LISF Installation Guide

Version 2.1, 9 Jul 2024

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Revision	Summary of Changes	Date
2.1	LISF Public 7.5.1 release	Jul 9, 2024
2.0	LISF Public 7.5.0 release	Jan 11, 2024
1.1	LISF 557WW 7.5.0 release	Nov 30, 2022
1.0	LISF Public 7.4.0 release	Jun 14, 2022

Chapter 1. Introduction

This document provides guidance on installing the Land Information System Framework (LISF) and its dependencies. It also provides technical information regarding supported environments.

Please see the *LDT Users' Guide*, the *LIS Users' Guide*, and/or the *LVT Users' Guide* for specific information regarding installing LDT, LIS, and/or LVT, respectively.

IMPORTANT	LISF is developed on Linux/Unix platforms. Its build process expects a case sensitive file system. Please make sure that you unpack and/or `git clone` the LISF source code into a directory within a case sensitive file system. In particular, if you are using LISF within a Linux-based virtual machine hosted on a Windows or Macintosh system, do not compile/run LISF from within a shared folder. Move the LISF source code into a directory within the virtual machine.
WARNING	The above may be true for some of LISF's dependencies. It is recommended to install LISF's dependencies within a case sensitive file system.

Chapter 2. Development Environments

2.1. Supported systems

LISF and its dependencies have been compiled and run on Linux PC (Intel/AMD based) systems, Cray systems, and IBM Power9 systems.

These instructions expect that you are using such a system. In particular you need:

2.1.1. Linux

Compilers

- Intel Fortran Compiler versions 2021 or 2022 with corresponding Intel C Compiler along with GNU's Compiler Collection version 11.2.0 or 12.1.0.
- or GNU's Compiler Collection version 11.2.0, both gfortran and gcc.

Tools

- GNU's make, gmake, version 3.77 or 3.81
- Perl, version 5.10
- Python, version 3.6

IMPORTANT	The use of Python 2.7 for building LISF is now deprecated. See Section Python support.

2.1.2. Cray/Linux

Compilers

- Intel Fortran Compiler version 2021 or 2022 with corresponding Intel C Compiler, along with GNU's Compiler Collection version 11.2.0 or 12.1.0.
- or Cray Compiler Environment (cce) version 14.0.0, along with GNU's Compiler Collection version 11.2.0.

Tools

- GNU's make, gmake, version 3.77 or 3.81
- Perl, version 5.10
- Python, version 3.6

IMPORTANT	The use of Python 2.7 for building LISF is now deprecated. See Section Python support.

2.1.3. IBM/Linux

Compilers

- GNU's Compiler Collection version 11.0, both gfortan and gcc.

Tools

- GNU's make, gmake, version 3.77 or 3.81
- Perl, version 5.10
- Python, version 3.6

IMPORTANT	The use of Python 2.7 for building LISF is now deprecated. See Section Python support.

2.1.4. Python support

The use of Python 2.7 for building LISF is now deprecated. If you only have Python 2.7, then edit the following four files

- ldt/make/makedep.py
- lis/make/makedep.py
- lis/make/plugins.py
- lvt/make/makedep.py

changing

```
#!/usr/bin/env python3
```

to

```
#!/usr/bin/env python
```

Future releases will depend on Python 3 only.

Chapter 3. Dependencies

This section documents the required and optional libraries needed to build LISF (LDT, LIS, and LVT).

3.1. Required Software Libraries

3.1.1. Message Passing Interface (MPI)

NOTE	LIS-only dependency

LIS may be compiled and run serially for small experiments, but, in general, you will want to run LIS with multiple processes (i.e., in parallel), making MPI support a practical requirement.

- vendor supplied (e.g., Intel MPI)
- MPICH version 3.3 (https://www.mpich.org/)
- Open MPI version 4 (https://www.open-mpi.org/)

NOTE	LIS does not support OpenMP style parallelization. There is some experimental support within LIS, but you should not enable it.
NOTE	LDT does not fully support running in parallel with MPI.
NOTE	LVT does not support running in parallel with MPI.

3.1.2. Earth System Modeling Framework (ESMF) version 8.1.1 (or higher)

URL: https://earthsystemmodeling.org/

Please read the ESMF User's Guide for details on installing ESMF with MPI support and without MPI support ("mpiuni").

3.1.3. ecCodes version 2.19.0 (or higher)

URL: https://confluence.ecmwf.int/display/ECC

NOTE	ecCodes is a requirement for LVT, but, given that many of the datasets used in LTD and LIS are in GRIB format, this library is a practical requirement for LISF.

3.1.4. NetCDF either version 3.6.3 or version 4.7.4 (or higher)

URL: 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-4.7.4 --disable-netcdf-4
% gmake
% gmake install
```

An example of installing NetCDF 4 with compression:

```
% CPPFLAGS=-I$HOME/local/hdf5/1.12.0/include \
> LDFLAGS=-L$HOME/local/hdf5/1.12.0/lib \
> ./configure --prefix=$HOME/local/netcdf/4.7.4 --enable-netcdf-4
% gmake
% gmake install
```

You must also download the *netcdf-fortran-4.5.3.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=$HOME/local/netcdf/4.7.4/lib:$LD_LIBRARY_PATH \
> CPPFLAGS=-I$HOME/local/netcdf/4.7.4/include \
> LDFLAGS=-L$HOME/local/netcdf/4.7.4/lib \
> ./configure --prefix=$HOME/local/netcdf/4.7.4
% gmake
% gmake install
```

3.2. Optional Software Libraries

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

3.2.1. 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.

HDF4 4.2.15 (or higher)

If you choose to have HDF version 4 support, please download the HDF source from https://portal.hdfgroup.org/display/support/Download+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.

HDF5 1.12.0

If you choose to have HDF version 5 support, please download the HDF source from 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.

3.2.2. HDF-EOS2 version 2.20v1.00 (or higher)

URL: http://hdfeos.org/software/library.php

NOTE	This library depends on HDF4.

3.2.3. GDAL version 2.4.4

NOTE	LDT and LVT dependency

URL: https://gdal.org

IMPORTANT	When installing the GDAL library, you must also install FortranGIS version 2.6 (or higher) from http://fortrangis.sourceforge.net. This library provides Fortran interfaces to the GDAL library.

3.2.4. GeoTIFF version 1.6.0 (or higher)

NOTE	LDT-only dependency

URL: https://github.com/OSGeo/libgeotiff

3.2.5. JCSDA CRTM version 2.0.2

NOTE	LIS-only dependency

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/ and fill out the CRTM.Subversion_Account_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:

```
% 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:

```
% 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
```

3.2.6. LIS-CMEM library

NOTE LIS-only dependency

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

```
% cd $WORKING/lib/lis-cmem3
% LIS_ARCH=linux_ifc make
```

NOTE If using the GNU compilers, set `LIS_ARCH` to linux_gfortran.

IMPORTANT linux_ifc and linux_gfortran are the only supported architectures.

3.2.7. LIS-CRTM-PROFILE-UTILITY library

NOTE LIS-only dependency

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

```
% cd $WORKING/lib/lis-crtm-profile-utility
% LIS_ARCH=linux_ifc make
% LIS_ARCH=linux_ifc make install
```

NOTE	If using the GNU compilers, set `LIS_ARCH` to linux_gfortran.

IMPORTANT	linux_ifc and linux_gfortran are the only supported architectures.

3.3. Second order dependencies

3.3.1. OpenJPEG version 2.4.0 (or higher)

URL: http://www.openjpeg.org/

NOTE	Required by ecCodes and GDAL.

3.3.2. SQLite3 version 3.35.0 (or higher)

URL: https://sqlite.org/

NOTE	Required by PROJ.

3.3.3. PROJ 7.1

URL: https://proj.org

NOTE	Required by GeoTIFF and GDAL.

3.3.4. PETSc 3.16.1

URL: https://petsc.org/

NOTE	Required by RAPID router

3.4. Notes

To install these libraries, follow the instructions provided at the various URL listed above. These 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. MPI (optional)
   ESMF has an optional dependency on MPI.
2. HDF 5 (optional)
   NetCDF has an optional dependency on HDF 5.
3. NetCDF (required)
   ESMF has an optional dependency on NetCDF.
   ecCodes has an optional dependency on NetCDF.
4. openJPEG (required)
   ecCodes depends on openJPEG.
5. ecCodes (required)
6. ESMF (required)
7. HDF 4 (optional)
   HDF-EOS2 depends on HDF 4.
8. HDF-EOS2 (optional)
9. SQLite3 (optional)
   PROJ depends on SQLite3
10. PROJ (optional)
    GeoTIFF and GDAL depend on PROJ
11. GeoTIFF (optional)
12. GDAL (optional)
13. FortranGIS (optional)
    Required to use GDAL
14. PETSc (optional)
    Required to use RAPID router

Note that due to the mix of programing 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.

Chapter 4. Platforms

The following tables provide some specific platforms with compiler and library versions that LISF has been tested with. See Appendix Additional platforms for more.

Table 1. SUSE Linux Enterprise Server 12.3

Library	Version
GNU compiler	11.2.0
Intel compiler	2021.4.0
Intel MPI	2021.4.0
HDF 5	1.12.1
NetCDF	4.8.1
NetCDF-Fortran	4.5.3
openJPEG	2.4.0
ecCodes	2.23.0
ESMF	8.1.1
HDF 4	4.2.15
HDF-EOS2	2.20v.1.00
SQLite3	3.35.0
PROJ	9.1.0
GeoTIFF	1.7.0
GDAL	3.5.2
FortranGIS	2.6
PETSc	3.16.1
JPEG	8d

Table 2. SUSE Linux Enterprise Server 12.3

Library	Version
GNU compiler	11.2.0
Intel MPI	2021.4.0
HDF 5	1.12.1
NetCDF	4.8.1
NetCDF-Fortran	4.5.3
openJPEG	2.4.0
ecCodes	2.23.0
ESMF	8.1.1

Library	Version
HDF 4	4.2.15
HDF-EOS2	3.0
SQLite3	3.35.0
PROJ	9.1.0
GeoTIFF	1.7.0
GDAL	3.5.2
FortranGIS	2.6
PETSc	3.16.1
JPEG	8d

Table 3. Cray/SUSE Linux Enterprise Server 15.2

Library	Version
GNU compiler	7.5.0
Intel compiler	2021.1
Cray MPI	8.1.5
HDF 5	1.12.0
NetCDF	4.7.4
NetCDF-Fortran	4.5.3
openJPEG	2.4.0
ecCodes	2.19.1
ESMF	8.1.1
HDF 4	4.2.15
HDF-EOS2	2.20v.1.00
SQLite3	3.35.0
PROJ	7.1.1
GeoTIFF	1.6.0
GDAL	2.4.4
FortranGIS	2.6

Table 4. Cray/SUSE Linux Enterprise Server 15.2

Library	Version
GNU compiler	11.2.0
Cray compiler	12.0.3
Cray MPI	8.1.9

Library	Version
HDF 5	1.12.0
NetCDF	4.7.4
NetCDF-Fortran	4.5.3
openJPEG	2.4.0
ecCodes	2.22.0
ESMF	8.1.1
HDF 4	4.2.15
HDF-EOS2	2.20v.1.00
SQLite3	3.35.0
PROJ	7.1.1
GeoTIFF	1.6.0
GDAL	2.4.4
FortranGIS	2.6

Table 5. IBM Power9/Red Hat Enterprise Linux Server 8.2

Library	Version
GNU compiler	11.1.0
SPECTRUM MPI	10.4.0.3-20210112
HDF 5	1.12.1
NetCDF	4.8.1
NetCDF-Fortran	4.5.3
openJPEG	2.4.0
ecCodes	2.23.0
ESMF	8.1.1
HDF 4	4.2.15
HDF-EOS2	2.20v.1.00
SQLite3	3.35.0
PROJ	7.1.1
GeoTIFF	1.7.0
GDAL	2.4.4
FortranGIS	2.6
JPEG	9d

Appendix A: Additional platforms

Table 6. SUSE Linux Enterprise Server 12.3

Library	Version
GNU compiler	11.2.0
Intel compiler	2021.4.0
Intel MPI	2021.4.0
HDF 5	1.12.1
NetCDF	4.8.1
NetCDF-Fortran	4.5.3
openJPEG	2.4.0
ecCodes	2.23.0
ESMF	8.1.1
HDF 4	4.2.15
HDF-EOS2	2.20v.1.00
SQLite3	3.35.0
PROJ	7.1.1
GeoTIFF	1.7.0
GDAL	2.4.4
FortranGIS	2.6
JPEG	8d

Table 7. SUSE Linux Enterprise Server 12.3

Library	Version
GNU compiler	11.2.0
Intel MPI	2021.4.0
HDF 5	1.12.1
NetCDF	4.8.1
NetCDF-Fortran	4.5.3
openJPEG	2.4.0
ecCodes	2.23.0
ESMF	8.1.1
HDF 4	4.2.15
HDF-EOS2	2.20v.1.00 Not installed; failed make check
SQLite3	3.35.0

Library	Version
PROJ	7.1.1
GeoTIFF	1.7.0
GDAL	2.4.4
FortranGIS	2.6
JPEG	8d

Table 8. Red Hat Enterprise Linux Server 7.8

Library	Version
GNU compiler	9.2.0
Intel compiler	19.0.5.281 20190815 (2019.5.281)
HDF 5	1.12.0
NetCDF	4.7.4
NetCDF-Fortran	4.5.3
openJPEG	2.3.1
ecCodes	2.18.0
Intel MPI	2019.5.281
ESMF	7.1.0r
HDF 4	4.2.15
HDF-EOS2	2.20v.1.00
libgeotiff	1.6.0
GDAL	2.4.4
FortranGIS	2.6
sqlite3	3.33.0
tiff	4.1.0
proj	7.1.1

Table 9. Red Hat Enterprise Linux Server 7.8

Library	Version
GNU compiler	7.3.0
Intel compiler	19.0.4.243 20190416 (2019.4.243)
HDF 5	1.10.5
NetCDF	4.6.3
NetCDF-Fortran	4.4.5
JasPer	2.0.14

Library	Version
ecCodes	2.12.0
Intel MPI	2019.4.243
ESMF	7.1.0r
HDF 4	4.2.14
HDF-EOS2	2.20v.1.00
libgeotiff	1.4.3
GDAL	2.4.1
FortranGIS	2.4

Table 10. Red Hat Enterprise Linux Server 7.8

Library	Version
GNU compiler	7.3.0
Intel compiler	2019.2.057
HDF 5	1.10.5
NetCDF	4.6.3
NetCDF-Fortran	4.4.5
JasPer	2.0.14
ecCodes	2.12.0
Intel MPI	2019.2.057
ESMF	7.1.0r
HDF 4	4.2.14
HDF-EOS2	2.20v.1.00
libgeotiff	1.4.3
GDAL	2.4.1
FortranGIS	2.4

Table 11. SUSE Linux Enterprise Server 12.3

Library	Version
GNU compiler	9.2.0
Intel compiler	19.1.3.304
HDF 5	1.10.1
NetCDF	4.5.0
NetCDF-Fortran	4.4.4
openJPEG	2.3.0

Library	Version
ecCodes	2.7.0
Intel MPI	20.0.0.166
ESMF	7.1.0r
HDF 4	4.2.13
HDF-EOS2	2.19v.1.00
JPEG	8d
GEOTIFF	1.4.3
GDAL	2.4.1
FortranGIS	2.4

Table 12. Cray XC40

Library	Version
GNU compiler	7.3.0
Intel compiler	18.0.3 20180410 (18.0.3.222)
HDF 5	1.10.5
NetCDF	4.6.3
NetCDF-Fortran	4.4.5
JasPer	2.0.14
ecCodes	2.12.0
Cray MPICH	7.5.3
ESMF	7.1.0r
HDF 4	4.2.14
HDF-EOS2	2.20v.1.00
libgeotiff	1.4.3
GDAL	2.4.1
FortranGIS	2.4
libtiff	4.0.6
libjbig	2.1
liblzma	5.2.2

Table 13. Cray XC40

Library	Version
Intel compiler	17.0.2.174
HDF 5	1.8.18

Library	Version
NetCDF	4.4.1.1
NetCDF-Fortran	4.4.4
JasPer	2.0.14
ecCodes	2.7.0
Cray-MPICH	7.5.3
ESMF	6.3.0rp1
HDF 4	4.2.12
HDF-EOS2	2.19v.1.00

Table 14. Cray XC40

Library	Version
Intel compiler	16.0.2.181
HDF 5	1.8.18
NetCDF	4.4.1.1
NetCDF-Fortran	4.4.4
JasPer	1.900.19
GRIB-API	1.19.0
Cray-MPICH	7.2.4
ESMF	6.3.0rp1
HDF 4	4.2.12
HDF-EOS2	2.19v.1.00

Table 15. Cray XC40

Library	Version
Intel compiler	15.0.2.164
Cray-HDF 5	1.8.14
Cray-NetCDF	4.3.3.1
JasPer	1.900.1
GRIB-API	1.14.0
Cray-MPICH	7.2.5
ESMF	6.2.0
HDF 4	4.2.11
HDF-EOS2	2.19v.1.00

Table 16. Red Hat Enterprise Linux Server 6.8

Library	Version
Intel compiler	15.1.133
HDF 5	1.8.15
NetCDF	4.3.3.1
NetCDF-Fortran	4.4.2
JasPer	1.900.1
GRIB-API	1.12.3
Intel MPI	5.0.3.048
ESMF	5.2.0rp3
HDF 4	4.2.11
HDF-EOS2	2.19v.1.00

Table 17. Red Hat Enterprise Linux Server 6.7

Library	Version
Intel compiler	14.0.2
HDF 5	1.8.14
NetCDF	4.3.1.1
NetCDF-Fortran	4.2
JasPer	1.900.1
GRIB-API	1.12.3
Open MPI	1.8.4
ESMF	5.2.0rp3
HDF 4	4.2.11
HDF-EOS2	2.19v.1.00

Table 18. Red Hat Enterprise Linux Server 6.7

Library	Version
Intel compiler	14.0.2
HDF 5	1.8.14
NetCDF	4.3.1.1
NetCDF-Fortran	4.2
JasPer	1.900.1
GRIB-API	1.12.3
Intel MPI	4.1.3
ESMF	5.2.0rp3

Library	Version
HDF 4	4.2.11
HDF-EOS2	2.19v.1.00

Table 19. SUSE Linux Enterprise Server 11.3

Library	Version
GNU compiler	7.3.0
HDF 5	1.10.1
NetCDF	4.5.0
NetCDF-Fortran	4.4.4
JasPer	2.0.14
ecCodes	2.7.0
Intel MPI	18.0.3.222
ESMF	7.1.0r
HDF 4	NA (does not compile)
HDF-EOS2	NA (does not compile)

Table 20. SUSE Linux Enterprise Server 11.3

Library	Version
Intel compiler	18.0.3.222
HDF 5	1.10.1
NetCDF	4.5.0
NetCDF-Fortran	4.4.4
JasPer	2.0.14
ecCodes	2.7.0
Intel MPI	18.0.3.222
ESMF	7.1.0r
HDF 4	4.2.13
HDF-EOS2	2.19v.1.00

Table 21. SUSE Linux Enterprise Server 11.3

Library	Version
GCC compiler	4.9.2
HDF 5	1.8.14
NetCDF	4.3.3.1
NetCDF-Fortran	4.2

Library	Version
JasPer	1.900.1
GRIB-API	1.12.3
Open MPI	1.8.4
ESMF	5.2.0rp3
HDF 4	4.2.11
HDF-EOS2	2.19v.1.00

Table 22. SUSE Linux Enterprise Server 11.3

Library	Version
Intel compiler	14.0.3.174
HDF 5	1.8.14
NetCDF	4.3.3.1
NetCDF-Fortran	4.2
JasPer	1.900.1
GRIB-API	1.12.3
Intel MPI	5.0.3.048
ESMF	5.2.0rp3
HDF 4	4.2.11
HDF-EOS2	2.19v.1.00