CSEG Update
Towards CCSM4 and Beyond

Mariana Vertenstein

CCSM Software Engineering Group

CSEG Members

Dave Bailey (CICE)

Tony Craig (CLP7, CCSM Performance/Porting, RACM)

Brian Eaton (CAM)

Chris Fischer (CCSM Testing/WACCM)

Brian Kauffman (Mapping/CLM-BGC/Data-Models)

Erik Kluzek (CLM)

Nancy Norton (POP)

Andrew Mai (CCSM Runs/Testing)

Mathew Rothstein (CAM, CCSM General)

Jon Wolfe (NRCM, CCSM Performance/Porting)

CCSM4 Script Enhancements

- Upgraded CCSM scripts
  - Now xml based
    - Auto-documentation of variables, grids, component sets, machines
  - More robust and extensible
    - Scripts now interact directly with CAM/CLM/CICE configure and build-namelist
    - More error checking of variables
  - Targeting a growing range of machines
    - BG/P and more linux clusters
    - Includes hybrid threading capability
  - Continue to extend CCSM test suite (e.g. memory/performance statistics now reported)

- Upgraded CCSM build
  - Permits use of only one Makefile in system
  - Now includes PIO/ESMF in build system
  - Now includes capability to build/run without MPI (serial mode)
  - IN PROGRESS: CAM and CLM migrating to CCSM Makefile

Runs are now easier to set up

- Created new input data subversion server
  - Before
    - model would crash as result of missing input data
    - Porting to new machines was very painful
  - Now
    - Components specify datasets needed for experiment
    - Scripts now check for existence of these datasets on local disk
    - Users can interact with input data server directly to automatically bring required datasets over to local disk
    - Greatly simplify port to new platforms
  - Plan to leverage this in CCSM4 release
- Create_production test accompanies every case
- Improved timing utilities help load balancing
- IN PROGRESS: documentation of new scripts

CPL7 Enhancements

- Introduced new "tri-grid" support
  - Previously atmosphere and land on same grid was hard-wired into coupler
  - Land and atmosphere can now be on different grids – ice and ocean must still be on same grid
  - Enables CAM on cubed sphere (HOMME and GFDL cubed sphere dycores) to couple with CCSM surface components
- Introduced new ice sheet component into CPL7
  - Will use this to advance work with GLIMMER
- Introduced new history/restart output capability
  - History output is CF compliant
  - All output now uses PIO
  - Can output averages and subsets of fields
- Introduced coupling to new components
  - Regional coupling to WRF/VIC on branch

CPL7 Enhancements (cont)

- Introduced new capability of interactive ensembles
  - (PetaApps - on high-res development tags)
- On the Horizon:
  - Incorporate ESMF compliant components interfaces
    - Each component will have new interfaces that are alternative to MCT (ESMF Stage 2 Effort)
  - New specification of fields that transferred between components
  - Incorporation of OpenMP in CPL7 code (and MCT)
  - Performance study of CPL7 (scaling, regridding,...)
  - Creation of CPL7 documentation (Reference/Users Guides)

CAM Enhancements

- Code Enhancements
  - New radiative constituents interfaces. Provides explicit specification (via namelist) of radiatively active gas and aerosol species and their optics.
  - New interface for specifying optical and microphysical properties of aerosol constituents.
  - Unification of CAM-Chem and the WACCM chemistry infrastructure.
  - New code for transient solar and eruptive volcanoes.
  - Dust and carbon deposition fluxes sent to the coupler.
  - New capability to run track1 (cam3.5.1) physics on unstructured grid. Needed to run AMIP simulations with the HOMME dycore.

CAM Enhancements (cont)

- Extension of Configure/Build/Run utilities
  - Supports backwards compatibility with old physics package (most importantly - "track1" physics)
  - Leverages the configure and build utilities of the CICE component (now the default CICE component in "stand-alone" CAM configuration)

- Scaling/Performance/Porting
  - Implemented PIO for history/restart output.
  - Implemented scalable reproducible distributed sums
  - Implemented support for using more processors for physics than dynamics
  - New support for BG/L and BG/P

- New Science
  - Cloud optics for RRTMG
  - Model Aerosol model
  - LLNL "super-fast" chemistry

Mapping Enhancements

- Using ESMF patch mapping files for atmosphere->ocn non-conservative mapping (improves curl of the wind stress)

- New scheme for land->ocean runoff smoothing (quicker to make, cheaper to use)

- Continuous science support - large number of new mapping files generated
  - Support for gx1v6, 1 degree tripole, .1 degree tripole

CLM Enhancements

- Infrastructure
  - Move users from CLM-only scripts to main CCSM scripts (new compsets)
  - New build-namelist system modeled after CAM
  - Add ability to easily set DATM data range in CCSM scripts
- DATM enhancements (important for model development)
  - Scale solar by cosine of solar zenith angle and ability to have different time-interpolation methods
- New Science
  - Dynamic land-use change and harvesting
  - Exchange dust and aerosol fluxes with driver
  - Addition of global urban model (always on now for all resolutions)
  - Increase soil layers from 10 to 15, new organic matter in soils
  - Incorporate SNICAR (SNow, ICe, and Aerosol Radiative model)
- Datasets
  - New Surface Datasets at all supported resolutions (including addition of glacier elevation classes)

CICE Enhancements

- **Functionality**
  - Finalized incorporation of CICE into CAM (as replacement to CAM-CSIM for prescribed SST/ICE-COV configuration)
  - New build-namelist and configure capability (more extensible and leveraged by both CCSM and CAM scripts)
  - Added new aerosols to model and implemented capability for prescribed aerosols deposition
  - Implemented multiple history output capability
- **Performance/Scalability**
  - Implemented OpenMP capability and carried out performance analysis
  - Implemented new timers (based on CCSM timing utility)
  - Optimized tracer performance
  - Implemented PIO for history/restart output
  - Implemented weighted space-filling curves (John Dennis, on high-res branch)

POP2 Enhancements

- New Functionality
  - double-precision time-averaged history files (aids testing/debugging)
  - time-manager unit tester
  - time-flags with reference/offset date
  - gx1v6 support
  - 1-degree tripole-grid support for testing purposes
  - CCSM-POP Developers' Guidelines document
 - space-filling curves (John Dennis)
- New Functionality in progress
  - validation of Open/MP (corrections to existing threading directives)
  - multiple time-averaged history file capability
  - LANL/CCSM POP2 infrastructure merge
  - PIO implementation for history/restarts
- New Science includes
  - overfows parameterization, submesoscale mixing, zenith angle dependent diurnal cycle, ice runoff, horizontally varying vertical background diffusivity in KPP, Langmuir parameterization

NRCM Developments

North East Pacific Grid (NEP4)

Final bathymetry at RHO-points   meter
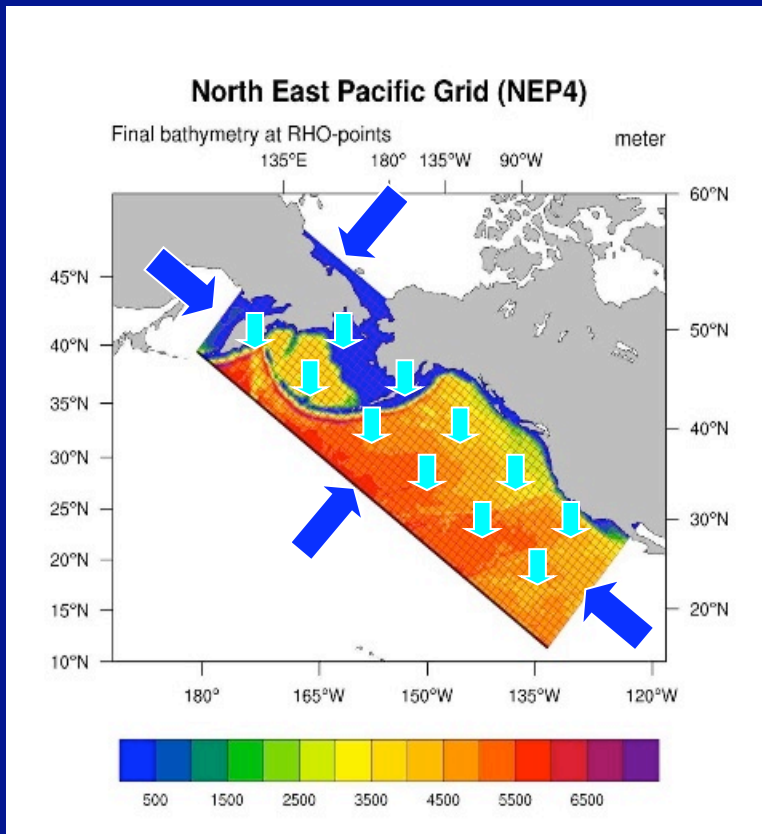
Ocean Lateral Boundary Data

Atmospheric Surface Data

- Goal – nest regional models inside a global climate model to resolve biases
- All work done in cpl6 framework
- Created OCN composite model, including routines to map data between POP and ROMS
- Added new communication path to get ATM data passed through the coupler to ROMS, including the capacity to pass more than one timestamp of data per day
- POP data now drives the ROMS lateral boundaries (2D and 3D data interpolation)
- ROMS now accepts forcing and control data from a run interface (instead of namelists and data files)
- Added merging algorithms to smoothly combine POP and ROMS SST data returned to coupler.
- Modified SCRIP to work with regional grids and two sets of masks.
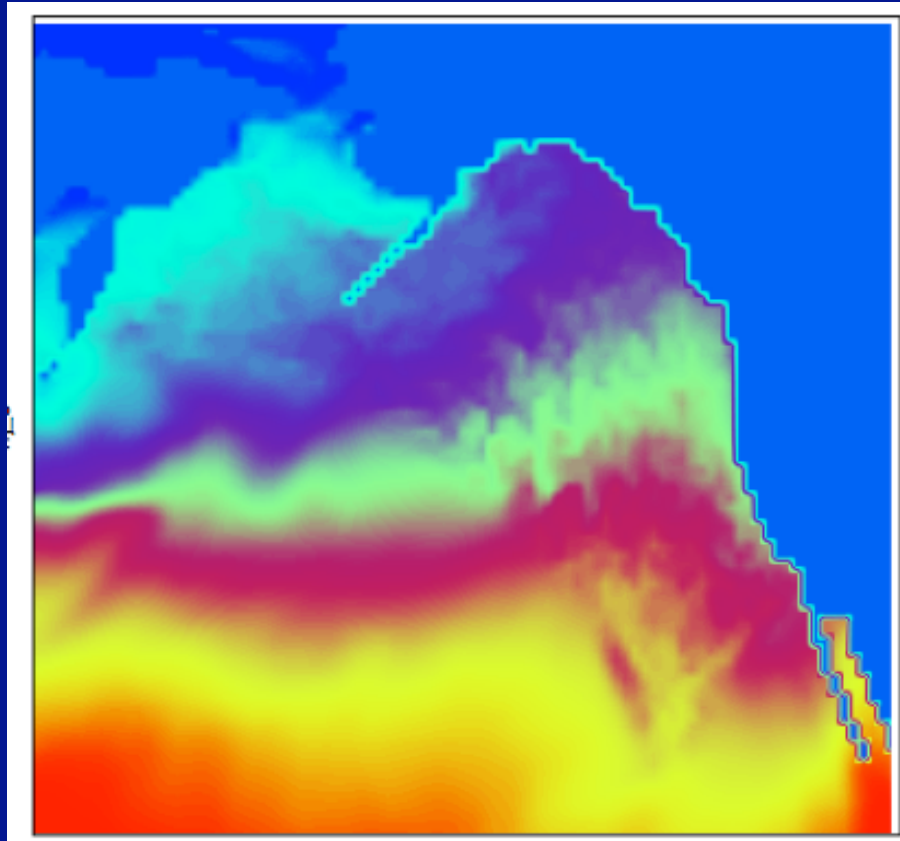
NRCM Data ATM forcing Experiment
T62_gx1 – 5 year run
Average OCN SST

Interactive Ensembles

NSF PetaApps proposal funded – three-year research and development effort, aimed at enabling a broad climate science capability for petascale systems
- Interactive ensembles using CCSM/CPL7
- Incorporate and examine use of PGAS language (Titanium) in CCSM
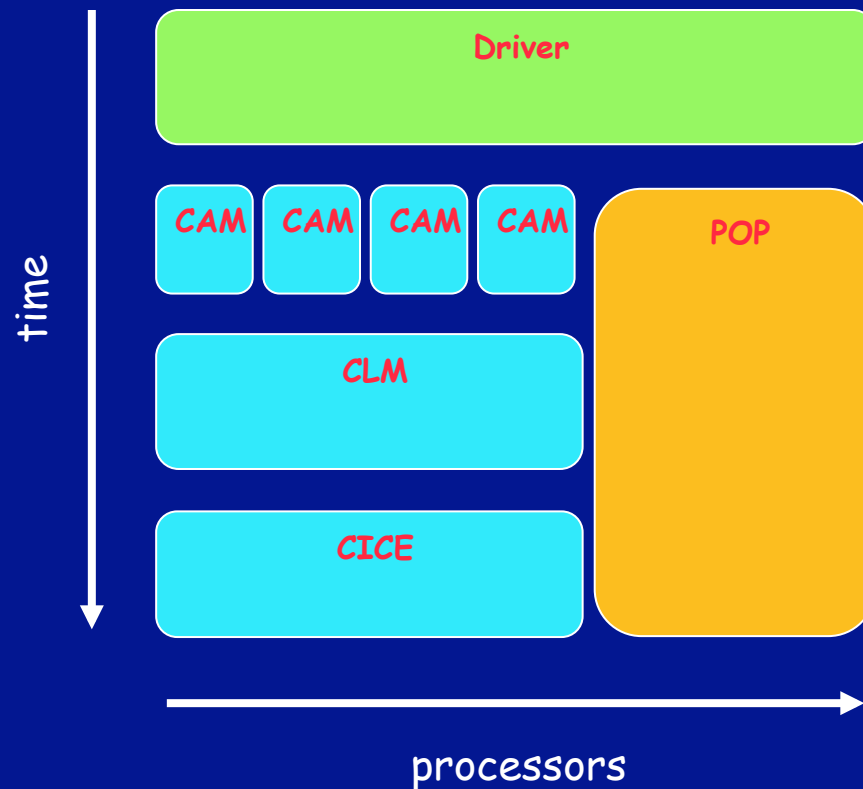
Interactive atmosphere ensembles integrated into cpl7 (extensible and minimally invasive design)

Will be used to understand how oceanic and atmospheric weather noise impacts climate variability

RACM

- RACM - Regional Arctic Climate Model (CCPP)
  - Mission: to develop a state-of-the-art Regional Arctic Climate system Model (RACM) including high-resolution atmosphere, land, ocean, sea ice and land hydrology components
  - CSEG is interacting on this project via work of Tony Craig
- Configuration:
  - Will include regional WRF, VIC (land), POP, CICE communicating via CPL7
- Challenges:
  - Dealing with regional grid issues including handling of non-overlapping grids, lack of wraparound points, and boundary conditions
- Status:
  - Working ongoing at ARSC, ported CCSM4 to midnight (SUN) and pingo (XT5.
  - Almost ready to test fully coupled arctic regional grid
  - Still work to do on mapping weights and other aspects to test "science"

Challenges

- BGC spin-ups
- I/O
  - Enable PIO throughout system (also PIO documentation, testing and support)
  - Design/implementation for asynchronous I/O
- High Resolution CCSM
  - Resolve restart issues, test routinely
  - New data model functionality will be needed to enable runs with Datm, Dice, Docn, Dlnd forcings at high resolution
  - Integration of PetaApps work into CCSM trunk
- GLIMMER development
- Integration of NRCM and RACM developments

Challenges (cont)

- ## IPCC Simulations
  - What code for CAM? What resolutions? Will need to ensure both robustness of code base and performance. Expanded and continual testing is becoming more and more critical.

- ## CCSM4 Release(s)
  - What should release process be? (svn instead of tar balls)
  - How can we provide more support?
  - How do we provide documentation (resources…)?