CESM Tutorial

11 - 15 August 2014
NCAR Mesa Lab, Boulder, Colorado

The tutorial is targeted at graduate students who wish to learn how to run, modify, and understand climate models for scientific applications. The focus will be on the CESM. Specific content will be tailored to meet students' needs.

Application web page:
http://www.regonline.com/2014-cesm-tutorial

Application deadline is 28 February 2014.

CESM SSC requests from the working groups:

- Determine priorities for the next year,
- Provide timeline of model developments for CESM2, including desired path and fallback options.

Proposed Plan for CESM2 development and release from CESM SSC

Purpose: Release CESM2, with a number of supported configurations in June 2016. Supported configurations will include pre-industrial control simulations and 20th century runs.

Model configuration targets:

- "Bleeding edge" physical climate model version (with CAM6)
- Physical climate model with WACCM
- Carbon cycle / BGC model version with enhanced atmospheric chemistry coupling
- Coupled ice sheet integrations

Scientifically-supported BGC/chemistry, WACCM, and ice sheet configurations would use older atmospheric model version (CAM5+ updates if available, see timeline below);

Staggered development would occur between "bleeding edge" physical climate model version and other supported configurations. As such, CESM2.X for example, may include a supported BGC/chemistry model version with the CESM2 "bleeding edge" physical climate model components.

Note that additional research options will also be available within CESM2.

CESM2 Timelines Provided by SSC

Jan 2014-Jan 2015: Component model developments continue. Coupled simulations are performed regularly with new component developments to assess incremental coupled model performance.

Early 2015: CAM5+ model version finalized, subject to tuning modifications, for use in the WACCM, BGC/chemistry, and CISM configurations.

July 2015: Component models for CESM2 are nearly final, subject to modification (tuning) based on coupled model performance.

July-Dec 2015: Coupled model simulations with finalized components for different supported configurations are performed; Tuning/modification of component models will occur as needed to maximize coupled simulation quality.

Jan 2016: CESM2 supported configurations are finalized, including final parameter settings, etc. for different component models.

Jan-June 2016: PI control runs and 20th century runs performed for supported CESM2 configurations.

June 2016: CESM2 Model release; To include PI control run, 20th century run, AMIP runs for supported configurations (at a minimum).

Post-June 2016: CESM2 scenario runs (and others) performed.

UPDATE FROM THE OCEAN MODEL WORKING GROUP

A Blend of Recent Activities and Near-Term Priorities

OMWG Goals from January 2013 Meeting:

- Address some long-standing algorithmic shortcomings of the Parallel Ocean Program version 2 (POP2),
- Path towards considering MPAS-O for use in future CESM versions,
- Continue i) to develop new (or improve existing) subgridscale parameterizations and ii) to investigate causes of model biases (in POP2),
- Work / science with eddy-permitting ocean model version,
- Model metrics and diagnostics.

SSC requests from working groups: near-term plans; model metrics and diagnostics; and document model development process / protocols

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Options for Ocean Model Developments Towards CESM2 (DRAFT)

(nominal 1° version)

Time Frame: July 2015

TRACK 0: current POP2 (as in CCSM4 / CESM1) + bug corrections

TRACK 1: Track 0 +

- KPP and GM modifications to reduce Southern Ocean biases,
- Tidal mixing changes,
- Langmuir mixing and WaveWatch III,
- Anisotropic GM,
- Parameterization of land-ocean freshwater exchange,
- Near-inertial wave mixing parameterization*,
- Alternative diapycnal mixing parameterizations from CPT.

TRACK 2: Track 1 +

- z* vertical coordinate,
- True freshwater surface fluxes,
- Conservative Robert filter in time

Numerics (Yu-Heng, Mat, Matt, Gokhan, Keith, Frank, Steve

Z*; Robert; natural bc

New grids (horizontal and vertical grids)

Diabatic
SteveJ, Peter, Frank, Gokhan, Mike, Baylor, Matt, Bill, Markus

CVMix in POP2

Tidal; NIW in CVMix; any KPP changes; additional CPT param.

IDEMIX (?)

Langmuir (WaveWatch) Phase I (prognostic) Baylor

Langmuir (WaveWatch) Baylor Phase II (ustokesdiag, but not u*)

Adiabatic
Baylor, Peter, Gokhan, Matt, Moore,

GM mods

AnisoGM (constant K) Baylor

AnisoGM Baylor

Coupling and bc's Bill, Frank, Yu-Heng, Dave

Diurnal cycle for upper ocean

Estuary parameterization

Options for Ocean Model Developments Towards CESM2 (DRAFT)

(nominal 1° version)

Time Frame: July 2015

TRACK 3: MPAS-O

- Ensure CESMification (parameterizations, etc.),
- Computational performance improvements,
- Diagnostics,
- Scale selective parameterizations,
- Implications for BGC, sea-ice, etc.,
- ??

Options for Ocean Model Developments Towards CESM2 (DRAFT)

(high resolution version)

Time Frame: July 2015

TRACK 0h: Make ASD configuration (62 level) the default out-of-the-box

TRACK 1h:

- Bring diapycnal parameterizations in alignment with Track 1 x1 model as appropriate,
- Anisotropic GM as an initial step to scale adaptivity
- Online diagnostics of z- and sigma- overturning streamfunctions, MHT, MST

Options for Ocean Model Developments Towards CESM2 (DRAFT)

(high resolution version)

Time Frame: July 2015

TRACK 2h:

- Bring vertical grid and numerics in alignment with Track 2 x1 model,
- Very high (~150 level) vertical resolution version as a tool to explore higher vertical mode physics,
- Incorporate alternative diapycnal mixing schemes coming out of CPT facilitated by high horizontal and vertical resolutions,
- Incorporate sub-meso and MOLES sub-grid parameterizations.

TRACK 3h: Moving lessons learned form Tracks 0h to 2h into MPAS-O

Options for Ocean Model Developments Towards CESM2 (DRAFT)

(low resolution version)

Time Frame: July 2015

TRACK 01: University community input; Likely lead university community.

Ocean data assimilation capability via DART (Data Assimilation Research Testbed) for Tracks 0, 1, and possibly 2.

Data assimilation with high resolution Tracks 0h, 1h, and possibly 2h will partly depend on funding (*e.g.*, EaSM III).

Data assimilation for Tracks 3 and 3h (MPAS-O): ?

All tracks require progress on metrics and diagnostics!

MAJOR CHALLENGES:

- Resources: specifically, people – no science liaison and minimal ocean SE support

CESM Ocean Component (POP2) Metrics and Diagnostics

Part I: CURRENT PRACTICE

Part II: DESIRED REDESIGN AND IMPROVEMENTS

- Diagnostics to assess high-resolution simulations such as eddy kinetic energy, eddy length scales, etc.
- Add new metrics, incorporating new or updated observational data sets, including hydrography.
- Expand diagnostics to include seasonal cycle and longer term variability for relevant variables.
- Consider creating a summary table for a set of *primary* metrics as well as a list of potentially large biases that the user should be aware of.
- Water mass analysis to assess i) atmosphere-ocean partitioning of carbon and heat on decadal to centennial timescales, ii) global and basin scale distributions of volumetric temperature and salinity census.
- Sea surface height analysis, taking advantage of available observations.
- CFC analysis to assess i) ventilation (e.g., Southern Ocean), ii) CFC distributions as a proxy for other relevant tracers.
- etc.

Addressing some POP2 Algorithmic Shortcomings
led by LANL

Some algorithmic developments are needed in POP2 to address existing / emerging science applications. For example, for sea level rise studies and incorporation of a land-ice component in CESM, abandoning the virtual salt flux approach to represent the exchange of freshwater between the ocean and other model components is a needed model development. More frequent coupling of the ocean – than the current once-a-day coupling – allows for resolution of diurnal cycle and inertial periods. Accordingly, the OMWG decided to undertake the following developments:

i) implement the z*vertical coordinate to address the possibility of thin (in comparison to free surface displacements) uppermost layers,

ii) eliminate the virtual salt fluxes (and associated treatment for other tracers such as Carbon) in favor of true freshwater surface fluxes,

iii) modify the time stepping scheme to introduce a conservative Robert filter to facilitate high frequency coupling, i.e., order 1 hr.

Work has been continuing in all three items. Progress has been slow, but LANL is still committed to incorporating these developments in POP2.

MPAS-O Model Development: 2014 Tasks

1. Complete and analyze CORE-forced simulations at eddy-parameterized and eddy-permitting resolutions.
2. Build HPC-scalable ocean analysis and diagnostics package
3. Implement Lagrangian particles, i.e. “numerical” Argo floats
4. Continue effort to further improve computational performance.

Todd Ringler

Continuing Developments in POP2
NCAR and community collaborations

- Climate Process Team (CPT) on internal wave mixing,
- CPT on sea-ice heterogeneity and its impacts on oceanic mixing,
- EaSM project on topographic control of the Gulf Stream,
- NOAA WAVEWATCH III model is a component in CESM, communicating with POP2,
- Anisotropic GM (live ….. dead …… revived!)

- Community Ocean Vertical Mixing (CVMix) project,
- Southern Ocean Biases (EaSM MOBY),
- Parameterization of land-ocean freshwater exchange.

Community Ocean Vertical Mixing (CVMix) Project

Joint work between NCAR, LANL, and GFDL

Motivation: CVMix is a software package that aims to provide transparent, robust, flexible, well-documented, shared Fortran source code for use in parameterizing vertical mixing processes in numerical ocean models. …. CVMix modules are written as kernels designed for use in a variety of Fortran ocean model codes such as MPAS-O, POP, and MOM …. When mature, CVMix modules will be freely distributed to the community using open source methodology.

CVMix package is nearly complete,

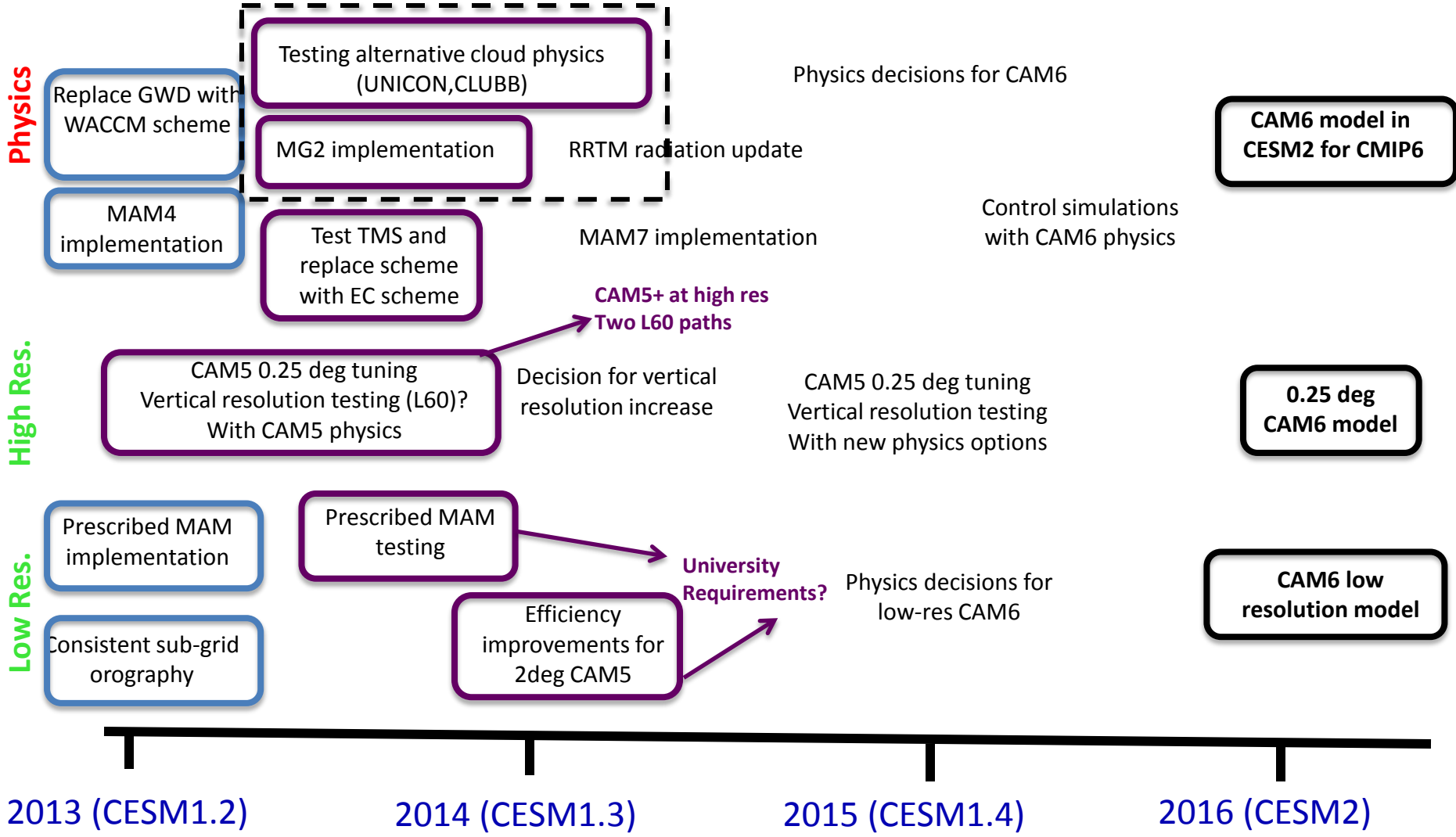
Includes changes from the original KPP scheme (software and redesign),

Implemented in MPAS-O, MOM6, and POP2,

Major testing in progress.

Example - CAM Development Timelines

The path towards CMIP6



(courtesy of Rich Neale)

Charge to Working Groups

CESM2: New science opportunities / draft science targets

- High level,
- Cross working group interests or something new for the CESM project,
- Complementing working group plans,
- Doable in the CESM2 time frame (a few years)

A few examples:

- Sea level change and land-ice – ocean interaction,
- Role of ocean in near-term (seasonal-to-decadal) climate variability,
- Model biases (possibly) impacting science to be done, e.g., Southern Ocean ventilation,
- ……