CESM2 Software Update

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Outline

- CMIP6 Computational Performance
- Cheyenne Status
- CESM2 new user-friendly infrastructure features
  - CIME
  - New porting capabilities with CIME
  - New Post-Processing capabilities
  - New Automated Workflow for CMIP6
## CESM2.0 Performance YS

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Resolution</th>
<th># of PEs</th>
<th>ThruPut yrs/day</th>
<th>Cost PE-hours/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully Coupled (B1850 case)</td>
<td>1-degree (f09_g16)</td>
<td>4224</td>
<td>22</td>
<td>4563</td>
</tr>
<tr>
<td>Ocean Spinup (GECO case)</td>
<td>1-degree (T62_g16)</td>
<td>1616</td>
<td>84</td>
<td>927</td>
</tr>
<tr>
<td>Land Spinup (I case)</td>
<td>1-degree (f09_g16)</td>
<td>2432</td>
<td>161</td>
<td>368</td>
</tr>
<tr>
<td>WACCM/DOCN (FW1850 case)</td>
<td>1-degree (f09_f09)</td>
<td>9600</td>
<td>6</td>
<td>33086</td>
</tr>
</tbody>
</table>

Ocean spinup: 2000 years  Land spinup: 1000 years

http://www.cesm.ucar.edu/models/cesm2.0/timing2.0/
http://www.cesm.ucar.edu/models/cesm2.0/timing2.0-spinup/

Current work is ongoing to optimize cheyenne performance
Cheyenne Status- CESM2.0 Code Base

- **Porting Status:**
  - CESM2.0 code ported to cheyenne

- **Testing:**
  - all system regression tests done on yellowstone are also done on cheyenne

- **Creating cases:**
  - scripts no longer need a machine name – auto-detect the platform
  ```
  ./create_newcase --case foo --compset B1850 --res f09_g16
  ```
Cheyenne Status – Older Code

- Following has already been ported:
  - Large Ensemble (LENS) configuration
  - Several other ASD configurations

- Following will be ported as early as possible – but likely after the release
  - CESM1.0.x
  - CESM1.2.2
  - Last Millennium configuration (LME)

- Only scientifically supported configurations will be tested as part of the port

- README will be provided for users to port other configurations (e.g. beta tags)

- CESM Forum will be monitored to answer questions on porting problems
Porting
CIME
(new python-based CESM infrastructure)

Infrastructure
PUBLIC Open Source Github Repository

Paradigm for DOE, NOAA, NSF Infrastructure Collaborations
Driver-Coupler Data Models Scripts System/Unit testing Mapping Utilities

Science code Restricted or Public Repositories

CESM DOE/ACME ESPC and/or NOAA/NEMS

addresses needs of multiple efforts
CESM2 Porting

- CIME will make porting to other platforms MUCH easier in CESM2 and beyond

- **Improved porting process** will make it easier for community to port to different machines (linux clusters, laptops, …)

- **Improved porting verification** leverages CIME ensemble consistency tests
Software Quality Assurance for CESM

**Goal:** Insure that changes during the CESM development life cycle do not *adversely* affect the results!

If \( X \neq \tilde{X} \), is the new result correct?

Is the new data *statistically distinguishable* from the original?
CESM-ECT Suite of Tools

<table>
<thead>
<tr>
<th>Tool</th>
<th>Target Module</th>
<th>Ensemble Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAM-ECT</td>
<td>CAM, CLM</td>
<td>annual average</td>
</tr>
<tr>
<td>UF-CAM-ECT (&quot;ultra-fast&quot;)</td>
<td>CAM, CLM</td>
<td>9th timestep</td>
</tr>
<tr>
<td>POP-ECT</td>
<td>POP, CICE</td>
<td>monthly average at month 12</td>
</tr>
</tbody>
</table>

- used routinely for CESM port-verification
  - (new machines/compilers)
- uncovered multiple errors in software and hardware stack
  - (expect *pass* but get *fail*)
- modifications expected to be climate-changing will *fail* the test

**Take away:** enables “letting go” of bit-for-bit reproducibility!
Post Processing and Diagnostics
CESM Post-Processing Tools

- New user-friendly integration of post-processing diagnostics into CIME experiment cases
  - Diagnostics (for atm, Ind, ice, ocn) are now parallel and much faster:
  - CMIP6 features have been added – transformation to CMOR compliant output
  - Regularly used on yellowstone and cheyenne for CESM2.0 development and ASD experiments

- CESM2.0 support:
  - Will be supported on yellowstone and cheyenne for the CESM2.0 release.
  - Support for other platforms will follow in post-release updates.

https://github.com/NCAR/CESM_postprocessing
create_postprocess
New command included with the CESM_Postprocessing Tools

create_newcase --case mycase --compset B1850 --res r09_g16

mycase

create_postprocess --caseroot mycase

mycase/postprocess

case.submit

case.run

case.st_archive

atm/hist

atm/averages

atm_diagnos2cs

Ind/hist

Ind/averages

Ind_diagnos2cs

rof/hist

ice/averages

Ice_diagnos2cs

ice/hist

ocn/averages

ocn_diagnos2cs

ocn/hist
Workflow
CMIP6 CESM Workflows Using Cylc

Provides an interface and workflow manager where users can run an entire CESM experiment suite and post process data automatically with only a couple of clicks.

- CESM2.0 support:
  - Cylc is installed on both yellowstone and cheyenne.
  - For CESM 2.0 will provide users with tools that automatically generate basic Cylc suites that users can run on yellowstone and cheyenne.
  - More general support for non-NCAR platforms will following in subsequent release updates.

https://github.com/NCAR/CESM_WF

The ability to automate the postprocessing, via clyc, while performing the runs has enabled us to complete 1,240 out of 1,860 total runs ~750 TB timeslice output - in about 1 month. Identifying and restarting failed submissions was trivial.
Cylc workflow manager

- mycase
- mycase/postprocess
- mycase/cylc

Cylc sends Autom2c Email status updates

Diagram:
- case.submit
- case.run
- case.st_archive
  - atm/hist
  - ice/hist
  - ocn/hist
  - Ind/hist
  - rof/hist
- atm/averages
- ice/averages
- 2meseries
- ocn/averages
- Ind/averages
- atm_diagnos2cs
- ice_diagnos2cs
- ocn_diagnos2cs
- Ind_diagnos2cs
Acknowledgements

- **CIME**
  - DOE: Jim Foucar, Rob Jacob, Jason Sarich, Andy Salinger, Andreas Wilke, Michael Deakin
  - NCAR: Jim Edwards, Bill Sacks, Alice Bertini, Chris Fischer, Kate Thayer-Calder

- **CECT (pyCECT)**
  - Allison Baker, Dorit Hammerling, Dan Milroy

- **Post-Processing and Workflows**
  - Alice Bertini, Sheri Michelson, Kevin Paul

- **Performance Optimization**
  - John Dennis, Brian Dobbins, Jim Edwards, Chris Kerr, Younsung Kim, Raj Kumar, Sheri Michelson
Configure/Build/Testing/Archiving Scripts
all python based as of CIME5

Mapping weight generation and checking tools
(ESMF_Regrid and runoff map maker)

Statistical Verification Tool (PyCECT)

Workflow Tool (Cylc)

Post Processing/ Diagnostics

Data Models

Driver/Coupler

Externals

PIO

MCT

Timers