Land Information System

LIS 7.1 Users’ Guide

August 4, 2016

Revision 1.5

History:

<table>
<thead>
<tr>
<th>Revision</th>
<th>Summary of Changes</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Updates for LIS 7.1rp7 Public Release</td>
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</tr>
</tbody>
</table>

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

1
History:

<table>
<thead>
<tr>
<th>Revision</th>
<th>Summary of Changes</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
<td>1.4</td>
<td>LIS 7.1 AFWA FY15 Deliverable</td>
<td>July 28, 2016</td>
</tr>
<tr>
<td>1.3</td>
<td>LIS 7.1rp1 Public Release</td>
<td>December 15, 2015</td>
</tr>
<tr>
<td>1.2</td>
<td>Note unavailability of MERRA2 forcing data</td>
<td>May 29, 2015</td>
</tr>
<tr>
<td>1.1</td>
<td>LIS 7.1 Public Release</td>
<td>May 27, 2015</td>
</tr>
<tr>
<td>1.0</td>
<td>LIS 7.1 Initial AFWA Release</td>
<td>April 13, 2015</td>
</tr>
</tbody>
</table>
Contents

1 Introduction ................................................................. 11
   1.1 What’s New ......................................................... 11
      1.1.1 LIS 7.1 ..................................................... 11
      1.1.2 LIS 7.0 ..................................................... 12
      1.1.3 LIS 6.2 ..................................................... 13
      1.1.4 LIS 6.1 ..................................................... 14
      1.1.5 LIS 6.0 ..................................................... 14
      1.1.6 LIS 5.0 ..................................................... 15
      1.1.7 LIS 4.2 ..................................................... 15
      1.1.8 LIS 4.1 ..................................................... 16
      1.1.9 LIS 4.0.2 .................................................... 16
      1.1.10 LIS 4.0 ..................................................... 16
      1.1.11 LIS 3.1 ..................................................... 16
      1.1.12 LIS 3.0 ..................................................... 17

2 Background .............................................................. 18
   2.1 LIS ................................................................. 18
   2.2 LIS core .......................................................... 19

3 Preliminary Information .................................................. 21

4 Obtaining the Source Code ............................................. 22
   4.1 Important Note Regarding File Systems .......................... 22
8 Output Data Processing

8.1 Fortran binary output format
8.2 GRIB1 output format
8.3 NetCDF output format

9 LIS config File

9.1 Overall driver options
9.2 Runtime options
9.3 Data assimilation
  9.3.1 AMSR-E (NASA) soil moisture assimilation
  9.3.2 AMSR-E (LPRM) soil moisture assimilation
  9.3.3 ECV soil moisture assimilation
  9.3.4 WindSat soil moisture assimilation
  9.3.5 ANSA Snow Covered Fraction (SCF) Assimilation
  9.3.6 MODIS snow cover fraction assimilation
  9.3.7 PMW snow depth or SWE assimilation
  9.3.8 GRACE TWS Assimilation
  9.3.9 SMOPS soil moisture assimilation
9.4 Radiative Transfer/Forward Models
  9.4.1 CRM2EM
  9.4.2 CMEM3
9.5 Optimization and Uncertainty Estimation
  9.5.1 Least squares
  9.5.2 Probability
9.5.3 Likelihood . . . . . . . . . . . . . . . . . . . . . . . . . . . 87
9.5.4 Genetic Algorithm . . . . . . . . . . . . . . . . . . . . . . 87
9.5.5 Differential Evolution Markov Chain (DEMCz) algorithm 89
9.5.6 Monte Carlo simulation . . . . . . . . . . . . . . . . . . . 90
9.5.7 Observations for Parameter Estimation . . . . . . . . . . . 90
9.5.8 AMSR_E SR Emissivity . . . . . . . . . . . . . . . . . . . . 90
9.5.9 AMSR-E (LPRM) pe soil moisture . . . . . . . . . . . . . 91
9.5.10 No obs . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 91
9.6 Parameters . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 91
9.6.1 Parameter options . . . . . . . . . . . . . . . . . . . . . . . 92
9.6.2 TBOT lag . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 96
9.6.3 MODIS real-time LAI . . . . . . . . . . . . . . . . . . . . . 97
9.6.4 NESDIS weekly greenness fraction . . . . . . . . . . . . . 97
9.6.5 SPORT greenness fraction . . . . . . . . . . . . . . . . . . . 97
9.6.6 VIIRS greenness fraction . . . . . . . . . . . . . . . . . . . 98
9.7 Forcings . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 99
9.7.1 GDAS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 99
9.7.2 GEOS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 99
9.7.3 ECMWF . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 100
9.7.4 ECMWF Reanalysis . . . . . . . . . . . . . . . . . . . . . . 100
9.7.5 PRINCETON . . . . . . . . . . . . . . . . . . . . . . . . . . 100
9.7.6 Rhone AGG . . . . . . . . . . . . . . . . . . . . . . . . . . . 100
9.7.7 GSWP2 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 101
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.7.8</td>
<td>GMAO GLDAS</td>
<td>102</td>
</tr>
<tr>
<td>9.7.9</td>
<td>GFS</td>
<td>102</td>
</tr>
<tr>
<td>9.7.10</td>
<td>MERRA-Land</td>
<td>103</td>
</tr>
<tr>
<td>9.7.11</td>
<td>MERRA2</td>
<td>103</td>
</tr>
<tr>
<td>9.7.12</td>
<td>GSWP1</td>
<td>104</td>
</tr>
<tr>
<td>9.8</td>
<td>Supplemental forcings</td>
<td>104</td>
</tr>
<tr>
<td>9.8.1</td>
<td>AGRMET radiation (latlon)</td>
<td>104</td>
</tr>
<tr>
<td>9.8.2</td>
<td>AGRMET radiation (polar stereographic)</td>
<td>105</td>
</tr>
<tr>
<td>9.8.3</td>
<td>CMAP precipitation</td>
<td>105</td>
</tr>
<tr>
<td>9.8.4</td>
<td>CEOP station data</td>
<td>105</td>
</tr>
<tr>
<td>9.8.5</td>
<td>SCAN station data</td>
<td>105</td>
</tr>
<tr>
<td>9.8.6</td>
<td>NLDAS1</td>
<td>106</td>
</tr>
<tr>
<td>9.8.7</td>
<td>NLDAS2</td>
<td>107</td>
</tr>
<tr>
<td>9.8.8</td>
<td>TRMM 3B42RT precipitation</td>
<td>108</td>
</tr>
<tr>
<td>9.8.9</td>
<td>TRMM 3B42V6 precipitation</td>
<td>109</td>
</tr>
<tr>
<td>9.8.10</td>
<td>TRMM 3B42V7 precipitation</td>
<td>109</td>
</tr>
<tr>
<td>9.8.11</td>
<td>CMORPH precipitation</td>
<td>109</td>
</tr>
<tr>
<td>9.8.12</td>
<td>Stage II precipitation</td>
<td>110</td>
</tr>
<tr>
<td>9.8.13</td>
<td>Stage IV precipitation</td>
<td>110</td>
</tr>
<tr>
<td>9.8.14</td>
<td>NARR</td>
<td>110</td>
</tr>
<tr>
<td>9.8.15</td>
<td>RFE2Daily</td>
<td>111</td>
</tr>
<tr>
<td>9.8.16</td>
<td>PET_USGS</td>
<td>111</td>
</tr>
<tr>
<td>9.8.17</td>
<td>RFE2 data bias corrected to GDAS</td>
<td>111</td>
</tr>
</tbody>
</table>
9.8.18 NAM242 ........................................ 112
9.8.19 WRFout ....................................... 112
9.8.20 GEOS5 Forecast .............................. 112
9.8.21 GDAS for LSWG .............................. 112
9.8.22 Bondville ..................................... 113
9.8.23 SNOTEL ....................................... 113
9.8.24 COOP ......................................... 114
9.8.25 VIC processed forcing ....................... 114
9.8.26 PALS station ................................ 115
9.8.27 PILDAS ....................................... 116
9.8.28 RDHM356 .................................... 116
9.9 Land surface models ............................ 118
9.9.1 Forcing only – Template ...................... 118
9.9.2 NCEP’s Noah-2.7.1 ......................... 118
9.9.3 NCAR’s Noah-3.2 .............................. 121
9.9.4 NCAR’s Noah-3.3 .............................. 124
9.9.5 NCAR’s Noah-3.6 .............................. 128
9.9.6 NoahMP 3.6 .................................. 131
9.9.7 CLM 2.0 ....................................... 138
9.9.8 VIC 4.1.1 ..................................... 139
9.9.9 VIC 4.1.2 ..................................... 140
9.9.10 Mosaic ....................................... 142
9.9.11 HySSiB ...................................... 144
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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 7.1. 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 Test Cases: 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 List Table: describes the user-configurable output variable options.
12 User Support:

1.1 What’s New

1.1.1 LIS 7.1

1. Includes Noah 3.6
2. Includes NoahMP 3.6
3. Includes CABLE 1.4b
4. Includes flood irrigation
5. Includes drip irrigation
6. Supports VIIRS Daily GVF data
7. Supports TRMM 3B42 V7 real time precipitation
8. Supports Gaussian T1534 GFS met forcing data
9. Supports MERRA-2 met forcing data — these data are not currently available to external users; they should become available in July 2015
10. Supports downscaling precipitation (PRISM) (NLDAS-2 only)

1.1.2 LIS 7.0

1. Requires companion Land Data Toolkit (LDT) input data and parameter preprocessor
2. Includes VIC 4.1.2.1
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 base-forcing 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.

1.1.3 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.
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 precipitation (for use in WRSI).
10. Support to apply lapse-rate correction to bottom temperature field (for use in Noah).
1.1.4 LIS 6.1

1. Includes Noah 3.1.
2. Includes Noah 3.2.
3. Support for SPoRT Daily GVF 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 snow-cover, and LPRM retrievals of AMSRE soil moisture.

1.1.5 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 implementation 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

**1.1.6 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.

**1.1.7 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
1.1.8  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 specific environment variables.

1.1.9  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.

1.1.10  LIS 4.0

1. VIC 4.0.5 – LIS’ implementation of VIC has been reinstated.

1.1.11  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.
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.
1.1.12 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 9 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.
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 hydromete-
orological 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 6 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.
3 Preliminary Information

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

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

```bash
% cd /path/to/LISv7.0
% ls
“…compiler flags, then run gmake.”
```

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

`/path/to/LISv7.0/src`
4 Obtaining the Source Code

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

Beginning with LIS public release 7.1rp1, the LIS source code is available as open source under the NASA Open Source Agreement (NOSA). Please see LIS’ web-site for a copy of the NOSA.

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

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 svn checkout the LIS 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 LIS source code into a directory within the virtual machine.

4.2 Public Release Source Code Tar File

The LIS 7.1 source code is available for download as a tar-file from LIS’ web-site. All users are encouraged to fill in the Registration Form and join the mailing list, both also accessible from LIS’ web-site. After downloading the LIS tar-file:

1. Create a directory to unpack the tar-file into. Let’s call it TOPLEVELDIR.
2. Place the tar-file in this directory.
   % mv LIS_public_release_7.1rp7.tar.gz TOPLEVELDIR
3. Go into this directory.
   % cd TOPLEVELDIR
4. Run gzip -dcs LIS_public_release_7.1rp7.tar.gz | tar xf -
   This command will unzip and untar the tar-file.
Note that the directory containing the LIS source code will be referred to as $WORKING throughout the rest of this document.

### 4.3 Checking Out the Source Code

The LIS source code is maintained in a Subversion repository. Due to several U.S. government restrictions, only the LIS development team and select collaborators may have access to the repository. Those developers must use the Subversion client (svn) to obtain the LIS source code. If you need any help regarding Subversion, please go to [http://subversion.apache.org/](http://subversion.apache.org/).

For those granted access to the LIS source code repository:

1. Create a directory to checkout the code into. Let’s call it `TOLEVELDIRE`.  
2. Go into this directory.  
   ```bash  
   % cd TOLEVELDIRE  
   ```  
3. Check out the source code into a directory called `src`.  
   For the public version, run the following command:  
   ```bash  
   % svn checkout https://progress.nccs.nasa.gov/svn/lis/7/public7.1 src  
   ```

Note that the directory containing the LIS source code will be referred to as $WORKING throughout the rest of this document.

### 4.4 Source files

Checking out the LIS source code (according the instructions in Section 4) will create a directory named `src`. The structure of `src` is as follows:

- `arch`  
  Directory containing the configurable options for building the LIS executable

- `configs`  
  some sample LIS configuration files

- `core`  
  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
    * **enkf**
      NASA GMAO’s Ensemble Kalman Filter algorithm for data assimilation
    * **enkfgrace**
      GRACE Ensemble Kalman 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:
    * **ANSA_SCF**
      Blended snow cover fraction from the AFWA NASA snow algorithm
    * **ECV_sm**
      ECV soil moisture
    * **GRACE**
      GRACE soil moisture
    * **LPRM_AMSREsm**
      Soil moisture retrievals from AMSRE derived using the land parameter retrieval model (LPRM) from University of Amsterdam
    * **MODISsea**
      MODIS snow cover area product in HDF4/HDFEOS format
    * **NASA_AMSREsm**
      NASA AMSRE soil moisture data in binary format
    * **PMW_snow**
      PMW snow
    * **RT_SMOPSsm**
      SMOPS real time soil moisture
    * **WindSat_sm**
      X-band soil moisture retrievals from WindSat
- **perturb**
  Directory containing the following perturbation algorithm implementations
  * **gmaopert**
    NASA GMAO’s perturbation algorithm

- **domains** Directory containing the domains in the following map projections / custom grids
  - **UTM**
    Universal Transverse Mercator grids
  - **hrap**
    Hydrologic Rainfall Analysis Project polar stereographic grid
  - **lambert**
    Lambert conformal grids
  - **latlon**
    Equidistant cylindrical grids
  - **merc**
    Mercator grids
  - **polar**
    Polar stereographic grids

- **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**
  Makefile and needed header files for building LIS executable
metforcing
Top level directory for base meteorological forcing methods, which includes the following implementations

- **3B42RT**
  Routines for handling the TRMM 3B42RT precipitation product

- **3B42RTv7**
  Routines for handling the TRMM 3B42RTv7 precipitation product

- **3B42V6**
  Routines for handling the TRMM 3B42V6 precipitation product

- **3B42V7**
  Routines for handling the TRMM 3B42V7 precipitation product

- **Bondville**
  Routines for handling the Bondville forcing products

- **PALSmetdata**
  Routines for handling the PALS station data

- **PILDAS**
  Routines for handling the PILDAS metforcing data

- **RFE2Daily**
  Routines for handling the RFE2 precipitation product from FEWS-NET (diurnally non-disaggregated)

- **RFE2gdas**
  Routines for handling the RFE2 precipitation product from FEWS-NET bias corrected against GDAS data

- **WRFout**
  Routines for handling WRF output as forcing input

- **agrrad**
  Routines for handling the AGRMET radiation product

- **agrradps**
  Routines for handling the AGRMET radiation product (polar stereographic projection)

- **ceop**
  Routines for handling the CEOP meteorological station data

- **cmap**
  Routines for handling the CMAP precipitation product

- **cmorph**
  Routines for handling the CMORPH precipitation product

- **coop**
  Routines for handling the COOP precipitation product

- **ecmwf**
  ECMWF meteorological forcing data
- `ecmwf_reanal`
  ECMWF reanalysis meteorological forcing data based on [1].

- `gdas`
  NCEP GDAS meteorological forcing data

- `gdasLSWG`
  GDAS profile data from the PMM land surface working group

- `gdasT1534`
  NCEP GDAS GFS T1534 meteorological forcing data

- `geos`
  NASA GEOS meteorological forcing data

- `geos5fcst`
  NASA GEOS 5 meteorological forecast forcing data

- `gfs`
  NCEP GFS meteorological forcing data

- `gdas`
  NASA GMAO GLDAS meteorological forcing data

- `gswp1`
  Global Soil Wetness Project-1 meteorological forcing data

- `gswp2`
  Global Soil Wetness Project-2 meteorological forcing data

- `merra_land`
  GMAO Modern Era Retrospective-Analysis for Research and Applications data

- `merra2`
  GMAO Modern Era Retrospective-Analysis for Research and Applications data

- `nam242`
  Routines for handling the North American Mesoscale Forecast System (NAM) 242 AWIPS Grid – Over Alaska product

- `narr`
  Routines for handling the North American Regional Reanalysis (3d) data

- `nldas1`
  Routines for handling the North American Land Data Assimilation System forcing product

- `nldas2`
  Routines for handling the North American Land Data Assimilation System 2 forcing product

- `pet_usgs`
  Routines for handling daily potential evapotranspiration data from the USGS FAO-PET method, using GDAS forcing fields as inputs
- **princeton**
  Renalaysis product from Princeton University (3)

- **rdhm356**
  Routines for handling NOAA OHD RDHM 3.5.6 forcing data

- **rhoneAGG**
  Rhone-AGG meteorological forcing data

- **scan**
  Routines for handling the Soil Climate Analysis Network precipitation product

- **snotel**
  SNOTEL meteorological forcing data

- **stg2**
  Routines for handling the NCEP Stage IV QPE precipitation product

- **stg4**
  Routines for handling the NCEP Stage II precipitation product

- **templateMetForc**
  An empty template for meteorological forcing data implementations

- **vicforcing**
  Routines for handling VIC 4.1.1 pre-processed meteorological forcing data

- **vicforcing.4.1.2**
  Routines for handling VIC 4.1.2 pre-processed meteorological forcing data

- **offline**
  Contains 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
    * **DEMCz**
      differential evolution monte carlo Z algorithm
    * **GA**
      Single objective Genetic Algorithm
    * **MCSIM**
      monte carlo simple propagation scheme

  - **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
  * `LS`
    Least squares based objective function
  * `P`
    Prior function definition

- `obs`
  Directory containing the following observation handlers for parameter estimation
  * `AMSRE_SR`
    AMSRE retrievals of emissivity
  * `EmptyObs`
  * `LPRM_AMSREsm`
    Soil moisture retrievals from AMSRE derived using the land parameter retrieval model (LPRM) from University of Amsterdam
  * `template`

- `params`
  Directory containing implementations of the following land surface model parameters
  - `gfrac`
    Routines for handling green vegetation fraction data products
  - `lai`
    Routines for handling Leaf/Stem area index data products

- `plugins`
  Modules defining the function table registry of extensible functionalities

- `routing`
  Directory containing routing models
  - `HYMAP_router`
  - `NLDAS_router`

- `rtms`
  Directory containing coupling routines to the following radiative transfer models
- **CMEM3**
  Community Microwave Emission Model from ECMWF

- **CRTM2EM**
  Routines to handle coupling to the JCSDA Community Radiative Transfer Model Emissions model

**runmodes**
Directory containing the following running modes in LIS

- **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

- **land**
  Directory containing implementations of the following land surface models
  - **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
  - **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
* rdhm.3.5.6
  NOAH OHD Research Distributed Hydrologic Model version 3.5.6
* 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

Each of these LSM directories 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_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. Routing interfaces:
   * routing
     Noah routines related to interacting with the routing schemes
- 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

Source code documentation may be found on [LIS web-site](http://lis-web-site). Follow the “Documentation” link.
5 Building the Executable

This section describes how to build the source code and create LIS’ executable — named LIS.

Please see Section 4.1 for information regarding using a case sensitive file system for compiling/running LIS.

5.1 Development Tools

This code has been compiled and run on Linux PC (Intel/AMD based) systems and Cray systems. These instructions expect that you are using such a system. In particular you need:

- Linux
  - Compilers
    - either Intel Fortran Compiler version 13 (13.1.3.192 or higher) with corresponding Intel C Compiler
      
      Note that LIS has been tested specifically with Intel compilers 13.1.3.192, 14.0.3.174, and 15.1.133.
      
    - GNU’s make, gmake, version 3.77 or 3.81
  - 

- Cray/Linux
  - Intel Fortran Compiler version 15.0.2 (or higher) with corresponding Intel C Compiler
  - GNU’s make, gmake, version 3.77

5.2 Required Software Libraries

In order to build the LIS executable, the following libraries must be installed on your system:

- Earth System Modeling Framework (ESMF) version 5.2.0rp3 (or higher). [http://www.earthsystemmodeling.org/download/releases.shtml]
Please read the ESMF User’s Guide for details on installing ESMF with MPI support and without MPI support (“mpiuni”).

Note that starting with ESMF version 5, the ESMF development team is trying to maintain backwards compatibility with its subsequent releases. The LIS development team, however, has neither compiled nor tested against versions of ESMF newer than 5.2.0rp3.

- JasPer version 1.900.1.  
  [http://www.ece.uvic.ca/~frodo/jasper/](http://www.ece.uvic.ca/~frodo/jasper/)

  Note that when running the `configure` command you must include the `--enable-shared` option.

- GRIB-API version 1.12.3 (or higher).  
  [https://software.ecmwf.int/wiki/display/GRIB/Home](https://software.ecmwf.int/wiki/display/GRIB/Home)

- NetCDF either version 3.6.3 or version 4.3.0 (or higher).  
  [http://www.unidata.ucar.edu/software/netcdf/](http://www.unidata.ucar.edu/software/netcdf/)

Please read the on-line documentation for details on installing NetCDF.

Additional notes for NetCDF 4:

- You must also choose whether to compile with compression enabled. Compiling with compression enabled requires HDF 5 and zlib libraries. To enable compression, add `--enable-netcdf-4` to the `configure` options. To disable compression, add `--disable-netcdf-4` to the `configure` options.

  An example of installing NetCDF 4 without compression:
  
  ```
  % ./configure --prefix=$HOME/local/netcdf-4.3.0 --disable-netcdf-4
  % gmake
  % gmake install
  ```

  An example of installing NetCDF 4 with compression:
  
  ```
  % CPPFLAGS=-I$HOME/local/hdf5/1.8.11/include \
  > LDFLAGS=-L$HOME/local/hdf5/1.8.11/lib \
  > ./configure --prefix=$HOME/local/netcdf/4.3.0 --enable-netcdf-4
  % gmake
  % gmake install
  ```

- You must also download the `netcdf-fortran-4.2.tar.gz` file. First install the NetCDF C library, then install the NetCDF Fortran library. Again, please read the on-line documentation for more details.

  An example of installing the NetCDF 4 Fortran library:
  
  ```
  % LD_LIBRARY_PATH=$HOME/local/netcdf/4.3.0/lib:$LD_LIBRARY_PATH \ 
  > CPPFLAGS=-I$HOME/local/netcdf/4.3.0/include \ 
  > LDFLAGS=-L$HOME/local/netcdf/4.3.0/lib \ 
  ```
> ./configure --prefix=$HOME/local/netcdf/4.3.0
% gmake
% gmake install

5.3 Optional Software Libraries

The following libraries are not required to compile LIS. They are used to extend the functionality of LIS.

- Message Passing Interface (MPI)
  If you wish to run LIS with multiple processes (i.e., in parallel), then you must install an MPI library package.
  - vendor supplied (e.g., Intel MPI) or
  - MPICH version 1.2.7p1 ([http://www-unix.mcs.anl.gov/mpi/mpich1/](http://www-unix.mcs.anl.gov/mpi/mpich1/))
  - Open MPI ([http://www.open-mpi.org/](http://www.open-mpi.org/))
  Note that LIS does not support OpenMP style parallelization. There is some experimental support within LIS, but you should not enable it.

- HDF
  You may choose either HDF version 4, HDF version 5, or both.
  HDF is used to support a number of remote sensing datasets.
  If you wish to use MODIS snow cover area observations or NASA AMSR-E soil moisture observations, then you need HDF 4 support.
  If you wish to use ANSA snow cover fraction observations, then you need HDF 5 support.
  If you wish to use PMW snow observations, then you need both HDF 4 and HDF 5 support.
  
  - HDF 4
    If you choose to have HDF version 4 support, please download the HDF source for version 4.2r4 (or later) from ([http://www.hdfgroup.org/products/hdf4](http://www.hdfgroup.org/products/hdf4)) and compile the source to generate the HDF library. Make sure that you configure the build process to include the Fortran interfaces by adding the --enable-fortran option to the configure command.
    Note that HDF4 contains its own embedded version of NetCDF. You must disable this support by adding the --disable-netcdf option to the configure command.
    Note that when compiling LIS with HDF 4 support, you must also download and compile HDF-EOS2 ([http://hdfeos.org/](http://hdfeos.org/)).
HDF 5
If you choose to have HDF version 5 support, please download the HDF source for version 1.8.11 (or later) from [http://www.hdfgroup.org/HDF5/](http://www.hdfgroup.org/HDF5/) and compile the source to generate the HDF library. Make sure that you configure the build process to include the Fortran interfaces by adding the `--enable-fortran` option to the `configure` command.

- JCSDA CRTM version 2.0.2
If you wish to enable LIS’ RTM support, then you must install the CRTM library from the Joint Centers for Satellite Data Assimilation (JCSDA). First go to [http://ftp.emc.ncep.noaa.gov/jcsda/CRTM/Repository/](http://ftp.emc.ncep.noaa.gov/jcsda/CRTM/Repository/) and fill out the CRTM.SubversionAccount_Request.pdf form. Once you have access to their Subversion repository, checkout revision 9604 of the trunk.

Please create a directory outside of the LIS source code to checkout the CRTM library into. Then, within that new directory, run:

```bash
% svn checkout -r 9604 https://svnemc.ncep.noaa.gov/projects/crtm/trunk
```

Then you must copy the LIS specific updates into this checked out CRTM code. See `$WORKING/lib/lis-crtm/README`.

Next compile and install the CRTM library:

```bash
% source Set_CRTM_Environment.sh
% cd src
% source configure/ifort.setup
Of course, choose the setup script that is appropriate for your environment.
% gmake
% gmake install
```

- LIS-CMEM library
If you wish to enable LIS’ RTM support, then you must manually compile an included library.

```bash
% cd $WORKING/lib/lis-cmem3
% gmake
```

- LIS-CRTM-PROFILE-UTILITY library
If you wish to enable LIS’ RTM support, then you must manually compile an included library.

```bash
% cd $WORKING/lib/lis-crtm-profile-utility
% gmake
% gmake install
```
To install these libraries, follow the instructions provided at the various URL listed above. These optional libraries have their own dependencies, which should be documented in their respective documentation.

Please note that your system may have several different compilers installed. You must verify that you are building these libraries with the correct compiler. You should review the output from the `configure`, `make`, etc. commands. If the wrong compiler is being used, you may have to correct your `$PATH` environment variable, or set the `$CC` and `$FC` environment variables, or pass additional settings to the `configure` scripts. Please consult the installation instructions provided at the various URL listed above for each library.

If you wish to install all the libraries (required and optional, excluding JCSDA CRTM, LIS-CMEM, and LIS-CRTM-PROFILE-UTILITY), here is the recommended order:

1. HDF 5 (optional)
   NetCDF has an optional dependency on HDF 5.
2. NetCDF (required)
   ESMF has an optional dependency on NetCDF.
   GRIB-API has an optional dependency on NetCDF.
3. JasPer (required)
   GRIB-API depends on JasPer.
4. GRIB-API (required)
5. MPI (optional)
   ESMF has an optional dependency on MPI.
6. ESMF (required)
7. HDF 4 (optional)
   HDF-EOS2 depends on HDF 4.
8. HDF-EOS2 (optional)

Note that due to the mix of programming languages (Fortran and C) used by LIS, you may run into linking errors when building the LIS executable. This is often due to (1) the Fortran compiler and the C compiler using different cases (upper case vs. lower case) for external names, and (2) the Fortran compiler and C compiler using a different number of underscores for external names.

When compiling code using Absoft’s Pro Fortran SDK, set the following compiler options:
These must be set for each of the above libraries.

### 5.4 Build Instructions

1. Perform the steps described in Section 4 to obtain the source code.

2. Goto the `$WORKING` directory. This directory contains two scripts for building the LIS executable: `configure` and `compile`.

3. 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
     ```bash
     % export LIS_ARCH=linux_ifc
     ```
   - For a Linux system with the GNU Fortran compiler
     ```bash
     % export LIS_ARCH=linux_gfortran
     ```

   It is suggested that you place this command in your `.profile` (or equivalent) startup file.

4. Run the `configure` script first by typing:

   ```bash
   % ./configure
   ```

   This script will prompt the user with a series of questions regarding support to compile into LIS, requiring the user to specify the locations of the required and optional libraries via several LIS specific environment variables. The following environment variables are used by LIS.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIS_FC</td>
<td>Fortran 90 compiler</td>
<td>required</td>
</tr>
<tr>
<td>LIS_CC</td>
<td>C compiler</td>
<td>required</td>
</tr>
<tr>
<td>LIS_MODES</td>
<td>path to ESMF module files</td>
<td>required</td>
</tr>
<tr>
<td>LIS_LIBES</td>
<td>path to ESMF library files</td>
<td>required</td>
</tr>
<tr>
<td>LIS_JASPER</td>
<td>path to JasPer library</td>
<td>required</td>
</tr>
<tr>
<td>LIS_GRI</td>
<td>path to GRIB-API library</td>
<td>required</td>
</tr>
<tr>
<td>LIS_NETCDF</td>
<td>path to NetCDF library</td>
<td>required</td>
</tr>
<tr>
<td>LIS_HDF4</td>
<td>path to HDF4 library</td>
<td>optional</td>
</tr>
<tr>
<td>LIS_HDF5</td>
<td>path to HDF5 library</td>
<td>optional</td>
</tr>
<tr>
<td>LIS_HDFEOS</td>
<td>path to HDFEOS library</td>
<td>optional</td>
</tr>
<tr>
<td>LIS_MINPACK</td>
<td>path to MINPACK library</td>
<td>optional</td>
</tr>
<tr>
<td>LIS_CRTM</td>
<td>path to CRTM library</td>
<td>optional</td>
</tr>
<tr>
<td>LIS_CRTM_PROF</td>
<td>path to LIS-CRTM Profile library</td>
<td>optional</td>
</tr>
<tr>
<td>LIS_CMEM</td>
<td>path to LIS-CMEM library</td>
<td>optional</td>
</tr>
</tbody>
</table>

38
Note that the \texttt{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.

It is suggested that you add these definitions to your \texttt{.profile} (or equivalent) startup file.

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 \texttt{LD_LIBRARY_PATH} environment variable. For example, say that you are using ESMF, GRIB-API, NetCDF, and HDF5. Then you must execute the following command (written using Bash shell syntax):

\begin{verbatim}
\end{verbatim}

It is also suggested that you add this command to your \texttt{.profile} (or equivalent) startup file.

5. An example execution of the configure script is shown below:

\begin{verbatim}
sh$ ./configure
    Setting up configuration for LIS version 7.0...
    Parallelism (0-serial, 1-dmpar, default=1):
    Use openMP parallelism (1=yes, 0=no, default=0):
    Optimization level (-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? (1=yes, 0=no, default=1):
    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 = 9):
    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):
    \hspace{1cm} 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.
\end{verbatim}

39
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-dmmpar, default=1): dmmpar refers to enabling MPI
- for **Use openMP parallelism** (1-yes, 0-no, default=0): select the default value of 0. OpenMP support is experimental. Please do not use.
- 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?** (1-yes, 0-no, default=1): select the default value of 1. 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.
- 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.

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.

6. 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.

7. Finally, copy the `LIS` executable into your running directory, `$RUNNING`. 
5.5 Generating documentation

LIS code uses the ProTex (http://gmao.gsfc.nasa.gov/software/protex/) documenting system [2]. The documentation in LaTeX format can be produced by using the `doc.sh` in the `$WORKING/utils` directory. This command produces documentation, generating a number of LaTeX files. These files can be easily converted to pdf using utilities such as `pdflatex`. 
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

Note that when using the Lahey Fortran compiler, you must issue this command to run the single-process version of LIS:

% ./LIS -Wl,T

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 capabilities 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 administrator 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 9 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.
7 Test-cases

This section describes how to obtain and how to use the test-cases provided by
the LIS team.

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

7.1 Public tests

These test-cases are provided for the general LIS user to run. They help demon-
strate a successful installation of LIS and its required libraries. They also
demonstrate how to configure several different use-cases of LIS. These test-
cases are comprised of three parts: a testcases sub-directory included in the LIS
source code, input data, and output data.

7.1.1 The testcases Sub-directory

The public test-cases are contained within the src/testcases/public directory.
The available tests are:

- **NLDAS2-a** NLDAS domain + NLDAS-2 forcing + Noah-3.3 LSM + NLDAS
  router or HYMAP router + AMSR-E DA soil moisture
- **NLDAS2-b** NLDAS domain + NLDAS-2 forcing + CLSM-F2.5 LSM + NL-
  DAS router or HYMAP router + GRACE DA
- **NLDAS2-c** RDHM 3.5.6 (Sac-HTET) over the NLDAS domain using NLDAS-
  2 forcing
- **GLDAS** VIC 4.1.2.1 over a global 1 deg domain using Princeton forcing
- **pmw_snowda_nam** PMW SNOW DA case over Alaska with NAM forcing
- **OPTUE** PMM related case featuring parameter and uncertainty estimation
- **geowrsi.2** GeoWRSI over an East Africa domain using USGS PET and RFE2
  precip

These test-case sub-directories contain the files needed to help you test LIS. In
particular, they contain the needed run-time configuration files, and they con-
tain scripts for downloading data. Each of the test-case sub-directory contains
a README file. Each README file contains a description of the test-case and
instructions regarding how to download and run the test-case.
7.1.2 Input and output data

The input and output data needed to run the public test-cases are hosted on LIS’ data portal. Access to the LIS data portal is required. Please see “LIS Test Cases” section of LIS’ web-site (http://lis.gsfc.nasa.gov/).

7.2 Internal tests

These test-cases are typically used by the LIS development team to test various components of the LIS source code. These test-cases are comprised of three parts: a testcases sub-directory included in the LIS source code, input data, and output data.

7.2.1 The testcases Sub-directory

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

These test-case sub-directories contain several files to help you test LIS. For example, the src/testcases/metforcing/gdas test-case contains six files:

1. README
   contains instructions on how to run the test-case.

2. ldt.config
   is the configuration file for LDT to process input parameters for the test-case.

3. lis.config
   is a configuration file to set the test-case.

4. MODEL_OUTPUT_LIST.TBL
   is a configuration file to set the output for the test-case.

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.
6. *testcase.ctl*
   is a GrADS descriptor file. This file is used with GrADS to plot the output data that is distributed via the LIS web-site (http://lis.gsfc.nasa.gov/) for this test-case.

### 7.2.2 Test-cases LDT

For each test-case, the LIS team has created a corresponding LDT input data file that contains all the required data for running LDT to generate the LIS input parameter file.

To obtain the LDT input data for a test-case:

2. Follow the “LIS Test Cases” link.
3. Follow the link corresponding to the desired test-case.

### 7.2.3 Test-cases Input

For each test-case, the LIS team has created a corresponding input data file that contains all the required data for running the test-case.

To obtain the input data for a test-case:

2. Follow the “LIS Test Cases” link.
3. Follow the link corresponding to the desired test-case.

### 7.2.4 Test-cases Output

For each test-case, the LIS team has created a corresponding output data file that contains all the output data produced from the test-case.

To obtain the output data for a test-case:

2. Follow the “LIS Test Cases” link.
3. Follow the link corresponding to the desired test-case.

7.2.5 Output Example

For example, output data for the “Noah 3.3 LSM TEST” contains:

```
OUTPUT/testcase/lislog.0000
OUTPUT/testcase/SURFACEMODEL.d01.stats
OUTPUT/testcase/SURFACEMODEL/2002/20021029/LIS_HIST_200210290300.d01.gs4r
OUTPUT/testcase/SURFACEMODEL/2002/20021029/LIS_HIST_200210290600.d01.gs4r
OUTPUT/testcase/SURFACEMODEL/2002/20021029/LIS_HIST_200210290900.d01.gs4r
OUTPUT/testcase/SURFACEMODEL/2002/20021029/LIS_HIST_200210291200.d01.gs4r
OUTPUT/testcase/SURFACEMODEL/2002/20021029/LIS_HIST_200210291500.d01.gs4r
OUTPUT/testcase/SURFACEMODEL/2002/20021029/LIS_HIST_200210291800.d01.gs4r
OUTPUT/testcase/SURFACEMODEL/2002/20021029/LIS_HIST_200210292100.d01.gs4r
OUTPUT/testcase/SURFACEMODEL/2002/20021030/LIS_HIST_200210300000.d01.gs4r
OUTPUT/testcase/SURFACEMODEL/2002/20021030/LIS_RST_NOAH33_200210300000.d01.nc
OUTPUT/testcase/SURFACEMODEL/2002/20021030/LIS_RST_NOAH33_200210301000.d01.nc
OUTPUT/testcase/SURFACEMODEL/2002/20021030/LIS_RST_NOAH33_200210301800.d01.gs4r
OUTPUT/testcase/SURFACEMODEL/2002/20021030/LIS_RST_NOAH33_200210302100.d01.gs4r
OUTPUT/testcase/SURFACEMODEL/2002/20021031/LIS_RST_NOAH33_200210310000.d01.nc
OUTPUT/testcase/SURFACEMODEL/2002/20021031/LIS_RST_NOAH33_200210310100.d01.nc
```
The file, *OUTPUT/testcase/lislog.0000*, is the log from the run.

The file, *OUTPUT/testcase/SURFACEMODEL.d01.stats*, contains statistics from the run.

The files labelled like *OUTPUT/testcase/SURFACEMODEL/2002/20021029/LIS_HIST_200210290300.d01.gs4r* contain the output from the run. Read the *testcase.ctl* file contained in the appropriate *testcases* sub-directory of the LIS source code for metadata pertaining to these output files.

The files labelled like *OUTPUT/testcase/SURFACEMODEL/2002/20021030/LIS_RST_NOAH33_200210300000.d01.nc* are restart files. They may be used to continue or restart a run. The data are valid for the date and time indicated by the date-stamp in the file name. For example, the restart data in this file, *OUTPUT/testcase/SURFACEMODEL/2002/20021030/LIS_RST_NOAH33_200210300000.d01.nc* are valid for 2002-10-30T00:00:00.

These output data files are large and require post-processing before reading them, see Section 8.
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 9.2 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 runtime, and that OUTPUT is a user-configurable name. See Section 9.2. 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:

<table>
<thead>
<tr>
<th>File Name</th>
<th>Synopsis</th>
</tr>
</thead>
<tbody>
<tr>
<td>SURFACEMODEL.d01.stats</td>
<td>Statistical summary of output</td>
</tr>
<tr>
<td>SURFACEMODEL</td>
<td>Directory containing output data</td>
</tr>
</tbody>
</table>

The SURFACEMODEL directory will contain sub-directories of the form YYYY/YYYMMDD, 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
```
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 9.12.

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 9.2 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 5.2).

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 5.2).
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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;retrospective&quot;</td>
<td>retrospective mode</td>
</tr>
<tr>
<td>&quot;WRF coupling&quot;</td>
<td>Coupled WRF mode</td>
</tr>
<tr>
<td>&quot;ensemble smoother&quot;</td>
<td>ensemble smoother mode</td>
</tr>
</tbody>
</table>

**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.

**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.

**Number of surface model types: 1**

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSM</td>
<td>land surface model</td>
</tr>
<tr>
<td>Lake</td>
<td>lake model</td>
</tr>
<tr>
<td>Glacier</td>
<td>glacier model</td>
</tr>
</tbody>
</table>
Surface model types: LSM

Surface model output interval: specifies the surface model output interval. See Section 9.13 for a description of how to specify a time interval.

Surface model output interval: 3hr

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>template lsm</td>
</tr>
<tr>
<td>Noah.2.7.1</td>
<td>Noah version 2.7.1</td>
</tr>
<tr>
<td>Noah.3.2</td>
<td>Noah version 3.2</td>
</tr>
<tr>
<td>Noah.3.3</td>
<td>Noah version 3.3</td>
</tr>
<tr>
<td>Noah.3.6</td>
<td>Noah version 3.6</td>
</tr>
<tr>
<td>NoahMP.3.6</td>
<td>NoahMP version 3.6</td>
</tr>
<tr>
<td>CLM.2</td>
<td>CLM version 2.0</td>
</tr>
<tr>
<td>VIC.4.1.1</td>
<td>VIC version 4.1.1</td>
</tr>
<tr>
<td>VIC.4.1.2</td>
<td>VIC version 4.1.2</td>
</tr>
<tr>
<td>Mosaic</td>
<td>Mosaic</td>
</tr>
<tr>
<td>HySSiB</td>
<td>HySSiB</td>
</tr>
<tr>
<td>GeoWRSI2</td>
<td>GeoWRSI version 2.0</td>
</tr>
<tr>
<td>CABLE.1.4b</td>
<td>CABLE version 1.4b</td>
</tr>
<tr>
<td>“CLSM F2.5”</td>
<td>Catchment Fortuna-2.5</td>
</tr>
<tr>
<td>RDHM.3.5.6</td>
<td>RDHM 3.5.6 (SacHTET and Snow17)</td>
</tr>
</tbody>
</table>

Land surface model: Noah.2.7.1

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

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.

**Met forcing chosen ensemble member:**

**Blending method for forcings:** specifies the blending method to combine forcings if more than one forcing dataset is used. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>overlay</td>
<td>datasets are overlaid on top of each other in the order they are specified</td>
</tr>
<tr>
<td>ensemble</td>
<td>each forcing dataset is assigned to a separate ensemble member.</td>
</tr>
</tbody>
</table>

**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:
<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;none&quot;</td>
<td>None</td>
</tr>
<tr>
<td>&quot;GDAS&quot;</td>
<td>GDAS</td>
</tr>
<tr>
<td>&quot;GEOS&quot;</td>
<td>GEOS</td>
</tr>
<tr>
<td>&quot;GEOS5 forecast&quot;</td>
<td>GEOS5 Forecast</td>
</tr>
<tr>
<td>&quot;ECMWF&quot;</td>
<td>ECMWF</td>
</tr>
<tr>
<td>&quot;GSWP1&quot;</td>
<td>GSWP1</td>
</tr>
<tr>
<td>&quot;GSWP2&quot;</td>
<td>GSWP2</td>
</tr>
<tr>
<td>&quot;ECMWF reanalysis&quot;</td>
<td>ECMWF Reanalysis</td>
</tr>
<tr>
<td>&quot;PRINCETON&quot;</td>
<td>Princeton</td>
</tr>
<tr>
<td>&quot;NLDAS1&quot;</td>
<td>NLDAS1</td>
</tr>
<tr>
<td>&quot;NLDAS2&quot;</td>
<td>NLDAS2</td>
</tr>
<tr>
<td>&quot;GLDAS&quot;</td>
<td>GLDAS</td>
</tr>
<tr>
<td>&quot;GFS&quot;</td>
<td>GFS</td>
</tr>
<tr>
<td>&quot;MERRA-Land&quot;</td>
<td>MERRA-Land</td>
</tr>
<tr>
<td>&quot;MERRA2&quot;</td>
<td>MERRA2</td>
</tr>
<tr>
<td>&quot;CMAP&quot;</td>
<td>CMAP</td>
</tr>
<tr>
<td>&quot;TRMM 3B42RT&quot;</td>
<td>TRMM 3B42RT</td>
</tr>
<tr>
<td>&quot;TRMM 3B42RTV7&quot;</td>
<td>TRMM 3B42RTV7</td>
</tr>
<tr>
<td>&quot;TRMM 3B42V6&quot;</td>
<td>TRMM 3B42V6</td>
</tr>
<tr>
<td>&quot;TRMM 3B42V7&quot;</td>
<td>TRMM 3B42V7</td>
</tr>
<tr>
<td>&quot;CPC CMORPH&quot;</td>
<td>CMORPH from CPC</td>
</tr>
<tr>
<td>&quot;CPC STAGEII&quot;</td>
<td>STAGEII from CPC</td>
</tr>
<tr>
<td>&quot;CPC STAGEIV&quot;</td>
<td>STAGEIV from CPC</td>
</tr>
<tr>
<td>&quot;NARR&quot;</td>
<td>North American Regional Reanalysis</td>
</tr>
<tr>
<td>&quot;RFE2(daily)&quot;</td>
<td>Daily rainfall estimator</td>
</tr>
<tr>
<td>&quot;RFE2(GDAS bias-corrected)&quot;</td>
<td>RFE2 data bias corrected to GDAS</td>
</tr>
<tr>
<td>&quot;CEOP&quot;</td>
<td>CEOP</td>
</tr>
<tr>
<td>&quot;SCAN&quot;</td>
<td>SCAN</td>
</tr>
<tr>
<td>&quot;GDAS(LSWG)&quot;</td>
<td>GDAS data for LSWG project</td>
</tr>
<tr>
<td>&quot;AGRMET radiation&quot;</td>
<td>AGRMET radiation</td>
</tr>
<tr>
<td>&quot;Bondville&quot;</td>
<td>Bondville site data</td>
</tr>
<tr>
<td>&quot;SNOTEL&quot;</td>
<td>SNOTEL data</td>
</tr>
<tr>
<td>&quot;COOP&quot;</td>
<td>COOP data</td>
</tr>
<tr>
<td>&quot;Rhone AGG&quot;</td>
<td>Rhone AGG forcing data</td>
</tr>
<tr>
<td>&quot;VIC processed forcing&quot;</td>
<td>VIC processed forcing</td>
</tr>
<tr>
<td>&quot;PALS station forcing&quot;</td>
<td>PALS station forcing</td>
</tr>
<tr>
<td>&quot;PILDAS&quot;</td>
<td>PILDAS</td>
</tr>
<tr>
<td>&quot;PET USGS&quot;</td>
<td>USGS PET 1.0 deg</td>
</tr>
<tr>
<td>&quot;NAM242&quot;</td>
<td>NAM 242 AWIPS Grid – Over Alaska</td>
</tr>
<tr>
<td>&quot;WRFout&quot;</td>
<td>WRF output</td>
</tr>
<tr>
<td>&quot;RDHM.3.5.6&quot;</td>
<td>RDHM 3.5.6 (SACHTET and Snow17)</td>
</tr>
<tr>
<td>&quot;LDT-generated&quot;</td>
<td>LDT-generated forcing files</td>
</tr>
</tbody>
</table>
Topographic correction method (met forcing): specifies whether to use elevation correction for base forcing. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;none&quot;</td>
<td>Do not apply topographic correction for forcing</td>
</tr>
<tr>
<td>&quot;lapse-rate&quot;</td>
<td>Use lapse rate correction for forcing</td>
</tr>
<tr>
<td>&quot;slope-aspect&quot;</td>
<td>Apply slope-aspect correction for forcing</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not enable spatial downscaling</td>
</tr>
<tr>
<td>1</td>
<td>Enable spatial downscaling</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;bilinear&quot;</td>
<td>bilinear scheme</td>
</tr>
<tr>
<td>&quot;budget-bilinear&quot;</td>
<td>conservative scheme</td>
</tr>
<tr>
<td>&quot;neighbor&quot;</td>
<td>neighbour scheme</td>
</tr>
</tbody>
</table>

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 precip field only (to conserve water). Other fields will still be interpolated with the bilinear option.

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

**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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>linear</td>
<td>linear scheme</td>
</tr>
<tr>
<td>trilinear</td>
<td>uber next scheme</td>
</tr>
</tbody>
</table>

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.

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

### 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 10) file for a complete specification description.

**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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;none&quot;</td>
<td>Do not write output</td>
</tr>
<tr>
<td>&quot;1d tilespace&quot;</td>
<td>Write output in a 1-D tile domain</td>
</tr>
<tr>
<td>&quot;2d gridspace&quot;</td>
<td>Write output in a 2-D grid domain</td>
</tr>
<tr>
<td>&quot;1d gridspace&quot;</td>
<td>Write output in a 1-D grid domain</td>
</tr>
</tbody>
</table>
Output methodology: "2d gridspace"

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not write restart files</td>
</tr>
<tr>
<td>1</td>
<td>Write restart files</td>
</tr>
</tbody>
</table>

Output model restart files: 1

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;binary&quot;</td>
<td>Write output in binary format</td>
</tr>
<tr>
<td>&quot;grib1&quot;</td>
<td>Write output in GRIB-1 format</td>
</tr>
<tr>
<td>&quot;netcdf&quot;</td>
<td>Write output in netCDF format</td>
</tr>
</tbody>
</table>

Output data format: netcdf

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;2 level hierarchy&quot;</td>
<td>2 levels of hierarchy</td>
</tr>
<tr>
<td>&quot;3 level hierarchy&quot;</td>
<td>3 levels of hierarchy</td>
</tr>
<tr>
<td>&quot;4 level hierarchy&quot;</td>
<td>4 levels of hierarchy</td>
</tr>
<tr>
<td>&quot;WMO convention&quot;</td>
<td>WMO convention for weather codes</td>
</tr>
</tbody>
</table>

Output naming style: "3 level hierarchy"

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.

<table>
<thead>
<tr>
<th>Output GRIB Table Version: 130</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output GRIB Center Id: 173</td>
</tr>
<tr>
<td>Output GRIB Subcenter Id: 4</td>
</tr>
<tr>
<td>Output GRIB Grid Id: 11</td>
</tr>
<tr>
<td>Output GRIB Process Id: 1</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>restart</td>
<td>A restart mode is being used</td>
</tr>
<tr>
<td>coldstart</td>
<td>A cold start mode is being used, no restart file read</td>
</tr>
</tbody>
</table>

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.

Start mode: coldstart

The start time is specified in the following format:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting year:</td>
<td>integer 2001 – present</td>
<td>specifying starting year</td>
</tr>
<tr>
<td>Starting month:</td>
<td>integer 1 – 12</td>
<td>specifying starting month</td>
</tr>
<tr>
<td>Starting day:</td>
<td>integer 1 – 31</td>
<td>specifying starting day</td>
</tr>
<tr>
<td>Starting hour:</td>
<td>integer 0 – 23</td>
<td>specifying starting hour</td>
</tr>
<tr>
<td>Starting minute:</td>
<td>integer 0 – 59</td>
<td>specifying starting minute</td>
</tr>
<tr>
<td>Starting second:</td>
<td>integer 0 – 59</td>
<td>specifying starting second</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ending year</td>
<td>integer 2001 – present</td>
<td>specifying ending year</td>
</tr>
<tr>
<td>Ending month</td>
<td>integer 1 – 12</td>
<td>specifying ending month</td>
</tr>
<tr>
<td>Ending day</td>
<td>integer 1 – 31</td>
<td>specifying ending day</td>
</tr>
<tr>
<td>Ending hour</td>
<td>integer 0 – 23</td>
<td>specifying ending hour</td>
</tr>
<tr>
<td>Ending minute</td>
<td>integer 0 – 59</td>
<td>specifying ending minute</td>
</tr>
<tr>
<td>Ending second</td>
<td>integer 0 – 59</td>
<td>specifying ending second</td>
</tr>
</tbody>
</table>

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.

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

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.

Output directory: OUTPUT

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

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.

**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).

**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.

**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).

**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.

**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).
| 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.

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

| 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.

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

| 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.

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

| 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.
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.

Minimum cutoff percentage (aspect bands): 0.05

This section specifies the 2-d layout of the processors in a parallel processing environment. 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. 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:**.

| 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>do not use a routing model</td>
</tr>
<tr>
<td>&quot;NLDAS router&quot;</td>
<td>use the NLDAS router</td>
</tr>
<tr>
<td>&quot;HYMAP router&quot;</td>
<td>use the HYMAP router</td>
</tr>
</tbody>
</table>

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

Routing model: none
Radiative transfer model: none
Number of application models: 0
9.3 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.

<table>
<thead>
<tr>
<th>Value Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
</tr>
<tr>
<td>Direct insertion</td>
</tr>
<tr>
<td>EnKF GMAO EnKF data assimilation</td>
</tr>
<tr>
<td>EnKS GRACE ensemble Kalman filter data assimilation</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>None</td>
</tr>
<tr>
<td>Direct insertion</td>
<td>Direct Insertion</td>
</tr>
<tr>
<td>EnKF</td>
<td>GMAO EnKF data assimilation</td>
</tr>
<tr>
<td>EnKS</td>
<td>GRACE ensemble Kalman filter data assimilation</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>AMSR-E(NASA) soil moisture</td>
<td>AMSRE L3 soil moisture daily gridded data (HDF format)</td>
</tr>
<tr>
<td>AMSR-E(LPRM) soil moisture</td>
<td>AMSRE L3 soil moisture daily gridded data (HDF format)</td>
</tr>
<tr>
<td>ECV soil moisture</td>
<td>ECV soil moisture</td>
</tr>
<tr>
<td>Windsat</td>
<td>Windsat</td>
</tr>
<tr>
<td>ANSA SCF</td>
<td>ANSA SCF</td>
</tr>
<tr>
<td>PMW snow</td>
<td>PMW-based SWE or snow depth</td>
</tr>
<tr>
<td>MODIS SCF</td>
<td>MODIS SCF</td>
</tr>
<tr>
<td>GRACE TWS</td>
<td>GRACE TWS</td>
</tr>
<tr>
<td>SMOOPS soil moisture</td>
<td>SMOOPS soil moisture</td>
</tr>
</tbody>
</table>

**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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Apply analysis increments</td>
</tr>
<tr>
<td>1</td>
<td>Do not apply analysis increments</td>
</tr>
</tbody>
</table>

Data assimilation exclude analysis increments: 0

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

See Section 9.13 for a description of how to specify a time interval.

Data assimilation output interval for diagnostics: 1da

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

Data assimilation number of observation types: 0

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not output the ensemble members</td>
</tr>
<tr>
<td>1</td>
<td>Output the ensemble members</td>
</tr>
</tbody>
</table>

Data assimilation output ensemble members: 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not output the processed observations</td>
</tr>
<tr>
<td>1</td>
<td>Output the processed observations</td>
</tr>
</tbody>
</table>

64
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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not output the innovations</td>
</tr>
<tr>
<td>1</td>
<td>Output the innovations</td>
</tr>
</tbody>
</table>

Data assimilation output innovations: 0

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not use a trained forward model</td>
</tr>
<tr>
<td>1</td>
<td>Use a trained forward model</td>
</tr>
</tbody>
</table>

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

Bias estimation

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“none”</td>
<td>No dynamic bias estimation</td>
</tr>
<tr>
<td>“Adaptive bias correction”</td>
<td>NASA GMAO dynamic bias estimation</td>
</tr>
</tbody>
</table>

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)

```plaintext
#np param t const t relax
Soil Temperature
1.0 0.05 86400.0
```

**Bias estimation attributes file:**

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

See Section [9.13](#) for a description of how to specify a time interval.

```plaintext
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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not use a bias restart file</td>
</tr>
<tr>
<td>read</td>
<td>Use a bias restart file</td>
</tr>
</tbody>
</table>

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

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

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

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not apply</td>
</tr>
<tr>
<td>1</td>
<td>Apply</td>
</tr>
</tbody>
</table>

### Apply perturbation bias correction:

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

See Section 9.13 for a description of how to specify a time interval.

### 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.

### Perturbations restart filename: none

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“none”</td>
<td>None</td>
</tr>
<tr>
<td>“GMAO scheme”</td>
<td>GMAO perturbation algorithm</td>
</tr>
</tbody>
</table>

### Forcing perturbation algorithm: none
Forcing perturbation frequency: specifies the forcing perturbation interval.

See Section 9.13 for a description of how to specify a time interval.

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.

```
#var min var max
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
```

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.

```
#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

Forcing perturbation attributes file: none

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“none”</td>
<td>None</td>
</tr>
<tr>
<td>“GMAO scheme”</td>
<td>GMAO perturbation algorithm</td>
</tr>
</tbody>
</table>

State perturbation algorithm: none

State perturbation frequency: specifies the prognostic variable perturbation interval.

See Section 9.13 for a description of how to specify a time interval.

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.

#name varmin varmax
SWE
0.0 100.0
Snowdepth
0.0 100.0

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:
State perturbation attributes file: none

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;none&quot;</td>
<td>None</td>
</tr>
<tr>
<td>&quot;GMAO scheme&quot;</td>
<td>GMAO perturbation algorithm</td>
</tr>
</tbody>
</table>

Observation perturbation algorithm: none

Observation perturbation frequency: specifies the observation perturbation interval.

See Section 9.13 for a description of how to specify a time interval.

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.

#error rate varmin varmax
ANSA SWE
10.0 0.01 500

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:

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

**Observation perturbation attributes file:** none

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

**IMS data directory:**

### 9.3.1 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.

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

**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.

<table>
<thead>
<tr>
<th>AMSR-E (LPRM) soil moisture data directory:</th>
<th>'input'</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMSR-E (LPRM) soil moisture use raw data:</td>
<td>0</td>
</tr>
<tr>
<td>AMSR-E (LPRM) scale observations:</td>
<td>1</td>
</tr>
<tr>
<td>AMSR-E (LPRM) use scaled standard deviation model:</td>
<td>1</td>
</tr>
<tr>
<td>AMSR-E (LPRM) model CDF file:</td>
<td>lsm_cdf.nc</td>
</tr>
<tr>
<td>AMSR-E (LPRM) observation CDF file:</td>
<td>obs_cdf.nc</td>
</tr>
<tr>
<td>AMSR-E (LPRM) soil moisture number of bins in the CDF:</td>
<td>100</td>
</tr>
</tbody>
</table>

9.3.3 ECV soil moisture assimilation

**ECV soil moisture data directory:** specifies the directory for the ECV soil moisture data.

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

**ECV use scaled standard deviation model:** specifies if the observation error standard deviation is to be scaled using model and observation standard
deviation.

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

**ECV observation CDF file**: specifies the name of the observation CDF file.

**ECV soil moisture number of bins in the CDF**: specifies the number of bins in the CDF.

<table>
<thead>
<tr>
<th>ECV soil moisture data directory:</th>
<th>'input'</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECV scale observations:</td>
<td>1</td>
</tr>
<tr>
<td>ECV use scaled standard deviation model:</td>
<td>1</td>
</tr>
<tr>
<td>ECV model CDF file:</td>
<td>lsm_cdf.nc</td>
</tr>
<tr>
<td>ECV observation CDF file:</td>
<td>obs_cdf.nc</td>
</tr>
<tr>
<td>ECV soil moisture number of bins in the CDF:</td>
<td>100</td>
</tr>
</tbody>
</table>

### 9.3.4 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.

<table>
<thead>
<tr>
<th>WindSat soil moisture data directory:</th>
<th>'input'</th>
</tr>
</thead>
<tbody>
<tr>
<td>WindSat scale observations:</td>
<td>1</td>
</tr>
<tr>
<td>WindSat model CDF file:</td>
<td>lsm_cdf.nc</td>
</tr>
<tr>
<td>WindSat observation CDF file:</td>
<td>obs_cdf.nc</td>
</tr>
<tr>
<td>WindSat number of bins in the CDF:</td>
<td>100</td>
</tr>
</tbody>
</table>
9.3.5 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):

\[
std = std \times scf\_obs \text{ if } scf\_obs \leq 50; 
std = std \times (100 - scf\_obs) \text{ if } scf\_obs > 50; 
\text{otherwise, } std \text{ remains to be the same as read in from the observation perturbation attributes file.}
\]

**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:
<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“standard”</td>
<td>use Rodell and Houser (2004)</td>
</tr>
<tr>
<td>“customized”</td>
<td>use Liu et al. (2013)</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSA SCF data directory:</td>
<td>./ANSA_SCF_UCO</td>
</tr>
<tr>
<td>ANSA SCF lower left lat:</td>
<td>35.025</td>
</tr>
<tr>
<td>ANSA SCF lower left lon:</td>
<td>-112.475</td>
</tr>
<tr>
<td>ANSA SCF upper right lat:</td>
<td>43.975</td>
</tr>
<tr>
<td>ANSA SCF upper right lon:</td>
<td>-105.525</td>
</tr>
<tr>
<td>ANSA SCF resolution (dx):</td>
<td>0.05</td>
</tr>
<tr>
<td>ANSA SCF resolution (dy):</td>
<td>0.05</td>
</tr>
<tr>
<td>ANSA SCF local time for assimilation:</td>
<td>10.0</td>
</tr>
<tr>
<td>ANSA SCF field name:</td>
<td>&quot;ansa_interpsnow&quot;</td>
</tr>
<tr>
<td>ANSA SCF file name convention:</td>
<td>&quot;ansa_all_YYYYMMDD.h5&quot;</td>
</tr>
<tr>
<td>ANSA SCF use triangular-shaped observation error:</td>
<td>1</td>
</tr>
<tr>
<td>ANSA SCF using EnKF with DI:</td>
<td>1</td>
</tr>
<tr>
<td>ANSA SCF direct insertion methodology:</td>
<td>&quot;customized&quot;</td>
</tr>
<tr>
<td>ANSA SCF amount of SWE (mm) to add to model:</td>
<td>10</td>
</tr>
<tr>
<td>ANSA SCF maximum SWE melt rate (mm/day):</td>
<td>50</td>
</tr>
<tr>
<td>ANSA SCF threshold of model SWE to be removed at once:</td>
<td>20</td>
</tr>
<tr>
<td>ANSA SCF length of snowmelt period in days:</td>
<td>15</td>
</tr>
</tbody>
</table>
9.3.6 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).

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

9.3.7 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 >0.7.

PMW snow data - apply mask with landcover type (1=yes, 0=no): spec-
ifies 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.

# 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_YYMMDD.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"

9.3.8 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not use</td>
</tr>
<tr>
<td>1</td>
<td>Use</td>
</tr>
</tbody>
</table>

GRACE data directory: ./GRACEOBS
GRACE use reported measurement error values:
9.3.9 SMOPS soil moisture assimilation

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

SMOPS soil moisture use ASCAT data: specifies if the ASCAT data layer is to be used.

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

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

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

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

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Use daily data feed</td>
</tr>
<tr>
<td>1</td>
<td>Use 6 hour data feed</td>
</tr>
</tbody>
</table>

SMOPS 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. ($e \mapsto e \times \sigma_m / \sigma_o$)

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“LIS”</td>
<td>YYYY/NPR_SMOPS_CMAP_DYYYYMDDHH.gr2</td>
</tr>
<tr>
<td>“other”</td>
<td>smops_dYYYYMDD_sHH0000_cness.gr2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SMOPS soil moisture data directory:</th>
<th>'input'</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMOPS soil moisture use ASCAT data:</td>
<td>1</td>
</tr>
<tr>
<td>SMOPS use scaled standard deviation model:</td>
<td>1</td>
</tr>
<tr>
<td>SMOPS model CDF file:</td>
<td>lsm_cdf.nc</td>
</tr>
</tbody>
</table>
SMOPS observation CDF file: obs_cdf.nc
SMOPS soil moisture number of bins in the CDF: 100
SMOPS use realtime data:
SMOPS soil moisture use scaled standard deviation model:
SMOPS naming convention: LIS

9.4 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRTM2EM</td>
<td>CRTM2EM</td>
</tr>
<tr>
<td>CMEM</td>
<td>CMEM</td>
</tr>
</tbody>
</table>

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

See Section 9.13 for a description of how to specify a time interval.

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

See Section 9.13 for a description of how to specify a time interval.

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

9.4.1 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.

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not enable correction</td>
</tr>
<tr>
<td>1</td>
<td>Enable correction</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>CRTM number of sensors: 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRTM number of layers: 64</td>
</tr>
<tr>
<td>CRTM number of absorbers: 2</td>
</tr>
<tr>
<td>CRTM number of clouds: 0</td>
</tr>
<tr>
<td>CRTM number of aerosols: 0</td>
</tr>
<tr>
<td>CRTM sensor id: amsua_n18</td>
</tr>
<tr>
<td>CRTM coefficient data path: ./Coefficient_Data/</td>
</tr>
<tr>
<td>RTM input soil moisture correction:</td>
</tr>
<tr>
<td>RTM input soil moisture correction src mean file:</td>
</tr>
<tr>
<td>RTM input soil moisture correction src sigma file:</td>
</tr>
<tr>
<td>RTM input soil moisture correction dst mean file:</td>
</tr>
<tr>
<td>RTM input soil moisture correction dst sigma file:</td>
</tr>
</tbody>
</table>
9.4.2 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:

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>Incidence Angle (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.925</td>
<td>55.0</td>
</tr>
<tr>
<td>10.65</td>
<td>55.0</td>
</tr>
<tr>
<td>18.7</td>
<td>55.0</td>
</tr>
<tr>
<td>23.8</td>
<td>55.0</td>
</tr>
<tr>
<td>36.5</td>
<td>55.0</td>
</tr>
<tr>
<td>89.0</td>
<td>55.0</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>CMEM3 sensor id:</th>
<th>amsre</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMEM3 number of frequencies:</td>
<td>./amsre-freqs.tx</td>
</tr>
<tr>
<td>CMEM3 frequencies file:</td>
<td></td>
</tr>
<tr>
<td>RTM input soil moisture correction:</td>
<td></td>
</tr>
</tbody>
</table>
9.5 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;none&quot;</td>
<td>no optimization</td>
</tr>
<tr>
<td>&quot;Genetic algorithm&quot;</td>
<td>Genetic Algorithm</td>
</tr>
<tr>
<td>&quot;Monte carlo sampling&quot;</td>
<td>MCSIM Algorithm</td>
</tr>
<tr>
<td>&quot;Differential evolution markov chain z&quot;</td>
<td>DEMCz Algorithm</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;No obs&quot;</td>
<td>no observations</td>
</tr>
<tr>
<td>&quot;AMSRE SR&quot;</td>
<td>AMSR-E (Colorado State Univ.)</td>
</tr>
<tr>
<td>&quot;AMSRE-E(LPRM) pe soil moisture&quot;</td>
<td>AMSR-E LPRM soil moisture</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Least squares&quot;</td>
<td>Least squares</td>
</tr>
<tr>
<td>&quot;Likelihood&quot;</td>
<td>Maximum likelihood</td>
</tr>
<tr>
<td>&quot;Probability&quot;</td>
<td>Maximize probability</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not write pe observations</td>
</tr>
<tr>
<td>1</td>
<td>Write pe observations</td>
</tr>
</tbody>
</table>
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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Use defaults</td>
</tr>
<tr>
<td>1</td>
<td>Use sampled values</td>
</tr>
</tbody>
</table>

(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.
9.5.1 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>distributed (ie, optimized for each cell independently)</td>
</tr>
</tbody>
</table>

**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.

9.5.2 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.

9.5.3 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.

9.5.4 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 pro-
duced by two parent solutions (1 or 2).

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>single point crossover</td>
</tr>
<tr>
<td>2</td>
<td>uniform crossover</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>jump mutation</td>
</tr>
<tr>
<td>1</td>
<td>creep mutation</td>
</tr>
</tbody>
</table>

**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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>do not use</td>
</tr>
<tr>
<td>1</td>
<td>use</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>restart</td>
<td>restart</td>
</tr>
<tr>
<td>coldstart</td>
<td>cold start</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GA restart file:</th>
<th>./OUTPUT/EXP999/GA/GA.188.GArst</th>
</tr>
</thead>
<tbody>
<tr>
<td>GA number of generations:</td>
<td>100</td>
</tr>
<tr>
<td>GA number of children per parent:</td>
<td>1</td>
</tr>
<tr>
<td>GA crossover scheme:</td>
<td>2</td>
</tr>
<tr>
<td>GA crossover probability:</td>
<td>0.5</td>
</tr>
<tr>
<td>GA use creep mutations:</td>
<td>0</td>
</tr>
<tr>
<td>GA creep mutation probability:</td>
<td>0.04</td>
</tr>
<tr>
<td>GA jump mutation probability:</td>
<td>0.02</td>
</tr>
<tr>
<td>GA use elitism:</td>
<td>1</td>
</tr>
<tr>
<td>GA start mode:</td>
<td>coldstart</td>
</tr>
</tbody>
</table>
9.5.5 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>restart</td>
<td>restart</td>
</tr>
<tr>
<td>coldstart</td>
<td>cold start</td>
</tr>
</tbody>
</table>

| 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 |
9.5.6 Monte Carlo simulation

This section provides specifications of the MCSIM algorithm instance. MCSIM randomly samples from user-specified probability distributions to generate parameter 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.

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>restart</td>
<td>restart</td>
</tr>
<tr>
<td>coldstart</td>
<td>cold start</td>
</tr>
</tbody>
</table>

**MCSIM restart file:** specifies the name of the MCSIM restart file.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCSIM number of iterations:</td>
<td>1</td>
</tr>
<tr>
<td>MCSIM start mode:</td>
<td>coldstart</td>
</tr>
<tr>
<td>MCSIM restart file:</td>
<td>none</td>
</tr>
</tbody>
</table>

9.5.7 Observations for Parameter Estimation

This section of the config file includes the observation specifications for parameter estimation

9.5.8 AMSRE_SR Emissivity

**AMSRE SR 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

AMSRE SR Emissivity Obs data directory: './obs/
AMSRE SR Emissivity observations attributes file: './AMSRE_SR_attributes.txt'
AMSRE SR number of observations threshold: 5

9.5.9 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.

LPRM AMSRE soil moisture data directory: './LPRM.v6'
LPRM AMSRE soil moisture observations attributes file: './LPRM_attributes.txt'

9.5.10 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.

9.6 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.

LIS domain and parameter data file: ./lis_input.d01.nc
9.6.1 Parameter options

**Landmask data source:** specifies the usage of landmask data in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not landmask</td>
</tr>
<tr>
<td>LDT</td>
<td>Read landmask from the LDT-generated LIS domain and parameter data file:</td>
</tr>
</tbody>
</table>

**Landcover data source:** specifies the usage of landcover data in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDT</td>
<td>Read landcover data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not read soil texture</td>
</tr>
<tr>
<td>LDT</td>
<td>Read soil texture data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
</tbody>
</table>

Soil texture data source: LDT

**Soil fraction data source:** specifies the usage of soil fraction parameters in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not read soil fractions</td>
</tr>
<tr>
<td>LDT</td>
<td>Read soil fractions data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
</tbody>
</table>

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:

**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:

**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:

**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:

**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:
Curvature data source: none

LAI data source: specifies the usage of LAI data in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not read LAI</td>
</tr>
<tr>
<td>LDT</td>
<td>Read LAI data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
<tr>
<td>“MODIS real-time”</td>
<td>Read MODIS real-time LAI</td>
</tr>
</tbody>
</table>

LAI data source: none

SAI data source: specifies the usage of LAI data in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not read SAI</td>
</tr>
<tr>
<td>LDT</td>
<td>Read SAI data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
<tr>
<td>“MODIS real-time”</td>
<td>Read MODIS real-time SAI</td>
</tr>
</tbody>
</table>

SAI data source: none

Albedo data source: specifies the usage of albedo data in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not read albedo</td>
</tr>
<tr>
<td>LDT</td>
<td>Read albedo data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
</tbody>
</table>

Albedo data source: LDT

Max snow albedo data source: specifies the usage of the maximum snow albedo in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not read max snow albedo</td>
</tr>
<tr>
<td>fixed</td>
<td>Use fixed max snow albedo from the “lis.config” file. This option is only available to the Noah-3.x LSMS.</td>
</tr>
<tr>
<td>LDT</td>
<td>Read max snow albedo data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
</tbody>
</table>
Max snow albedo data source: LDT

**Greenness data source:** specifies the usage of greenness fraction data in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not read greenness fraction</td>
</tr>
<tr>
<td>LDT</td>
<td>Read greenness data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
<tr>
<td>“NESDIS weekly”</td>
<td>Read NESDIS weekly greenness fraction</td>
</tr>
<tr>
<td>“SPORT”</td>
<td>Read SPORT greenness fraction</td>
</tr>
<tr>
<td>VIIRS</td>
<td>Read VIIRS greenness fraction</td>
</tr>
</tbody>
</table>

Greenness data source: LDT

**Roughness data source:** specifies the usage of roughness data in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not read roughness</td>
</tr>
<tr>
<td>LDT</td>
<td>Read roughness data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
</tbody>
</table>

Roughness data source: none

**Porosity data source:** specifies the usage of soil porosity data in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not read soil porosity</td>
</tr>
<tr>
<td>LDT</td>
<td>Read porosity data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
</tbody>
</table>

Porosity data source: none

**Ksat data source:** specifies the usage of hydraulic conductivity data in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not read hydraulic conductivity</td>
</tr>
<tr>
<td>LDT</td>
<td>Read hydraulic conductivity data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
</tbody>
</table>

Ksat data source: none
Ksat data source: none

**B parameter data source:** specifies the usage of b parameter data in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not read b parameter</td>
</tr>
<tr>
<td>LDT</td>
<td>Read b parameter data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
</tbody>
</table>

B parameter data source: none

**Quartz data source:** specifies the usage of quartz data in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not read quartz</td>
</tr>
<tr>
<td>LDT</td>
<td>Read quartz data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
</tbody>
</table>

Quartz data source: none

**Emissivity data source:** specifies the usage of emissivity data in the run. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>Do not read emissivity</td>
</tr>
<tr>
<td>LDT</td>
<td>Read emissivity data from the LDT-generated LIS domain and parameter data file:</td>
</tr>
</tbody>
</table>

Emissivity data source: none

**9.6.2 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:
<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not adjust deep soil temperature</td>
</tr>
<tr>
<td>1</td>
<td>Adjust deep soil temperature</td>
</tr>
</tbody>
</table>

**TBOT skin temperature lag days**: specifies the number of lag days.

| TBOT lag skin temperature update option: 0
| TBOT skin temperature lag days: 0 |

### 9.6.3 MODIS real-time LAI

**MODIS LAI data directory**: specifies the location of the MODIS real-time LAI files.

### 9.6.4 NESDIS weekly greenness fraction

**NESDIS greenness data directory**: specifies the location of the NESDIS weekly greenness files.

### 9.6.5 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not use realtime mode</td>
</tr>
<tr>
<td>1</td>
<td>Use realtime mode</td>
</tr>
</tbody>
</table>
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.

| 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 |

9.6.6 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not use realtime mode</td>
</tr>
<tr>
<td>1</td>
<td>Use realtime mode</td>
</tr>
</tbody>
</table>

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.

| 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 |

9.7 Forcings

9.7.1 GDAS

GDAS forcing directory: specifies the location of the GDAS forcing files.

| GDAS forcing directory: ./input/FORCING/GDAS/ |

9.7.2 GEOS

GEOS forcing directory: specifies the location of the GEOS forcing files.

| GEOS forcing directory: ./input/FORCING/GEOS/BEST_LK/ |
9.7.3 ECMWF

ECMWF forcing directory: specifies the location of the ECMWF forcing files.

**ECMWF forcing directory:** ./input/FORCING/ECMWF/

9.7.4 ECMWF Reanalysis

ECMWF Reanalysis forcing directory: specifies the location of the ECMWF Reanalysis forcing files.

ECMWF Reanalysis maskfile: specifies the file containing the ECMWF Reanalysis land/sea mask.

ECMWF Reanalysis domain x-dimension size: specifies the number of columns of the ECMWF Reanalysis domain.

ECMWF Reanalysis domain y-dimension size: specifies the number of rows of the ECMWF Reanalysis domain.

**ECMWF Reanalysis forcing directory:** ./input/FORCING/ECMWF-REANALYSIS/
**ECMWF Reanalysis maskfile:** ./input/FORCING/ECMWF-REANALYSIS/ecmwf_land_sea.05
**ECMWF Reanalysis domain x-dimension size:** 720
**ECMWF Reanalysis domain y-dimension size:** 360

9.7.5 PRINCETON

PRINCETON forcing directory: specifies the location of the PRINCETON forcing files.

**PRINCETON forcing directory:** ./input/FORCING/PRINCETON

9.7.6 Rhone AGG

Rhone AGG forcing directory: specifies the location of the Rhone AGG forcing files.
Rhone AGG domain x-dimension size: specifies the number of columns of the native domain parameters of the Rhone AGG forcing data. The map projection is specified in the driver modules defined for the Rhone AGG routines.

Rhone AGG domain y-dimension size: specifies the number of rows of the native domain parameters of the Rhone AGG forcing data. The map projection is specified in the driver modules defined for the Rhone AGG routines.

<table>
<thead>
<tr>
<th>Rhone AGG forcing directory: ./input/FORCING/RHONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhone AGG domain x-dimension size: 5</td>
</tr>
<tr>
<td>Rhone AGG domain y-dimension size: 6</td>
</tr>
</tbody>
</table>

9.7.7 GSWP2

GSWP2 landmask file: specifies the GSWP2 landmask file.

GSWP2 domain x-dimension size: specifies the number of columns of the GSWP2 domain.

GSWP2 domain y-dimension size: specifies the number of rows of the GSWP2 domain.

GSWP2 number of forcing variables: specifies the number of GSWP2 forcing variables.

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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>File Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSWP2 landmask file:</td>
<td>./input/gswp2data/Fixed/landmask_gswp.nc</td>
</tr>
<tr>
<td>GSWP2 domain x-dimension size:</td>
<td>360</td>
</tr>
<tr>
<td>GSWP2 domain y-dimension size:</td>
<td>150</td>
</tr>
<tr>
<td>GSWP2 number of forcing variables:</td>
<td>10</td>
</tr>
<tr>
<td>GSWP2 2m air temperature map:</td>
<td>./input/gswp2data/Tair_cru/Tair_cru</td>
</tr>
<tr>
<td>GSWP2 2m specific humidity map:</td>
<td>./input/gswp2data/Qair_cru/Qair_cru</td>
</tr>
<tr>
<td>GSWP2 wind map:</td>
<td>./input/gswp2data/Wind_ncep/Wind_ncep</td>
</tr>
<tr>
<td>GSWP2 surface pressure map:</td>
<td>./input/gswp2data/PSurf_ecor/PSurf_ecor</td>
</tr>
<tr>
<td>GSWP2 convective rainfall rate map:</td>
<td>./input/gswp2data/Rainf_C_gswp/Rainf_C_gswp</td>
</tr>
<tr>
<td>GSWP2 rainfall rate map:</td>
<td>./input/gswp2data/Rainf_gswp/Rainf_gswp</td>
</tr>
<tr>
<td>GSWP2 snowfall rate map:</td>
<td>./input/gswp2data/Snowf_gswp/Snowf_gswp</td>
</tr>
<tr>
<td>GSWP2 incident shortwave radiation map:</td>
<td>./input/gswp2data/SWdown_srb/SWdown_srb</td>
</tr>
<tr>
<td>GSWP2 incident longwave radiation map:</td>
<td>./input/gswp2data/LWdown_srb/LWdown_srb</td>
</tr>
</tbody>
</table>

### 9.7.8 GMAO GLDAS

**GLDAS forcing directory**: specifies the location of the GMAO GLDAS forcing files.

```
GLDAS forcing directory: ./FORCING/GLDAS_GMAO/
```

### 9.7.9 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.
9.7.10  MERRA-Land

**MERRA-Land forcing directory:** specifies the location of the MERRA-Land forcing files.

**MERRA-Land use lowest model level forcing:** specifies whether to use the lowest model level forcing. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not use the lowest model level forcing.</td>
</tr>
<tr>
<td>1</td>
<td>Use the lowest model level forcing.</td>
</tr>
</tbody>
</table>

9.7.11  MERRA2

**MERRA2 forcing directory:** specifies the location of the MERRA2 forcing files.

Please note that MERRA2 forcing data are not currently available to external users. They should become available in July 2015.

**MERRA2 use lowest model level forcing:** specifies whether to use the lowest model level forcing. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not use the lowest model level forcing.</td>
</tr>
<tr>
<td>1</td>
<td>Use the lowest model level forcing.</td>
</tr>
</tbody>
</table>

**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.

**MERRA2 forcing directory:**

- MERRA2 use lowest model level forcing:
- MERRA2 use corrected total precipitation:

### 9.7.12 GSWP1

**GSWP1 forcing directory:** specifies the location of the GSWP1 forcing files.

- **GSWP1 domain x-dimension size:** specifies the number of columns of the native domain parameters of the GSWP1 forcing data. The map projection is specified in the driver modules defined for the GSWP1 routines.
- **GSWP1 domain y-dimension size:** specifies the number of rows of the native domain parameters of the GSWP1 forcing data. The map projection is specified in the driver modules defined for the GSWP1 routines.
- **GSWP1 number of forcing variables:** specifies the number of forcing variables provided by GSWP1 at the model initialization step.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSWP1 forcing directory:</td>
<td>./input/FORCING/GSWP1</td>
</tr>
<tr>
<td>GSWP1 domain x-dimension size:</td>
<td>360</td>
</tr>
<tr>
<td>GSWP1 domain y-dimension size:</td>
<td>150</td>
</tr>
<tr>
<td>GSWP1 number of forcing variables:</td>
<td>9</td>
</tr>
</tbody>
</table>

### 9.8 Supplemental forcings

#### 9.8.1 AGRMET radiation (latlon)

**AGRRAD forcing directory:** specifies the directory containing AGRMET radiation data.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGRRAD forcing directory:</td>
<td>./input/FORCING/AGRRAD</td>
</tr>
</tbody>
</table>
9.8.2 AGRMET radiation (polar stereographic)

**AGRRADPS forcing directory:** specifies the directory containing AGRMET polar stereographic radiation data.

| AGRRADPS forcing directory: | ./input/FORCING/AGRRADPS |

9.8.3 CMAP precipitation

**CMAP forcing directory:** specifies the location of the CMAP forcing files.

| CMAP forcing directory: | ./input/FORCING/CMAP |

9.8.4 CEOP station data

**CEOP station forcing — during EOP1**

**CEOP location index:** specifies the location of the CEOP station.

**CEOP forcing directory:** specifies the location of the CEOP forcing files.

**CEOP metadata file:** specifies the file containing CEOP metadata.

| CEOP location index: | 3 #SGP location |
| CEOP forcing directory: | ./input/FORCING/CEOP/sgp.cfr |
| CEOP metadata file: | ./input/FORCING/CEOP/sgp.mdata |

9.8.5 SCAN station data

**SCAN forcing directory:** specifies the location of the SCAN forcing files.

**SCAN metadata file:** specifies the file containing SCAN metadata.

| SCAN forcing directory: | ./input/FORCING/SCAN |
| SCAN metadata file: | ./input/FORCING/SCAN/msu_scan.mdata |
### 9.8.6 NLDAS1

**NLDAS1 forcing directory:** specifies the location of the NLDAS-1 forcing files.

**NLDAS1 data center source:** specifies the center that produced the NLDAS1 files. (This is specified to distinguish the filenames.) Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“GES-DISC”</td>
<td>NASA GES-DISC</td>
</tr>
<tr>
<td>“NCEP”</td>
<td>NCEP</td>
</tr>
</tbody>
</table>

**NLDAS1 precipitation field:** specifies the field to be used for the precipitation. “NLDAS1” will use the standard gauge-based precipitation data from NLDAS-1. “EDAS” will use the EDAS model precipitation data instead. “STAGEII” will use the unbiased-corrected STAGE II radar estimated precipitation, and use the EDAS model precipitation for times/locations when the data from STAGE II is unavailable.

**NLDAS1 shortwave radiation field:** specifies the field to be used for the downward shortwave radiation at the surface. “NLDAS1” will use GOES SW radiation when/where it is available, and use the EDAS SW radiation otherwise. “EDAS” will simply use EDAS radiation at all times and locations.

**NLDAS1 apply CONUS mask:** specifies whether to apply the CONUS mask. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not apply CONUS mask</td>
</tr>
<tr>
<td>1</td>
<td>Apply CONUS mask</td>
</tr>
</tbody>
</table>

**NLDAS1 CONUS mask file:** specifies the NLDAS1 CONUS mask file.

**NLDAS1 mask lower left lat:** specifies the lower left latitude of the NLDAS1 mask domain. (cylindrical latitude/longitude projection)

**NLDAS1 mask lower left lon:** specifies the lower left longitude of the NLDAS1 mask domain. (cylindrical latitude/longitude projection)

**NLDAS1 mask upper right lat:** specifies the upper right latitude of the NLDAS1 mask domain. (cylindrical latitude/longitude projection)

**NLDAS1 mask upper right lon:** specifies the upper right longitude of the NLDAS1 mask domain. (cylindrical latitude/longitude projection)
**NLDAS1** mask resolution (dx): specifies the resolution of the NLDAS1 mask domain along the east-west direction.

**NLDAS1** mask resolution (dy): specifies the resolution of the NLDAS1 mask domain along the north-south direction.

<table>
<thead>
<tr>
<th>NLDAS1 forcing directory:</th>
<th>./input/FORCING/NLDAS1</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLDAS1 data center source:</td>
<td>&quot;GES-DISC&quot;</td>
</tr>
<tr>
<td>NLDAS1 precipitation field:</td>
<td>NLDAS1</td>
</tr>
<tr>
<td>NLDAS1 shortwave radiation field:</td>
<td>NLDAS1</td>
</tr>
<tr>
<td>NLDAS1 apply CONUS mask:</td>
<td>0</td>
</tr>
<tr>
<td>NLDAS1 CONUS mask file:</td>
<td></td>
</tr>
<tr>
<td>NLDAS1 mask lower left lat:</td>
<td>25.0625</td>
</tr>
<tr>
<td>NLDAS1 mask lower left lon:</td>
<td>-124.9375</td>
</tr>
<tr>
<td>NLDAS1 mask upper right lat:</td>
<td>52.9375</td>
</tr>
<tr>
<td>NLDAS1 mask upper right lon:</td>
<td>-67.0625</td>
</tr>
<tr>
<td>NLDAS1 mask resolution (dx):</td>
<td>0.125</td>
</tr>
<tr>
<td>NLDAS1 mask resolution (dy):</td>
<td>0.125</td>
</tr>
</tbody>
</table>

### 9.8.7 NLDAS2

**NLDAS2** forcing directory: specifies the location of the NLDAS2 forcing files.

**NLDAS2** data center source: specifies the center that produced the NLDAS2 files. (This is specified to distinguish the filenames.) Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“GES-DISC”</td>
<td>NASA GES-DISC</td>
</tr>
<tr>
<td>“NCEP”</td>
<td>NCEP</td>
</tr>
</tbody>
</table>

**NLDAS2 use model level data:** specifies whether or not to read in the model level data (instead of 2/10m fields) from the NLDAS2 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>do not use</td>
</tr>
<tr>
<td>1</td>
<td>use</td>
</tr>
</tbody>
</table>
**NLDAS2 use model based swdown**: specifies whether or not to read in the un-bias corrected model downward shortwave radiation data (in lieu of the bias corrected data) from the NLDAS2 forcing dataset (will open up and read “B” files). The data source is the NARR shortwave. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>do not use</td>
</tr>
<tr>
<td>1</td>
<td>use</td>
</tr>
</tbody>
</table>

**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 NLDAS2 forcing dataset (will open up and read “B” files). The data source is the NARR precipitation. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>do not use</td>
</tr>
<tr>
<td>1</td>
<td>use</td>
</tr>
</tbody>
</table>

**NLDAS2 use model based pressure**: specifies whether or not to read in the model base pressure data (instead of the observation based pressure) from the NLDAS2 forcing dataset (will open up and read “B” files). The data source is the pressure at the NARR lowest model level. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>do not use</td>
</tr>
<tr>
<td>1</td>
<td>use</td>
</tr>
</tbody>
</table>

---

**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

---

**9.8.8 TRMM 3B42RT precipitation**

**TRMM 3B42RT forcing directory**: specifies the location of the TRMM 3B42RT forcing files.

**TRMM 3B42RT forcing directory**: ./input/FORCING/3B42RT/
TRMM 3B42RTV7 forcing directory: specifies the location of the TRMM 3B42RT Version 7 forcing files.

9.8.9 TRMM 3B42V6 precipitation

TRMM 3B42V6 timestep: specifies the timestep for reading the TRMM 3B42V6 data.

See Section 9.13 for a description of how to specify a time interval.

TRMM 3B42V6 forcing directory: specifies the location of the TRMM 3B42V6 forcing files.

9.8.10 TRMM 3B42V7 precipitation

TRMM 3B42V7 timestep: specifies the timestep for reading the TRMM 3B42V7 data.

See Section 9.13 for a description of how to specify a time interval.

TRMM 3B42V7 forcing directory: specifies the location of the TRMM 3B42V7 forcing files.

9.8.11 CMORPH precipitation

CMORPH forcing directory: specifies the location of the CMORPH precipitation forcing files.
9.8.12 Stage II precipitation

STAGE2 forcing directory: specifies the location of the STAGE2 forcing files.

STAGE2 forcing directory: ./input/FORCING/STII

9.8.13 Stage IV precipitation

STAGE4 forcing directory: specifies the location of the STAGE4 forcing files.

STAGE4 forcing directory: ./input/FORCING/STIV

9.8.14 NARR

NARR forcing directory: specifies the location of the NARR forcing files.

NARR forcing directory: ./input/Code/NARR/

NARR domain x-dimension size: specifies the number of columns of the native domain parameters of the NARR forcing data.

NARR domain x-dimension size: 768

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: 386

NARR domain z-dimension size: specifies the number of rows of the native domain parameters of the NARR forcing data.

NARR domain z-dimension size: 30
9.8.15 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.

```
RFE2Daily forcing directory: ./input/MET_FORCING/RFE2.0_CPC/Africa/
RFE2Daily time offset: 0 # for use by GeoWRSI
```

9.8.16 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>current</td>
<td>Retrospective or current time-based PET files</td>
</tr>
<tr>
<td>climatology</td>
<td>Climatology-based PET files</td>
</tr>
</tbody>
</table>

```
USGS PET forcing directory: ./PET_USGS
```

9.8.17 RFE2 data bias corrected to GDAS

**RFE2gdas forcing directory**: specifies the location of the RFE2gdas forcing files.

```
RFE2gdas forcing directory:
```
9.8.18 NAM242

NAM242 forcing directory: specifies the location of the “NAM 242 AWIPS Grid – Over Alaska” forcing files

| NAM242 forcing directory: ./input/MET_FORCING/NAM242 |

9.8.19 WRFout

WRF output forcing directory: specifies the location of the WRF output data files.

WRF output domain x-dimension size: specifies the number of columns of the native domain parameters of the WRF output data.

WRF output domain y-dimension size: specifies the number of rows of the native domain parameters of the WRF output data.

WRF nest id: specifies the nest id of the WRF output data files.

| WRF output forcing directory: ./input/wrfout/ |
| WRF output domain x-dimension size: 741 |
| WRF output domain y-dimension size: 588 |
| WRF nest id: 1 |

9.8.20 GEOS5 Forecast

GEOS5 forecast forcing directory: specifies the location of the GEOS5 forecast forcing files.

| GEOS5 forecast forcing directory: |

9.8.21 GDAS for LSWG

GDASLSWG forcing file: specifies the location of the GDASLSWG forcing file.
GDASLSWG domain lower left lat: specifies the lower left latitude of the GDASLSWG domain. (cylindrical latitude/longitude projection)

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

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

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

GDASLSWG domain resolution (dx): specifies the resolution of the of the GDASLSWG domain along the east-west direction.

GDASLSWG domain resolution (dy): specifies the resolution of the of the GDASLSWG domain along the north-south direction.

---

9.8.22 Bondville

Bondville forcing file: specifies the location of the Bondville forcing file.

---

9.8.23 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.
**SNOTEL forcing directory:**
**SNOTEL metadata file:**
**SNOTEL coord file:**

**9.8.24 COOP**

**COOP forcing directory:** specifies the location of the COOP forcing files.

**COOP metadata file:** specifies the location of the COOP metadata file.

**COOP coord file:** specifies the location of the COOP coordinate file.

**9.8.25 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 VIC processed forcing data along the east-west direction.

VIC forcing domain resolution (dy): specifies the resolution 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.

| 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: |

9.8.26 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.

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:

9.8.27 PILDAS

PILDAS forcing directory: specifies the location of the PILDAS forcing files.

PILDAS forcing version: specifies the version of the PILDAS forcing data.

PILDAS forcing use lowest model level fields: specifies whether to use the lowest model level fields. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not use lowest level</td>
</tr>
<tr>
<td>1</td>
<td>Use lowest level</td>
</tr>
</tbody>
</table>

9.8.28 RDHM356

RDHM precipitation forcing directory: specifies the location of the RDHM precipitation forcing files.

RDHM temperature forcing directory: specifies the location of the RDHM temperature forcing files.

RDHM precipitation scale factor: specifies the RDHM precipitation scale factor, which is used to scale the integer type XMRG data into real number representing precipitation amount.
**RDHM precipitation interval:** specifies the frequency of the precipitation forcing data, in seconds.

**RDHM temperature interval:** specifies the frequency of the temperature forcing data, in seconds.

**RDHM run window lower left hrap y:** lower left HRAP Y coordinate of run domain

**RDHM run window lower left hrap x:** lower left HRAP X coordinate of run domain

**RDHM run window upper right hrap y:** upper right HRAP Y coordinate of run domain

**RDHM run window upper right hrap x:** upper right HRAP X coordinate of run domain

**RDHM run window hrap resolution:** spatial resolution (in HRAP unit) of run domain

**RDHM temperature undefined value:** specifies the undefined value for the temperature forcing data.

**RDHM precipitation undefined value:** specifies the undefined value for the precipitation forcing data.

**RDHM constant wind speed:** Constant wind speed (m/s) for entire run domain

<table>
<thead>
<tr>
<th><strong>Variable</strong></th>
<th><strong>Value</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>RDHM precipitation forcing directory</td>
<td>../testcase/precip</td>
</tr>
<tr>
<td>RDHM temperature forcing directory</td>
<td>../testcase/tair</td>
</tr>
<tr>
<td>RDHM precipitation scale factor</td>
<td>1.0</td>
</tr>
<tr>
<td>RDHM precipitation interval</td>
<td>3600</td>
</tr>
<tr>
<td>RDHM temperature interval</td>
<td>3600</td>
</tr>
<tr>
<td>RDHM run window lower left hrap y</td>
<td>48</td>
</tr>
<tr>
<td>RDHM run window lower left hrap x</td>
<td>17</td>
</tr>
<tr>
<td>RDHM run window upper right hrap y</td>
<td>821</td>
</tr>
<tr>
<td>RDHM run window upper right hrap x</td>
<td>1059</td>
</tr>
<tr>
<td>RDHM run window hrap resolution</td>
<td>1.0</td>
</tr>
<tr>
<td>RDHM temperature undefined value</td>
<td>-1.0</td>
</tr>
<tr>
<td>RDHM precipitation undefined value</td>
<td>-1.0</td>
</tr>
<tr>
<td>RDHM constant wind speed</td>
<td>4.0</td>
</tr>
</tbody>
</table>

**Generated metforcing directory:** specifies the location of the LDT gener-
ated meteorological forcing files. Files generated in LDT are in netCDF format, and they are automatically loaded and handled by the LIS-7 reader.

Generated metforcing directory: ./LDT_OUTPUT/

9.9 Land surface models

9.9.1 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 9.13 for a description of how to specify a time interval.

TEMPLATE model timestep: 1hr

9.9.2 NCEP’s Noah-2.7.1

Noah.2.7.1 model timestep: specifies the timestep for the run.

See Section 9.13 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 9.13 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zobler</td>
</tr>
<tr>
<td>2</td>
<td>STATSGO</td>
</tr>
</tbody>
</table>

Noah.2.7.1 number of soil classes: specifies the number of soil classes in the above mapping scheme. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Zobler</td>
</tr>
<tr>
<td>19</td>
<td>STATSGO</td>
</tr>
</tbody>
</table>

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).

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 \( m^3/m^3 \))

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 \( m^3/m^3 \))
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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noah.2.7.1 model timestep:</td>
<td>15mn</td>
</tr>
<tr>
<td>Noah.2.7.1 restart output interval:</td>
<td>1mo</td>
</tr>
<tr>
<td>Noah.2.7.1 restart file:</td>
<td>./LIS.E111.2004012100.00.d01.Noah271rst</td>
</tr>
<tr>
<td>Noah.2.7.1 vegetation parameter table:</td>
<td>./noah271_parms/noah.vegparms_UMD.txt</td>
</tr>
<tr>
<td>Noah.2.7.1 soil parameter table:</td>
<td>./noah271_parms/noah.soilparms_STATSGO-FAO.txt</td>
</tr>
<tr>
<td>Noah.2.7.1 use PTF for mapping soil properties:</td>
<td>0</td>
</tr>
<tr>
<td>Noah.2.7.1 number of vegetation parameters:</td>
<td>7</td>
</tr>
<tr>
<td>Noah.2.7.1 soils scheme:</td>
<td>2 # 1-Zobler; 2-STATSGO</td>
</tr>
<tr>
<td>Noah.2.7.1 number of soil classes:</td>
<td>16 # 9 for Zobler</td>
</tr>
<tr>
<td>Noah.2.7.1 number of soil layers:</td>
<td>4</td>
</tr>
<tr>
<td>Noah.2.7.1 layer thicknesses:</td>
<td>0.1 0.3 0.6 1.0</td>
</tr>
<tr>
<td>Noah.2.7.1 initial skin temperature:</td>
<td>290.000        # Kelvin</td>
</tr>
<tr>
<td>Noah.2.7.1 initial soil temperatures:</td>
<td>290.000 290.000 290.000 290.000 # Kelvin</td>
</tr>
<tr>
<td>Noah.2.7.1 initial total soil moistures:</td>
<td>0.2000000 0.2000000 0.2000000 0.2000000 # volumetric</td>
</tr>
<tr>
<td>Noah.2.7.1 initial liquid soil moistures:</td>
<td>0.2000000 0.2000000 0.2000000 0.2000000 # volumetric</td>
</tr>
<tr>
<td>Noah.2.7.1 initial canopy water:</td>
<td>0.0            # depth (m)</td>
</tr>
<tr>
<td>Noah.2.7.1 initial snow depth:</td>
<td>0.0            # depth (m)</td>
</tr>
<tr>
<td>Noah.2.7.1 initial snow equivalent:</td>
<td>0.0            # SWE</td>
</tr>
<tr>
<td>Noah.2.7.1 reference height for forcing T and q:</td>
<td>20.0</td>
</tr>
<tr>
<td>Noah.2.7.1 reference height for forcing u and v:</td>
<td>20.0</td>
</tr>
</tbody>
</table>
9.9.3 NCAR’s Noah-3.2

Noah.3.2 model timestep: specifies the timestep for the run.

See Section 9.13 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 9.13 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zobler</td>
</tr>
<tr>
<td>2</td>
<td>STATSGO</td>
</tr>
</tbody>
</table>

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).

Noah.3.2 use distributed soil depth map: specifies whether to use a dis-
tributed 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 \( m^3/m^3 \))

**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 \( m^3/m^3 \))

**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.

| 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 # volume |
Noah.3.2 initial liquid soil moistures: 0.2000000 0.2000000 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
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

### 9.9.4 NCAR’s Noah-3.3

**Noah.3.3 model timestep:** specifies the timestep for the run.

See Section [9.13](#) 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 [9.13](#) 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zobler</td>
</tr>
<tr>
<td>2</td>
<td>STATSGO</td>
</tr>
</tbody>
</table>

**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).

**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 $m^3/m^3$)

**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 $m^3/m^3$)
**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 SFCDIFF routine in Noah-3.3, or to use the previous SFCDIFF routine. The typical option is to use the updated SFCDIFF 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 SFCDIFF 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.

<table>
<thead>
<tr>
<th>Noah.3.3 model timestep:</th>
<th>15mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noah.3.3 restart output interval:</td>
<td>1mo</td>
</tr>
<tr>
<td>Noah.3.3 restart file:</td>
<td>LIS.E111.200805140000.d01.Noah33rst</td>
</tr>
<tr>
<td>Noah.3.3 vegetation parameter table:</td>
<td>../../noah33_parms/VEGPARM.TBL</td>
</tr>
<tr>
<td>Noah.3.3 soil parameter table:</td>
<td>../../noah33_parms/SOILPARM.TBL</td>
</tr>
<tr>
<td>Noah.3.3 general parameter table:</td>
<td>../../noah33_parms/GENPARM.TBL</td>
</tr>
<tr>
<td>Noah.3.3 use PTF for mapping soil properties:</td>
<td>0</td>
</tr>
<tr>
<td>Noah.3.3 soils scheme:</td>
<td>2</td>
</tr>
<tr>
<td>Noah.3.3 number of soil layers:</td>
<td>4</td>
</tr>
<tr>
<td>Noah.3.3 layer thicknesses:</td>
<td>0.1 0.3 0.6 1.0</td>
</tr>
<tr>
<td>Noah.3.3 use distributed soil depth map:</td>
<td>0</td>
</tr>
<tr>
<td>Noah.3.3 use distributed root depth map:</td>
<td>0</td>
</tr>
<tr>
<td>Noah.3.3 initial skin temperature:</td>
<td>290.0000</td>
</tr>
<tr>
<td>Noah.3.3 initial soil temperatures:</td>
<td>290.0000 290.0000 290.0000 290.0000</td>
</tr>
<tr>
<td>Noah.3.3 initial total soil moistures:</td>
<td>0.2000000 0.2000000 0.2000000 0.2000000</td>
</tr>
<tr>
<td>Noah.3.3 initial liquid soil moistures:</td>
<td>0.2000000 0.2000000 0.2000000 0.2000000</td>
</tr>
<tr>
<td>Noah.3.3 initial canopy water:</td>
<td>0.0</td>
</tr>
<tr>
<td>Noah.3.3 initial snow depth:</td>
<td>0.0</td>
</tr>
<tr>
<td>Noah.3.3 initial snow equivalent:</td>
<td>0.0</td>
</tr>
<tr>
<td>Noah.3.3 fixed max snow albedo:</td>
<td>0.0</td>
</tr>
<tr>
<td>Noah.3.3 fixed deep soil temperature:</td>
<td>0.0</td>
</tr>
<tr>
<td>Noah.3.3 fixed vegetation type:</td>
<td>0</td>
</tr>
<tr>
<td>Noah.3.3 fixed soil type:</td>
<td>0</td>
</tr>
<tr>
<td>Noah.3.3 fixed slope type:</td>
<td>0</td>
</tr>
<tr>
<td>Noah.3.3 sfcdif option:</td>
<td>1</td>
</tr>
<tr>
<td>Noah.3.3 z0 veg-type dependence option:</td>
<td>0</td>
</tr>
</tbody>
</table>

# 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 0.00

# 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 0.18

# Background (i.e., snow-free) roughness length (m) - by month
# - used only for first timestep; subsequent timesteps use
Noah.3.3 background roughness length: 0.18 0.17 0.16 0.15 0.15 0.15 0.15 0.16 0.16 0.17 0.18
9.9.5 NCAR’s Noah-3.6

Noah.3.6 model timestep: specifies the timestep for the run.

See Section 9.13 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 9.13 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zobler</td>
</tr>
<tr>
<td>2</td>
<td>STATSGO</td>
</tr>
</tbody>
</table>

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).

**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 $m^3/m^3$)

**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 $m^3/m^3$)

**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.

<table>
<thead>
<tr>
<th>Noah.3.6 model timestep:</th>
<th>15mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noah.3.6 restart output interval:</td>
<td>1mo</td>
</tr>
<tr>
<td>Noah.3.6 restart file:</td>
<td>LIS.E111.200805140000.d01.Noah36rst</td>
</tr>
<tr>
<td>Noah.3.6 vegetation parameter table:</td>
<td>../../noah36_parms/VEGPARM.TBL</td>
</tr>
</tbody>
</table>
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
Noah.3.6 initial liquid soil moistures: 0.2000000 0.2000000 0.2000000 0.2000000 # volumetric
Noah.3.6 initial canopy water: 0.0 # depth
Noah.3.6 initial snow depth: 0.0 # depth
Noah.3.6 initial snow equivalent: 0.0 # SWE depth
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 0.0 0
# 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 0.18 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

9.9.6 NoahMP 3.6

NOAHMP36 model timestep: specifies the timestep for NoahMP.

See Section 9.13 for a description of how to specify a time interval.
NOAHMP36 restart output interval: specifies the restart output interval for NoahMP.

See Section 9.13 for a description of how to specify a time interval.

NOAHMP36 number of soil layers: specifies the number of soil layers for NoahMP soil moisture/temperature.

NOAHMP36 number of snow layers: specifies the number of snow layers for NoahMP snow model.

NOAHMP36 landuse_tbl_name: specifies the file name of the NoahMP vegetation parameter table.

NOAHMP36 soil_tbl_name: specifies the file name of the NoahMP soil parameter table.

NOAHMP36 gen_tbl_name: specifies the file name of the NoahMP general parameter table.

NOAHMP36 noahmp_tbl_name: specifies the file name of the NoahMP multi-physics parameter table.

NOAHMP36 landuse_scheme_name: specifies the NoahMP landuse scheme name (e.g. USGS, check the NoahMP land use parameter table).

NOAHMP36 soil_scheme_name: specifies the NoahMP soil scheme name (e.g. STAS, check NoahMP soil parameter table).

NOAHMP36 dveg_opt: specifies the vegetation model. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>prescribed [table LAI, shdfac=FVEG]</td>
</tr>
<tr>
<td>2</td>
<td>dynamic</td>
</tr>
<tr>
<td>3</td>
<td>table LAI, calculate FVEG</td>
</tr>
<tr>
<td>4</td>
<td>table LAI, shdfac=maximum</td>
</tr>
</tbody>
</table>

NOAHMP36 crs_opt: specifies the canopy stomatal resistance scheme. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ball-Berry</td>
</tr>
<tr>
<td>2</td>
<td>Jarvis</td>
</tr>
</tbody>
</table>

NOAHMP36 btr_opt: specifies the soil moisture factor for stomatal resistance. Acceptable values are:
<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Noah</td>
</tr>
<tr>
<td>2</td>
<td>CLM</td>
</tr>
<tr>
<td>3</td>
<td>SSiB</td>
</tr>
</tbody>
</table>

**NOAHMP36 run_opt**: specifies the runoff and groundwater. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SIMGM</td>
</tr>
<tr>
<td>2</td>
<td>SIMTOP</td>
</tr>
<tr>
<td>3</td>
<td>Schaake96</td>
</tr>
<tr>
<td>4</td>
<td>BATS</td>
</tr>
</tbody>
</table>

**NOAHMP36 sfc_opt**: specifies surface layer drag coefficient. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M-O</td>
</tr>
<tr>
<td>2</td>
<td>Chen97</td>
</tr>
</tbody>
</table>

**NOAHMP36 frz_opt**: specifies the supercooled liquid water scheme. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NY06</td>
</tr>
<tr>
<td>2</td>
<td>Koren99</td>
</tr>
</tbody>
</table>

**NOAHMP36 inf_opt**: specifies the frozen soil permeability scheme. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NY06</td>
</tr>
<tr>
<td>2</td>
<td>Koren99</td>
</tr>
</tbody>
</table>

**NOAHMP36 rad_opt**: specifies the radiation transfer scheme. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>gap=F(3D,cosz)</td>
</tr>
<tr>
<td>2</td>
<td>gap=0</td>
</tr>
<tr>
<td>3</td>
<td>gap=1–Fveg</td>
</tr>
</tbody>
</table>

**NOAHMP36 alb_opt**: specifies the snow surface albedo scheme. Acceptable values are:
<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BATS</td>
</tr>
<tr>
<td>2</td>
<td>CLASS</td>
</tr>
</tbody>
</table>

**NOAHMP36 snf_opt**: specifies the rainfall and snowfall determination scheme. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jordan91</td>
</tr>
<tr>
<td>2</td>
<td>BATS</td>
</tr>
<tr>
<td>3</td>
<td>Noah</td>
</tr>
</tbody>
</table>

**NOAHMP36 tbot_opt**: specifies the lower boundary of soilu temperature scheme. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>zero-flux</td>
</tr>
<tr>
<td>2</td>
<td>Noah</td>
</tr>
</tbody>
</table>

**NOAHMP36 stc_opt**: specifies the snow and soil temperature time scheme. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>semi-implicit</td>
</tr>
<tr>
<td>2</td>
<td>fully implicit</td>
</tr>
</tbody>
</table>

**NOAHMP36 soil layer thickness**: specifies the thicknesses of the NoahMP layers.

**NOAHMP36 sc_idx**: specifies the NoahMP soil color type, an integer index from 1 to 8. Defaults to 4.

**NOAHMP36 CZIL option (iz0tlnd)**: specifies whether to use the Chen adjustment of Czil. Defaults to 0. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>do not use</td>
</tr>
<tr>
<td>1</td>
<td>use</td>
</tr>
</tbody>
</table>

**NOAHMP36 restart file**: specifies the NoahMP restart file.

**NOAHMP36 restart file format**: specifies the NoahMP restart file format, default: netcdf

**NOAHMP36 initial albold**: specifies the NoahMP initial albold (albedo of previous time step).
NOAHMP36 initial sneqvo: specifies the NoahMP initial snow mass at the last time step (mm).

NOAHMP36 initial stc: specifies the NoahMP initial soil temperature.

NOAHMP36 initial sh2o: specifies the NoahMP initial soil moisture (liquid part).

NOAHMP36 initial smc: specifies the NoahMP initial soil moisture (total).

NOAHMP36 initial tah: specifies the NoahMP initial canopy air temperature (K).

NOAHMP36 initial eah: specifies the NoahMP initial canopy air vapor pressure (Pa).

NOAHMP36 initial fwet: specifies the NoahMP initial wetted or snowed fraction of canopy.

NOAHMP36 initial canliq: specifies the NoahMP initial intercepted liquid water (mm).

NOAHMP36 initial canice: specifies the NoahMP initial intercepted ice mass (mm).

NOAHMP36 initial tv: specifies the NoahMP initial vegetation temperature (K).

NOAHMP36 initial tg: specifies the NoahMP initial ground temperature (skin temperature) (K).

NOAHMP36 initial qsnov: specifies the NoahMP initial snowfall on the ground (mm/s).

NOAHMP36 initial snowh: specifies the NoahMP initial snow depth (m).

NOAHMP36 initial sneqv: specifies the NoahMP initial snow water equivalent (mm).

NOAHMP36 initial zwt: specifies the NoahMP initial depth to water table (m).

NOAHMP36 initial wa: specifies the NoahMP initial water storage in aquifer (mm).

NOAHMP36 initial wt: specifies the NoahMP initial water in aquifer and sat-
turated soil (mm).

**NOAHMP36 initial wslake**: specifies the NoahMP initial lake water storage (mm).

**NOAHMP36 initial lfmass**: specifies the NoahMP initial leaf mass (used only for dveg_opt=2) (g/m²).

**NOAHMP36 initial rtmass**: specifies the NoahMP initial mass of fine roots (g/m²).

**NOAHMP36 initial stmass**: specifies the NoahMP initial stem mass (g/m²).

**NOAHMP36 initial wood**: specifies the NoahMP initial mass of wood (including woody roots) (g/m²).

**NOAHMP36 initial stblcp**: specifies the NoahMP initial stable carbon in deep soil (g/m²).

**NOAHMP36 initial fastcp**: specifies the NoahMP initial short-lived carbon in shallow soil (g/m²).

**NOAHMP36 initial lai**: specifies the NoahMP initial leaf area index.

**NOAHMP36 initial sai**: specifies the NoahMP initial stem area index.

**NOAHMP36 initial cm**: specifies the NoahMP initial momentum drag coefficient (s/m).

**NOAHMP36 initial ch**: specifies the NoahMP initial sensible heat exchange coefficient (s/m).

**NOAHMP36 initial tauss**: specifies the NoahMP initial snow aging term.

**NOAHMP36 initial smcwtd**: specifies the NoahMP initial soil water content between bottom of the soil and water table (m³/m³).

**NOAHMP36 initial deeprech**: specifies the NoahMP initial recharge to or from the water table when deep (m).

**NOAHMP36 initial rech**: specifies the NoahMP initial recharge to or from the water table when shallow (m).

**NOAHMP36 initial zlvl**: specifies the NoahMP initial reference height of temperature and humidity (m).
NOAHMP36 model timestep: "15mn"
NOAHMP36 restart output interval: 1da
NOAHMP36 number of soil layers: 4
NOAHMP36 number of snow layers: 3
NOAHMP36 landuse parameter table: "/input/noahmp_params/VEGPARM.TBL"
NOAHMP36 soil parameter table: "/input/noahmp_params/SOILPARM.TBL"
NOAHMP36 general parameter table: "/input/noahmp_params/GENPARM.TBL"
NOAHMP36 MP parameter table: "/input/noahmp_params/MPTABLE.TBL"
NOAHMP36 option of vegetation model: 4
NOAHMP36 option of canopy stomatal resistance: 1
NOAHMP36 option of soil moisture factor for stomatal resistance: 1
NOAHMP36 option of runoff and groundwater: 1
NOAHMP36 option of surface layer drag coefficient: 2
NOAHMP36 option of supercooled liquid water: 1
NOAHMP36 option of frozen soil permeability: 1
NOAHMP36 option of radiation transfer: 1
NOAHMP36 option of snow surface albedo: 2
NOAHMP36 option of rainfall and snowfall: 1
NOAHMP36 option of lower boundary of soil temperature: 1
NOAHMP36 option of snow and soil temperature time scheme: 1
NOAHMP36 soil layer thickness: 0.1 0.3 0.6 1.0
NOAHMP36 soil color index: 4
NOAHMP36 CZIL option (iz0tlnd): 0
NOAHMP36 zlvl: 6.0
NOAHMP36 zlvl_wind: 6.0
NOAHMP36 restart file: ./OUTPUT/opt_dveg_4/SURFACEMODEL/201212/LIS_RST_NOAHMP36_201212312100.d01.nc
NOAHMP36 restart file format: "netcdf"
NOAHMP36 initial albold: 0.1899999976
NOAHMP36 initial sneqvo: 0.0
NOAHMP36 initial stc: 266.09950 274.0445000 276.8954000 279.915200
NOAHMP36 initial sh2o: 0.2981597 0.2940254 0.2713114 0.3070948
NOAHMP36 initial smc: 0.2981597 0.2940254 0.2713114 0.3070948
NOAHMP36 initial tah: 263.94998
NOAHMP36 initial eah: 261.68518
NOAHMP36 initial fwet: 0.0
NOAHMP36 initial canliq: 0.0003935303
NOAHMP36 initial canice: 0.0000000000
NOAHMP36 initial tv: 263.6908874612
NOAHMP36 initial tg: 263.6908874612
NOAHMP36 initial qsnw: 0.0
NOAHMP36 initial snowh: 0.0010600531
NOAHMP36 initial sneqv: 0.0002095700
NOAHMP36 initial zwt: 2.5000000000
NOAHMP36 initial wa: 4900.0000000000
NOAHMP36 initial wt: 4900.0000000000
| NOAHMP36 initial wslake: 0.0000000000 |
| NOAHMP36 initial lfmass: 9.0000000000 |
| NOAHMP36 initial rtmass: 500.0000000000 |
| NOAHMP36 initial stmass: 3.3299999237 |
| NOAHMP36 initial wood: 500.0000000000 |
| NOAHMP36 initial stblcp: 1000.0000000000 |
| NOAHMP36 initial fastcp: 1000.0000000000 |
| NOAHMP36 initial lai: 0.5000000000 |
| NOAHMP36 initial sai: 0.1000000015 |
| NOAHMP36 initial cm: 0.0000000000 |
| NOAHMP36 initial ch: 0.0000000000 |
| NOAHMP36 initial tauss: 0.0 |
| NOAHMP36 initial smcwtld: 0.0 |
| NOAHMP36 initial deeprech: 0.0 |
| NOAHMP36 initial rech: 0.0 |
| NOAHMP36 initial zlvl: 6.0 |

### 9.9.7 CLM 2.0

**CLM model timestep**: specifies the timestep for the run.

See Section [9.13](#) 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 [9.13](#) for a description of how to specify a time interval.

**CLM restart file**: specifies the CLM active restart file.

**CLM vegetation parameter file**: 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.
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

9.9.8 VIC 4.1.1

VIC411 model timestep: specifies the timestep for the run.

See Section 9.13 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 9.13 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
For VIC sub-grid tiling, tiling is based on vegetation fractions from the VEGPARAM file. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>VIC tiling</td>
</tr>
<tr>
<td>1</td>
<td>LIS tiling</td>
</tr>
</tbody>
</table>

**VIC411 global parameter file:** This is VIC’s configuration file. Please see VIC’s documentation at: [http://www.hydro.washington.edu/Lettenmaier/Models/VIC/index.shtml](http://www.hydro.washington.edu/Lettenmaier/Models/VIC/index.shtml) 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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIC411 model timestep:</td>
<td>1hr</td>
</tr>
<tr>
<td>VIC411 model step interval:</td>
<td>3600</td>
</tr>
<tr>
<td>VIC411 restart output interval:</td>
<td>1da</td>
</tr>
<tr>
<td>VIC411 veg tiling scheme:</td>
<td>1</td>
</tr>
<tr>
<td>VIC411 global parameter file:</td>
<td>./input/vic411_global_file_nldas2_testcase</td>
</tr>
<tr>
<td>VIC411 total number of veg types:</td>
<td>13</td>
</tr>
<tr>
<td>VIC411 convert units:</td>
<td>1</td>
</tr>
</tbody>
</table>

**9.9.9 VIC 4.1.2**

**VIC412 model timestep:** specifies the timestep for the run.

See Section 9.13 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 9.13 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>binary</td>
<td>binary format</td>
</tr>
<tr>
<td>netcdf</td>
<td>netCDF format</td>
</tr>
</tbody>
</table>

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.

For VIC sub-grid tiling, tiling is based on vegetation fractions from the VEGPARAM file. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>VIC tiling</td>
</tr>
<tr>
<td>1</td>
<td>LIS tiling</td>
</tr>
</tbody>
</table>

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:
http://www.hydro.washington.edu/Lettenmaier/Models/VIC/index.shtml
for more information about configuring VIC.

<table>
<thead>
<tr>
<th>VIC412 model timestep:</th>
<th>1hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIC412 model step interval:</td>
<td>3600</td>
</tr>
<tr>
<td>VIC412 restart file:</td>
<td>./vic412.rst</td>
</tr>
<tr>
<td>VIC412 restart file format:</td>
<td>&quot;binary&quot;</td>
</tr>
<tr>
<td>VIC412 restart output interval:</td>
<td>1da</td>
</tr>
<tr>
<td>VIC412 veg tiling scheme:</td>
<td>1</td>
</tr>
<tr>
<td>VIC412 total number of veg types:</td>
<td>13</td>
</tr>
<tr>
<td>VIC412 convert units:</td>
<td>1</td>
</tr>
</tbody>
</table>

9.9.10 Mosaic

Mosaic model timestep: specifies the timestep for the run.

See Section 9.13 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 9.13 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>FAO</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not use observation height from forcing</td>
</tr>
<tr>
<td>1</td>
<td>Use observation height from forcing</td>
</tr>
</tbody>
</table>

Mosaic use forcing data aerodynamic conductance: specifies whether to use aerodynamic conductance field from the forcing dataset.

Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not use aerodynamic conductance from forcing data</td>
</tr>
<tr>
<td>1</td>
<td>Use aerodynamic conductance from forcing dataset</td>
</tr>
</tbody>
</table>

Mosaic use distributed soil depth map: specifies whether to use a distributed soil depth map.

Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not use distributed soil depth map</td>
</tr>
<tr>
<td>1</td>
<td>Use distributed soil depth map</td>
</tr>
</tbody>
</table>

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
9.9.11 HySSiB

**HYSSiB model timestep**: specifies the timestep for the run.

See Section 9.13 for a description of how to specify a time interval.

**HYSSiB restart output interval**: defines the restart writing interval for HySSiB. The typical value used in the LIS runs is 24 hours (1da).

See Section 9.13 for a description of how to specify a time interval.

**HYSSiB restart file**: specifies the HySSiB active restart file.

**HYSSiB vegetation parameter table**: specifies the HySSiB static vegetation parameter table file.

**HYSSiB albedo parameter table**: specifies the HySSiB static albedo parameter table file.

**HYSSiB topography stand dev file**: specifies the HySSiB topography standard deviation file.

**HYSSiB number of vegetation parameters**: specifies the number of vegetation parameters.

**HYSSiB number of vegetation 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.

---

<table>
<thead>
<tr>
<th>Mosaic initial soil temperature:</th>
<th>290</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mosaic use forcing data observation height:</td>
<td>0</td>
</tr>
<tr>
<td>Mosaic use forcing data aerodynamic conductance:</td>
<td>0</td>
</tr>
<tr>
<td>Mosaic use distributed soil depth map:</td>
<td>0</td>
</tr>
</tbody>
</table>
HYSSIB initial soil temperature: specifies the initial soil temperature in Kelvin.

| 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               |

### 9.9.12 Catchment Fortuna-2.5

**CLSM F2.5 model timestep:** specifies the timestep for the run.

See Section 9.13 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 9.13 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 $m^3/m^3$)

**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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not use the MODIS albedo</td>
</tr>
<tr>
<td>1</td>
<td>Use the MODIS albedo</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLSM F2.5 model timestep:</th>
<th>30mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLSM F2.5 restart output interval:</td>
<td>1da</td>
</tr>
<tr>
<td>CLSM F2.5 restart file:</td>
<td>./clmsf25.rst</td>
</tr>
<tr>
<td>CLSM F2.5 top soil layer depth:</td>
<td>0.02</td>
</tr>
<tr>
<td>CLSM F2.5 initial soil moisture:</td>
<td>0.30</td>
</tr>
<tr>
<td>CLSM F2.5 initial soil temperature:</td>
<td>290.0</td>
</tr>
<tr>
<td>CLSM F2.5 fixed reference height:</td>
<td>10.0</td>
</tr>
<tr>
<td>CLSM F2.5 turbulence scheme:</td>
<td>0</td>
</tr>
<tr>
<td>CLSM F2.5 use MODIS albedo flag:</td>
<td>1</td>
</tr>
</tbody>
</table>

### 9.9.13 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 [9.13](#) 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 [9.13](#) for a description of how to specify a time interval.

**WRSI restart file:** specifies the WRSI active restart file.

```
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"
```

### 9.9.14 RDHM 3.5.6

**RDHM356 model timestep:** specifies the timestep for the run.
See Section [9.13](#) for a description of how to specify a time interval.

**RDHM356 restart output interval:** defines the restart writing interval for
RDHM356.
See Section [9.13](#) 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 SacHTET 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Old version</td>
</tr>
<tr>
<td>2</td>
<td>New version</td>
</tr>
</tbody>
</table>

Note, if set to 1, zero snow depth causes problems.

RDHM356 SNOW17_OPT: SNOW-17 option Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use Snow-17</td>
</tr>
<tr>
<td>else</td>
<td>Do not use Snow-17</td>
</tr>
</tbody>
</table>

RDHM356 SACHTET_OPT: SAC-HTET option Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use Sac-HTET</td>
</tr>
<tr>
<td>else</td>
<td>Do not use Sac-HTET</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not normalize</td>
</tr>
<tr>
<td>1</td>
<td>Normalize</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0</td>
<td>Use energy-based Penman</td>
</tr>
<tr>
<td>0</td>
<td>Use non-Penman-based ETP</td>
</tr>
<tr>
<td>&gt; 0</td>
<td>Use empirical Penman equation</td>
</tr>
</tbody>
</table>

**RDHM356 TOPT**: specifies the optimum air temperature, in Kelvin.

**RDHM356 RDST**: specifies the tension water redistribution scheme. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Use OHD version of SRT (uses reference gradient instead of actual)</td>
</tr>
<tr>
<td>1</td>
<td>Use Noah version of SRT</td>
</tr>
</tbody>
</table>

**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:
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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Victor’s version</td>
</tr>
<tr>
<td>1</td>
<td>Eric’s version</td>
</tr>
</tbody>
</table>

Value Description
0 Victor’s version
1 Eric’s version

RDHM356 tmxmn file: 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.

```plaintext
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 0.6 0.75 1.0
RDHM356 DSINT: 0.05 0.25 0.6 0.75 1.0
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 file: "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
```
9.10 Irrigation

Irrigation scheme: specifies the name of the irrigation scheme to use. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>No irrigation scheme</td>
</tr>
<tr>
<td>Sprinkler</td>
<td>Demand sprinkler scheme</td>
</tr>
<tr>
<td>Flood</td>
<td>Demand flood scheme</td>
</tr>
</tbody>
</table>

Irrigation output interval: defines the output writing interval for irrigation.

See Section 9.13 for a description of how to specify a time interval.

Irrigation threshold: defines the irrigation trigger threshold for the flood and sprinkler irrigation schemes.

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

Drip irrigation max root depth file: specifies the location of the max
root depth file for flood irrigation.

<table>
<thead>
<tr>
<th>Irrigation scheme</th>
<th>&quot;none&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation output interval</td>
<td>&quot;1da&quot;</td>
</tr>
<tr>
<td>Irrigation threshold</td>
<td>0.50</td>
</tr>
<tr>
<td>Sprinkler irrigation max root depth file:</td>
<td></td>
</tr>
<tr>
<td>Flood irrigation max root depth file:</td>
<td></td>
</tr>
<tr>
<td>Drip irrigation max root depth file:</td>
<td></td>
</tr>
</tbody>
</table>

## 9.11 Routing

### 9.11.1 HYMAP routing

**HYMAP routing model time step:** specifies the timestep for the run.

See Section [9.13](#) 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 [9.13](#) for a description of how to specify a time interval.

**HYMAP run in ensemble mode:** specifies whether to run in ensemble mode.

Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not run in ensemble mode</td>
</tr>
<tr>
<td>1</td>
<td>Run in ensemble mode</td>
</tr>
</tbody>
</table>

**HYMAP routing method:** specifies the HYMAP routing method to use. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>kinematic</td>
<td>use kinematic method</td>
</tr>
<tr>
<td>diffusive</td>
<td>use diffusive method</td>
</tr>
</tbody>
</table>

**HYMAP routing model linear reservoir flag:** specifies whether to use model linear reservoir. Acceptable values are:
Value Description
1 Use
2 Do not use

**HYMAP routing model evaporation option:** specifies whether to compute evaporation in flood plains. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Compute evaporation in flood plains</td>
</tr>
<tr>
<td>2</td>
<td>Do not compute evaporation in flood plains</td>
</tr>
</tbody>
</table>

**HYMAP routing model start mode:** specifies if a restart mode is being used. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>restart</td>
<td>A restart mode is being used</td>
</tr>
<tr>
<td>coldstart</td>
<td>A cold start mode is being used, no restart file read</td>
</tr>
</tbody>
</table>

**HYMAP routing model restart interval:** defines the restart writing interval for the HYMAP router.

See Section 9.13 for a description of how to specify a time interval.

**HYMAP routing model restart file:** specifies the HYMAP router active restart file.

**HYMAP routing LIS output directory:** specifies the name of the top-level output directory for HYMAP router. Acceptable values are any 40 character string.
9.11.2 NLDAS routing

**NLDAS routing model output interval:** defines the output writing interval for the NLDAS router.

See Section 9.13 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 9.13 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>restart</td>
<td>A restart mode is being used</td>
</tr>
<tr>
<td>coldstart</td>
<td>A cold start mode is being used, no restart file read</td>
</tr>
</tbody>
</table>

**NLDAS routing model restart file:** specifies the NLDAS router active restart file.
9.12 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:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output start year:</td>
<td>integer 2001 – present</td>
<td>specifying output start year</td>
</tr>
<tr>
<td>Output start month:</td>
<td>integer 1 – 12</td>
<td>specifying output start month</td>
</tr>
<tr>
<td>Output start day:</td>
<td>integer 1 – 31</td>
<td>specifying output start day</td>
</tr>
<tr>
<td>Output start hour:</td>
<td>integer 0 – 23</td>
<td>specifying output start hour</td>
</tr>
<tr>
<td>Output start minutes:</td>
<td>integer 0 – 59</td>
<td>specifying output start minute</td>
</tr>
<tr>
<td>Output start seconds:</td>
<td>integer 0 – 59</td>
<td>specifying output start second</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not restrict output to a specified time</td>
</tr>
<tr>
<td>1</td>
<td>Restrict output to a specified time</td>
</tr>
</tbody>
</table>

The specific output writing time is specified in the following format:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific output writing time (month):</td>
<td>integer 1 – 12</td>
<td>specifying output month</td>
</tr>
<tr>
<td>Specific output writing time (day):</td>
<td>integer 1 – 31</td>
<td>specifying output day</td>
</tr>
<tr>
<td>Specific output writing time (hour):</td>
<td>integer 0 – 23</td>
<td>specifying output hour</td>
</tr>
<tr>
<td>Specific output writing time (minute):</td>
<td>integer 0 – 59</td>
<td>specifying output minute</td>
</tr>
<tr>
<td>Specific output writing time (second):</td>
<td>integer 0 – 59</td>
<td>specifying output second</td>
</tr>
</tbody>
</table>

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.

Model output attributes file: './MODEL_OUTPUT_LIST.TBL'

9.13 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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ss</td>
<td>seconds</td>
</tr>
<tr>
<td>mn</td>
<td>minutes</td>
</tr>
<tr>
<td>hr</td>
<td>hours</td>
</tr>
<tr>
<td>da</td>
<td>days</td>
</tr>
<tr>
<td>mo</td>
<td>months</td>
</tr>
<tr>
<td>yr</td>
<td>years</td>
</tr>
</tbody>
</table>

Units of months assumes a 30-day month.

Units of years assumes a 365-day year.
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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>do not include the variable</td>
</tr>
<tr>
<td>1</td>
<td>include the variable</td>
</tr>
</tbody>
</table>

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. Availability 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 W/m2 # 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
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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>do not write the variable</td>
</tr>
<tr>
<td>1</td>
<td>write the variable</td>
</tr>
</tbody>
</table>

**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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>No sign</td>
</tr>
<tr>
<td>UP DN</td>
<td>Up or Down (Used for fluxes, Precip)</td>
</tr>
<tr>
<td>IN OUT</td>
<td>In or Out of the grid cell (Used for runoff, baseflow)</td>
</tr>
<tr>
<td>INC DEC</td>
<td>Increase or Decrease (Used for change in storager terms)</td>
</tr>
<tr>
<td>S2L L2S</td>
<td>Solid to Liquid and Liquid to Solid (for phase change terms)</td>
</tr>
<tr>
<td>S2V V2S</td>
<td>Solid to Vapor and Vapor to Solid (for phase change terms)</td>
</tr>
<tr>
<td>E N</td>
<td>Eastward and Northward (used for Wind components)</td>
</tr>
</tbody>
</table>

**Time Average option** determines how temporally process the variable. Acceptable values are:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Instantaneous output</td>
</tr>
<tr>
<td>1</td>
<td>Time averaged output</td>
</tr>
<tr>
<td>2</td>
<td>Instantaneous and Time averaged output</td>
</tr>
<tr>
<td>3</td>
<td>Accumulated output</td>
</tr>
</tbody>
</table>

**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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not compute minimum and maximum values</td>
</tr>
<tr>
<td>1</td>
<td>Do compute minimum and maximum values</td>
</tr>
</tbody>
</table>

**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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Do not compute standard deviation</td>
</tr>
<tr>
<td>1</td>
<td>Do compute standard deviation</td>
</tr>
</tbody>
</table>

**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.

### #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 DN 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)

162
<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainf:</td>
<td>1 kg/m²s DN</td>
<td>Rainfall rate (kg/m²s)</td>
</tr>
<tr>
<td>RainfConv:</td>
<td>1 kg/m²s DN</td>
<td>Convective rainfall rate (kg/m²s)</td>
</tr>
<tr>
<td>TotalPrecip:</td>
<td>1 kg/m²s DN</td>
<td>Total precipitation rate (kg/m²s)</td>
</tr>
<tr>
<td>Evap:</td>
<td>1 kg/m²s UP</td>
<td>Total evapotranspiration (kg/m²s)</td>
</tr>
<tr>
<td>Qs:</td>
<td>1 kg/m²s OUT</td>
<td>Surface runoff (kg/m²s)</td>
</tr>
<tr>
<td>Qrec:</td>
<td>0 kg/m²s IN</td>
<td>Recharge (kg/m²s)</td>
</tr>
<tr>
<td>Qab:</td>
<td>1 kg/m²s OUT</td>
<td>Subsurface runoff (kg/m²s)</td>
</tr>
<tr>
<td>Qsm:</td>
<td>0 kg/m²s S2L</td>
<td>Snowmelt (kg/m²s)</td>
</tr>
<tr>
<td>RHMin:</td>
<td>0 - - -</td>
<td>Minimum 2-meter relative humidity (-)</td>
</tr>
<tr>
<td>Ch:</td>
<td>0 m/s - -</td>
<td>Surface exchange coefficient for heat</td>
</tr>
<tr>
<td>Cm:</td>
<td>0 m/s - -</td>
<td>Surface exchange coefficient for momentum</td>
</tr>
<tr>
<td>SnowT:</td>
<td>0 K - -</td>
<td>Snow surface temperature (K)</td>
</tr>
<tr>
<td>VegT:</td>
<td>0 K - -</td>
<td>Vegetation canopy temperature (K)</td>
</tr>
<tr>
<td>BareSoilT:</td>
<td>0 K - -</td>
<td>Temperature of bare soil (K)</td>
</tr>
<tr>
<td>AvgSurfT:</td>
<td>1 K - -</td>
<td>Average surface temperature (K)</td>
</tr>
<tr>
<td>RadT:</td>
<td>0 K - -</td>
<td>Surface radiative temperature (K)</td>
</tr>
<tr>
<td>Albedo:</td>
<td>1 - - -</td>
<td>Surface albedo (-)</td>
</tr>
<tr>
<td>SWE:</td>
<td>1 kg/m² -</td>
<td>Snow Water Equivalent (kg/m²)</td>
</tr>
<tr>
<td>SWEVeg:</td>
<td>0 kg/m² -</td>
<td>SWE intercepted by vegetation (kg/m²)</td>
</tr>
<tr>
<td>SurfStor:</td>
<td>0 kg/m² -</td>
<td>Surface water storage (kg/m²)</td>
</tr>
<tr>
<td>SoilMoist:</td>
<td>1 kg/m² -</td>
<td>Average layer soil moisture (kg/m²)</td>
</tr>
<tr>
<td>SoilTemp:</td>
<td>1 K - -</td>
<td>Average layer soil temperature (K)</td>
</tr>
<tr>
<td>SmlLiqFrac:</td>
<td>0 - - -</td>
<td>Average layer fraction of liquid moisture (-)</td>
</tr>
<tr>
<td>SmlFrozFrac:</td>
<td>0 - - -</td>
<td>Average layer fraction of frozen moisture (-)</td>
</tr>
<tr>
<td>SoilWet:</td>
<td>0 m/s/m3 -</td>
<td>Total soil wetness (-)</td>
</tr>
<tr>
<td>RootTemp:</td>
<td>0 K - -</td>
<td>Rootzone temperature (K)</td>
</tr>
<tr>
<td>PotEvap:</td>
<td>0 kg/m²s UP</td>
<td>Potential evapotranspiration (kg/m²s)</td>
</tr>
<tr>
<td>ECanop:</td>
<td>0 kg/m²s UP</td>
<td>Interception evaporation (kg/m²s)</td>
</tr>
<tr>
<td>TVeg:</td>
<td>0 kg/m²s UP</td>
<td>Vegetation transpiration (kg/m²s)</td>
</tr>
<tr>
<td>ESoil:</td>
<td>0 kg/m²s UP</td>
<td>Bare soil evaporation (kg/m²s)</td>
</tr>
<tr>
<td>EWater:</td>
<td>0 kg/m²s UP</td>
<td>Open water evaporation (kg/m²s)</td>
</tr>
<tr>
<td>RootMoist:</td>
<td>0 kg/m² -</td>
<td>Root zone soil moisture (kg/m²)</td>
</tr>
<tr>
<td>CanopInt:</td>
<td>0 kg/m² -</td>
<td>Total canopy water storage (kg/m²)</td>
</tr>
<tr>
<td>EvapSnow:</td>
<td>0 kg/m²s -</td>
<td>Snow evaporation (kg/m²s)</td>
</tr>
<tr>
<td>SubSnow:</td>
<td>0 kg/m²s -</td>
<td>Snow sublimation (kg/m²s)</td>
</tr>
<tr>
<td>SubSurf:</td>
<td>0 kg/m²s -</td>
<td>Sublimation of the snow free area (kg/m²s)</td>
</tr>
<tr>
<td>ACond:</td>
<td>0 m/s - -</td>
<td>Aerodynamic conductance</td>
</tr>
<tr>
<td>CCond:</td>
<td>0 m/s - -</td>
<td>Canopy conductance</td>
</tr>
<tr>
<td>SoilET:</td>
<td>0 kg/m² -</td>
<td>Soil evaporation</td>
</tr>
<tr>
<td>AResist:</td>
<td>0 m/s - -</td>
<td>Aerodynamic resistance</td>
</tr>
<tr>
<td>WaterTableD:</td>
<td>0 m - -</td>
<td>Water table depth (m)</td>
</tr>
<tr>
<td>TWS:</td>
<td>0 mm - -</td>
<td>Terrestrial water storage (mm)</td>
</tr>
</tbody>
</table>
# 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

# 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 DN 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 51 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 53 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
PARDP_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 1 196 10 # 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
vic_pet_tall: 0 kg/m²s - 1 0 0 1 166 1 # Potential evap (transpiration only) from tall reference crop
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]
TotalLWRInitial: 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]
TotalLWRVeg: 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]
TotalLWFLOWER: 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]
WRS1a: 0 - - 0 0 0 1 0 10 # WRSI anomaly [-]
growing_season: 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]
WRS1_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 intended 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 1 256 10 # Frost
sac_uztwc: 0 mm - 0 0 0 1 256 10 # UZTWC
sac_uzfvc: 0 mm - 0 0 0 1 256 10 # UZFVC
sac_lztvc: 0 mm - 0 0 0 1 256 10 # LZTWC
sac_lzfscc: 0 mm - 0 0 0 1 256 10 # LZFSC
sac_lzfpcc: 0 mm - 0 0 0 1 256 10 # LZFPC
sac_adimpcc: 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_lzfsf: 0 mm - 0 0 0 1 256 10 # LZFSH
sac_lzfpf: 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 # AEAJD
snow17_neghs: 0 mm - 0 0 0 1 256 10 # NEHHS
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_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_Tvml: 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_CT: 0 - - 0 0 0 1 256 10 # Temperature at the bottom of upper layer of sediments
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_Hbl: 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_UPRa: 0 - - 0 0 0 1 256 10 # Lake friction velocity in surface water
<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Value</th>
<th>Notes</th>
</tr>
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<td>Lake_WConv:</td>
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<tr>
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<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Lake_Qbot:</td>
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</tr>
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<tr>
<td>RiverDepth:</td>
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</tr>
<tr>
<td>RiverVelocity:</td>
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<td>-</td>
</tr>
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<td>-</td>
</tr>
<tr>
<td>FloodEvap:</td>
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<td>0</td>
<td>-</td>
</tr>
<tr>
<td>FloodStor:</td>
<td>m³</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>FloodDepth:</td>
<td>m</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>FloodVelocity:</td>
<td>m/s</td>
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<td>-</td>
</tr>
<tr>
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<td></td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>FloodedArea:</td>
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<td>-</td>
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<tr>
<td>SurfElev:</td>
<td>m</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>RunoffStor:</td>
<td>m³</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>BaseflowStor:</td>
<td>m³</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>RTM emissivity:</td>
<td></td>
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<td>-</td>
</tr>
<tr>
<td>RTM Tb:</td>
<td>K</td>
<td>0</td>
<td>-</td>
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<tr>
<td>RTM SoilMoist:</td>
<td>m³/m³</td>
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<td>-</td>
</tr>
<tr>
<td>Irrigated water:</td>
<td>kg/m²s</td>
<td>0</td>
<td>-</td>
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</table>
12 User Support

This section describes how to request help from and provide feedback to the LIS development team.

12.1 Modeling Guru

The NASA Center for Climate Simulation (NCCS) hosts a system called Modeling Guru, [https://modelingguru.nasa.gov](https://modelingguru.nasa.gov). This system is a collection of forums discussing many of NASA’s modelling efforts and related topics. LIS has a “community” within Modeling Guru.

This is system is open for reading, but registration is required to post questions. The front page of Modeling Guru provides information regarding requesting an account.

12.2 Requesting help

To request help from the LIS development team, please visit our community within Modeling Guru at [https://modelingguru.nasa.gov/community/atmospheric/lis](https://modelingguru.nasa.gov/community/atmospheric/lis). Select the “Discussions” tab. Please review the existing posts; your question may already be answered. If it is not, then please “Start a discussion” to post your question there. Note that posting a question requires a registered account (see Section 12.1).

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 the `lis.config` file, the `MODEL_OUTPUT_LIST.TBL` file, the `ldt.config` file, etc.

Please note that the LIS 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.

Please note that, due to U.S. federal law, we are not allowed to respond to anyone from a designated country. (See [http://oiir.hq.nasa.gov/nasaecp/](http://oiir.hq.nasa.gov/nasaecp/)). 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.
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.
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

<table>
<thead>
<tr>
<th>Data type</th>
<th>Missing/Undefined value</th>
</tr>
</thead>
<tbody>
<tr>
<td>character*1</td>
<td>CHAR(255)</td>
</tr>
<tr>
<td>integer*1</td>
<td>-128</td>
</tr>
<tr>
<td>integer*4</td>
<td>-9999 (?)</td>
</tr>
<tr>
<td>real*4</td>
<td>(?)</td>
</tr>
</tbody>
</table>
B.5 File name extension convention and access code samples

A LIS binary file name extension 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: \textit{datafile1.2gs4r}

Sample Fortran code segment to read this file:

```fortran
Real*4 v1(NC, NR), v2(NC, NR)
Open(12, file="datafile1.2gs4r", form="unformatted")
read(12)v1
read(12)v2
Close(12)
```

Example2: \textit{datafile2.15gd4i}

Sample Fortran code segment to read this file:

```fortran
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: \textit{soilcolor.1ls1c}

Sample Fortran code segment to read this file:

```fortran
Character*1 color(NL)
Open(12, file="soilcolor.1ls1c", form="unformatted")
read(12)color
Close(12)
```
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Code contributors included:

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References

