CIME Workflow Introduction and its usage in

Medium Range Weather Application 1.0 and S2S Application

https://github.com/ESMCI/cime

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Outline

- What is CIME
- What is the CIME Case Control System (CCS)
  - Usage of CCS in CESM and CMIP6
  - Usage of CCS in UFS – example workflow
  - Brief overview of CCS testing capabilities
- CIME workflow in UFS MR Weather App
- CIME workflow in UFS S2S App

What is CIME?

CIME is a collection of infrastructure utilities

(1) Case Control system
Workflow infrastructure for creating, configuring, building and running experiments
includes extensible system and unit testing framework

(2) Coupling Infastructure
NUOPC CMEPS
Community Mediator for Earth Prediction Systems

(3) Data Models
Hierarchical Model Development

(4) External Libraries
e.g. PIO, GPTL

(5) Other Tools
e.g. Statistical Verification Tool (PyCECT)

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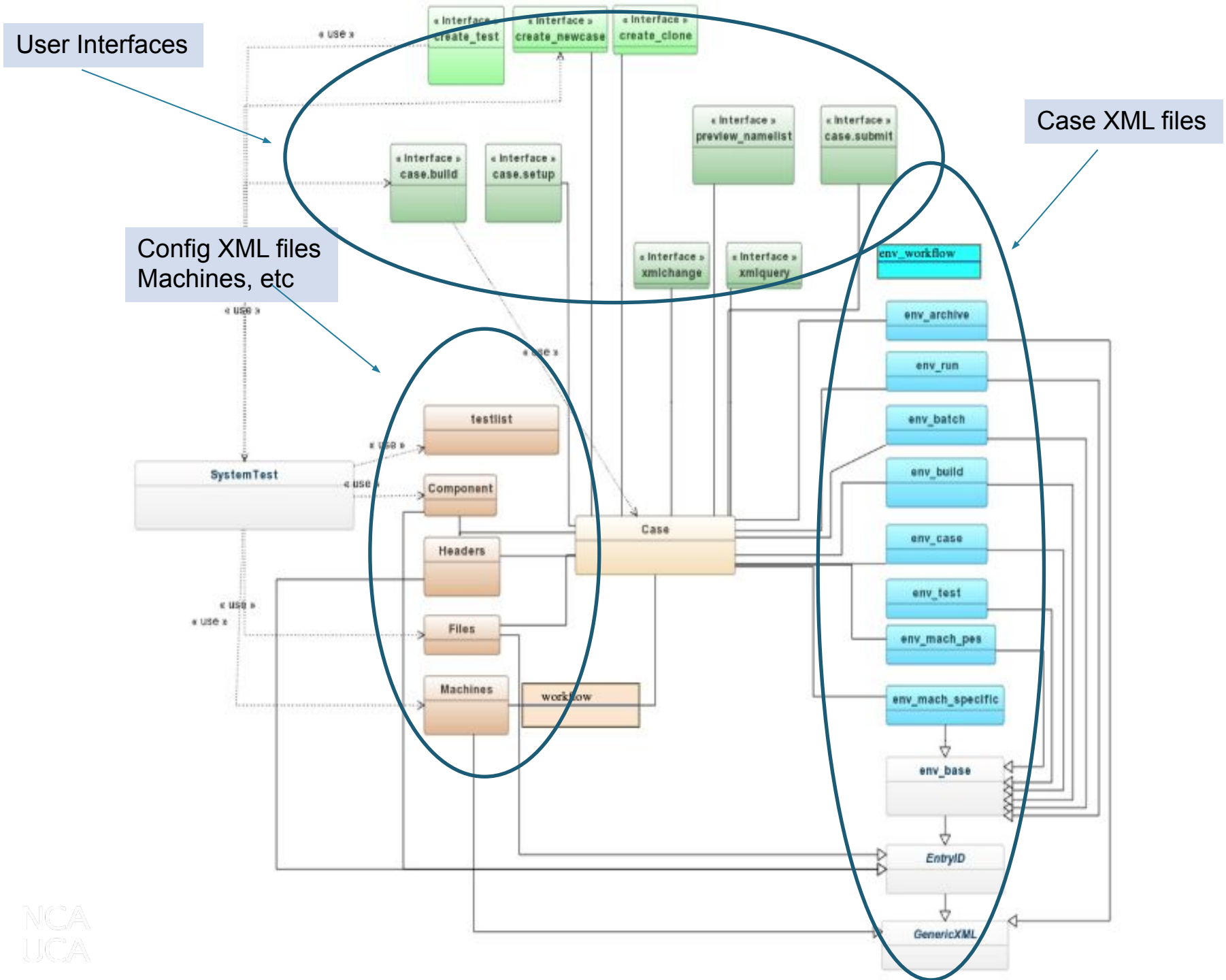
CIME Case Control System (CCS)

What is the CIME CCS?

- Provides a user-friendly, reproducible workflow for configuring, compiling and executing Earth system models.
  - **Experiments can be created, configured, built and run by invoking only 4 commands**
- Comprises an extensible set of coordinated object-oriented python scripts which uses a library of python objects along with data in xml to design, build and control the run of an earth system model experiment
  - Compatible with python2.7 and phython3
- Open collaboration on public GitHub repository to enable user-friendly workflows for ESMs
  - The CCS has been designed to facilitate and encourage community collaboration!
- Multi-agency
  - Fundamental to both CESM and DOE/E3SM, NORSC/NorESM and UFS MR Weather Application


User Interfaces
Case XML files
Config XML files
Machines, etc
« interface »
create_test
« interface »
create_newcase
« interface »
create_clone
« interface »
preview_namelist
« interface »
case.submit
« interface »
case.build
« interface »
case.setup
« interface »
xmlchange
« interface »
xmlquery
« use »
testlist
SystemTest
Component
Case
Headers
Files
Machines
workflow
env_workflow
env_archive
env_run
env_batch
env_build
env_case
env_test
env_mach_pes
env_mach_specific
env_base
EntryID
GenericXML

CIME CCS Capabilities

- User-friendly and standardized workflow for **BOTH** model development and production runs
- Capability to create **user customizations**
  - Input parameter and source code modifications
- Extensible set of **out-of-the box tested configurations**
- Experiment **provenance for reproducibility** and documentation
- Capability to **integrate with a workflow** engine or leverage its own workflow capabilities (e.g. UFS MR App)
- Facilitates **user-friendly port of model to new machines**
  - HPC, Linux clusters and even MAC laptops
- Leads to robust code base due to **CCS testing functionality**
  - CCS is testable via a stand-alone checkout of CIME
  - CCS also provides model component and coupled system testing capabilities
- Has extensive user documentation http://esmci.github.io/cime/

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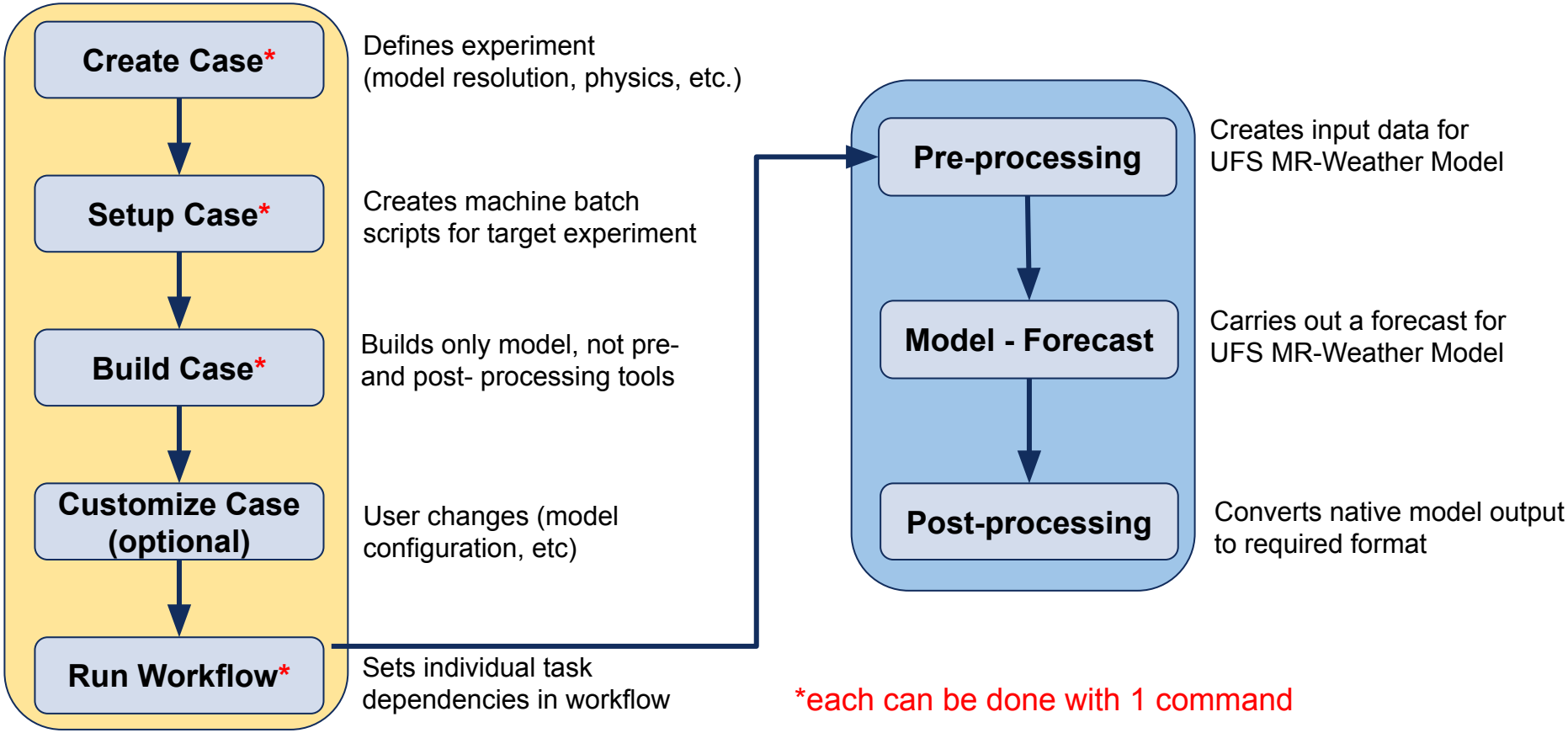
CCS Testing Capabilities

CCS provides an extensible system and unit test capability for:

- Verifying that restarts are bit-for-bit
- Determining model performance
- Verifying that pe-layout changes are bit-for-bit
- Verifying that threading implementation is correct
- Comparing against previous saved baselines (tracks if unexpected answer changes appear)
- Determining if memory leak is present
- Determining if code changes result in a performance degradation
- Tracking if model input parameter changes have occurred since last baseline

Workflow in UFS MR Weather App

Overview of UFS MR App workflow using CIME



*each can be done with 1 command

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Pre-processing

- *Pre-processor function*:
  - Conversion of raw input data to the required model input format, including change of resolution
  - Two raw input data formats are supported (NEMSIO, GRIB2)

- *CIME workflow:*
  - Automatically downloads necessary raw model input data to local disk (dependent on initial date requested)
  - Automatically generates the input parameters needed by the pre-processor (dependent on resolution and number of vertical layers)
  - Executes the pre-processor

Model Forecast With CIME Workflow

- Automatically creates experiment relevant model configuration settings
- Provides ability for user to customize the initialization date, forecast length, model parameters, processor layout, and other aspects of the run
  - Recognizes if this is a run that is continued from a previous startup
- Submits the forecast job to the batch system for execution
  - As part of submission, automatically stages all required input datasets (output from the pre-processor)

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Post-Processing

- The tool that is used by the workflow is the Unified Post Processor (UPP)
- It converts native NetCDF output from the model to the GRIB2 format on standard isobaric coordinates in the vertical
  - Also calculates additional diagnostic fields that are not part of model output
- The CIME workflow automatically creates the required scripts and necessary input for the UPP as part of the workflow

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UFS MR Weather Application

- Create MR Weather application

```
$ git clone -b ufs-v1.0.0 https://github.com/ufs-community/ufs-mrweather-app.git
$ cd ufs-mrweather-app
$ ./manage_externals/checkout_externals
$ cd cime/scripts
$ ./create_newcase --compset GFSv15p2 --res C384 --case ufs.mrweather-app.c384 --workflow ufs-mrweather
$ ./case.setup
```

Checkout app. (CIME, FV3)

CCPP GFSv15p2

resolution FV3 (C384)

workflow: CHGRES, forecast and GFS Post

- Change configuration

```
$ ./xmlchange JOB_WALLCLOCK_TIME=00:30:00
$ ./xmlchange USER_REQUESTED_WALLTIME=00:30:00
$ ./xmlchange DOUT_S=FALSE
$ ./xmlchange STOP_OPTION=nhours
$ ./xmlchange STOP_N=36
```

simulation length

- Build and run

```
$ ./case.build
```

```
$ ./case.submit
```

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Workflow in S2S Application

UFS S2S Application

- Create S2S application

```
$ git clone -b cmeps_v0.5.1 https://github.com/ESCOMP/UFSCOMP.git
$ cd UFSCOMP
$ ./manage_externals/checkout_externals
$ cd cime/scripts
$ ./create_newcase --compset UFS_S2S --res C384_t025 --case ufs.s2s.c384_t025 --driver nuopc --run-unsupport
$ ./case.setup
```

Checkout app.
(CIME, CMEPS, FV3, MOM6 and CICE)

resolution: FV3 (C384) and MOM6 & CICE (0.25º)

- Change configuration

```
$ ./xmlchange RUN_REFDATE=2012-01-01
$ ./xmlchange RUN_STARTDATE=2012-01-01
$ ./xmlchange JOB_WALLCLOCK_TIME=00:30:00
$ ./xmlchange USER_REQUESTED_WALLTIME=00:30:00
$ ./xmlchange DOUT_S=FALSE
$ ./xmlchange STOP_OPTION=nhours
$ ./xmlchange STOP_N=1
$ echo "ice_ic = \"\$ENV{UGCSINPUTPATH}/cice5_model.res_2012010100.nc\"" >> user_nl_cice
```

changes simulation start date

simulation length

changes ice initial condition

- Build and run

```
$ ./case.build
```

```
$ ./case.submit
```

CIME CCS and the Graduate Student Test

Measure of how successful the UFS project is in opening its code and development processes to the broader community.

How easily can a student:

- Get, build, run, and change code, test code for correct operation
- Evaluate code with standard diagnostic packages
- Get documentation, user support, and training
- For more information: https://ufscommunity.org/#/science/gst

Medium-Range Weather App GST

- Dorian example - default + change the CNN concentration
- Visually compare the total cloud cover field
- Fill out a questionnaire about the experience

Input from Neil Jacobs (who ran the Graduate Student Test for the UFS Medium-Range Weather App):

"After spending years playing with every model from MM5 and WRF to GFS, I can tell you this release is by far the most user friendly model I've ever run".

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Thank you!