

Namelist and Code Modifications

Part 1: Namelist Modifications

Part 2: Code Modifications

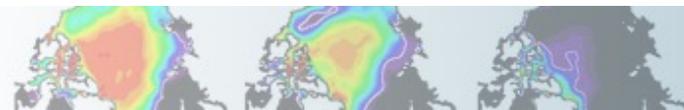
Part 3: Exercises Overview

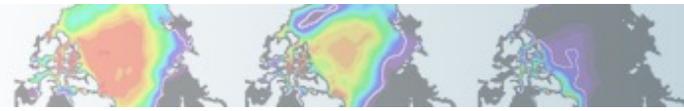
Cecile Hannay, CAM Science Liaison
Atmospheric Modeling and Predictability Section
Climate and Global Dynamics Division



**“I can only show you the door.
You're the one that has to walk through it”**

(The Matrix, 1999)





Part 1: Namelist Modifications

In this section, we will:

- review the “CESM flow” and how to make namelist changes,
- see where to find documentation for namelist variables
- as an illustration, we will customize the output history files to get high frequency output



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Review: The 4 commands to run CESM

Set of commands to build and run the model on "cheyenne"

```
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# go into the case you just created in the last step
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# (2) invoke case.setup
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Review: The 4 commands to run CESM

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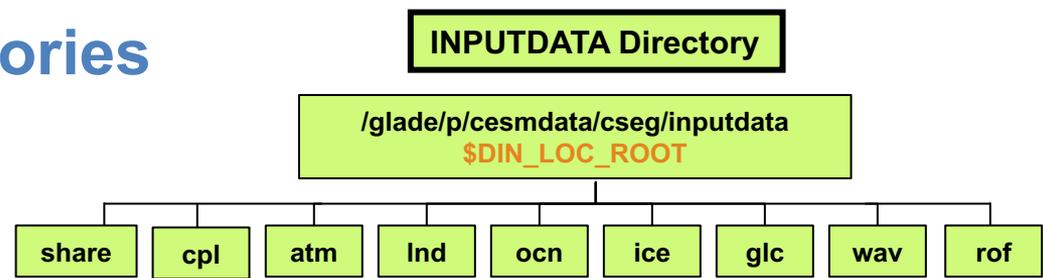
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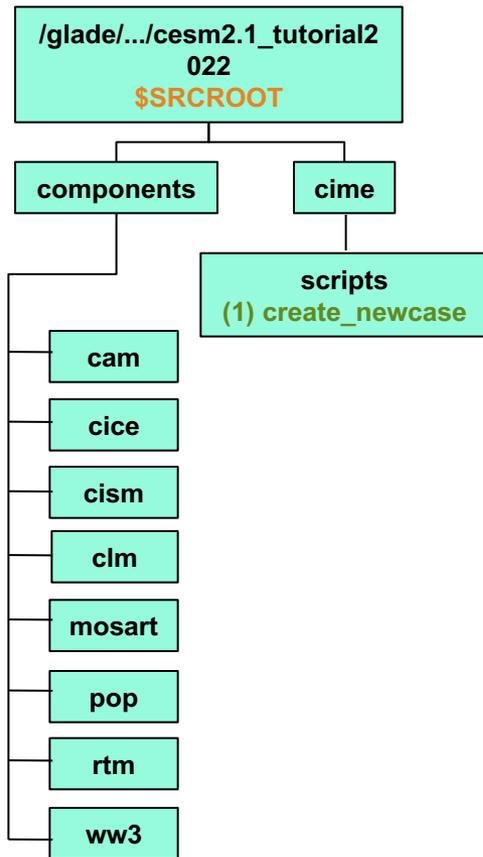
# (3) build the executable
qcmd -- ./case.build ← "qcmd" is for Cheyenne only

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```

Overview of CESM directories before create_newcase



CESM Code



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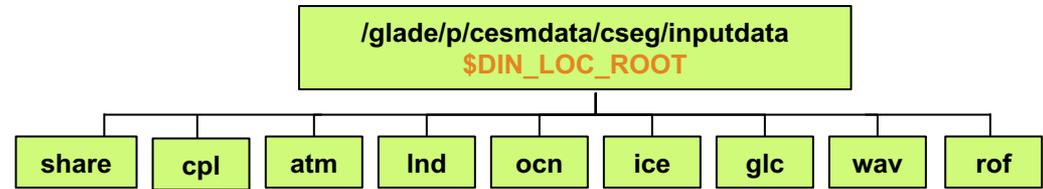
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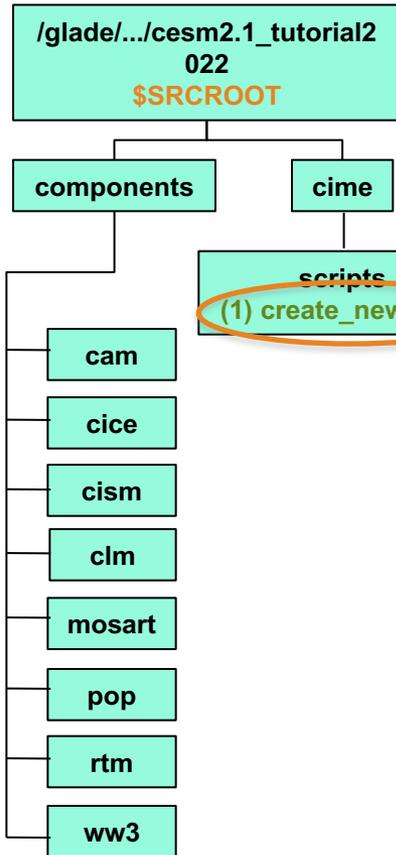
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INPUTDATA Directory



CESM Code



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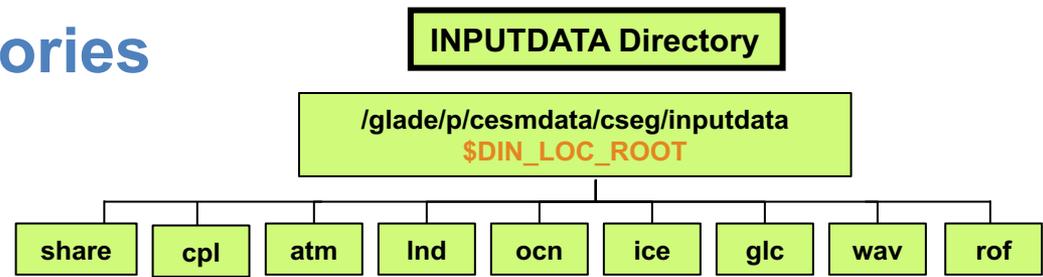
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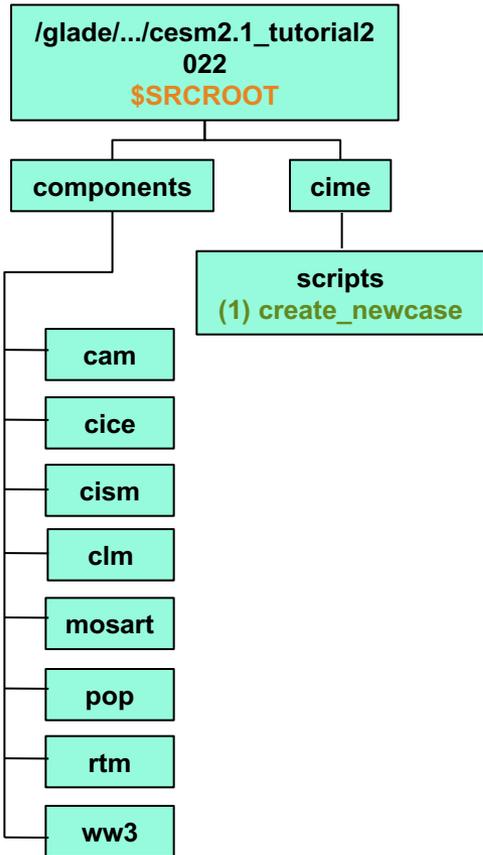
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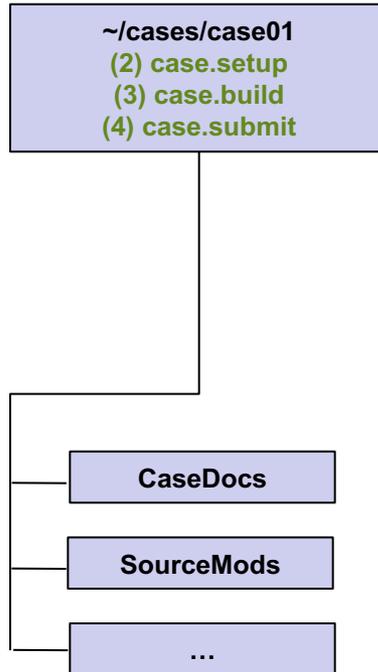
Overview of CESM directories after create_newcase



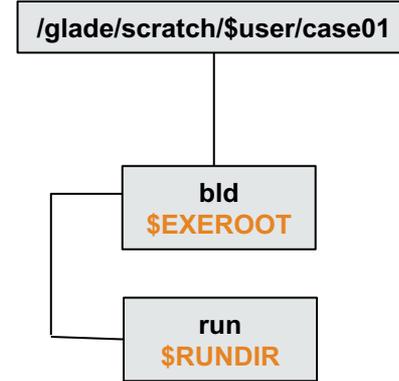
CESM Code



CASE Directory



Build/Run Directory



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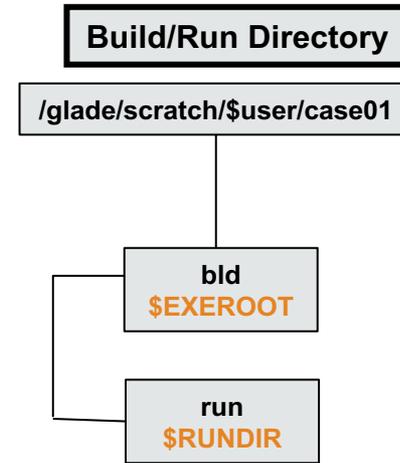
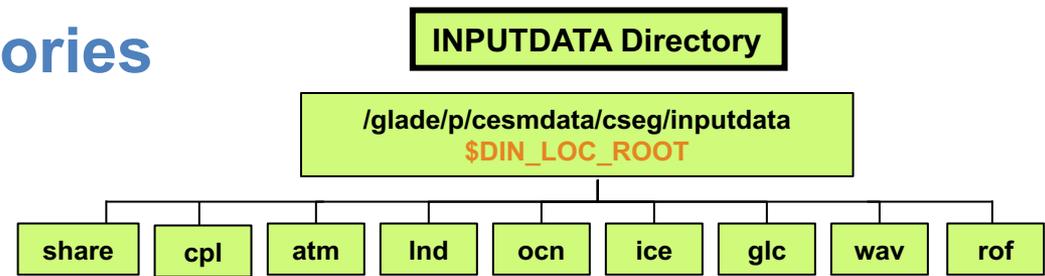
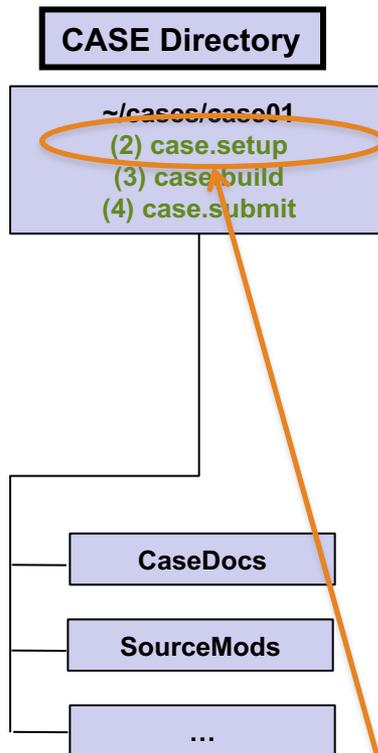
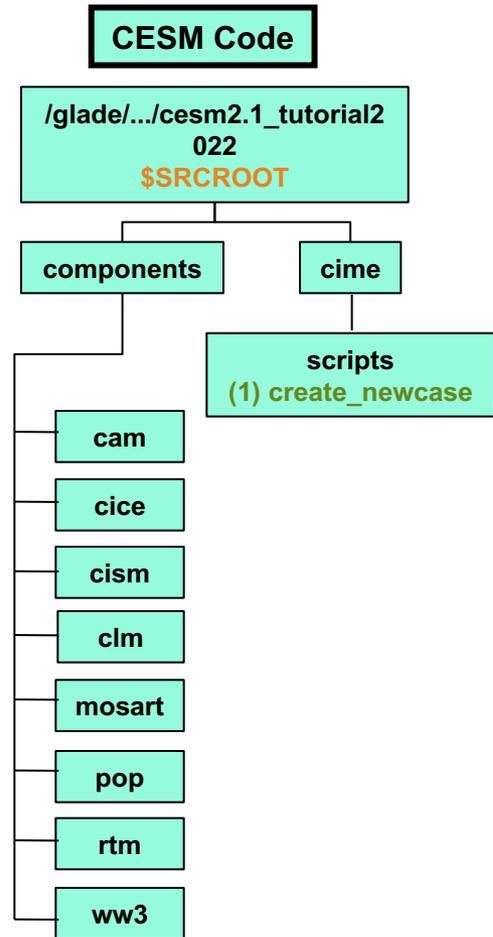
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Overview of CESM directories + 4 CESM commands



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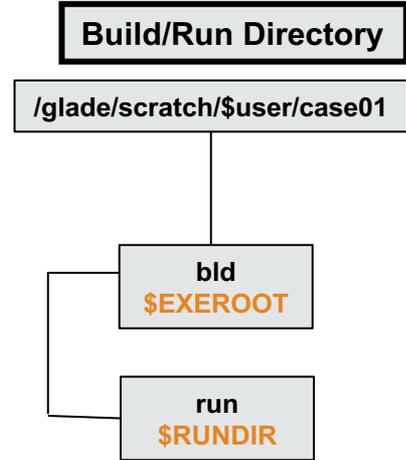
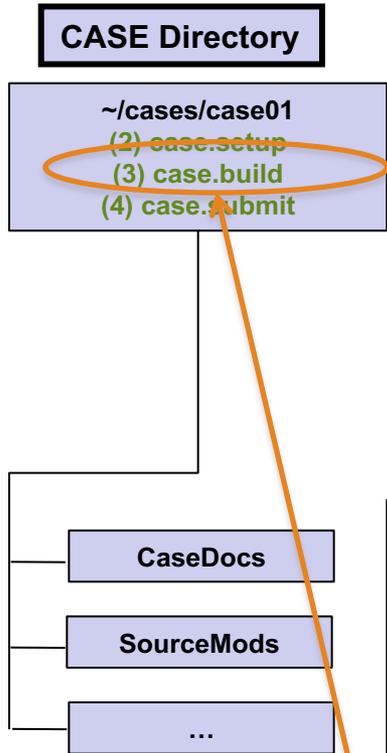
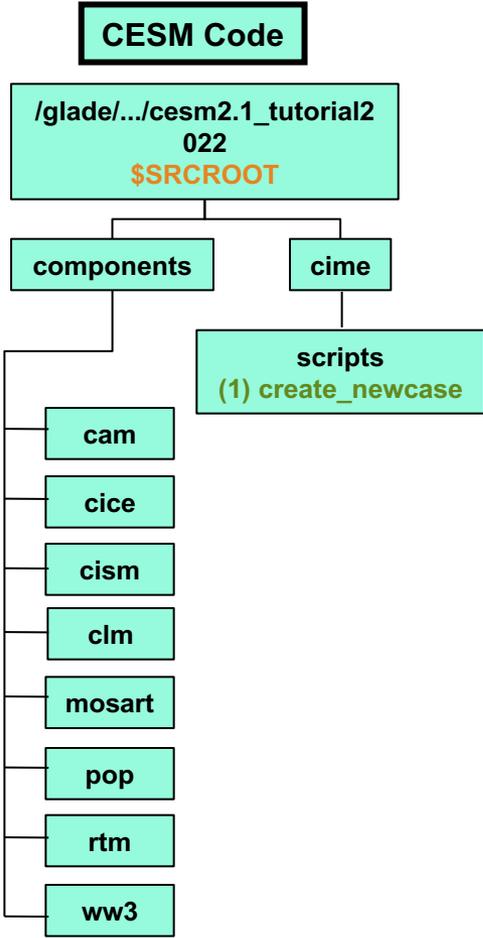
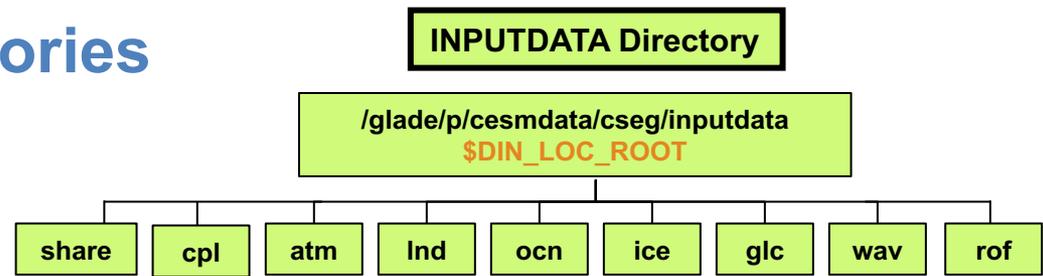
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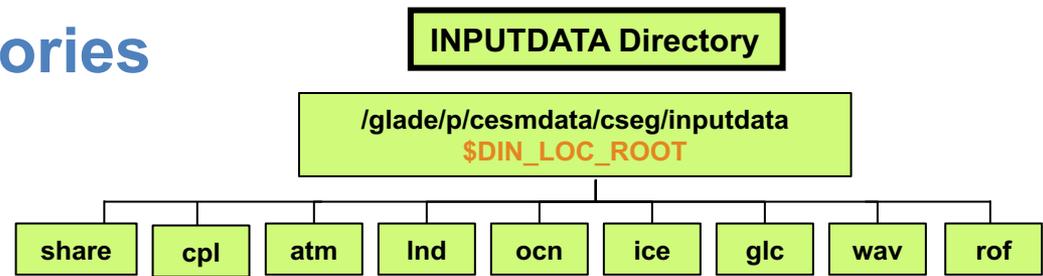
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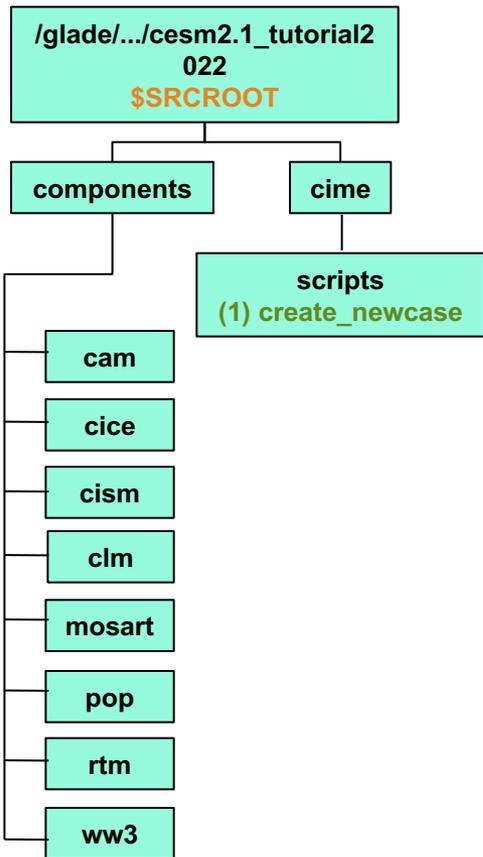
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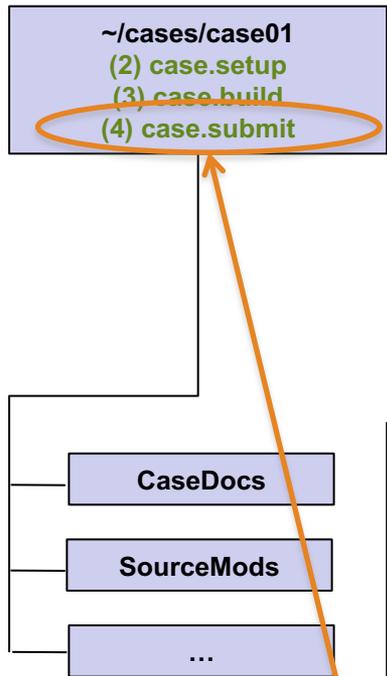
Overview of CESM directories + 4 CESM commands



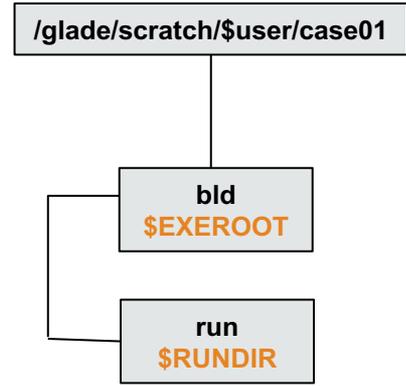
CESM Code



CASE Directory



Build/Run Directory



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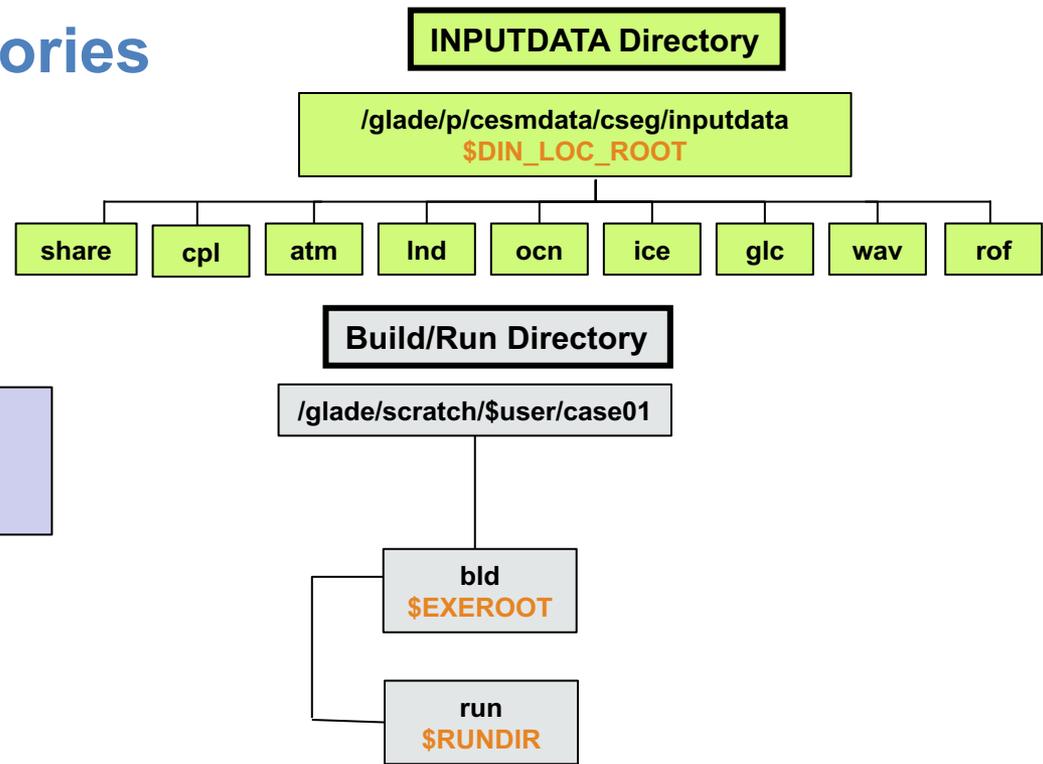
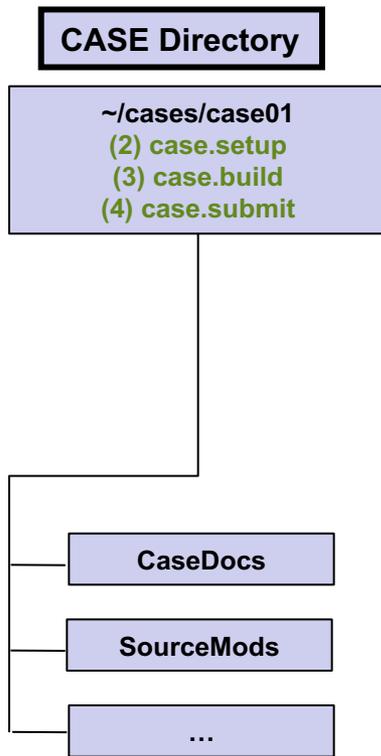
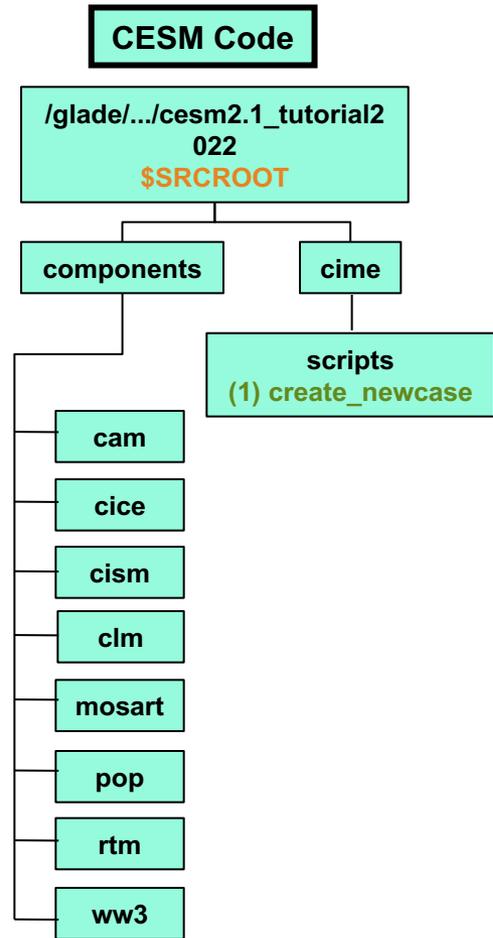
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Overview of CESM directories + 4 CESM commands



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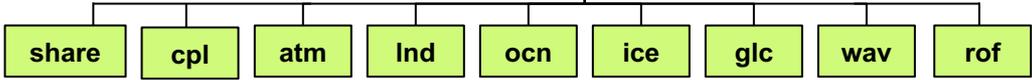
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This is when you can modify the namelists

Overview of CESM directories + 4 CESM commands

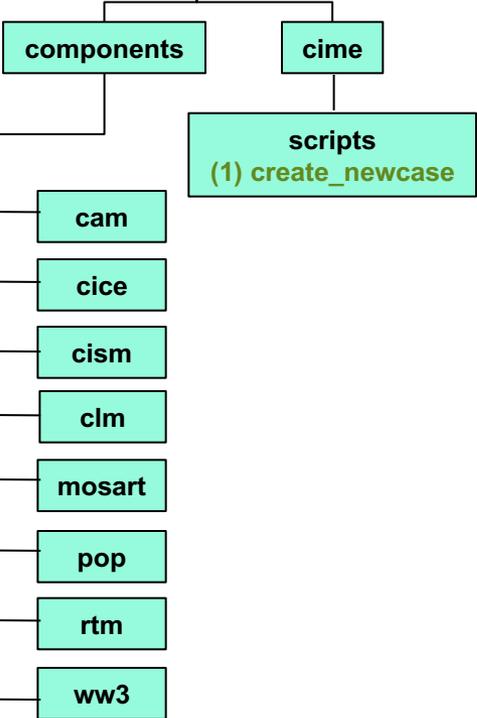
INPUTDATA Directory

/glade/p/cesmdata/cseg/inputdata
\$DIN_LOC_ROOT



CESM Code

/glade/.../cesm2.1_tutorial2
022
\$SRCROOT



CASE Directory

```

~/cases/case01
(2) case.setup
(3) case.build
(4) case.submit
user_nl_cam
user_nl_cice
user_nl_cism
user_nl_clm
user_nl_cpl
user_nl_mosart
user_nl_pop
user_nl_ww
  
```

case.setup creates namelist modification files `user_nl_XXX` this is **where you modify your namelists**



Build/Run Directory

/glade/scratch/\$user/case01

bld
\$EXEROOT

The build script creates **namelists** in the run directory

```

run
$RUNDIR
atm_in
cism_in
drv_flds_in
drv_in
ice_in
lnd_in
mosart_in
pop_in
wav_in
  
```

This is used by the model at runtime

(should not be edited)



```

CaseDocs
atm_in
cism_in
drv_flds_in
drv_in
ice_in
lnd_in
mosart_in
pop_in
wav_in
  
```

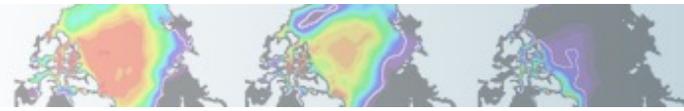
CaseDocs contains **copy of the namelists** for reference only

(should not be edited)



SourceMods

...



Part 1: Namelist Modifications

In this section, we will:

- review the “CESM flow” and how to make namelist changes,
- **see where to find documentation for namelist variables**
- as an illustration, we will customize the output history files to get high frequency output



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Where to find info about namelists ?

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

Community Earth System Model CESM2

Current Releases

The latest CESM development release is CESM2.2.0
The latest CESM production release is CESM2.1.3

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INSTRUCTIONS

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.

View the [CESM2 release series information](#) to learn more

[CESM2 RELEASE SERIES INFORMATION](#)

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 Experiments, Data & Diagnostic Output *
- CESM1 Experiment Diagnostics
- CESM Naming Conventions

* This page now contains links to datasets on ESGF, CDG, glade and NCAR HPSS as well as diagnostic plots and caseroor details.

Quick Start

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- Getting Help
- CESM2 Use Cases
- Download the CESM2 Code
- CESM2.2 Quickstart Guide
- CESM2.1 Quickstart Guide
- CESM2 Known Issues

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 User Guide

* 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.

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

Supported Machines & Performance Data

- Supported Machines and Compilers
- Timing, Performance and Load Balancing Data
- Running on a Medium-Sized Linux Cluster
- Verify a Machine

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

CESM2 QUICKLINKS

CESM GitHub

CESM2.2 Quickstart Guide

CESM2.1 Quickstart Guide

Downloading Instructions

> Prognostic Components

CESM Software Engineering Group

Experiments, Data & Diagnostic Output

RELATED INFORMATION

Data Management & Distribution Plan

Development, Project Policies & Terms of Use

Publication / Acknowledgment Information

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CESM2 Copyright

CESM

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Support Policy

CESM2.1 Quickstart Guide

CESM PROJECT

The CESM project is supported primarily by the National Science Foundation (NSF).

Administration of the CESM is maintained by the Climate and Global Dynamics Laboratory (CGD) at the National Center for Atmospheric Research (NCAR).

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.

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

In "Prognostic Components" or in "Components Configuration Settings", you can find information about namelist variables in:
"Component Fortran Namelist settings"

Where to find info about namelists ?

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CIME Documenta

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Supported & Performance

- Supported Machines
- Performance
- Running on a Medium
- Verify a Machine Por

CESM Models / CESM Releases / CESM2 / Component Configuration Settings

Component Configuration

CESM2 VERSION

Settings

Viewing model version

2.2.0

HTML created on

2020-09-23

Select a setting from the options below or use the **CESM2 Version** button to change CESM versions

Atmosphere Models

Active / Prognostic Atmosphere

CAM

- CAM Namelist Definitions
- CAM CASEROOT Variable Definitions

Climatological Data Atmosphere

DATM

- DATM Namelist Definitions
- DATM CASEROOT Variable Definitions

Land Models

Active / Prognostic Land

CLM

- CLM5.0 Namelist Definitions
- CLM5.0 CASEROOT Variable Definitions

Climatological Data Land

DUND

- DUND Namelist Definitions
- DUND CASEROOT Variable Definitions

River Models

Active / Prognostic River Runoff Model

MOSART

- MOSART Namelist Definitions
- MOSART CASEROOT Variable Definitions

Active / Prognostic River Runoff Model

RTM

- RTM Namelist Definitions
- RTM CASEROOT Variable Definitions

Climatological Data River

DROF

- DROF Namelist Definitions
- DROF CASEROOT Variable Definitions

Ocean Models

Active / Prognostic Ocean

POP2

Climatological Data Ocean

DOCN (Includes Aquaplanet)

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Namelist definitions for every component

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Supported Hardware & Performance

- Supported Machines
- Performance
- Running on a Medium
- Verify a Machine Port

Component Configuration

CESM2 VERSION ▼ CESM2 QUICKLINKS CESM2 GITHUB

Settings

Viewing model version **2.2.0** HTML created on **2020-09-28**

Select a setting from the options below or use the **CESM2 Version** button to

Atmosphere Models

Active / Prognostic Atmosphere **CAM** Climatological Data **DATM**

- CAM Namelist Definitions
- CAM CASEROOT Variable Definitions
- DATM Namelist Definitions
- DATM CASEROOT Variable Definitions

Land Models

Active / Prognostic Land **CLM** Climatological Data **DLND**

- CLM5.0 Namelist Definitions
- CLM5.0 CASEROOT Variable Definitions
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River Models

Active / Prognostic River Runoff Model **MOSART** Active / Prognostic River Runoff Model **RTM**

- MOSART Namelist Definitions
- MOSART CASEROOT Variable Definitions
- RTM Namelist Definitions
- RTM CASEROOT Variable Definitions

Climatological Data River **DROF**

- DROF Namelist Definitions
- DROF CASEROOT Variable Definitions

Ocean Models

Active / Prognostic Ocean **POP2** Climatological Data Ocean **DOCN (Includes Aquaplanet)**

CLM Namelist Definitions

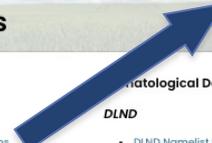
CESM2 VERSION ▼

Viewing component tag **release-cesm2.2.01** Viewing model version **2.2.0** HTML created on **2020-09-28**

SHOW ALL **HIDE ALL**

Show 10 entries Search:

Variable	Namelist Group	Category	Entry Type
albice	clm_inparm	clm_physics	real(2)
all_active	clm_inparm	clm_physics	logical
all_urban	clmexp	mksurdata	logical
allowlakeprod	ch4par_in	clm_methane	logical
anoxia	clm_inparm	clm_vertcn	logical
atm_cl3_filename	clm_inparm	clm_isotope	char*256
atm_cl4_filename	clm_inparm	clm_isotope	char*256
baseflow_scalar	soilhydrology_inparm	clm_physics	real
baset_latvary_intercept	crop	physics	real
baset_latvary_slope	crop	physics	real



Where to find info about namelists ?

CAM6.3 Namelist Definitions

CESM2 VERSION ▾

Viewing component tag

cam_cesm2_2_rel_02

Viewing model version

2.2.0

HTML created on

2020-09-28

SHOW ALL

HIDE ALL

Show 10 entries

Search: nhtfrq

Variable	↑↓ Namelist Group	↑↓ Category	↑↓ Entry Type	↑↓
 nhtfrq	cam_history_nl	history	integer(10)	

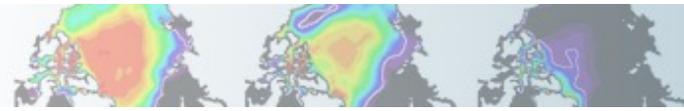
Valid Values ['any integer(10)']

Possible Default Values is 9 for: {'scam': '1'}

Description and out-of-the-box Default

Array of write frequencies for each history file series.
If `nhtfrq(1) = 0`, the file will be a monthly average.
Only the first file series may be a monthly average. If
`nhtfrq(i) > 0`, frequency is specified as number of
timesteps. If `nhtfrq(i) < 0`, frequency is specified
as number of hours.

Default: 0,-24,-24,-24,-24,-24,-24,-24,-24



Part 1: Namelist Modifications

In this section, we will:

- review the “CESM flow” and how to make namelist changes,
- see where to find documentation for namelist variables
- as an illustration, we will customize the output history files to get high frequency output



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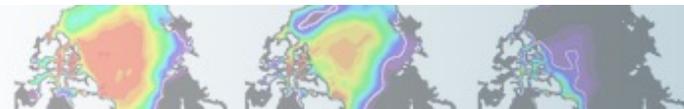
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Let's change the output frequency in CAM**

By default, CESM outputs **monthly average** history files but you can output at other frequency.

For instance: to change the output frequency of a CAM history file from **monthly average** to **daily average**, we use the namelist variable: ***nhtfrq=-24***

***** In this tutorial, examples will be coming from the atmospheric model. Concepts are transferable to other model components.***



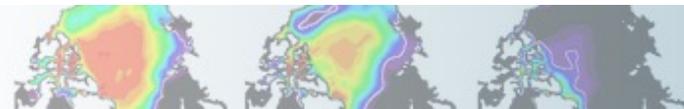
Customizing CAM history files

In this section, we will cover:

- how to change the **output frequency**
- how to output **extra variables**
- how to output **extra history files**
- how to control the **number of time samples** written to a history file

This can be achieved with 3 namelist variables:

- ***nhtfrq***: sets the output frequency
- ***fincl***: add variables to the history file
- ***mfilt***: maximum number of time samples written to a history file



Customizing CAM history files: *nhtfrq*

The **default** history file from CAM is a **monthly average**.

We can change the output frequency with the namelist variable *nhtfrq*

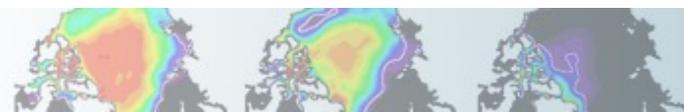
If *nhtfrq*=0, the file will be a **monthly average**

If *nhtfrq*>0, frequency is input as number of **timesteps**.

If *nhtfrq*<0, frequency is input as number of **hours**.

For instance to change the history file from **monthly average** to **daily average**, we set the namelist variable:

nhtfrq = -24



Customizing CAM history files: mfilt

To control the **number of time samples** in the history file, we can use the variable *mfilt*

For instance, to specify that we want 10 time samples on each history file, we set the namelist variable:

mfilt = 10

For instance, if we output daily data for a 1 year run:

nhfrq = -24

mfilt = 365

=> *1 history file with 365 time samples*

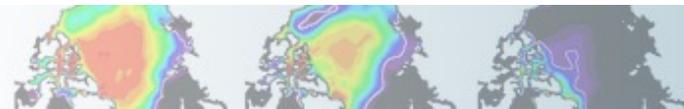
nhfrq = -24

mfilt = 1

=> *365 history files with 1 time sample*

NB: we cannot change *mfilt* for monthly frequency.

For monthly frequency, we always have: *mfilt = 1*



Customizing CAM history files: fincl

You can output up to 10 history files: “h0”, “h1”, ..., “h9”.

The file “h0” contains the default variables (in the code: “call add_default”). This includes the variables necessary for the *AMWG package*.

For the files “h1” to “h9”, the user has to specify the variables to output.

To control the list of fields in the history files we can use the namelist variables

h0 *h1* ... *h9*
fincl1 *fincl2* ... *fincl10*

For instance, the line:

```
fincl1 = 'PRECT'
```

is used to add the field '*PRECT*' to the file “h0”

Customizing CAM history files: fincl

Using a ":" following a field gives the **averaging flag** for the output field.

Valid flags are:

A ==> Average

B ==> GMT 00:00:00 average

I ==> Instantaneous

M ==> Minimum

X ==> Maximum

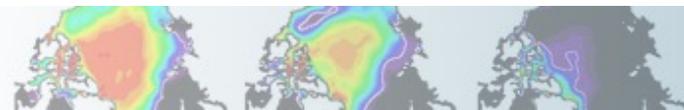
L ==> Local-time

S ==> Standard deviation

For instance, the line:

fincl1 = 'PRECT:M'

is used to add the minimum of 'PRECT' to the file "h0"



Example of customizing history files

For instance, what happens if we set:

```
fincl2 = 'T:I','Q:I','U:I','V:I'
```

```
nhtfrq = 0, -3
```

```
mfilt = 1, 8
```

In addition to the monthly history file “h0”,
we output the file “h1” with **instantaneous values of T, Q, U, V**
we output these variables every **3 hour**
We have **8 time samples** in each h1 file (we create a new file every
day)

NB: If you plan to run the AMWG diagnostic package, it is recommended to leave the “h0” file untouched and to add extra history files

Outputting high frequency data in other components

Here is a few variables to control output frequency of **land**, **ice** and **ocean**

CLM

hist_nhtfrq: output frequency of the history file

hist_mfilt: number of samples on each history file

hist_fincl: adding variables and auxiliary history files

Example

user_nl_clm to output 4 extra history files with daily, six-hourly, hourly, and every time-step values of TG and TV (leaving the primary history files as monthly):

hist_fincl2 = 'TG', 'TV'

hist_fincl3 = 'TG', 'TV'

hist_fincl4 = 'TG', 'TV'

hist_fincl5 = 'TG', 'TV'

hist_nhtfrq = 0, -24, -6, -1, 1

http://www.cesm.ucar.edu/models/cesm2/settings/current/clm5_0_nml.html

Outputting high frequency data in other components

CICE

histfreq: Frequency of output written to history files ('1', 'm', 'd', 'y', ...)

histfreq_n: Frequency history data is written to history files

hist_avg: if false => instantaneous values
if true => time-averages

Example

user_nl_cice to output an extra history file with daily values (leaving the primary history file as monthly):

histfreq = 'm','d','x','x','x'

histfreq_n = 1,1,1,1,1

See: http://www.cesm.ucar.edu/models/cesm2/settings/current/cice_nml.html

Outputting high frequency data in other components

POP2

tavg_freq = frequency at which the model fields are written

tavg_freq_opt = units of time for 'tavg_freq' ('nmonth', 'nhour', 'once', ...)

tavg_file_freq = frequency at which the model files are written

tavg_file_freq_opt = units of time for 'tavg_file_freq' ('nmonth', 'nhour', ...)

https://www.cesm.ucar.edu/models/cesm2/settings/current/pop2_nml.html

For instance, to output a timeseries of daily averages bundled into a monthly file:

tavg_freq_opt = 'nday'

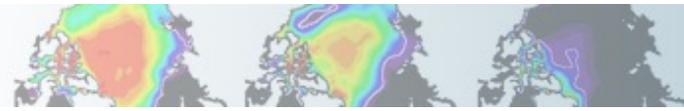
tavg_freq = 1

tavg_file_freq_opt = 'nmonth'

tavg_file_freq = 1



Changing tavg_nml variables is non standard
Do not modify these variables directly in user_nl_pop2
Use the workaround explained in user_nl_pop2



Part 2: Code Modification

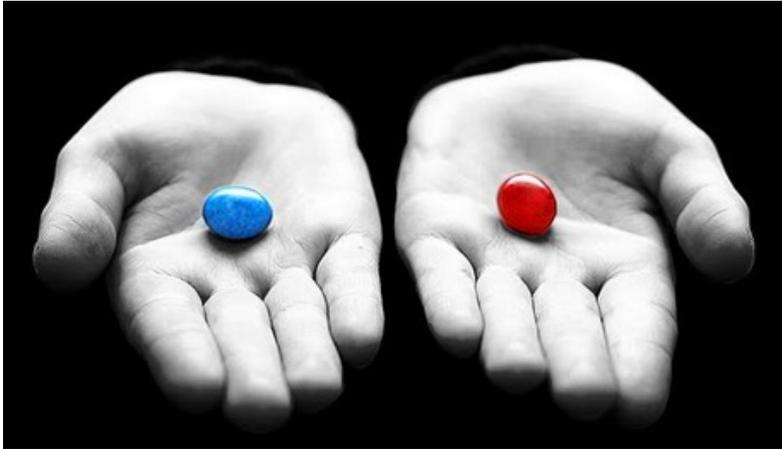
In this section, we will learn how to do simple code modifications such adding a new variable



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Your choice: The Red Pill or the Blue Pill



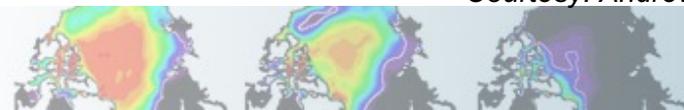
The Matrix (1999): Neo, the main character is offered the choice between a red pill and a blue pill.

-The **blue pill** would allow him to remain in the Matrix (a fictional computer-generated world)

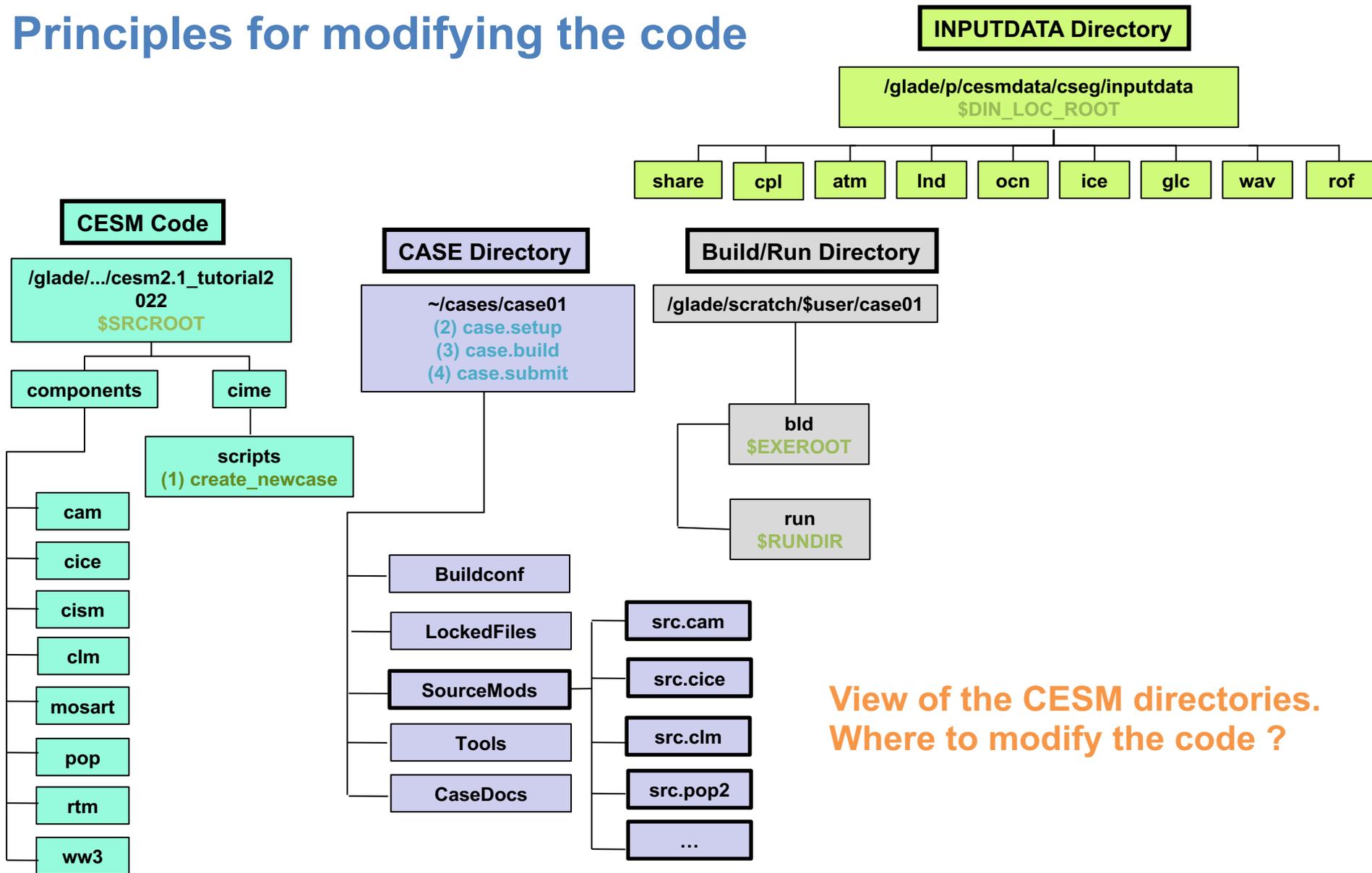
-The **red pill** would lead to his "escape" from the Matrix into the real world and embracing the sometimes painful truth of reality.



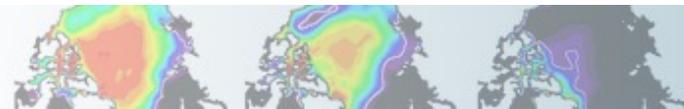
Courtesy: Andrew Gettelman



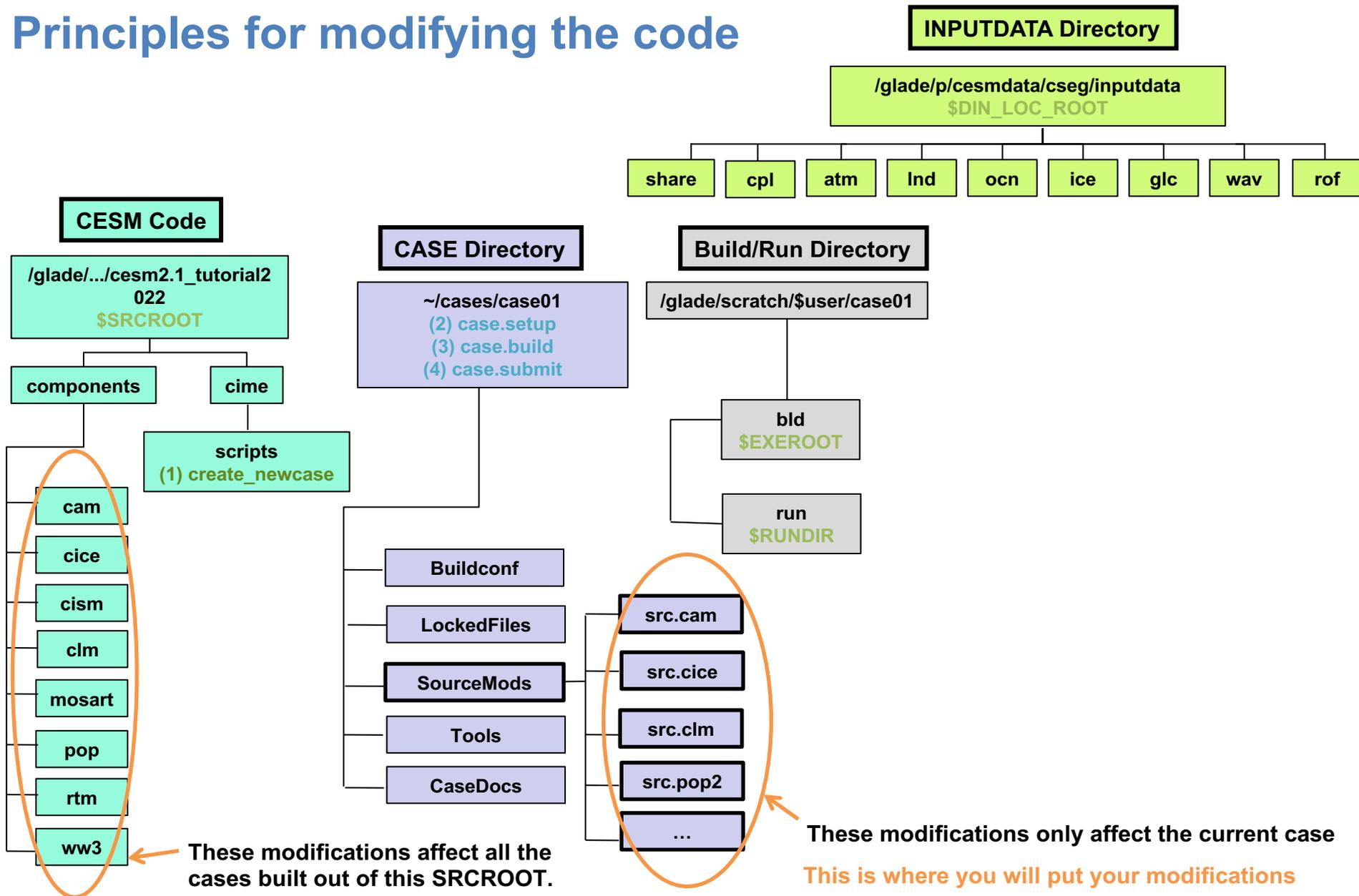
Principles for modifying the code



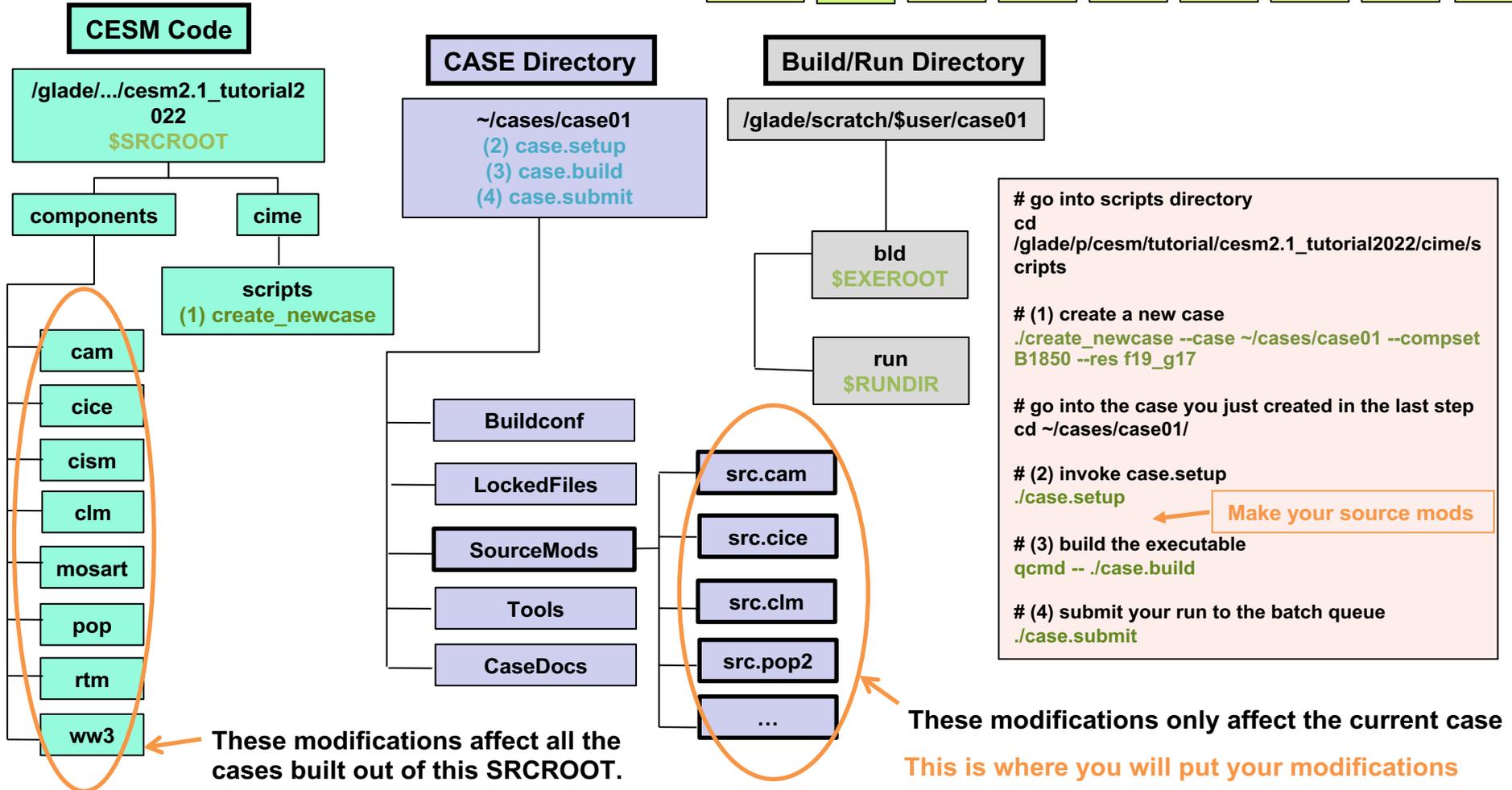
View of the CESM directories.
Where to modify the code ?



Principles for modifying the code



Principles for modifying the code



Modifying a subroutine

Steps to modify the code:

- Find the subroutine you want to modify
- Copy this subroutine in SourceMods
- Make your mods
- Compile and run the model

Output an extra variable

- One common thing you may want to do is to **add code to output a new variable**
- For instance, CAM has a field to output the temperature at 500 mbar (T500) but not at 750mb. Let's add a field to output the temperature at 750 mbar (T750)

This can be done by a succession of calls:

call addfld ('T750', ...)

→ Add a field to master field list

call add_default ('T750',...)

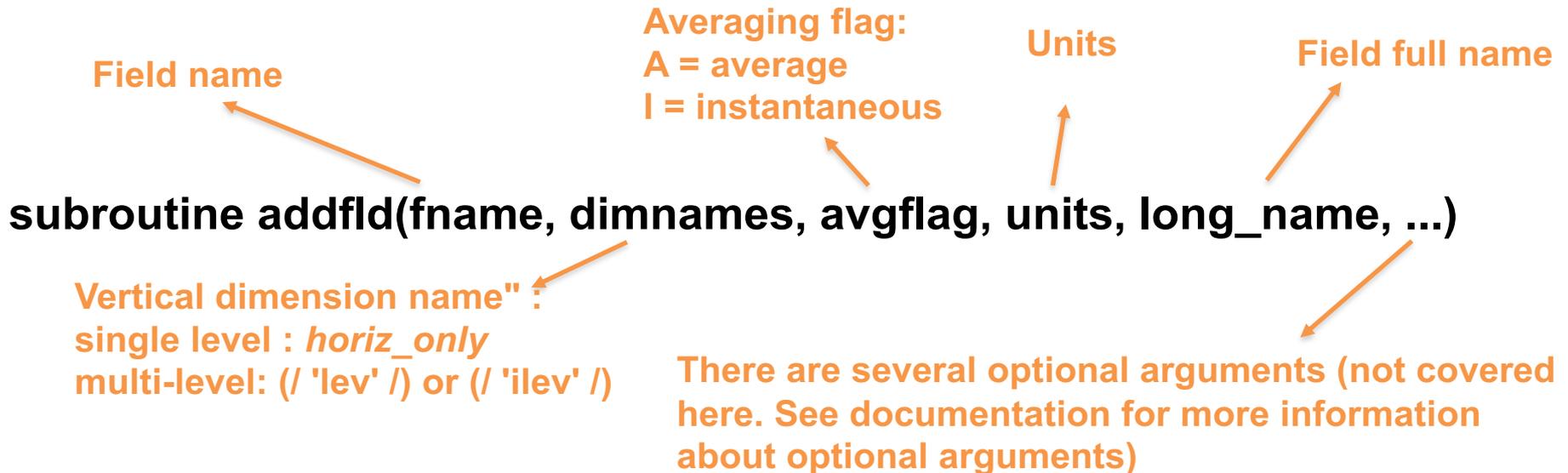
→ Add this field to "h0" by default (optional)

call outfld('T750', ...)

→ Collect values for this field and write to history file

Syntax: addfld

addfld = Add a field to master field list



Example:

call addfld ('T500', horiz_only, 'A', 'K', 'Temperature at 500 mbar pressure surface')

Syntax: add_default

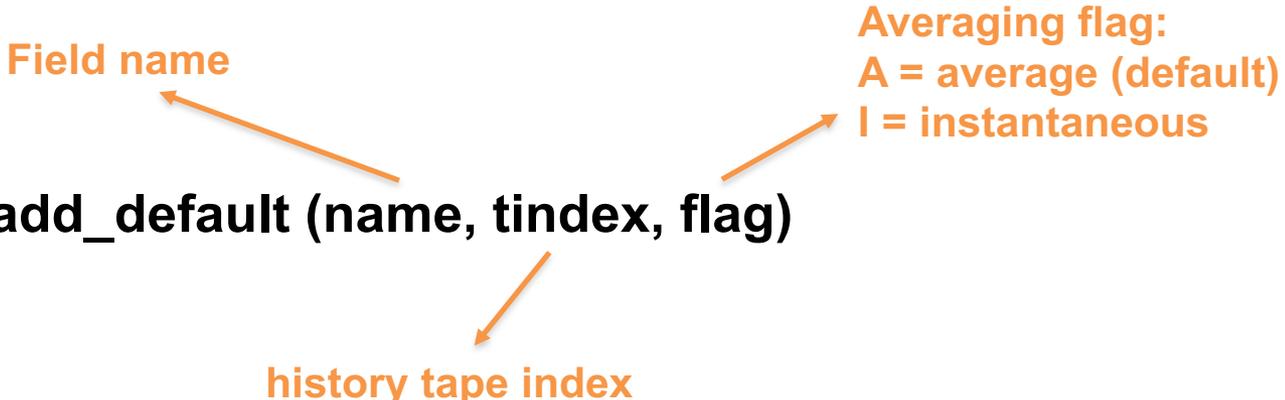
add_default = Add a field to the list of default fields on history file

Field name

**Averaging flag:
A = average (default)
I = instantaneous**

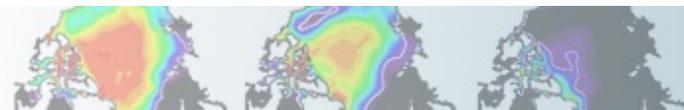
```
subroutine add_default (name, tindex, flag)
```

history tape index

A diagram with three orange arrows pointing from labels to parameters in the subroutine signature. One arrow points from 'Field name' to 'name', another from 'history tape index' to 'tindex', and a third from 'Averaging flag' to 'flag'.

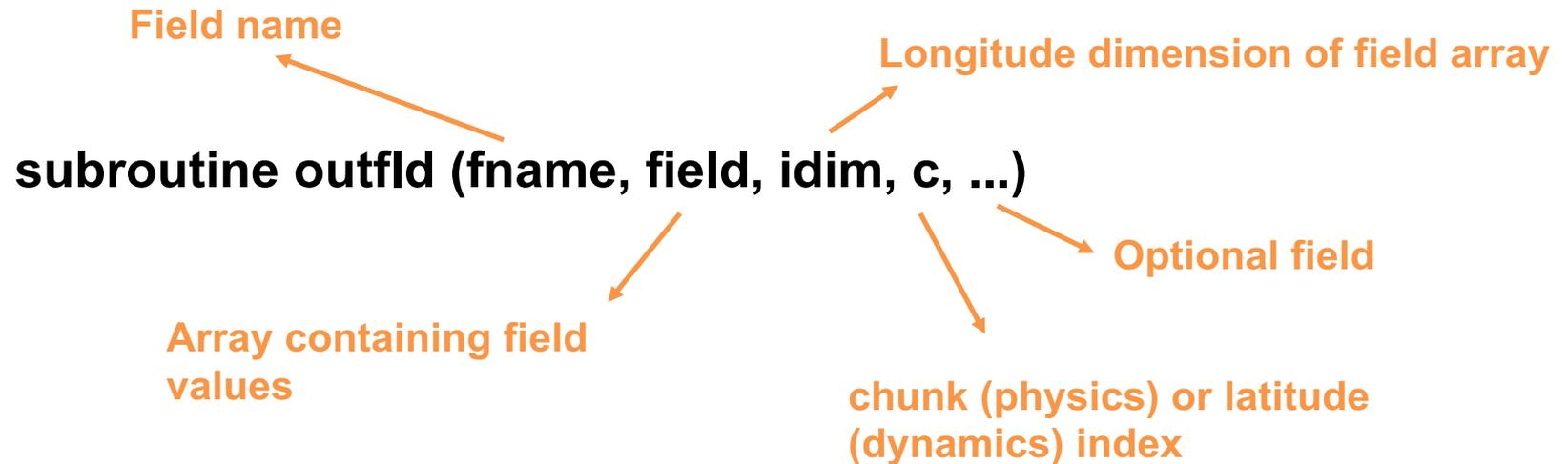
Example:

```
call add_default ('T500', 1, '')
```



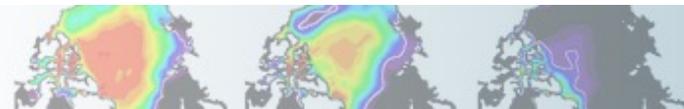
Syntax: outfld

outfld = accumulate (or take min, max, etc. as appropriate) input field into its history buffer for appropriate tapes



Example:

call outfld('T500', p_surf, pcols, lchnk)



Where to find help ?

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

Community Earth System Model CESM2



Current Releases

The latest CESM development release is CESM2.2.0
The latest CESM production release is CESM2.1.3

[LEARN MORE](#) [VIEW EXPERIMENTS](#) [DOWNLOADING INSTRUCTIONS](#)

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.

[View the CESM2 release series information to learn more](#)

[CESM2 RELEASE SERIES INFORMATION](#)

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 Experiments, Data & Diagnostic Output *
- CESM1 Experiment Diagnostics
- CESM Naming Conventions

* This page now contains links to datasets on ESGF, CDG, glade and NCAR HPSS as well as diagnostic plots and caseroof details.

★ Quick Start

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

📖 CIME Documentation

Common Infrastructure for Modeling the Earth

↔ Prognostic Components

Each model component page contains

CESM2 QUICKLINKS

CESM GitHub

CESM2.2 Quickstart Guide

CESM2.1 Quickstart Guide

Downloading Instructions

> Prognostic Components

CESM Software Engineering Group

Experiments, Data & Diagnostic Output

RELATED INFORMATION

Data Management & Distribution Plan

Development Project Policies & Terms of Use

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Mailing Lists

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Support Policy

CESM2.1 Quickstart Guide

CESM PROJECT

The CESM project is supported primarily by the National Science Foundation (NSF).

Administration of the CESM is maintained by the Climate and Global Dynamics Laboratory (CGD) at the National Center for Atmospheric Research (NCAR).

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 webpage is a gold mine for **model documentation**

If you cannot find an answer in the model documentation, post your question on the **DiscussCESM Forums**

Exercise Overview



- **Exercise 1: Namelist modification**
Customize your history output
- **Exercise 2: Namelist + Code modification**
Add a new output field to the code
- **Exercise 3: Change a tuning parameter**

Find the exercises, hints and solutions on the CESM tutorial webpage:

<https://www.cesm.ucar.edu/events/tutorials/2022/coursework.html>

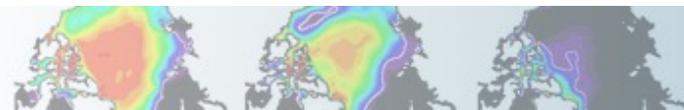
Reference, exercises and solutions



At the request of previous year students(*), I am providing:

- The current slides serve as **reference** while you do the exercises
- The **exercises** are in a separate document (easier to manipulate)
- That document also has detailed **solutions** to the exercises

(*): I truly value your feedback. Please feel free to reach with suggestions



Exercises and solutions



My own recommendation:

DON'T LOOK AT THE SOLUTIONS DURING THE LAB !!!

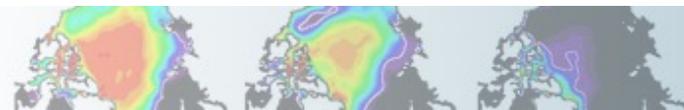


I believe:

- *“I can only show you the door. You're the one that has to walk through it”*
- **You will only learn if you try the exercises by yourself.**
- **You will only learn if you do mistakes.**
- **Copy/paste will teach you little, indeed.**
- **Your best bet is to try, do mistakes, ask your helper, interact with each others, look at the documentation, try to understand what is wrong...**

But this is my own opinion, and everybody learns differently.

So do what is best for you 😊





Before we start the lab

Let's make sure you update your profile to avoid `JOB_QUEUE` mistakes.

For `tcsh` users:

```
cp /glade/p/cesm/tutorial/tcshrc ~/.tcshrc  
source ~/.tcshrc
```

For `bash` users:

```
cp /glade/p/cesm/tutorial/profile ~/.profile  
source ~/.profile
```

If you have an existing `.tcshrc` and `.profile` file and do not wish to overwrite it, please open the file and edit the variable

```
TUTORIAL_QUEUE= R5498990
```

To run jobs after 5pm: *./xmlchange JOB_QUEUE=regular*