Land Information System
Version 6.0
LIS software architecture
LIS software architecture
LIS software architecture
LIS software architecture
LIS software architecture
Core Layer Enhancements
Uses ESMF3 series
Uses ESMF3 series
Core modules redesigned as “tight containers”

only public methods and variables are exposed
Uses ESMF3 series
Core modules redesigned as “tight containers”
  only public methods and variables are exposed
Strict checking of configuration settings
Uses ESMF3 series

Core modules redesigned as “tight containers”
only public methods and variables are exposed

Strict checking of configuration settings

Anew suite of spatial upscaling algorithms
Uses ESMF3 series
Core modules redesigned as “tight containers” only public methods and variables are exposed
Strict checking of configuration settings
A new suite of spatial upscaling algorithms
Support for 3d meteorological data
Uses ESMF3 series
Core modules redesigned as “tight containers”
only public methods and variables are exposed

Strict checking of configuration settings
A new suite of spatial upscaling algorithms
Support for 3d meteorological data
Supports computational halos
Uses ESMF3 series
Core modules redesigned as “tight containers”
only public methods and variables are exposed
Strict checking of configuration settings
A new suite of spatial upscaling algorithms
Support for 3D meteorological data
Supports computational halos
Uses ESMF3 series
Core modules redesigned as “tight containers”
only public methods and variables are exposed
Strict checking of configuration settings
Anew suite of spatial upscaling algorithms
Support for 3d meteorological data
Supports computational halos
Uses ESMF3 series
Core modules redesigned as “tight containers”
only public methods and variables are exposed
Strict checking of configuration settings
A new suite of spatial upscaling algorithms
Support for 3d meteorological data
Supports computational halos
Uses ESMF3 series
Core modules redesigned as “tight containers”
only public methods and variables are exposed
Strict checking of configuration settings
Anew suite of spatial upscaling algorithms
Support for 3d meteorological data
Supports computational halos

Halo size along x: 10
Halo size along y: 10
Configurable I/O

Model independent

Binary, Grib 1, NETCDF

Options for unit conversions

Options for temporal averaging
Configurable I/O

Model independent

Binary, Grib I, NETCDF

Options for unit conversions

Options for temporal averaging

<table>
<thead>
<tr>
<th>#Name</th>
<th>Select?</th>
<th>Units</th>
<th>Timeavg</th>
<th>Max/min</th>
<th>Vert.levels</th>
<th>Gribid</th>
<th>Grib category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swnet:</td>
<td>1</td>
<td>W/m²</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>111</td>
<td>10</td>
</tr>
<tr>
<td>Lwnet:</td>
<td>1</td>
<td>W/m²</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>112</td>
<td>10</td>
</tr>
<tr>
<td>Qle:</td>
<td>1</td>
<td>W/m²</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>121</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totalprecip:</td>
<td>1</td>
<td>kg/m²</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>164</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SoilMoist:</td>
<td>1</td>
<td>m³/m³</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>84</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#Parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landcover:</td>
<td>1</td>
<td>--</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>186</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#Parameters
Incremental forcing overlays
Incremental forcing overlays

“Spatial Mosaicing” of different forcings concurrently
Incremental forcing overlays

“Spatial Mosaicing” of different forcings concurrently

Multiple, incremental overlays of different supplemental forcings
Incremental forcing overlays

“Spatial Mosaicing” of different forcings concurrently

Multiple, incremental overlays of different supplemental forcings

NLDAS + GDAS
Incremental forcing overlays

“Spatial Mosaicing” of different forcings concurrently

Multiple, incremental overlays of different supplemental forcings
Incremental forcing overlays

“Spatial Mosaicing” of different forcings concurrently

Multiple, incremental overlays of different supplemental forcings

Optional data masks
Incremental forcing overlays

“Spatial Mosaicing” of different forcings concurrently

Multiple, incremental overlays of different supplemental forcings

Optional data masks

No mask applied

CONUS mask applied
Incremental forcing overlays
### Incremental forcing overlays

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base forcing source</td>
<td>1 # GDAS</td>
</tr>
<tr>
<td>Number of base forcing variables</td>
<td>10</td>
</tr>
<tr>
<td>Use elevation correction (base forcing)</td>
<td>1 #1-use lapse rate</td>
</tr>
<tr>
<td>Spatial interpolation method (base forcing)</td>
<td>1 #1-bilinear</td>
</tr>
<tr>
<td>Temporal interpolation method (base forcing)</td>
<td>1 #1-linear</td>
</tr>
<tr>
<td>Number of supplemental forcing sources</td>
<td>3 # 0 or higher</td>
</tr>
<tr>
<td>Supplemental forcing sources</td>
<td>4 2 16 # NLDAS+CMAP+STAGEIV</td>
</tr>
<tr>
<td>Number of supplemental forcing variables</td>
<td>10 1 1</td>
</tr>
<tr>
<td>Use elevation correction (supplemental forcing)</td>
<td>0 0 0 #1-use lapse rate</td>
</tr>
<tr>
<td>Spatial interpolation method (supplemental forcing)</td>
<td>1 2 2</td>
</tr>
<tr>
<td>Temporal interpolation method (supplemental forcing)</td>
<td>1 1 1</td>
</tr>
</tbody>
</table>
## Incremental forcing overlays

<table>
<thead>
<tr>
<th>Base forcing source:</th>
<th>1 # GDAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of base forcing variables:</td>
<td>10</td>
</tr>
<tr>
<td>Use elevation correction (base forcing):</td>
<td>1 #1-use lapse rate</td>
</tr>
<tr>
<td>Spatial interpolation method (base forcing):</td>
<td>1 #1-bilinear</td>
</tr>
<tr>
<td>Temporal interpolation method (base forcing):</td>
<td>1 #1-linear</td>
</tr>
<tr>
<td>Number of supplemental forcing sources:</td>
<td>3 # 0 or higher</td>
</tr>
<tr>
<td>Supplemental forcing sources:</td>
<td>4 2 16 # NLDAS+CMAP+STAGEIV</td>
</tr>
</tbody>
</table>

### #ALMA Name select vlevels units

<table>
<thead>
<tr>
<th>Name</th>
<th>Select</th>
<th>Vlevels</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tair:</td>
<td>1 1 K</td>
<td># Near Surface Air Temperature</td>
<td></td>
</tr>
<tr>
<td>Qair:</td>
<td>1 1 kg/kg</td>
<td># Near Surface Specific Humidity</td>
<td></td>
</tr>
<tr>
<td>SWdown:</td>
<td>1 1 W/m²</td>
<td># Incident Shortwave Radiation</td>
<td></td>
</tr>
<tr>
<td>SWdirect:</td>
<td>0 1 W/m²</td>
<td># Incident Shortwave Radiation</td>
<td></td>
</tr>
<tr>
<td>SWdiffuse:</td>
<td>0 1 W/m²</td>
<td># Incident Shortwave Radiation</td>
<td></td>
</tr>
<tr>
<td>LWdown:</td>
<td>1 1 W/m²</td>
<td># Incident Longwave Radiation</td>
<td></td>
</tr>
<tr>
<td>Wind_E:</td>
<td>1 1 W/m²</td>
<td># Eastward Wind</td>
<td></td>
</tr>
<tr>
<td>Wind_N:</td>
<td>1 1 m/s</td>
<td># Northward Wind</td>
<td></td>
</tr>
<tr>
<td>Psurf:</td>
<td>1 1 Pa</td>
<td># Surface Pressure</td>
<td></td>
</tr>
<tr>
<td>Rainf:</td>
<td>1 1 kg/m²s</td>
<td># Rainfall Rate</td>
<td></td>
</tr>
<tr>
<td>Snowf:</td>
<td>0 1 kg/m²s</td>
<td># Snowfall Rate</td>
<td></td>
</tr>
<tr>
<td>CRainf:</td>
<td>1 1 kg/m²s</td>
<td># Convective Rainfall Rate</td>
<td></td>
</tr>
<tr>
<td>Forc_Hgt:</td>
<td>0 1 m</td>
<td># Height of Forcing Variables</td>
<td></td>
</tr>
<tr>
<td>Ch:</td>
<td>0 1 -</td>
<td># Surface Exchange Coefficient for Heat</td>
<td></td>
</tr>
</tbody>
</table>
Incremental data assimilation overlays

Allows concurrent instances of data assimilation
Incremental data assimilation overlays

Allows concurrent instances of data assimilation
Incremental data assimilation overlays

Allows concurrent instances of data assimilation

MODIS sca
Incremental data assimilation overlays

Allows concurrent instances of data assimilation
Incremental data assimilation overlays

Allows concurrent instances of data assimilation

MODIS LST

AMSRE soil moisture

MODIS sca
ESMF-compliant coupling to WRF
ESMF-compliant coupling to WRF

LIS
ESMF-compliant coupling to WRF
ESMF-compliant coupling to WRF
ESMF-compliant coupling to WRF
ESMF-compliant coupling to WRF
Abstractions Layer Enhancements
Dynamic bias estimation
Dynamic bias estimation

Allows the incorporation of a dynamic bias estimation algorithms
Dynamic bias estimation

Allows the incorporation of a dynamic bias estimation algorithms

Data Assimilation
Dynamic bias estimation

Allows the incorporation of a dynamic bias estimation algorithms

Data Assimilation

Refined interfaces (More QA/QC options, I/O of processed observations)
Dynamic bias estimation
Allows the incorporation of a dynamic bias estimation algorithms

Data Assimilation
Refined interfaces (More QA/QC options, I/O of processed observations)

Land Surface Parameters
Dynamic bias estimation
Allows the incorporation of a dynamic bias estimation algorithms

Data Assimilation
Refined interfaces (More QA/QC options, I/O of processed observations)

Land Surface Parameters
Eliminated map projection dependencies
Radiative Transfer Models
Radiative Transfer Models

Allows the incorporation of radiative transfer and forward modeling methods
Radiative Transfer Models

Allows the incorporation of radiative transfer and forward modeling methods

Towards a radiance-based data assimilation system
Radiative Transfer Models

Allows the incorporation of radiative transfer and forward modeling methods

Towards a radiance-based data assimilation system
Radiative Transfer Models

Allows the incorporation of radiative transfer and forward modeling methods

Towards a radiance-based data assimilation system

LIS Core
Radiative Transfer Models

Allows the incorporation of radiative transfer and forward modeling methods
Towards a radiance-based data assimilation system
Radiative Transfer Models

Allows the incorporation of radiative transfer and forward modeling methods

Towards a radiance-based data assimilation system
Radiative Transfer Models

Allows the incorporation of radiative transfer and forward modeling methods
Towards a radiance-based data assimilation system
Radiative Transfer Models

Allows the incorporation of radiative transfer and forward modeling methods
Towards a radiance-based data assimilation system
Optimization
Optimization

Allows the incorporation of optimization algorithms
Optimization

Allows the incorporation of optimization algorithms
Optimization

Allows the incorporation of optimization algorithms
Optimization

Allows the incorporation of optimization algorithms
Optimization

Allows the incorporation of optimization algorithms
Optimization

Allows the incorporation of optimization algorithms

- Parameters in the LSM
- Decision (Variable) Space
- LIS Core
- Optimization Algorithm
  - PEST
  - GA
  - SCE-UA
- Objective (Constraint) Space
- Observations
  - Soil Moisture Fluxes, ....
Model Layer Additions
LSMs: Noah 3.1 (supports concurrent use of multiple Noah versions), TESSEL, PLACE, CLM3.5
LSMs: Noah 3.1 (supports concurrent use of multiple Noah versions), TESSEL, PLACE, CLM3.5

Running Mode: RTM forward mode, Parameter estimation mode
LSMs: Noah 3.1 (supports concurrent use of multiple Noah versions), TESSEL, PLACE, CLM3.5

Running Mode: RTM forward mode, Parameter estimation mode

Meteorological Forcing: GFS, GDAS (reads 9hr forecasts), GEOS (reads GEOS5 format), NARR profiles; NLDAS, NLDAS-II, SALDAS redesigned as supplemental forcings
LSMs: Noah 3.1 (supports concurrent use of multiple Noah versions), TESSEL, PLACE, CLM3.5

Running Mode: RTM forward mode, Parameter estimation mode

Meteorological Forcing: GFS, GDAS (reads 9hr forecasts), GEOS (reads GEOS5 format), NARR profiles; NLDAS, NLDAS-II, SALDAS redesigned as supplemental forcings

Dynamic bias estimation: GMAO bias estimation algorithm (Dee 2003)
LSMs: Noah 3.1 (supports concurrent use of multiple Noah versions), TESSEL, PLACE, CLM3.5

Running Mode: RTM forward mode, Parameter estimation mode

Meteorological Forcing: GFS, GDAS (reads 9hr forecasts), GEOS (reads GEOS5 format), NARR profiles; NLDAS, NLDAS-II, SALDAS redesigned as supplemental forcings

Dynamic bias estimation: GMAO bias estimation algorithm (Dee 2003)

Optimization: PEST, Genetic Algorithm, SCE-UA
LSMs:  Noah 3.1 (supports concurrent use of multiple Noah versions), TESSEL, PLACE, CLM3.5

Running Mode: RTM forward mode, Parameter estimation mode

Meteorological Forcing: GFS, GDAS (reads 9hr forecasts), GEOS (reads GEOS5 format), NARR profiles; NLDAS, NLDAS-II, SALDAS redesigned as supplemental forcings

Dynamic bias estimation: GMAO bias estimation algorithm (Dee 2003)

Optimization: PEST, Genetic Algorithm, SCE-UA

Radiative Transfer Models: CRTM
LSMs: Noah 3.1 (supports concurrent use of multiple Noah versions), TESSEL, PLACE, CLM3.5

Running Mode: RTM forward mode, Parameter estimation mode

Meteorological Forcing: GFS, GDAS (reads 9hr forecasts), GEOS (reads GEOS5 format), NARR profiles; NLDAS, NLDAS-II, SALDAS redesigned as supplemental forcings

Dynamic bias estimation: GMAO bias estimation algorithm (Dee 2003)

Optimization: PEST, Genetic Algorithm, SCE-UA

Radiative Transfer Models: CRTM

Land Surface Parameters: Real-time GVF (AVHRR, MODIS), MODIS (C5) landcover, LAI, GVF, albedo
LSMs: Noah 3.1 (supports concurrent use of multiple Noah versions), TESSEL, PLACE, CLM3.5

Running Mode: RTM forward mode, Parameter estimation mode

Meteorological Forcing: GFS, GDAS (reads 9hr forecasts), GEOS (reads GEOS5 format), NARR profiles; NLDAS, NLDAS-II, SALDAS redesigned as supplemental forcings

Dynamic bias estimation: GMAO bias estimation algorithm (Dee 2003)

Optimization: PEST, Genetic Algorithm, SCE-UA

Radiative Transfer Models: CRTM

Land Surface Parameters: Real-time GVF (AVHRR, MODIS), MODIS (C5) landcover, LAI, GVF, albedo

Data Assimilation: AMSR-E soil moisture (NASA, USDA, UVA), ISCCP LST, MODIS SCA (standard and gap-filled), ANSA
LSMs: Noah 3.1 (supports concurrent use of multiple Noah versions), TESSEL, PLACE, CLM3.5

Running Mode: RTM forward mode, Parameter estimation mode

Meteorological Forcing: GFS, GDAS (reads 9hr forecasts), GEOS (reads GEOS5 format), NARR profiles; NLDAS, NLDAS-II, SALDAS redesigned as supplemental forcings

Dynamic bias estimation: GMAO bias estimation algorithm (Dee 2003)

Optimization: PEST, Genetic Algorithm, SCE-UA

Radiative Transfer Models: CRTM

Land Surface Parameters: Real-time GVF (AVHRR, MODIS), MODIS (C5) landcover, LAI, GVF, albedo

Data Assimilation: AMSR-E soil moisture (NASA, USDA, UVA), ISCCP LST, MODIS SCA (standard and gap-filled), ANSA
Useful (unsupported!) utilities
Ensemble restart generator: Generates a restart file for an ensemble run from a single ensemble member restart file
Ensemble restart generator: Generates a restart file for an ensemble run from a single ensemble member restart file

GrADS control file generator: Generates a GrADS control file for a LIS simulation
Ensemble restart generator: Generates a restart file for an ensemble run from a single ensemble member restart file

GrADS control file generator: Generates a GrADS control file for a LIS simulation

Restart Converter: Generates a fine resolution restart file from a coarse resolution LIS restart file
Ensemble restart generator: Generates a restart file for an ensemble run from a single ensemble member restart file

GrADS control file generator: Generates a GrADS control file for a LIS simulation

Restart Converter: Generates a fine resolution restart file from a coarse resolution LIS restart file

More to come.... Contributions encouraged....
Caveats

No “public” release yet
Considerable changes to LIS configuration
Documentation and Testcases are still being updated