Coupling MOM6 in CESM
Software Challenges and Advances

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The current state of MOM6 in CESM

- MOM6 is fully incorporated in CESM testing and tagging workflow/database.
- A functional release in upcoming CESM 2.2.
  - Not fully scientifically vetted.

- What’s currently available:
  - **Compsets:** CMOM, GMOM, BMOM
  - **Drivers:** MCT, NUOPC
  - **Grids:**
    - tx0.66v1 (*workhorse*)
    - gx1v6 (*testing only*)
    - tx0.25v1 (*testing only*)
CESM Component Sets

CMOM
COMPSET

CESM
MCT/NUOPC

ATM
datm
ICE
dice
OCN
MOM6

LND
ROF
drof
WAV
GLC
ESP

Active component
Data component
Stub component
CESM Component Sets

CESM

GMOM

COMPSET

LND

ROF
drof

GLC

ESP

ATM
datm

ICE
CICE

OCN
MOM6

WAV

Active component
Data component
Stub component

Coupling MOM6 in CESM
CESM Component Sets

BMOM COMPSET

- ATM CAM
- ICE CICE
- LND CLM
- OCN MOM6
- WAV
- ESP
- GLC CISM
- ROF MOSART
- ICE CICE

Active component
Data component
Stub component

Coupling MOM6 in CESM
Collaboration with the MOM6 community

- CESM
  - MOM_interface
    - superstructure & configs
  - NCAR/MOM6
    - core & caps
  - MOM6-examples
    - configs
  - GFDL/MOM6
    - core & caps
    - git fork
  - other MOM6 community forks
    - git fork

Coupling MOM6 in CESM
Coupling MOM6 in CESM: Activities and Milestones

Project start

- Project start
- MCT cap
- MOM interface
- NUOPC cap
- MOM_RPS
- CVMix
- BMOM
- GM-E
- Lateral parameterizations
- CESM2.2 config.
- CSEG integr.
- comp. opt.
- CESM2.2 config.

Timeline:
- 07/’17
- 01/’18
- 07/’18
- 01/’19
- 07/’19
- 01/’20
- 07/’20

Colors:
- Pink: coupling
- Purple: infra/superstructure
- Orange: parameterization
- Blue: configuration
Software Challenges

▶ A collaborative effort across multiple institutions:
  ▶ occasional differences in conventions, standards, and priorities.
▶ Actively evolving codebases:
  ▶ MOM6 – new science and parameterizations. 1.5k commits per year.
  ▶ CIME – active development
  ▶ NUOPC and CMEPS: a brand new coupling infrastructure.
▶ Implementation discrepancies between FMS and CESM:
  ▶ time manager, i/o, model constants, etc.
▶ Lack of flexible and versatile diagnostics and analysis tools.
Things that helped

- Open development – supported by both NCAR/CESM and GFDL
  - GitHub

- Active and vibrant MOM6 community
  - e.g., weekly meetings with GFDL and broader MOM6 community.
    - discussions, code reviews, troubleshooting, etc.

- CSEG’s well-established development workflow and tools.
  - CESM testing and tagging workflow
  - CIME infrastructure
Our priorities:

- Correctness first.
  - Rigorous testing at every stage of development.
  - Utilize both CESM and GFDL’s MOM6 testing capabilities.
  - *Formal Methods* to verify a fix in KPP implementation of MOM6.
    

- Separation of concerns.
  - As evident in the repository structure at the highest level.

- Support diverse scientific and practical choices via modularity.
  - MOM6 accommodates a diverse set of physics, parameterizations, vertical coords, etc.
  - Each institution implements its own collection of configurations.

- Optimization
  - A recent addition to our priorities.
  - In collaboration with CISL.
Example: MOM6 Runtime Parameter Management in CESM

▶ **Goal:**
  ▶ Define and maintain out-of-the-box configs of MOM6 within CESM.
  ▶ Find a common ground between conventional MOM6 approach and CESM.
  ▶ Address complex interdependence between MOM6 parameters and CESM parameters.

▶ **Approach:**
  ▶ Repurpose conventional MOM6 input parameter files.
  ▶ **MOM_RPS**: A Python module that generates MOM6 runtime input files.
    ▶ Invoked by CIME.
    ▶ Conditionals and formulas that use arbitrary Python expressions.
    ▶ CSEG is currently exploring the potential adoption by other components.
Example: MOM6 Runtime Parameter Management in CESM

**input parameter template definition:**

```
DT_THERM:
$OCN_GRID == "MISOMIP": 1800.0
else: >
    = ( ( $NCPL_BASE_PERIOD == "decade" ) * 86400.0 * 3650 +
      ( $NCPL_BASE_PERIOD == "year" ) * 86400.0 * 365 +
      ( $NCPL_BASE_PERIOD == "day"  ) * 86400.0 +
      ( $NCPL_BASE_PERIOD == "hour" ) * 3600 ) / $OCN_NCPL
```

```
OCN_GRID=tx0.66v1, NCPL_BASE_PERIOD="day", OCN_NCPL=24
```

```
DT_THERM = 3600.0
```
Remarks

- A functional MOM6 release in upcoming CESM 2.2.
- Online user manual: “MOM6 in CESM”:
  - https://github.com/ESCOMP/MOM_interface/wiki
- MOM6 webinar series (04/13/20 - 08/03/20)
  - Tutorials, science talks, case studies.
- Ongoing activities:
  - Improve GMOM and BMOM.
  - Incorporate MARBL (BGC).
  - More parameterization-related developments.
  - Regional applications and simpler models.
  - Computational optimizations.
Thanks!

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