# Coupling MOM6 in CESM

Software Challenges and Advances

G.Marques,	Alper Altuntas S.Bachman, F.Bryan, G.Danabasoglu, K.Lindsay, M.Vertenstein, J.Edwards et al. National Center for Atmospheric Research
NCAR	2020 CESM Workshop – SEWG Meeting
JCAR	June 17, 2020

#### 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**





#### **CESM Component Sets**





#### **CESM Component Sets**





## Collaboration with the MOM6 community





# Coupling MOM6 in CESM: Activities and Milestones





#### 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.
    - "Hybrid Theorem Proving as a Lightweight Method for Verifying Numerical Software, Altuntas and Baugh (2018) "
- 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 == "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! altuntas@ucar.edu

