MOM6, SIS2 and OM4
(ocean-ice components of CM4)

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Contributions from Hallberg, Griffies, Zhang, Dunne, Winton, and the rest of the MOM6 and OWG teams
Modular Ocean Model, version 6 (MOM6)

- MOM6 unified the efforts of MOM4/5 and GOLD
  - Open development philosophy
  - Community model
    - Adopted by NCEP, NCAR, Universities, ...
- Arbitrary Lagrangian Eulerian method in the vertical
  - Used for general & hybrid coordinates
  - Lagrangian-remap method
  - Unconditionally stable and accurate
  - Wetting/drying
  - Reduced spurious heat uptake
- Global ice-shelf/ocean coupling
  - Requires ALE for wetting/drying
- Energetically consistent closures
  - Internal wave driven mixing (CPT)
  - Community software (CVmix)
  - Eddies in eddy-permitting models
  - Second order mesoscale closure
- Boundary layer physics
  - Mixed layers
  - Overflows
- Numerics and formulation
  - Transport schemes, Solvers
  - Dynamically integrated sea-ice
  - Reduced cost of bio-tracers
Sea-Ice Simulator, version 2 (SIS2)

- C-grid for compatibility with ocean
  - Permits single point channels
- Improved thermodynamics and radiative transfer (following CICE / IcePack)
- Can carry tracers
  - Evolving sea-ice salinity, ice age, ...
- Improved conservation
- Improved numerical stability
- Improved coupled stability
MOM6 open development via GitHub

- Developing MOM6 on GitHub has removed barriers to collaboration
- Complete openness has attracted partners
- Continual + independent development
  - No “release delays”
- Numerous activities
  - 89 forks (as of Oct ‘19)
  - 5 major hubs/partners
MOM6 collaborations

GODAS
SST (same scale)

1° MOM3 (circa 1999)

Hybrid-GODAS

GODAS

1/4° MOM6 (OM4 configuration, 2018)

1/12° MOM6 (GFDL)

NOAA-EMC

NCAR

Rutgers
FSU/Navy

ESPC

Courtesy Yan Xue, NCEP-CPC

Courtesy Gustavo Marques, NCAR

Alan Wallcraft, FSU

CCS from Curchitser & Hedstrom, Rutgers/UAF

HYCOM 1/12°

MOM6 1/12°

Geophysical Fluid Dynamics Laboratory Review
October 29-31, 2019
OM4.0: Resolution and DWBC

• Justification for $\frac{1}{2}^\circ$ and $\frac{1}{4}^\circ$ horizontal resolutions

Horizontal speed at 2500m depth [m/s]
OM4.0: Benefits of new algorithms

- Hybrid vertical coordinate significantly reduced spurious heat uptake

Horizontally averaged potential temperature change over 5 cycles of CORE-IAF

OM4 paper (Adcroft et al., 2019)
OM4.0: Role of eddies

- Transition of laminar to eddying motion at mid-latitudes happens between $\frac{1}{2}^\circ$-$\frac{1}{4}^\circ$ resolutions
- Mesoscale eddies partly control ocean heat uptake
  - parameterize at coarse resolution

OM4 paper (Adcroft et al., 2019)
Future directions: OM4.1 & fine resolution

• OM4.1 and fine-resolution
  • Scale aware parameterizations to unify physics of OM4 configurations across resolutions
  • Require finer than 1/8° to permit some ice-shelf cavities
  • Require < 1km resolution near grounding line

• Planning a hierarchy of fine resolutions starting with 1/8°
  • Better resolution of mesoscale at high latitudes
Future directions: MOM6 regional modeling

- Regional climate impacts / Process studies / Hi-res development
- Exploratory development in collaboration with Rutgers group
Summary

• MOM6 has grown up into a community model
  • NCEP, NCAR, Universities, ...

• Open development paradigm has resulted in multiple productive collaborations on both code and science

• Latest generation of ocean configurations (OM4.0):
  • Reduced spurious heat uptake
  • Better representation of mesoscale eddies
  • Reduced biases

• Future directions include
  • Continued improvement of global configurations
  • Fine-resolution global simulation with ice-shelf interactions
  • Regional MOM6 capability and applications