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

Presented by
Alistair Adcroft (CIMES)

Contributions from Hallberg, Griffies, Zhang, Dunne, Winton, and the rest of the MOM6 and OWG teams

Geophysical Fluid Dynamics Laboratory Review

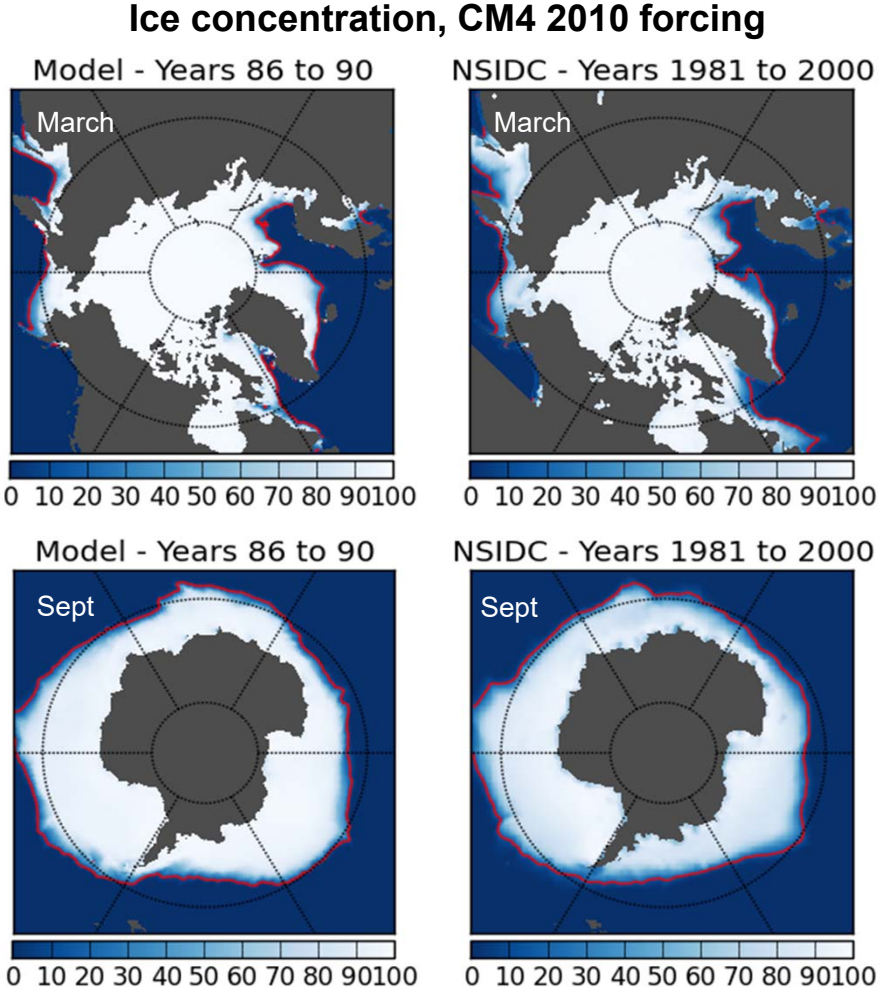
October 29-31, 2019

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

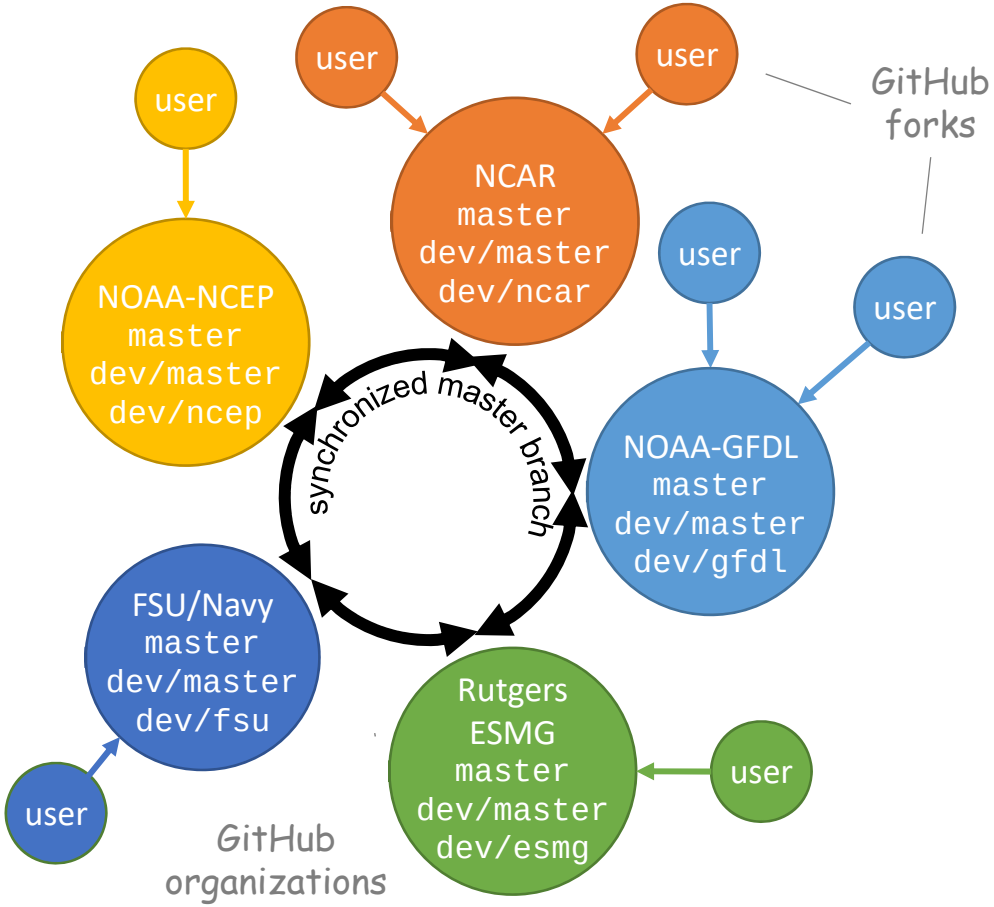
Sea-Ice Simulator, version 2 (SIS2)

- 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

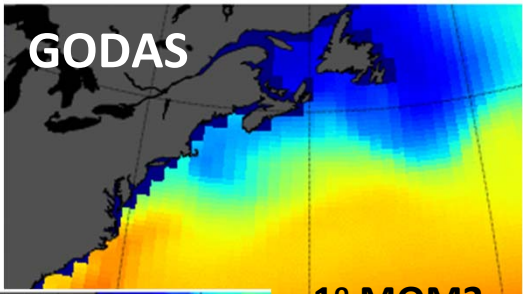


MOM6 open development via GitHub

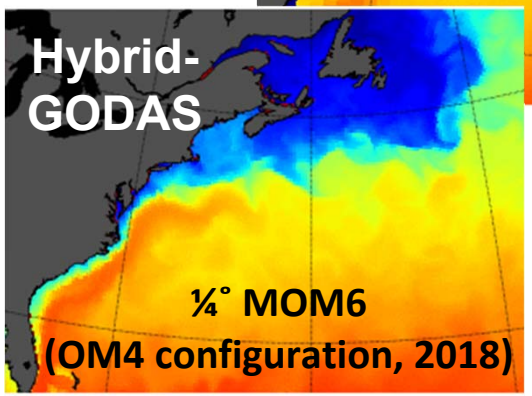
- Developing MOM6 on **GitHub** has removed barriers to collaboration
- Complete openness has attracted partners
- Continual + independent development
  - No “release delays”
- Numerous activities
  - 89 forks (as of Oct ‘19)
  - 5 major hubs/partners



MOM6 collaborations

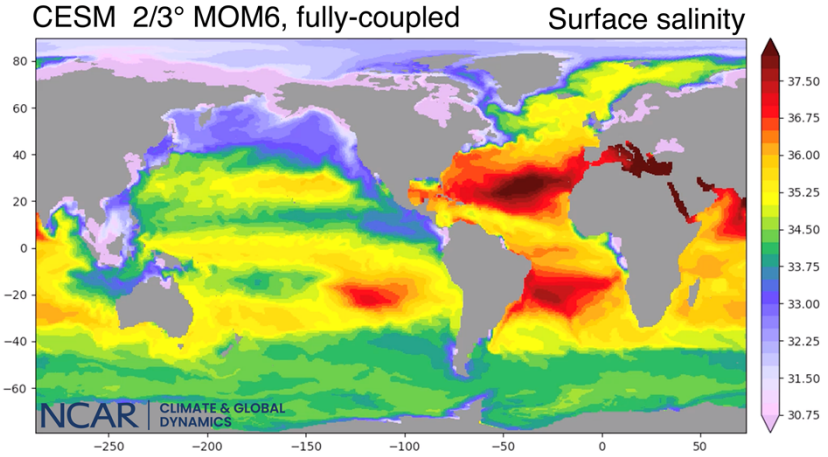


SST
(same scale)



Courtesy
Yan Xue, NCEP-CPC

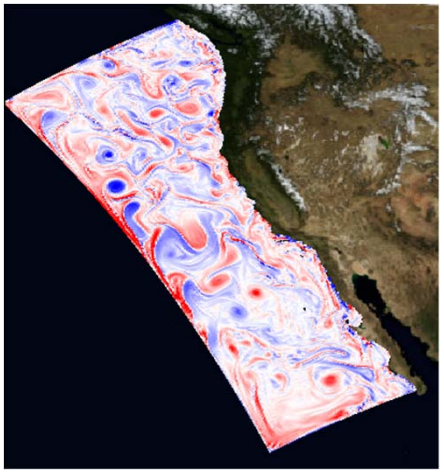
Courtesy *Gustavo Marques*, NCAR



NOAA-EMC

NCAR

MOM6
(GFDL)

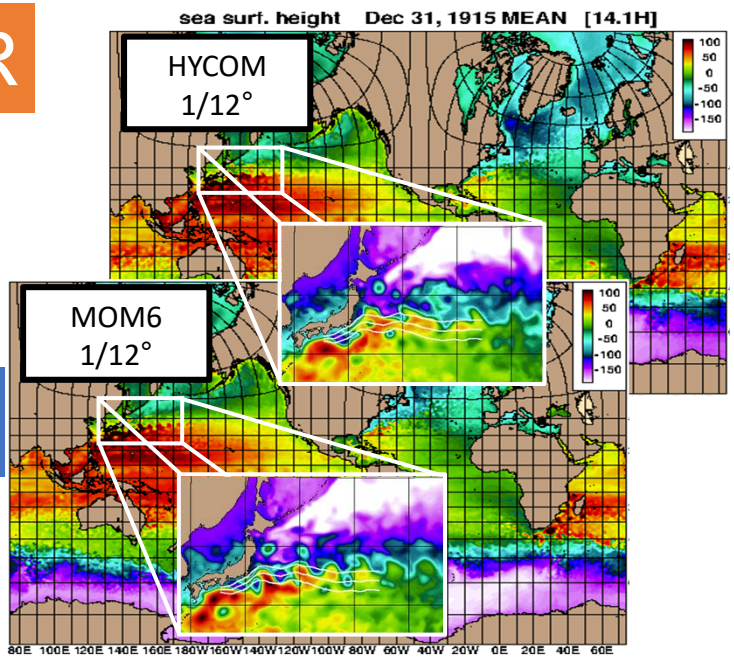


Rutgers

FSU/Navy
ESPC

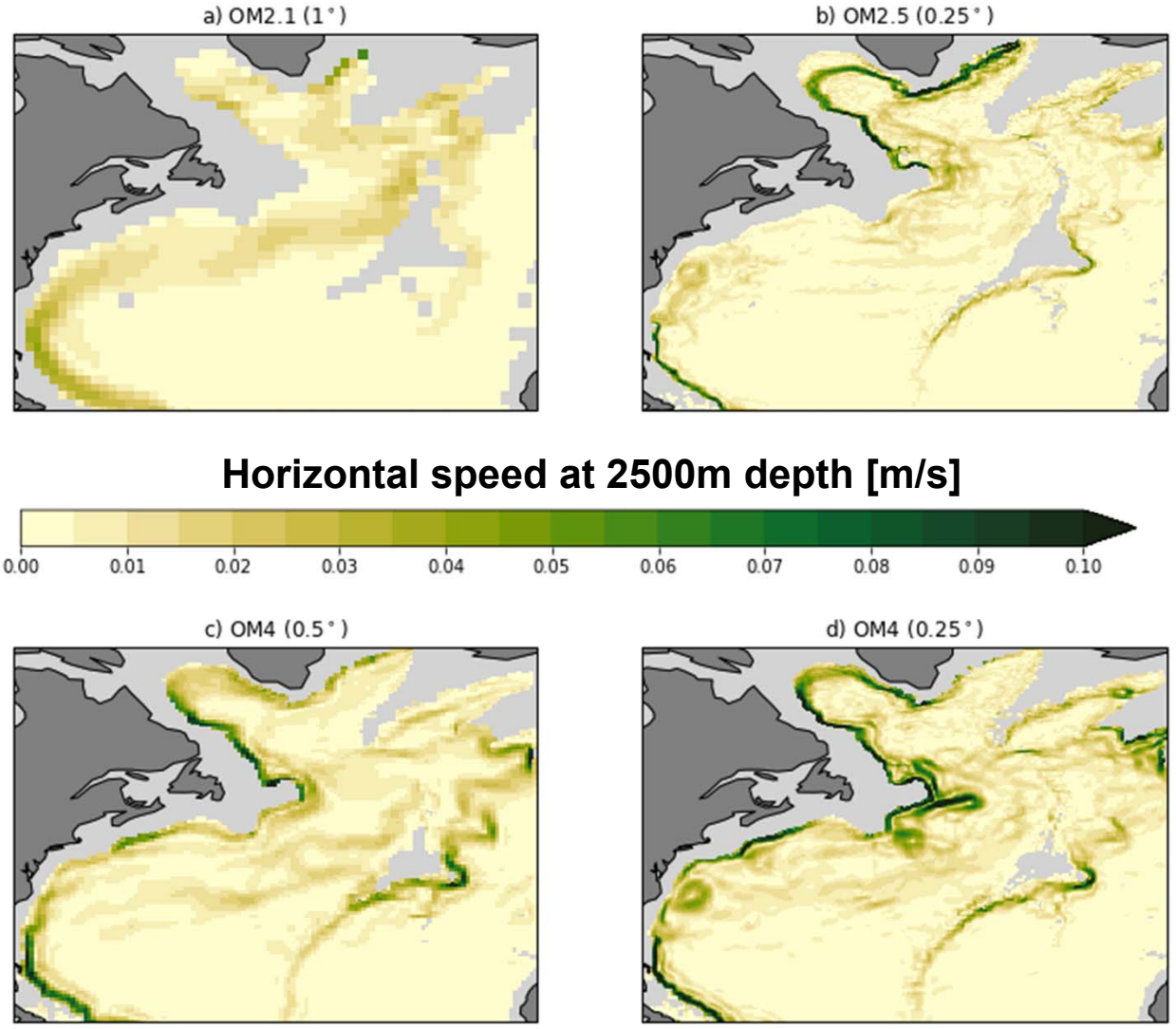
CCS from *Curchitser & Hedstrom*, Rutgers/UAF

Alan Wallcraft
FSU



OM4.0: Resolution and DWBC

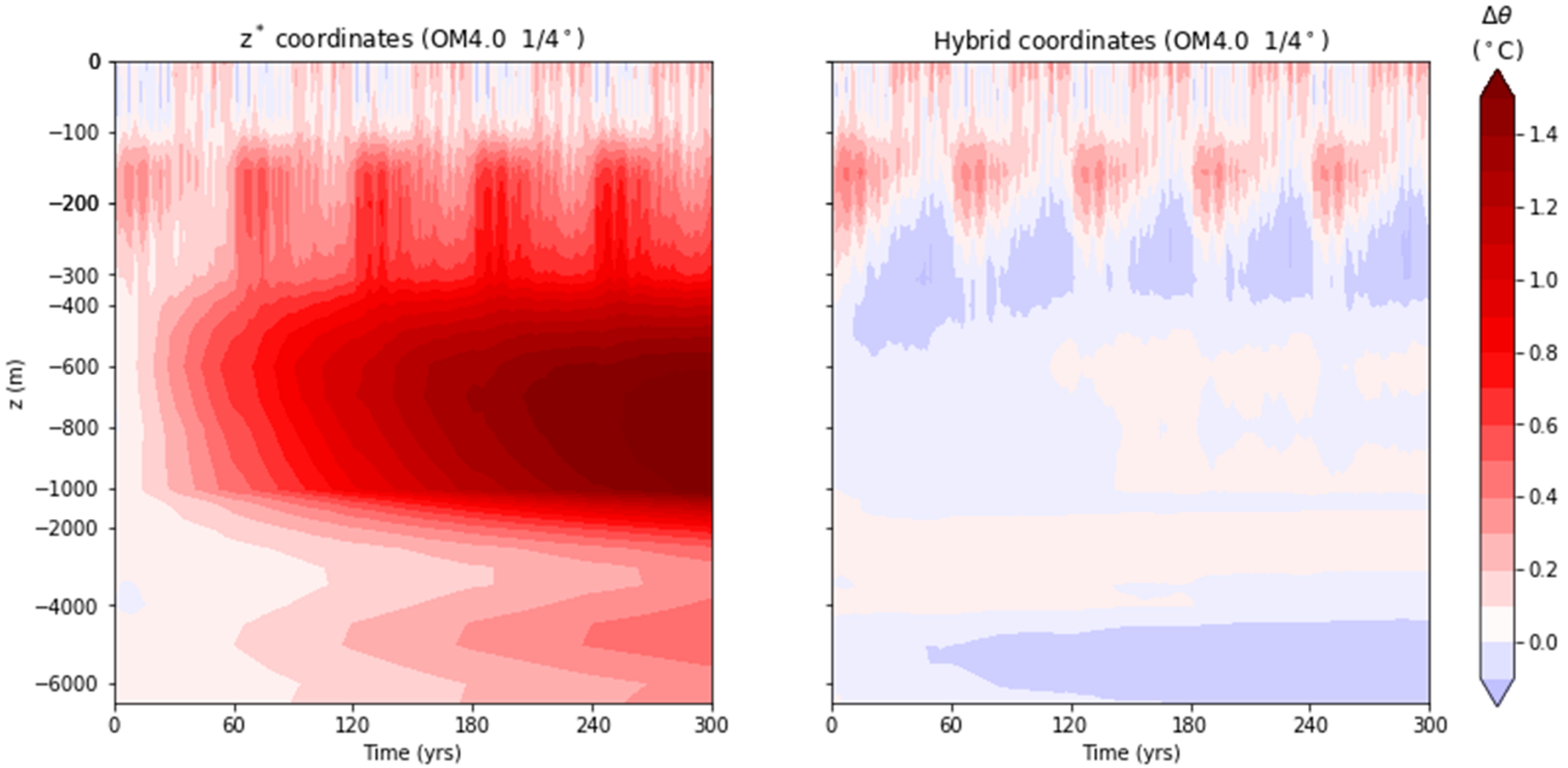
- Justification for ½° and ¼° horizontal resolutions



OM4.0: Benefits of new algorithms

- Hybrid vertical coordinate significantly reduced spurious heat uptake

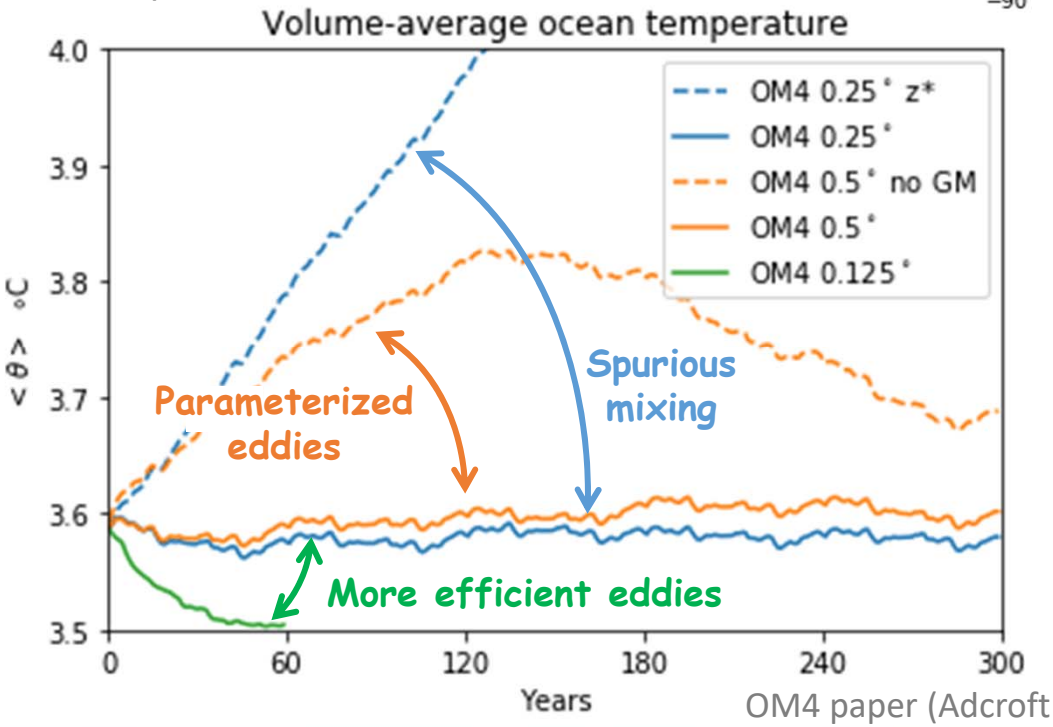
OM4 paper (Adcroft et al., 2019)

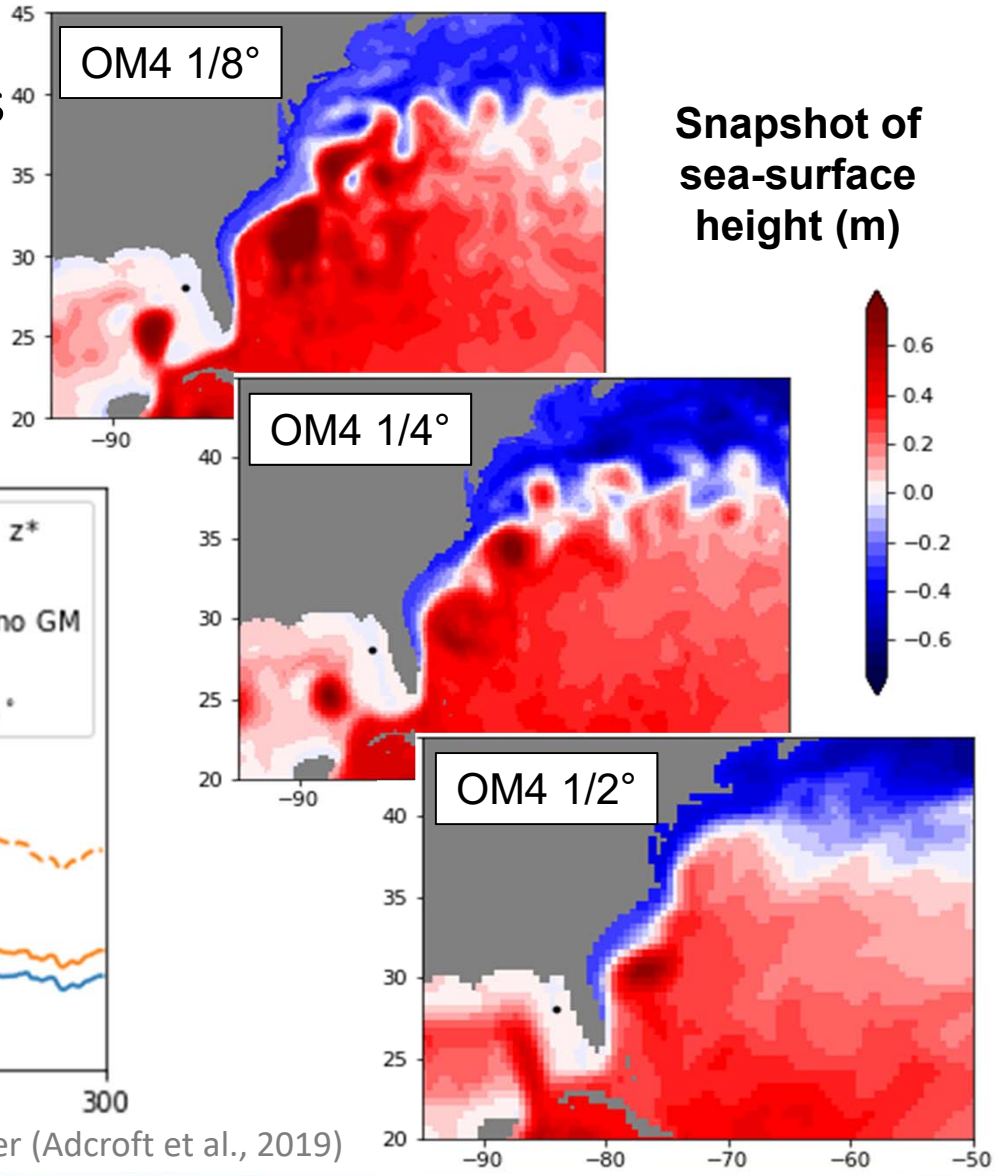


Horizontally averaged potential temperature change over 5 cycles of CORE-IAF

OM4.0: Role of eddies

- Transition of laminar to eddying motion at mid-latitudes happens between ½°-¼° resolutions
- Mesoscale eddies partly control ocean heat uptake
  - parameterize at coarse resolution

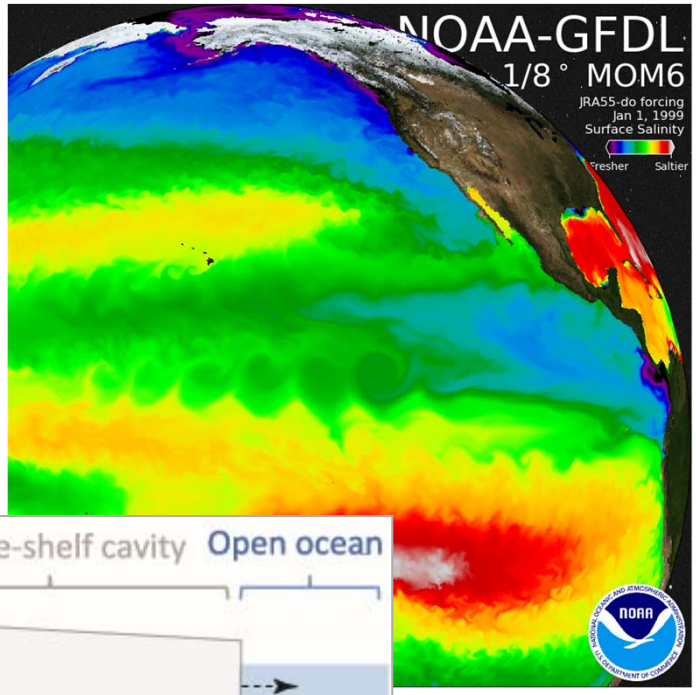


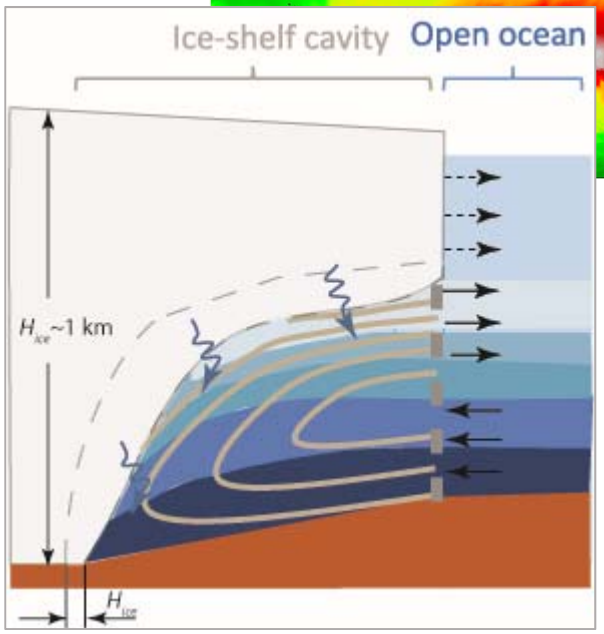


OM4 paper (Adcroft et al., 2019)

Future directions: OM4.1 & fine resolution

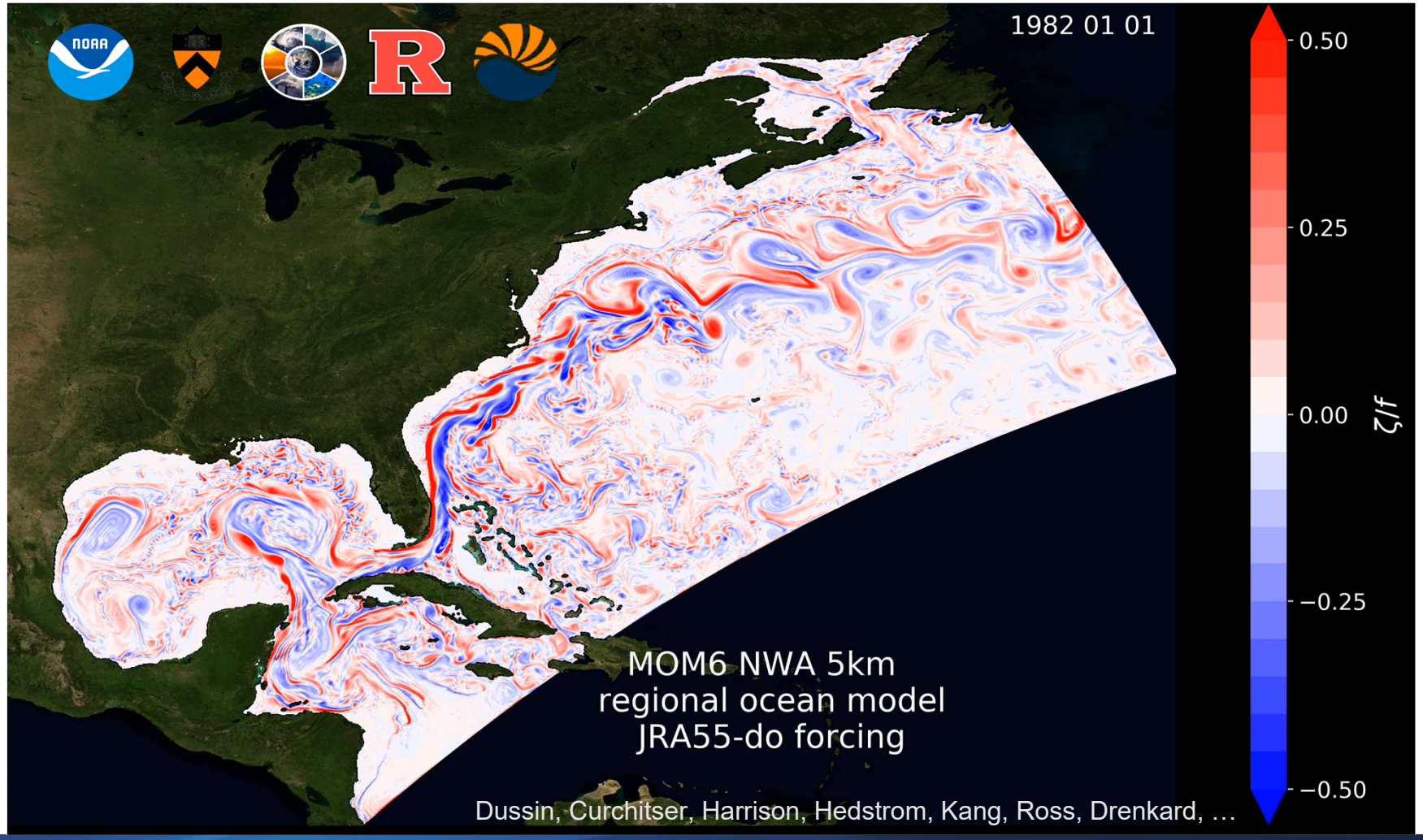
- OM4.1 and fine-resolution
  - Scale aware parameterizations to unify physics of OM4 configurations across resolutions
  - Require finer than 1/8° to permit some ice-shelf cavities
  - Require < 1km resolution near grounding line
- Planning a hierarchy of fine resolutions starting with 1/8°
  - Better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