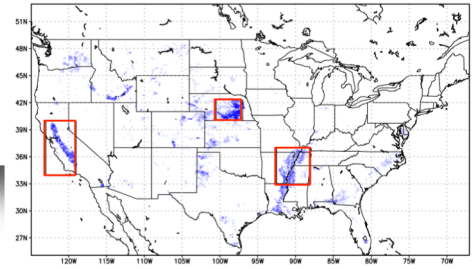
```
#Number of locations
1
#Location style (1-lat/lon, 2-col/row, 3-tile)
2
#Location name, (next line) SW-col, SW-row, NE-col, NE-row,
min number of grid points
WEST_US
1  1  20 30 5
EAST_US
1  1  10 10 5
 .....
 .....
```

Style 3: Specify 1-d tile bounding indices

```
#Number of locations
1
#Location style (1-lat/lon, 2-col/row, 3-tile)
3
#Location name, (next line) Start index, Ending index,
min number of grid points
WEST_US
1  20 5
EAST_US
1  10 5
.....
.....
```

Style 4: List of lat/lons to specify a region

```
#Number of locations
2
#Location style
4
#number of points followed by lat/lon of each point
REGION1
3
34.4 -103.2
33.4 -100.2
32.1 -99.3
REGION2
2
40.2 -103.3
42.2 -104.2
```



Style 5: Regions defined by a categorical map

```
#Number of stations
3
#style
5
#names
NEWENGLAND
1
MIDATLANTIC
1
SOUTHATLANTIC
1
#categorical map
../huc02_conus_0.125dg.1gd4r
```

Configuration: Metrics attributes

```
Metrics attributes file:                    ./METRICS.TBL
```

#name total in-time writeTS extractTS threshold SC ADC short_name

```
Mean:                          1  1  0  1  -9999.0  -9999.0 0  0  #Mean
Min:                           0  0  0  0  -9999.0  -9999.0 0  0  #Minimum
MinTime:                       0  0  0  0  -9999.0  -9999.0 0  0  #MinTime
Max:                           0  0  0  0  -9999.0  -9999.0 0  0  #Maximum
MaxTime:                       0  0  0  0  -9999.0  -9999.0 0  0  #MaxTime
Sum:                           0  0  0  0  -9999.0  -9999.0 0  0  #Sum
Anomaly:                       0  0  0  0  -9999.0  -9999.0 0  0  #Anomaly
Standard deviation:            0  0  0  0  -9999.0  -9999.0 0  0  #Std
RMSE:                          0  0  0  0  -9999.0  -9999.0 0  0  #RMSE
Bias:                          0  0  0  0  -9999.0  -9999.0 0  0  #Bias
ubRMSE:                        0  0  0  0  -9999.0  -9999.0 0  0  #ubRMSE
Mean absolute error:           0  0  0  0  -9999.0  -9999.0 0  0  #MAE
Anomaly RMSE:                  0  0  0  0  -9999.0  -9999.0 0  0  #ARMSE
Anomaly correlation:           0  0  0  0  -9999.0  -9999.0 0  0  #ARMSE
Raw correlation:               0  0  0  0  -9999.0  -9999.0 0  0  #RCORR
Rank correlation:              0  0  0  0  -9999.0  -9999.0 0  0  #RnkCORR
.....
.....

Probability of detection (PODy):       0  0  0  0  0.1     0.3     0  0  #PODy
Probability of detection (PODn):       0  0  0  0  0.1     0.3     0  0  #PODn
False alarm ratio (FAR):               0  0  0  0  0.1     0.3     0  0  #FAR
Probability of false detection (POFD): 0  0  0  0  0.1     0.3     0  0  #POFD
Critical success index (CSI):          0  0  0  0  0.1     0.3     0  0  #CSI
Accuracy measure (ACC):                0  0  0  0  0.1     0.3     0  0  #ACC
Frequency bias (FBIAS):                0  0  0  0  0.1     0.3     0  0  #FBIAS
Equitable threat score (ETS):          0  0  0  0  0.1     0.3     0  0  #ETS
Area metric:                           0  0  0  0  -9999.0  -9999.0 0  0  #Area
Nash sutcliffe efficiency:             0  0  0  0  -9999.0  -9999.0 0  0  #NSE
Metric entropy:                        0  0  0  0  -9999.0  -9999.0 0  0  #mentropy
Information gain:                      0  0  0  0  -9999.0  -9999.0 0  0  #igain
Fluctuation complexity:                0  0  0  0  -9999.0  -9999.0 0  0  #fcomplexity
Effective complexity:                  0  0  0  0  -9999.0  -9999.0 0  0  #ecomplexity
Hausdorff norm:                        0  0  0  0  -9999.0  -9999.0 0  0  #Hnorm
Standard precipitation index:          0  0  0  0  -9999.0  -9999.0 0  0  #SPI
Standard runoff index:                 0  0  0  0  -9999.0  -9999.0 0  0  #SRI
Standardized soil water index:         0  0  0  0  -9999.0  -9999.0 0  0  #SSWI
Standardized ground water index:       0  0  0  0  -9999.0  -9999.0 0  0  #SGWI
Percentile:                            0  0  0  0  -9999.0  -9999.0 0  0  #Percentile
```

- Each line specifies an analysis metric
- 8 entries for each metric

- Metric name (use the user's guide or the master file)
- Use option (0 or 1)
- Time option (0 or 1 ; whether to compute the metric at the temporal averaging interval and output them at the stats output intervals)
- Temporal output - whether to write gridded metric files at the stats output interval (time option must also be enabled)
- Extract time series - whether to extract (ASCII) time series files for the metric, for each sub-domains specified in the time series location file
- min threshold: min threshold value to be used in computing categorical metrics
- max threshold: max threshold value to be used in computing categorical metrics
- Compute average seasonal cycle (monthly, 3-monthly)
- Compute average diurnal cycle

Finally, details of the datastreams…

```
LIS output interval:                              "1da"
LIS output analysis data class:                   "LSM"
LIS output number of surface model types:          1
LIS output surface model types:                   "LSM"
LIS output model name:                            "Noah.3.3"
LIS output domain and parameter file:            ../DATA_Noah33_CONUS/lis_input.d01.nc
LIS output directory:                            ../DATA_Noah33_CONUS/OUTPUT
LIS output naming style:                         "3 level hierarchy"
LIS output methodology:                          "2d gridspace"
LIS output format:                               "netcdf"
LIS output attributes file:                      ../DATA_Noah33_CONUS/NOAH33_OUTPUT_LIST.TBL
LIS output maximum number of surface type tiles per grid:     1
LIS output minimum cutoff percentage (surface type tiles):    0.10
LIS output maximum number of soil texture tiles per grid:     1
LIS output minimum cutoff percentage (soil texture tiles):    0.10
LIS output maximum number of soil fraction tiles per grid:    1
LIS output minimum cutoff percentage (soil fraction tiles):   0.10
LIS output maximum number of elevation bands per grid:        1
LIS output minimum cutoff percentage (elevation bands):       0.10
LIS output maximum number of slope bands per grid:            1
LIS output minimum cutoff percentage (slope bands):           0.10
LIS output maximum number of aspect bands per grid:           1
LIS output minimum cutoff percentage (aspect bands):          0.10
LIS output number of ensembles per tile:                   1
LIS output nest index:                                     1
LIS output elevation data source:                         none
LIS output slope data source:                             none
LIS output aspect data source:                            none
LIS output soil texture data source:                      none
LIS output soil fraction data source:                     none
LIS output number of soil moisture layers:                4
LIS output number of soil temperature layers:             4
LIS output soil moisture layer thickness:              0.1 0.3 0.6 1.0
LIS output soil temperature layer thickness:           0.1 0.3 0.6 1.0
```

Description of the LIS output

- Output interval
- Analysis data class (LSM, routing, RTM, Irrigation, ..)
- LDT generated input file used in the LIS run
- Output attributes table used in the LIS run
- Output naming style, format, methodology
- Subgrid tiling settings used in the LIS run
- Soil layering information