



WACCM-X:

The Whole Atmosphere Community Climate Model - eXtended

WACCM-X is a model of the entire atmosphere that extends into the thermosphere to ~500 km altitude, and includes the ionosphere. It is the work of many people at the National Center for Atmospheric Research in the Geospace section of the High Altitude Observatory, in the Atmospheric Chemistry, Observations, and Modeling Laboratory, the Climate and Global Dynamics division, and external collaborators.

WACCM-X is built on WACCM

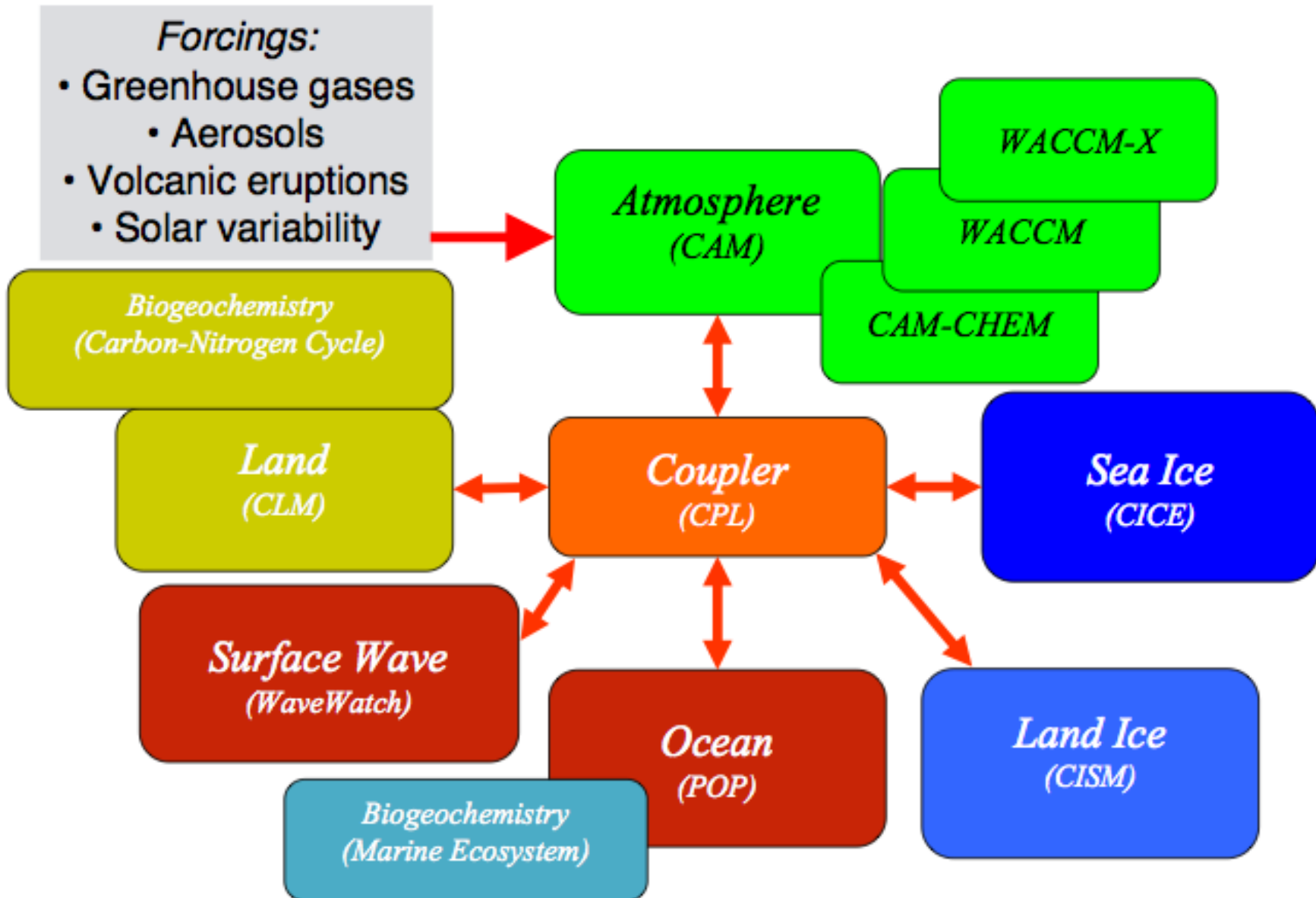
WACCM is built on CAM

CAM is the NCAR Community Atmosphere Model

CAM, WACCM, and WACCM-X are run as the atmospheric component within the Community Earth System Model (CESM), which also includes components for land, oceans, sea ice, and land ice.

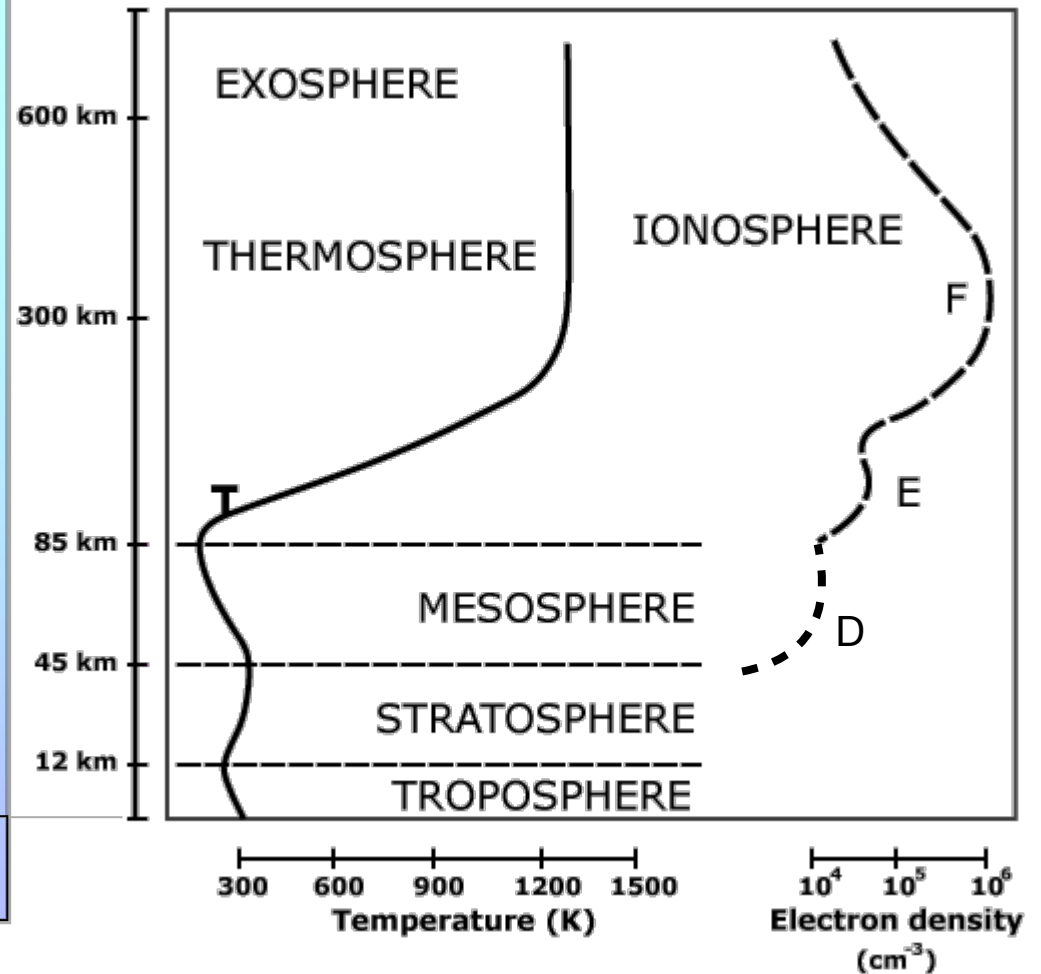
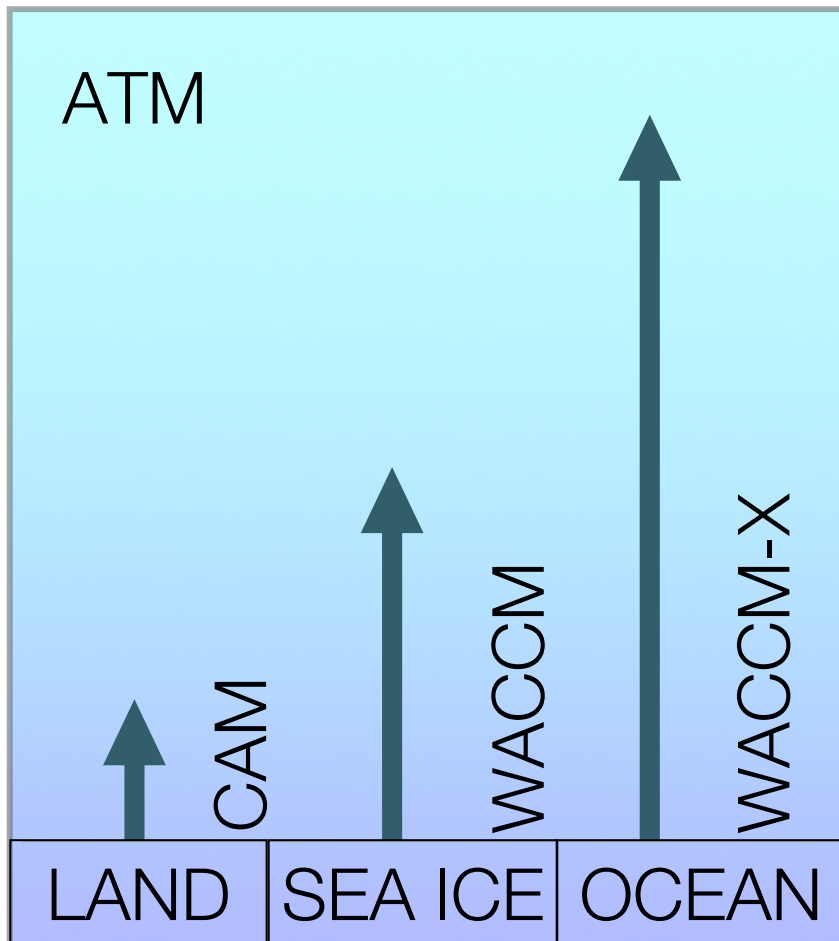


CESM components



NCAR Community Earth System Model (CESM) atmosphere components

CESM

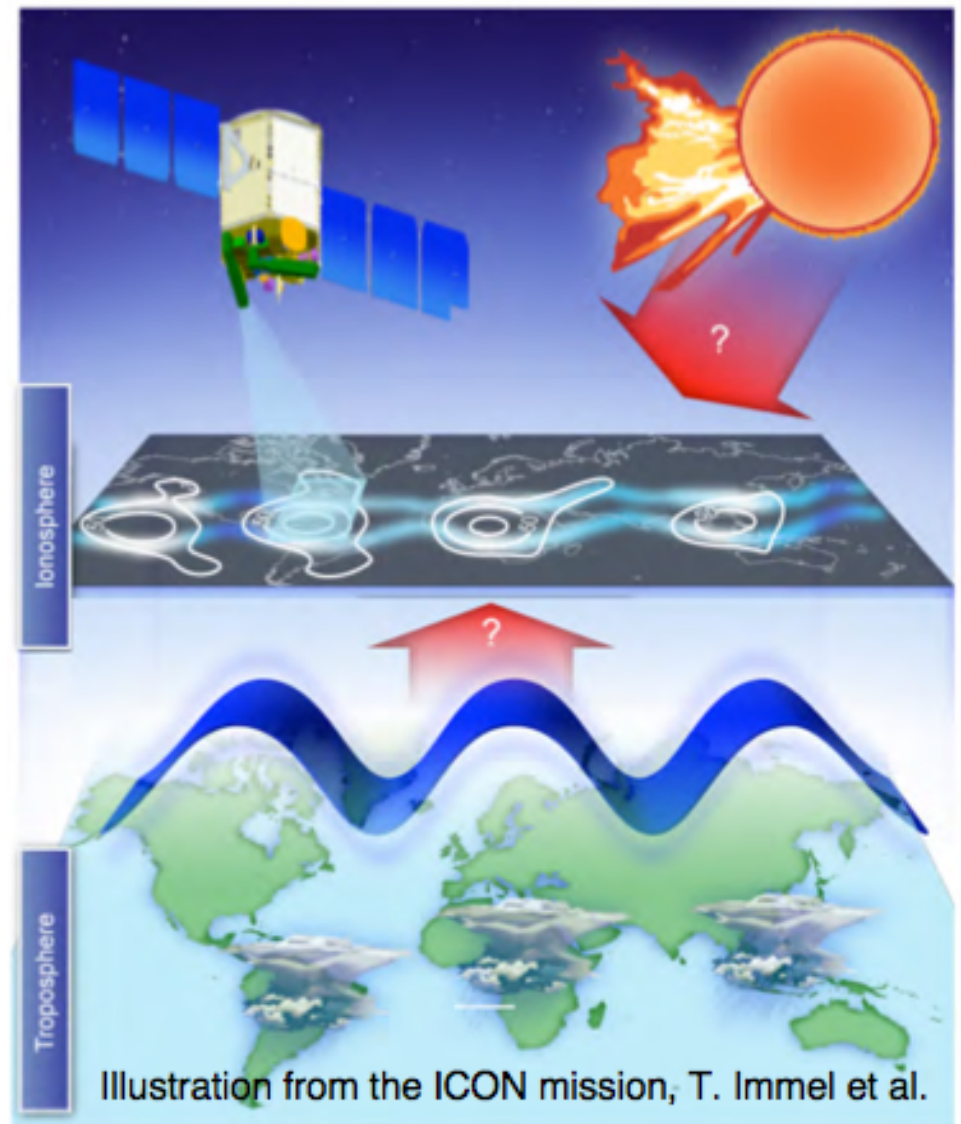


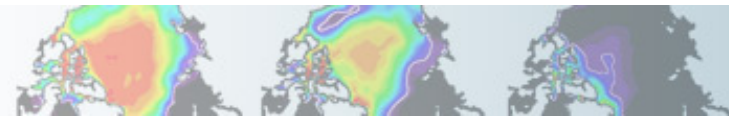
Why WACCM-X?

Because the thermosphere- ionosphere system responds to variability from the Earth's lower atmosphere as well as solar-driven "space weather"

Including:

- Waves and tides
- Tropospheric weather
- Middle-atmosphere events
- Seasonal variations
- Anthropogenic trace gases





CESM2: WACCM6 & WACCM-X

	WACCM6	WACCM-X
# levels	70-88	125-145
model top	6×10^{-6} hPa (~140 km)	4×10^{-10} hPa (500~600 km)
Horizontal resolution	$0.95^\circ \times 1.25^\circ$	$1.9^\circ \times 2.5^\circ$
Time step	30 min.	5 min.
Specified Dynamics	✓	✓
Chemistry	TSMILT, MA	MA
Non-orographic GW	✓	✓
Molecular diffusion	minor	minor and major
Auroral physics	✓	✓
Ions	E-region or E&D-region	E-region
Ion transport		✓
E Dynamo		✓

CESM Web Page: <http://www.cesm.ucar.edu>

The image shows a browser window displaying the CESM website. The browser's address bar shows www.cesm.ucar.edu. The website header includes the text "CESM | COMMUNITY EARTH SYSTEM MODEL" and a "Google Custom Search" box. A navigation menu contains links for HOME, ABOUT, ADMINISTRATION, WORKING GROUPS, MODELS, and EVENTS. A red box highlights the text "Supported releases (i.e. model versions)", with a red arrow pointing to the "CESM SUPPORTED RELEASES" option in the "MODELS" dropdown menu. Below the navigation is a large banner image of a mountain range. A dark overlay on the right side of the banner contains the text "CESM WORK" and "19 - 22 June 2017, NCAR Green Auditorium, Boulder, CO" with a "Learn More" button. At the bottom of the page, there are four columns of content: "CESM Experiments" (with a flask icon), "CESM Releases" (with a globe icon), "CESM Support" (with a gear icon), and "CESM Projects" (with a stylized 'A' icon).

CESM | COMMUNITY EARTH SYSTEM MODEL

Google Custom Search

HOME ABOUT ADMINISTRATION WORKING GROUPS **MODELS** EVENTS

Supported releases (i.e. model versions)

OVERVIEW
CESM SUPPORTED RELEASES
SCIENTIFICALLY VALIDATED
EXPERIMENTS
CMIP6
PROJECTS
COMMUNITY PROJECTS
SIMPLER MODELS
DISCUSSESM
LEGACY

CESM WORK
19 - 22 June 2017, NCAR
Green Auditorium, Boulder, CO

Learn More

CESM Experiments
CMIP6
IPCC Experiments
CESM1.2

CESM Releases
Supported Releases
Scientifically Validated
Legacy Models

CESM Support
DiscussCESM Bulletin Board
Support Policy
FAQs

CESM Projects
EaSM | Earth System Modeling
Climate Data Guide
CLIVAR Climate Process Teams

CESM Models Web Page:

<http://www.cesm.ucar.edu/models/current.html>

The screenshot shows a web browser window displaying the CESM Models page. The browser's address bar shows the URL www.cesm.ucar.edu/models/current.html. The page header includes the UCAR | NCAR | CESM :: COMMUNITY EARTH SYSTEM MODEL logo and a search bar. A navigation menu contains links for HOME, ABOUT, ADMINISTRATION, WORKING GROUPS, MODELS, and EVENTS. A breadcrumb trail indicates the current location: / CESM Models / CESM Supported Releases. A red box highlights the text "Latest release is CESM2.0" with a red arrow pointing to the "CESM2.0.0" link in the "Supported CESM Release Versions" table.

UCAR | NCAR | CESM :: COMMUNITY EARTH SYSTEM MODEL

Google Custom Search

HOME ABOUT ADMINISTRATION WORKING GROUPS MODELS EVENTS

/ CESM Models / CESM Supported Releases

CESM Models | CESM Supported Releases

You should use the most recent version of the model that is available unless you are trying to replicate previous results or create a branch run from a previous experiment. A complete list of **CESM scientifically validated configurations** is available for users needing to run the model in one of these configurations.

Supported CESM Release Versions	
CESM2.0.0	What's New
CESM1.2.z	Release Notes
CESM 1.1.z	Notable Improvements
CESM 1.0.z	Notable Improvements

CESM Model Version Naming Conventions

CESM X.Y.Z - CESM model release versions include three numbers separated by a dot (.) where:

- X - corresponds to the major release number indicating significant science changes.
- Y - corresponds to the addition of new infrastructure and new science capabilities for targeted components.
- Z - corresponds to release bug fixes and machine updates.

Each release includes the complete collection of component model source code, documentation, and input data. For model output data, see the [Experiments and Output Data](#) section of this website.

Users should read the [CESM Data Management & Distribution Plan](#) which documents the procedures for the storage and distribution of data associated with the CESM project.

CESM Project

CESM is a fully-coupled, community, global climate model that provides state-of-the-art computer simulations of the Earth's past, present, and future climate states.

CESM is sponsored by the National Science Foundation (NSF) and the U.S. Department of Energy (DOE). Administration of the CESM is maintained by the Climate and Global Dynamics Laboratory (CGD) at the National Center for Atmospheric Research (NCAR).

CESM Models

- Overview
- Supported Releases
- Scientifically Validated Configurations
- Experiments
- CMIP6
- Projects

CESM2 Web Page:

<http://www.cesm.ucar.edu/models/cesm2/>

CESM Models | CESM2



About CESM2

CESM is a fully-coupled, community, global climate model that provides state-of-the-art computer simulations of the Earth's past, present, and future climate states.

- [What's New in CESM2](#)
- [CESM Naming Conventions](#)
- [Supported Release Tags and Notes](#)

Release notes

Scientific Validation

Scientific validation consists of a multi-decadal model run of the given component set at the target resolution, followed by scientific review of the model output diagnostics.

- [CESM2 Scientifically Validated Configurations](#)
- [Experiment Diagnostics](#)
- [Experiment Output Datasets](#) * [↗](#)

* Please see [CESM2 Scientifically Validated Configurations](#) for data download details.

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CESM2 Quicklinks

- [Quick Start Guide](#) ← Quick start
- [Downloading The Code](#) ← Download the code
- [Scientifically Validated Configurations](#)
- [Prognostic Components](#)

Related Information

- [Data Management & Distribution Plan](#) ← Data Management & Distribution
- [Development Project Policies & Terms of Use](#)
- [DiscussCESM Forums Bulletin Board](#)
- [CESM2 Copyright](#)
- [CESM Support Policy](#)
- [CESM2 Included Packages Copyright](#)

CESM2 Web Page:

<http://www.cesm.ucar.edu/models/cesm2/>

Getting help

★ Quick Start

See the selected links below to help you quickly get started with CESM2

- [Getting Help](#)
- [CESM2 Use Cases](#)
- [CESM2 Quick Start Guide](#)
- [Download the CESM2 Code](#)

📖 CIME Documentation

Common Infrastructure for Modeling the Earth contains the coupling infrastructure, support scripts, data models and utility libraries needed to create a single-executable coupled Earth System Model.

** CIME does not contain any prognostics components and is available in a stand-alone package that can be compiled and tested with just its data components.*

- [CIME User Guide](#)

⇄ Prognostic Components

Each model component page contains descriptions and documentation for active or prognostic models.

- [Atmosphere](#)
- [Land](#)
- [Land Ice](#)
- [Ocean](#)
- [River Runoff](#)
- [Sea Ice](#)
- [Wave](#)

Component models documentation

⚙️ Configurations and Grids

Component configurations include settings required for CIME enabled models; both prognostic and data model components. These settings include:

- [Grid Resolutions](#)
- [Component Sets](#)
- [Component Configuration Settings](#)

** Includes Fortran namelists and CASEROOT variable definitions*

📊 Supported Machines & Performance Data

- [Supported Machines and Compilers](#)
- [Performance and Load Balancing Data](#)
- [Running on a Medium-Sized Linux Cluster](#)
- [Verify a Machine Port](#)

Performance and Load Balancing

📖 External Library Documentation

- [Parallel I/O Library \(PIO\)](#)
- [Model Coupling Toolkit \(MCT\)](#)
- [Earth System Modeling Framework \(ESMF\)](#)
- [External Python Based Tools *](#)

** Support for these tools is currently limited to NCAR machines only*

📦 Model Input Data

As of CESM2, the input data necessary to run all supported component sets is made available from a number of different public repositories including:

[GridFTP](#) | [Anonymous FTP](#) | [Subversion](#)



Important

Do not attempt to checkout the whole input data repository, it is currently over 20 TB



Note

The [CIME User Guide](#) explains how to obtain the subset of input data required for your needs



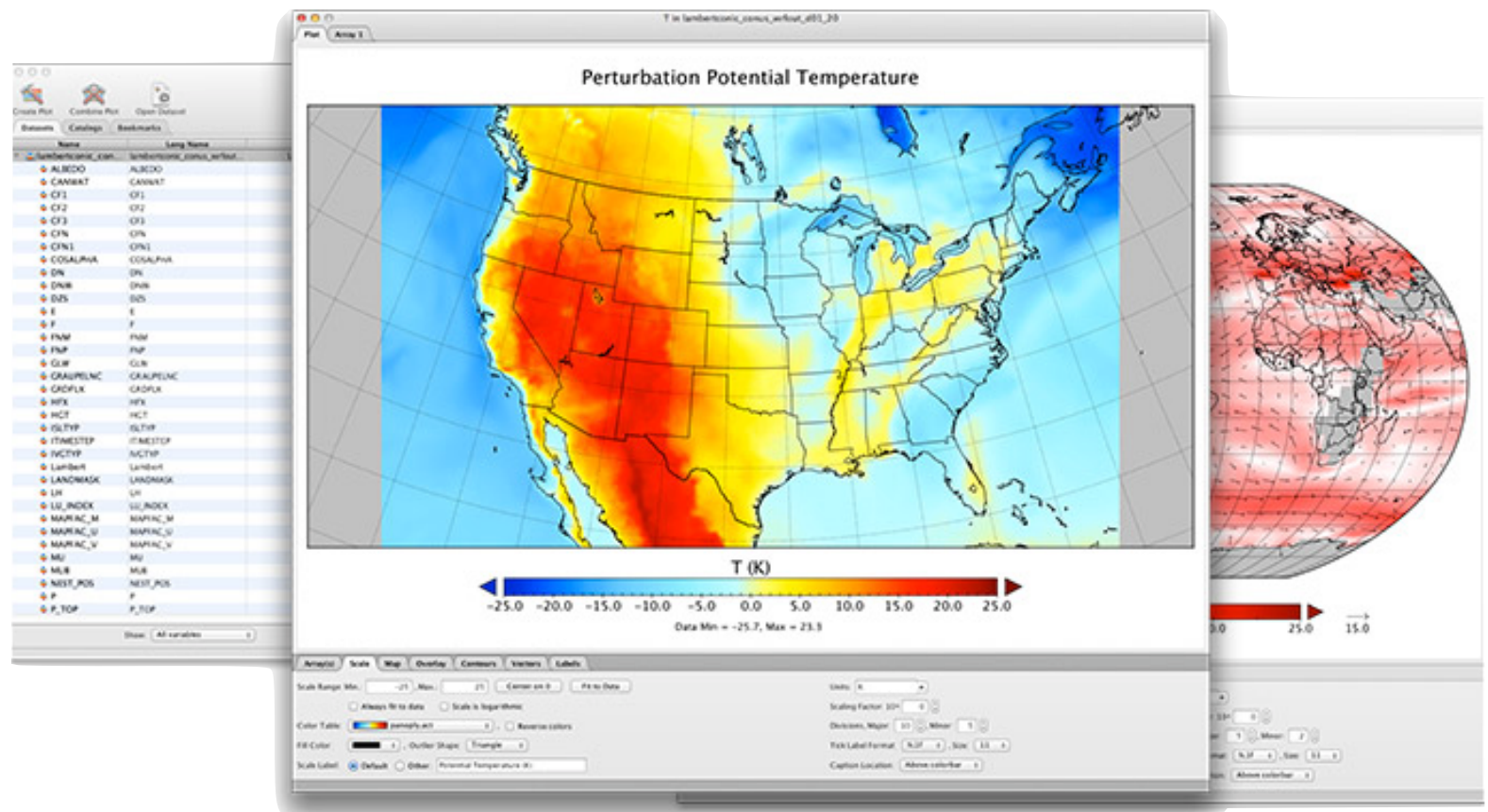
Looking at WACCM-X output

- **netCDF:** self-describing binary data format used for primary CESM output
- **History files:** WACCM-X output is written to several output streams, each with a particular frequency and averaging characteristic
 - **h0:** monthly averages
 - `f.e20.FXSD.f19_f19.001.cam.h0.2000-01.nc` (January 2000)
 - `f.e20.FXSD.f19_f19.001.cam.h0.2000-02.nc` (February 2000)
 - **h1:** hourly instantaneous
 - `f.e20.FXSD.f19_f19.001.cam.h1.2000-01-01-00000.nc` (January 1, 2000)
 - `f.e20.FXSD.f19_f19.001.cam.h1.2000-01-01-00000.nc` (January 2, 2000)
 - **h2:** daily instantaneous
 - **h3:** daily averages
 - **h4:** 5-day averages
 - **h5:** daily averages, zonal mean circulation diagnostics



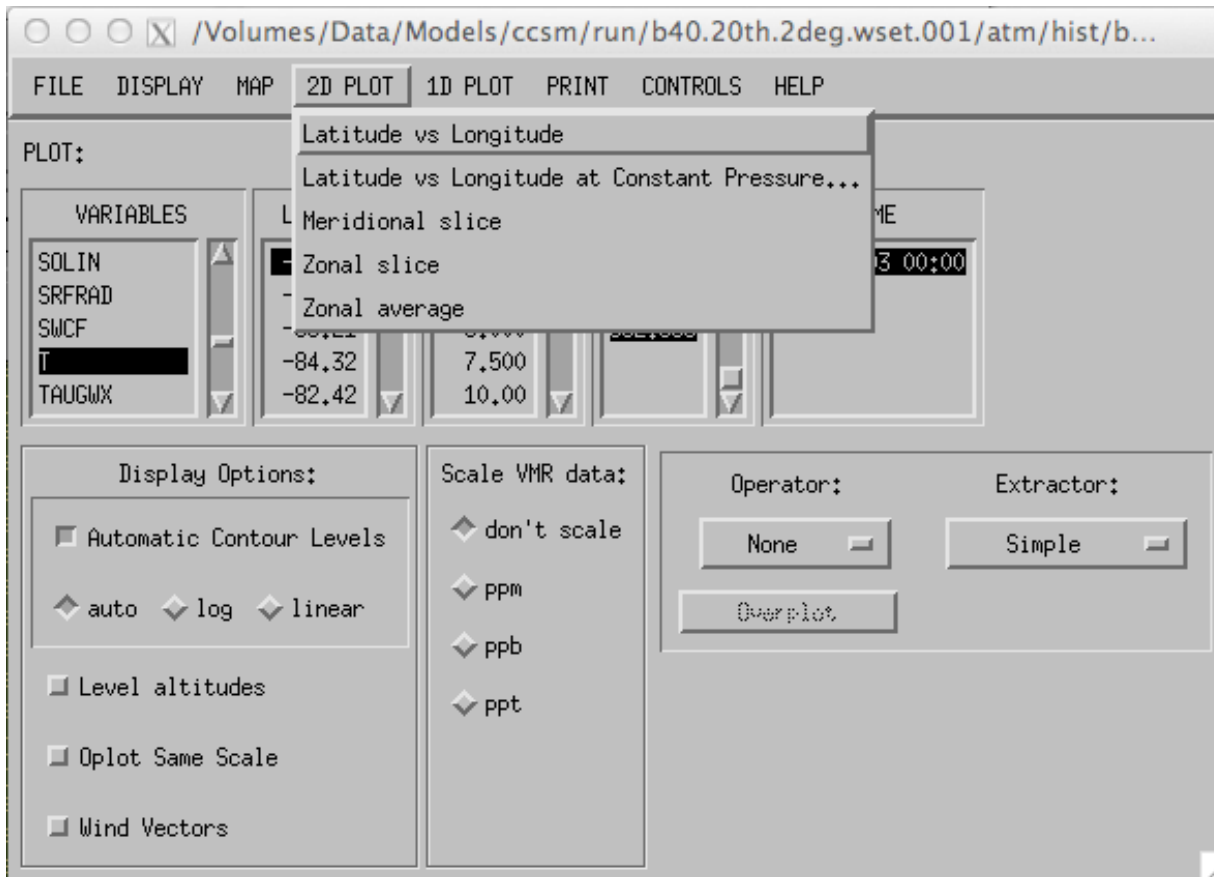
Looking at WACCM-X output

- WACCM-X history output files may be analyzed with standard analysis tools, including **Matlab**, **IDL**, **NCL**, and **NCO**.
- **Panoply**: netCDF data viewer for macOS, Windows, and Linux from NASA Goddard. Free download at <https://www.giss.nasa.gov/tools/panoply/>



Looking at WACCM-X output: GEOV

- GEOV** is an IDL-based viewer for geophysical history files created by NCAR's CAM, WACCM and MOZART models. GEOV can be downloaded from the WACCM webpage at http://www.cesm.ucar.edu/working_groups/Whole-Atmosphere/code-release.html



FILE DISPLAY MAP 2D PLOT 1D PLOT PRINT CONTROLS HELP

PLOT:

VARIABLES

SOLIN			
SRFRAD			
SWCF			
T	-84.32	7.500	
TAUGWX	-82.42	10.00	

Latitude vs Longitude
 Latitude vs Longitude at Constant Pressure...
 Meridional slice
 Zonal slice
 Zonal average

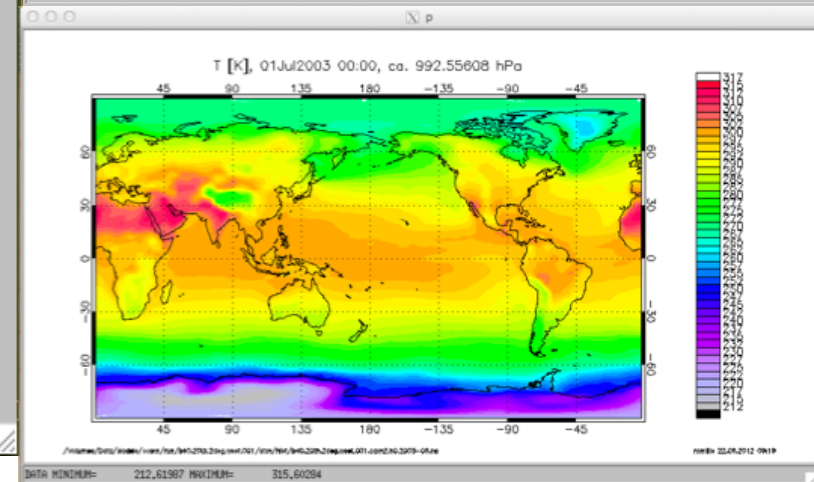
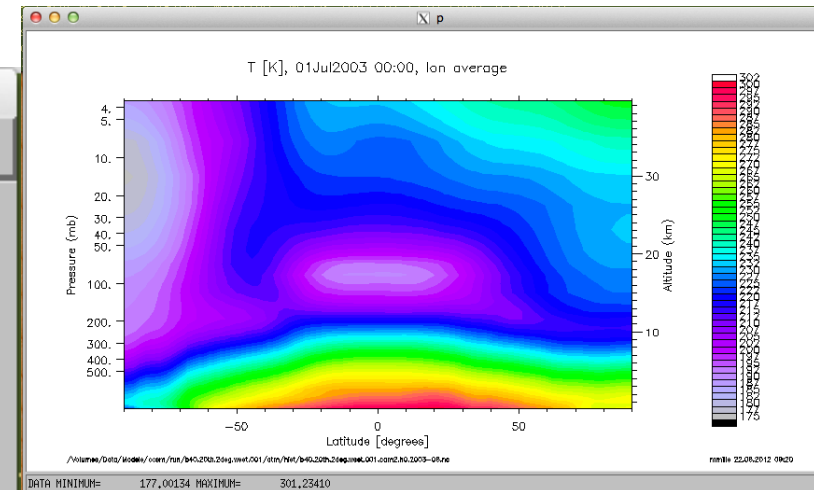
Display Options:

- Automatic Contour Levels
- auto log linear
- Level altitudes
- Oplot Same Scale
- Wind Vectors

Scale VMR data:

- don't scale
- ppm
- ppb
- ppt

Operator: None
 Extractor: Simple
 Overplot





Looking at WACCM-X output: GEOV

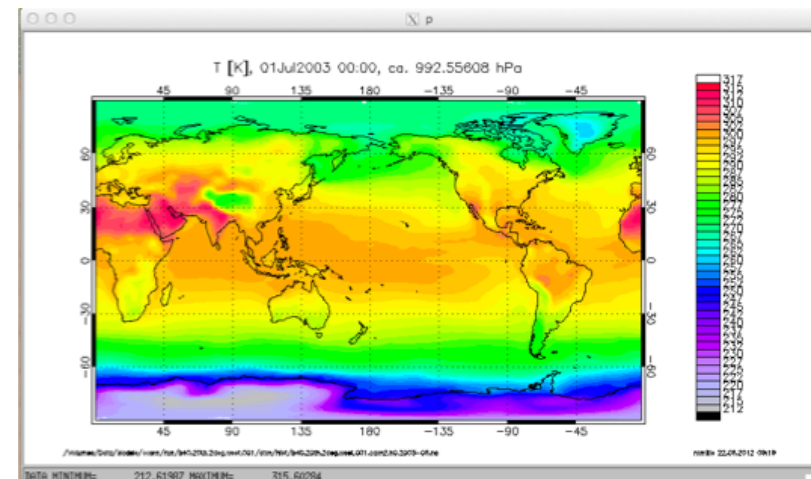
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- Run GEOV on cheyenne with:

```
module load idl
```

```
setenv IDL_STARTUP ~fvitt/idl_startup
```

```
idl geov
```



Hardware and software requirements

- **Supported platforms**

- CESM currently runs **“out of the box”** on NCAR machines ([cheyenne](#)), as well as a number of other computing platforms
- Always review the model version release notes and DiscussCESM Forums (<https://bb.cgd.ucar.edu>) for up-to-date machine specific issues.

- **Running CESM on other platforms**

- **Requires porting and software**
 - git, Subversion, Fortran and C compilers, NetCDF library, ESMF, MPI
- See model version release notes and DiscussCESM Forums for guidance



*out of the box =
works immediately
after installation
without any
modification*



NCAR supercomputer access



- Large Allocation Requests
 - > 400,000 core-hours on Cheyenne
 - CISL accepts requests for large allocations of NCAR resources every six months, in **March** and **September**.
- Small Allocation Requests
 - \leq 400,000 core-hours on the Cheyenne system
 - U.S. university researchers who are supported by NSF awards can request a small allocation **for each NSF award**.
 - Also available to **graduate students** and **post-docs** at U.S. universities; no NSF award or panel review is required.
 - Small requests typically receive a partial allocation **within a few business days**. Once the initial allocation is consumed, you can email alloc@ucar.edu to request additional core-hours up to a total allowed.
- Small Data Access Requests
 - Faculty and research staff at U.S. universities, U.S. non-profit research organizations, and [UCAR affiliates](#) can request read-only access to NCAR-housed data at no charge.
 - These accounts are granted sufficient access to read data from GLADE and HPSS for up to three years. They may be renewed by sending email to alloc@ucar.edu and stating the additional time period needed.

<https://www2.cisl.ucar.edu/user-support/allocations/university-allocations>

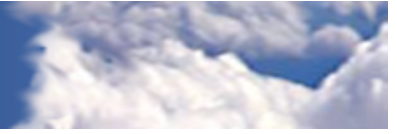
Basic Work Flow: Creating and Running WACCM-X

- If not running at NCAR, some one-time set-up steps are needed:

- Download the current CESM release code in 3 lines:

```
> git clone -b release-cesm2.0.0 https://github.com/ESCOMP/cesm.git  
> cd cesm  
> ./manage_externals/checkout_externals
```

- Creating an input data root directory (not covered here)
- Porting (not covered here)
- Creating and running a case
 - Create a new case
 - Invoke case.setup
 - Build the executable
 - Run the model and output data flow



Installing the ESMF library on non-NCAR computers

- If not running at NCAR, and the Earth System Modeling Framework (ESMF) library isn't installed, you will need to install it yourself. Use the same compiler you will use for CESM. This example uses the (recommended) Intel compiler:

```
#!/bin/tcsh -f
#
module purge
module load intel/16.0.3
module load mpt/2.15

setenv ESMF_INSTALL_PREFIX /glade/u/home/fvitt/esmf_7_0_0
setenv ESMF_DIR /glade/u/home/fvitt/esmf_7_0_0/esmf
#setenv ESMF_BOPT 'g'
setenv ESMF_BOPT 'O'
setenv ESMF_ABI 64
setenv ESMF_COMM mpi
setenv ESMF_COMPILER intel

cd $ESMF_DIR
gmake lib
```



Logging in to **cheyenne** and finding the source code

YubiKey authentication tokens enable authorized users to access a variety of UCAR resources. For detailed instructions, see:

<https://www2.cisl.ucar.edu/user-support/authentication-and-security/yubikey>



Logging in:

```
ssh -X -l username cheyenne.ucar.edu
```

Source code for released model versions can be found here:

```
ls /glade/p/cesm/releases
```

CESM2.0 is there under `cesm2_0`. To create a new case, go to the “`cime/scripts`” subdirectory under the model version source code directory:

```
cd /glade/p/cesm/releases/cesm2_0/cime/scripts
```

There you will find the tool used to create a new run: **[create_newcase](#)**.

Work Flow: Super Quick Start

WACCM-X can be run with a set of **4 commands**.

Set of commands to build and run the model on **Cheyenne**:

- Go into the scripts directory in the source code:

```
cd /glade/p/cesm/releases/cesm2_0_0/cime/scripts
```

1. create a new case in the directory “cases/cheyenne” in your home directory:

```
./create_newcase --res f19_f19 --compset FXHIST
--case ~/cases/cheyenne/f.e20.FXHIST.f19_f19.001
--run-unsupported
```

Go into the case you just created in the last step:

```
cd ~/cases/cheyenne/f.e20.FXHIST.f19_f19.001
```

2. invoke case.setup

```
./case.setup
```

3. build the executable

```
./case.build
```

4. submit your run to the batch queue

```
./case.submit
```

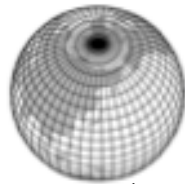


Creating a new case

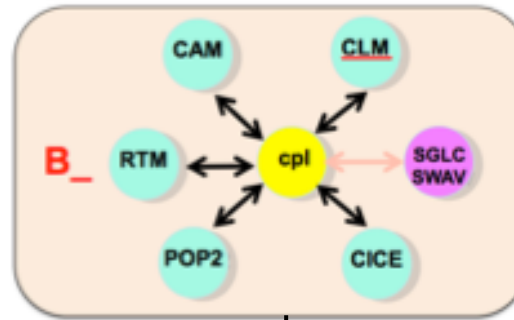
In the cime/scripts directory, **create_newcase** is the tool that generates a new model case.

create_newcase requires **3 arguments**:

Which resolution?



**Which model configuration ?
Which set of components ?**



What is the casename ?



```
./create_newcase --res f19_f19 --compset FXHIST
--case ~/cases/cheyenne/f.e20.FXHIST.f19_f19.001
```

To check the current syntax of create_newcase:

```
./create_newcase --help
```



What is a compset?

“**FXHIST**” is an example of a component set, or “compset”, which defines the configuration of the CESM component models: atmosphere, land, ocean, sea ice, and land ice.

All WACCM-X components use non-interactive data models for ocean and sea ice, and do not include interactive land ice. Such compsets all begin with the letter “F”.

To list available WACCM-X compsets, while under cime/scripts type:

```
./query_config --compsets | grep %WXIE
```

short name	long name
FXHIST	: FRC1_CAM40%WXIE_CLM45%SP_CICE%PRES_DOCN%DOM_RTM_SGLC_SWAV WACCM-X historical 1850-2014
FX2000climo	: 2000_CAM40%WXIE_CLM45%SP_CICE%PRES_DOCN%DOM_RTM_SGLC_SWAV WACCM-X climatological present-day, static year 2000
FXSD	: SDYN_CAM40%WXIE_CLM45%SP_CICE%PRES_DOCN%DOM_RTM_SGLC_SWAV WACCM-X nudged with specified dynamics (SD)

For more help on query_config:

```
./query_config --help
```

What horizontal resolution does WACCM-X use?

WACCM-X runs at 1.9° latitude x 2.5° longitude, which is abbreviated as “f19_f19”

To list the grids available:

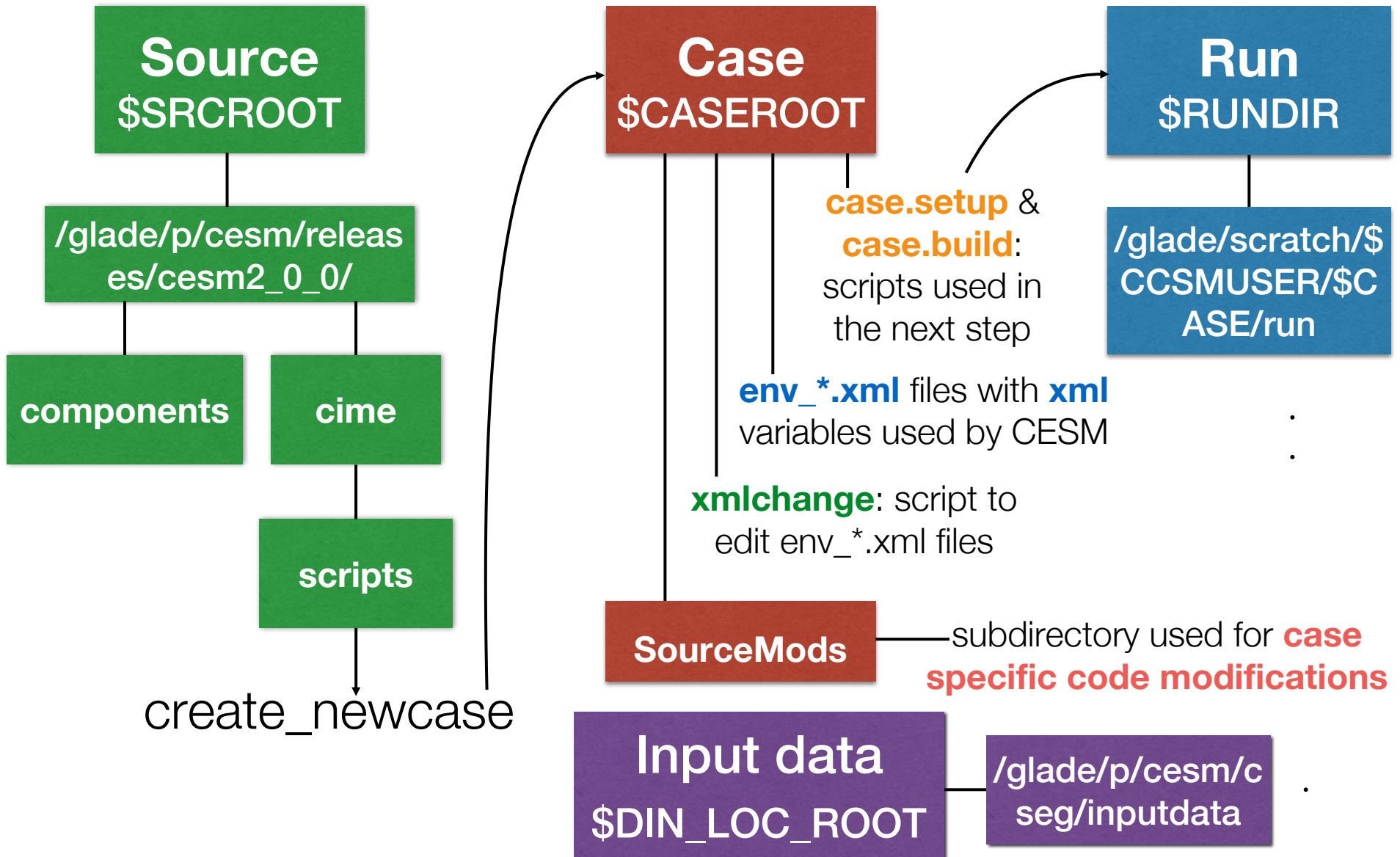
```
./query_config -grids
```

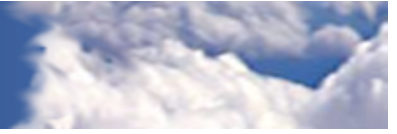
```
alias: f19_f19 (only for compsets that are not _POP )  
non-default grids are: atm:1.9x2.5  lnd:1.9x2.5  ocnice:1.9x2.5  
mask is: gx1v6
```

Again, to create a WACCM-X case:

```
./create_newcase -compset FXHIST -res f19_f19  
-case ~/cases/cheyenne/f.e20.FXHIST.f19_f19.001
```

Overview of directories





Compiling: Setup & Build

After creating your case, go to the case directory:

```
cd ~/cases/cheyenne/f.e20.FXHIST.f19_f19.001
```

Set up the case:

```
./case.setup
```

Build the case (Cheyenne):

```
qcmd -- case.build
```

Build the case (elsewhere):

```
./case.build
```

Problems? Try:

```
./case.setup --reset
```

```
./case.build --clean
```

```
./case.build
```


Is this case ready to run?

```
▶ xmlquery BUILD_COMPLETE --full
```

```
BUILD_COMPLETE: value=TRUE  
  valid_values: ['FALSE', 'TRUE']  
  description: Status output: if TRUE, models have been built  
successfully. (DO NOT EDIT)>
```

```
▶ xmlquery STOP_OPTION,STOP_N --full
```

```
STOP_OPTION: value=ndays  
  valid_values: ['none', 'end', 'nminutes', 'nhour', 'nmonths', 'never',  
'nhours', 'nseconds', 'nstep', 'nyear', 'nmonth', 'nminute', 'nsecond',  
'ifdays0', 'date', 'nyears', 'nday', 'nsteps', 'ndays']  
  description: Sets the run length along with STOP_N and STOP_DATE
```

```
STOP_N: value=5  
  description: Provides a numerical count for $STOP_OPTION.
```

About env_*.xml files

- env_*.xml files contain variables used by scripts. Some can be changed by the user.
 - env_case.xml: set by create_newcase and cannot be modified
 - env_mach_pes.xml: specifies layout of components
 - env_build.xml: specifies build information
 - env_batch.xml: sets arguments for batch submit command
 - env_run.xml: sets run time information (such as length of run, frequency of restarts, ...) **User interacts with this file most frequently.**
- Here's a snippet of the env_run.xml file:

```

<!--"sets the run length in conjunction with STOP_N and STOP_DATE, valid values: none,never,nst
eps,nstep,nseconds,nsecond,nminutes,nminute,nhours,nhour,ndays,nday,nmonths,nmonth,nyears,nyea
r,date,ifdays0,end (char) " -->
<entry id="STOP_OPTION" value="ndays" />

<!--"sets the run length in conjunction with STOP_OPTION and STOP_DATE (integer) " -->
<entry id="STOP_N" value="5" />

```

"id" - variable name

"value" - variable value

CESM will run for 5 days

- To modify a variable in an xml file, use **xmlchange**
 - xmlchange STOP_N=20



Okay, let's run!

```
./case.submit
```

Monitor the job status:

```
qstat -u $USER
```

Job ID	Username	Queue	Jobname	SessID	NDS	TSK	Req'd Memory	Req'd Time	Elap S	Time
1283009.chadmin	mmills	regular	68.nonudge	50344	16	576	--	12:00	R	04:57

Who's paying for this run?

```
xmlquery PROJECT
```

Let's change that!

```
xmlchange PROJECT=newaccount
```

Kill the running job and resubmit?

```
qdel 1283009
```

```
./case.submit
```