Coupling MOM6 in CESM

Software Challenges and Advances

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The current state of MOM6 in CESM

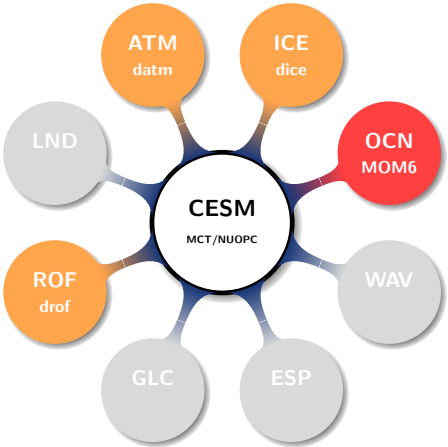
- MOM6 is fully incorporated in CESM testing and tagging workflow/database.
- A *functional* release in upcoming CESM 2.2.
  - Not fully scientifically vetted.

- 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

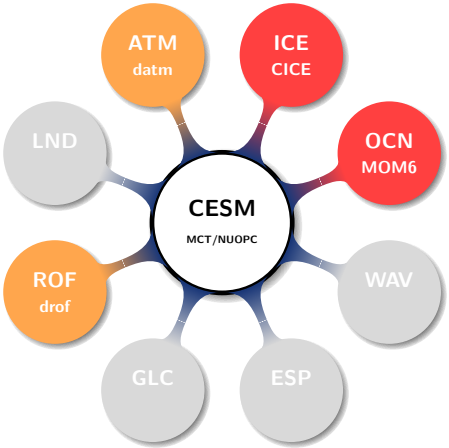
CMOM
COMPSET



- Active component
- Data component
- Stub component

CESM Component Sets

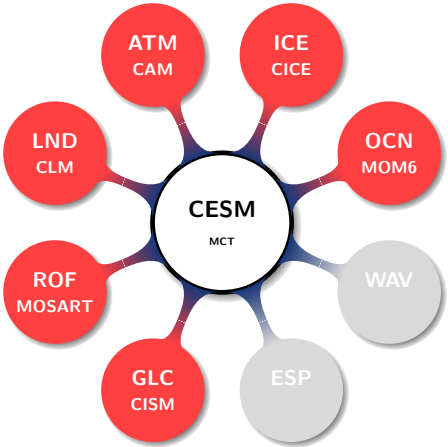
GMOM
COMPSET



- Active component
- Data component
- Stub component

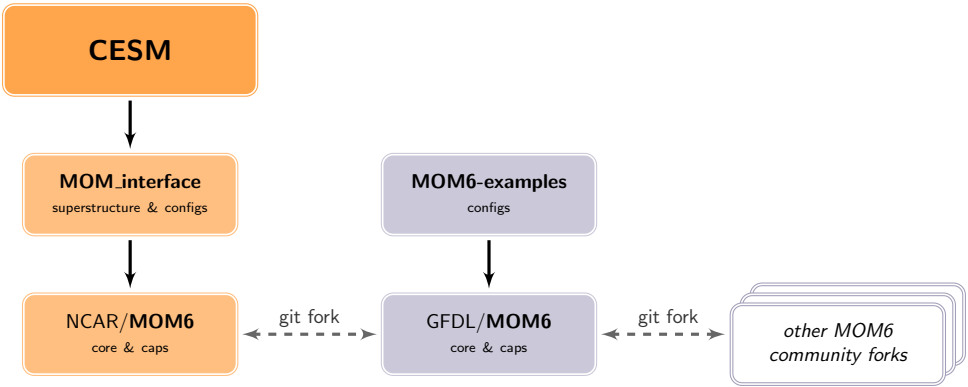
CESM Component Sets

BMOM
COMPSET

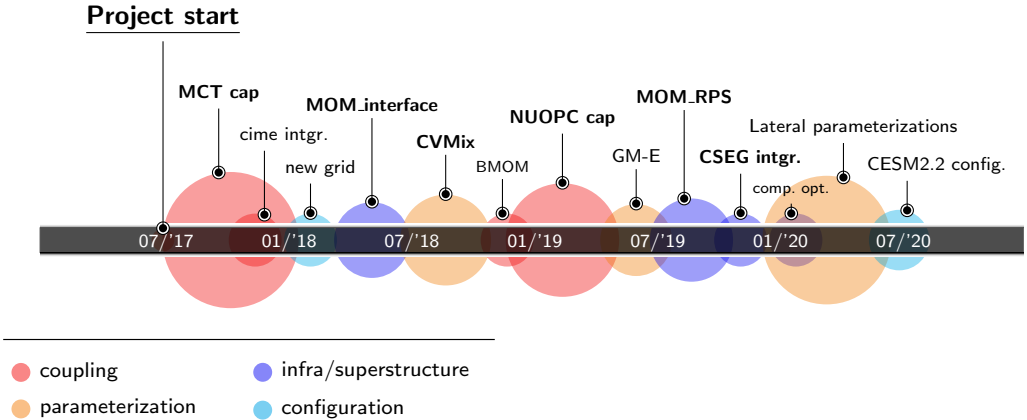


- Active component
- Data component
- Stub component

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 =="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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