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Modelagem com o MOM6 nos EUA: Presente e Futuro

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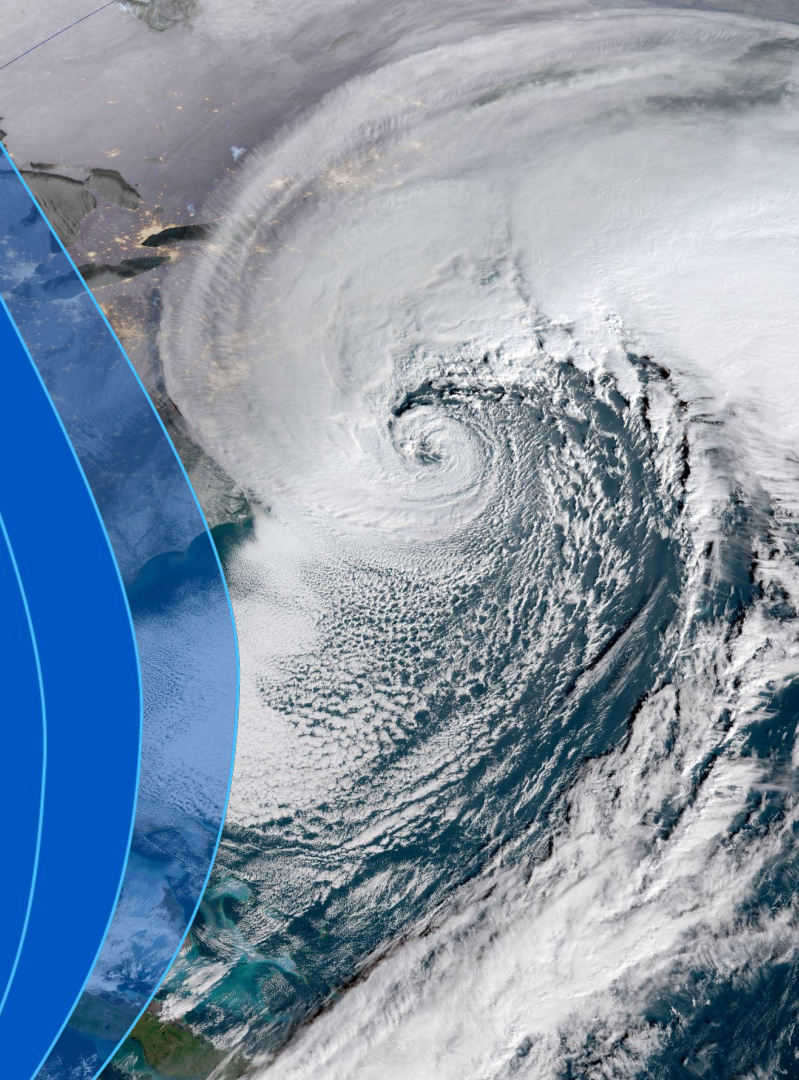
NSF NCAR orientation for NSF program staff - May 20-22 2026



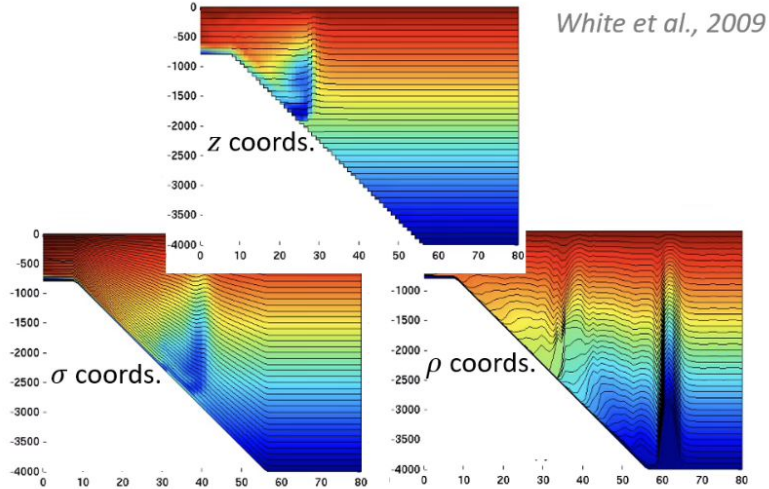
The Modular Ocean Model version 6 (MOM6): dycore, parameterizations, and development strategy

The Modular Ocean Model version 6 (MOM6) dynamical core

- **Finite volume solver**
  - Hydrostatic Boussinesq or non-Boussinesq equation

→ Non-Boussinesq models contain all effects within the ocean acting on the sea level

- **Arbitary-Lagrangian-Eulerian**
  - Generalized vertical coordinates
  - No vertical CFL limit → ultra-fine vertical resolution
  - Sub-cycled gravity waves
  - Built-in wetting and drying



White et al., 2009

Credit: Alistair Adcroft

MOM6 sub-grid scale parameterizations

- **Mesoscale eddies**
  - Many ways to prescribe diffusivities
    - MEKE, Jansen et al. (2015)
    - GEOMETRIC, Marshall et al. (2012)
  - Gent & McWilliams (1990)
    - Ferrari et al., 2010
  - Neutral diffusion (aka Redi tensor)
    - Shao et al., 2020; Marques et al. (2023)

- **Backscatter**
  - MEKE, Jansen et al. (2015)
  - GM+E, Bachman et al. (2019)
  - Stochastic GM+E, Grooms et al. (2025)
  - LEITH, Grooms et al. (2023)

- **Surface boundary layer**
  - KPP via Cvmix, Large et al. (1994)
  - ePBL, Reichl and Hallberg (2018)
  - Bulk mixed layer

- **Submesoscale eddies**
  - Fox-Kemper et al. (2008)
  - Bodner et al. (2023)

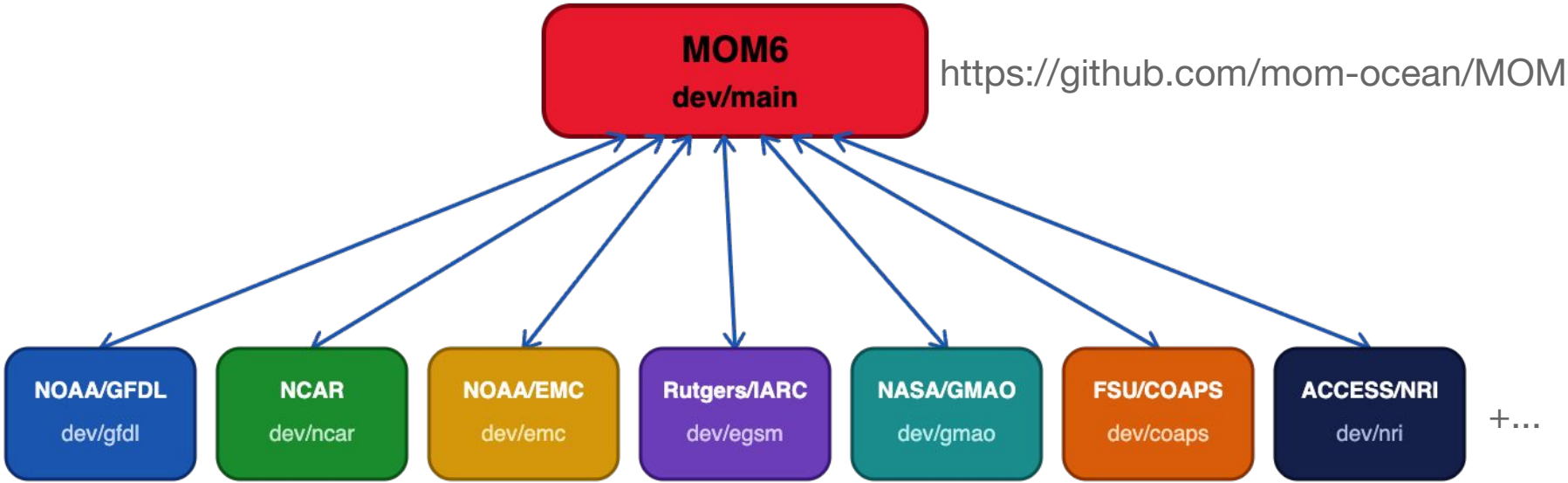
- **Shear-mixing**
  - Jackson et al. (2008)
  - CVmix (LMD94)

- **SW penetration**
  - Manizza et al. (2005)
  - Ohlmann (2003)
  - Morel (1988)

- **Bottom boundary layer**
- **Geothermal**
- **Internal tide-driven mixing**

MOM6 collaborative development arrangement

- Open development via GitHub
- Current governance mechanism: monthly developer calls
- Multiple development groups working with forks from common source



Data Assimilation options in MOM6

Joint Effort for Data assimilation Integration (JEDI)

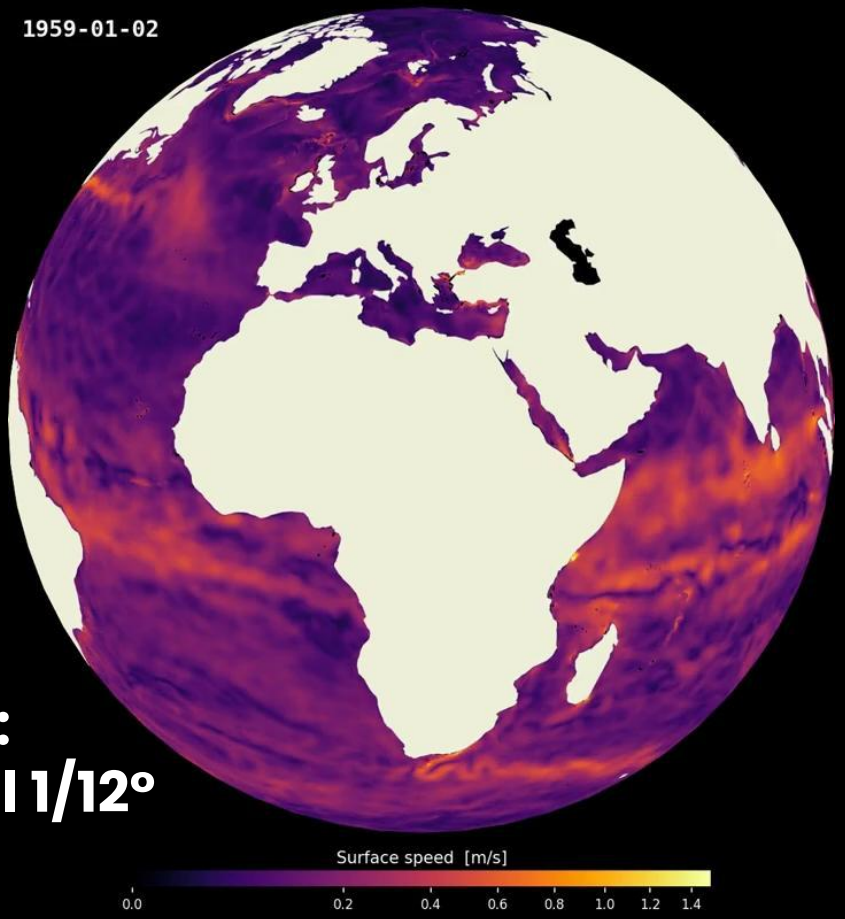
- NOAA/PSL currently running the JEDI-based SOCA (Sea-Ice, Ocean, and Coupled Assimilation) data assimilation system (MOM6+CICE) in **3D-Var** mode, while an experimental EnKF implementation is still under evaluation. The best sources for more information are the SOCA repository and documentation, with a paper currently under review and expected later this year.

Data Assimilation Research Testbed (DART)

- There is a working global configuration of MOM6 + DART in the CESM framework at workhorse resolution ingesting in-situ observations from the World Ocean Database.

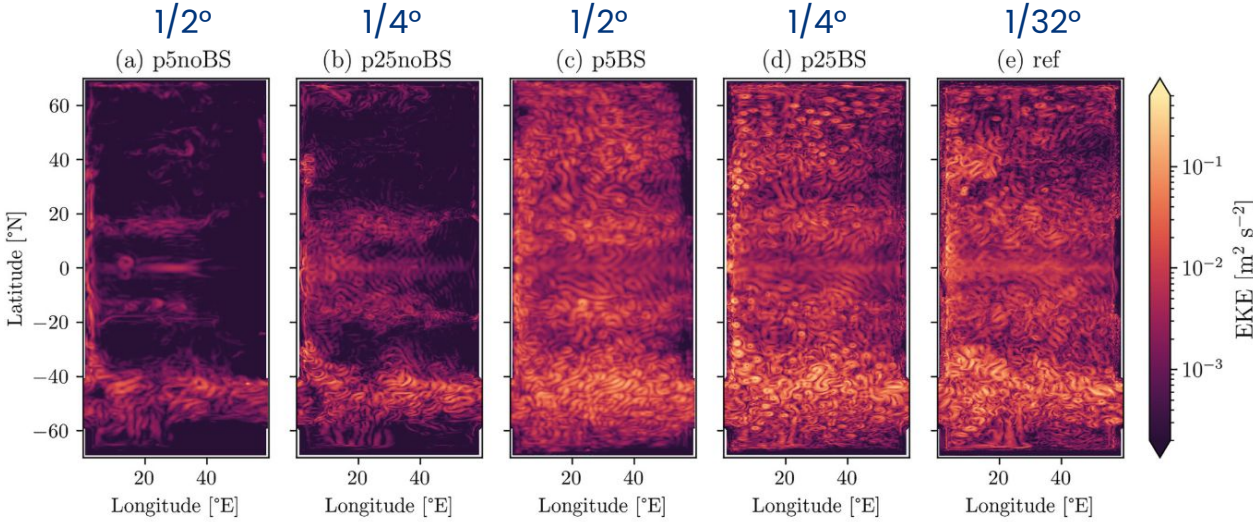
Future Directions: Physical & Numerical Development/Applications

Surface speed (m/s)



Under development:
CESM3/MOM6 global 1/12°
OCN/ICE/WAV

Energy Backscatter in MOM6



Pudig et al. (2026)

Idealized simulations → backscatter can capture key mesoscale processes, including kinetic energy inverse cascades, isopycnal slumping, and along-isopycnal tracer mixing

Global ocean models are highly sensitive to where backscatter is applied. To successfully balance eddy energy and realistic heat transport, backscatter cannot be broadly applied in the Southern Ocean, and instead confined to western boundary currents

JAMES | Journal of Advances in Modeling Earth Systems

Research Article | Open Access

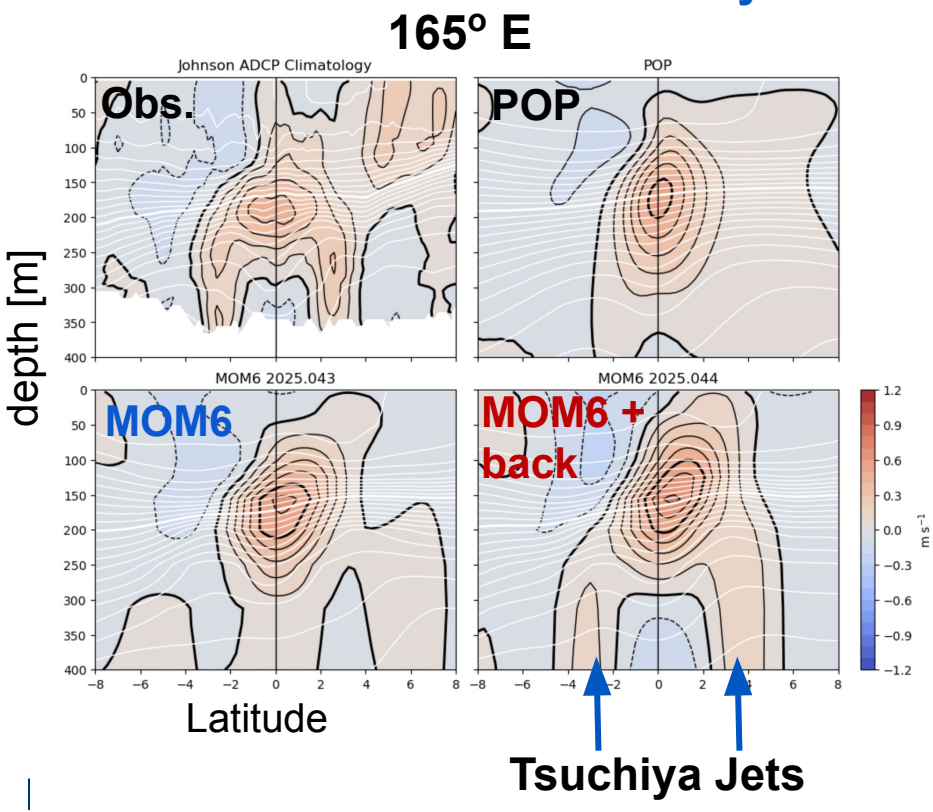
Balancing Backscatter and Diffusion in a 1/4° Forced Global Ocean Model

H. Yassin, G. Marques, I. Grooms

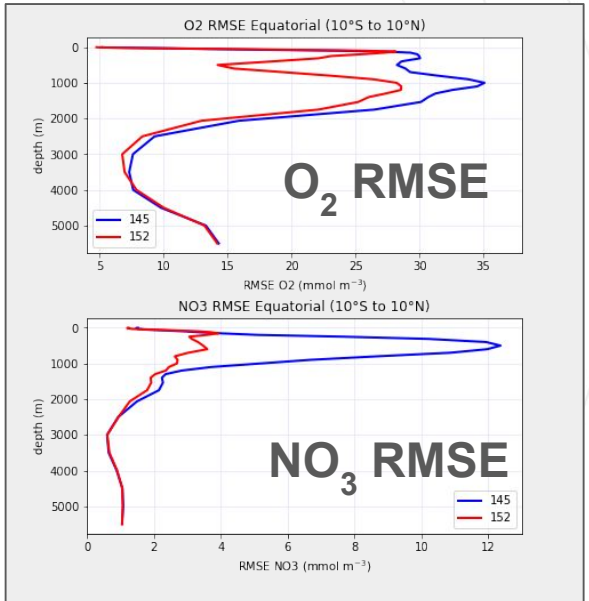
First published: 26 March 2026 | https://doi.org/10.1029/2025MS005462 | VIEW METRICS

Energy Backscatter in CESM3 workhorse (2/3°)

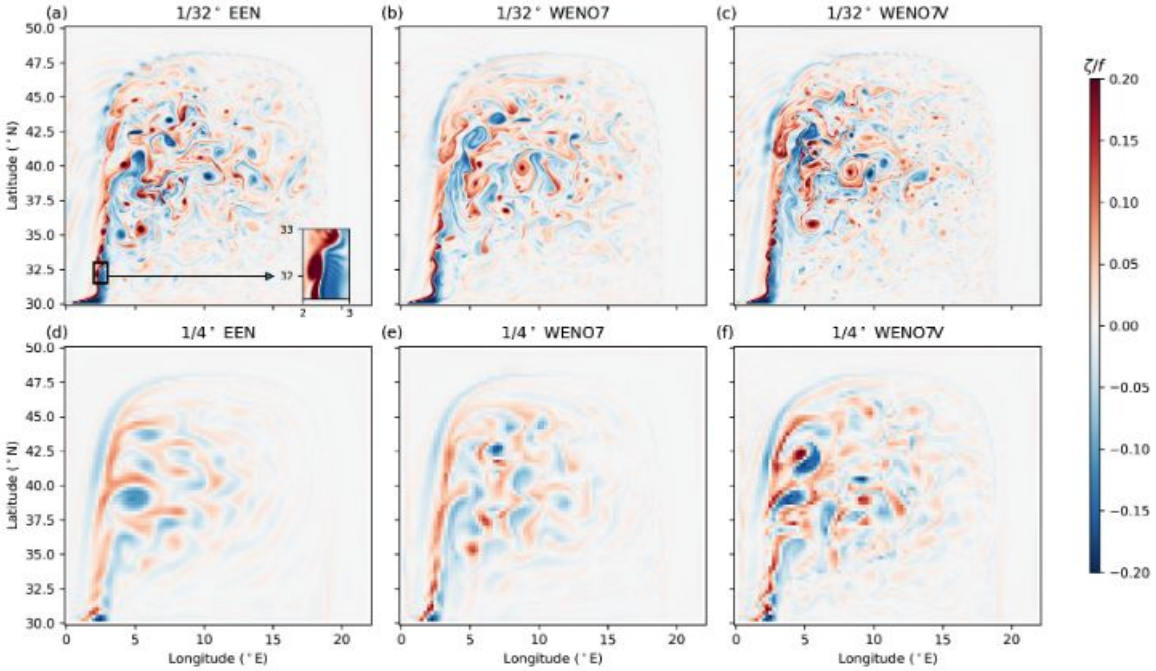
Transects of zonal velocity



- Emergence of **Tsuchiya jets** when backscatter is applied
- Jets reduce biases in the extent of oxygen minimum zones, critical for ocean BGC processes



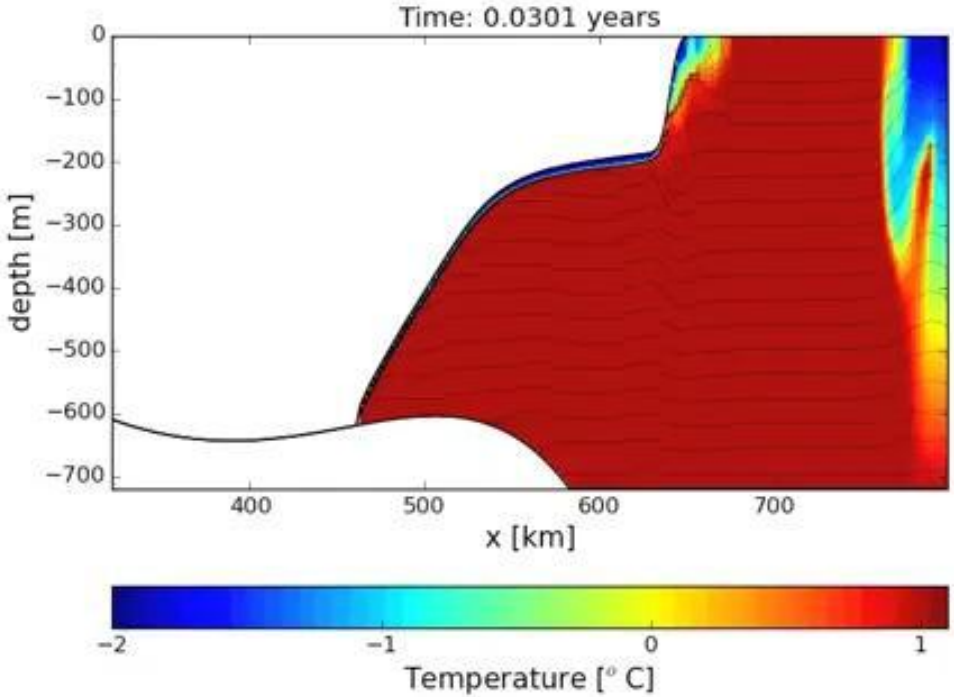
High-order schemes



From Zhang et al. (submitted, JAMES)

- A 7th-order weighted essentially non-oscillatory (WENO) advection scheme was implemented in MOM6
- High-order schemes enhance apparent resolution, providing benefits similar to increased horizontal resolution

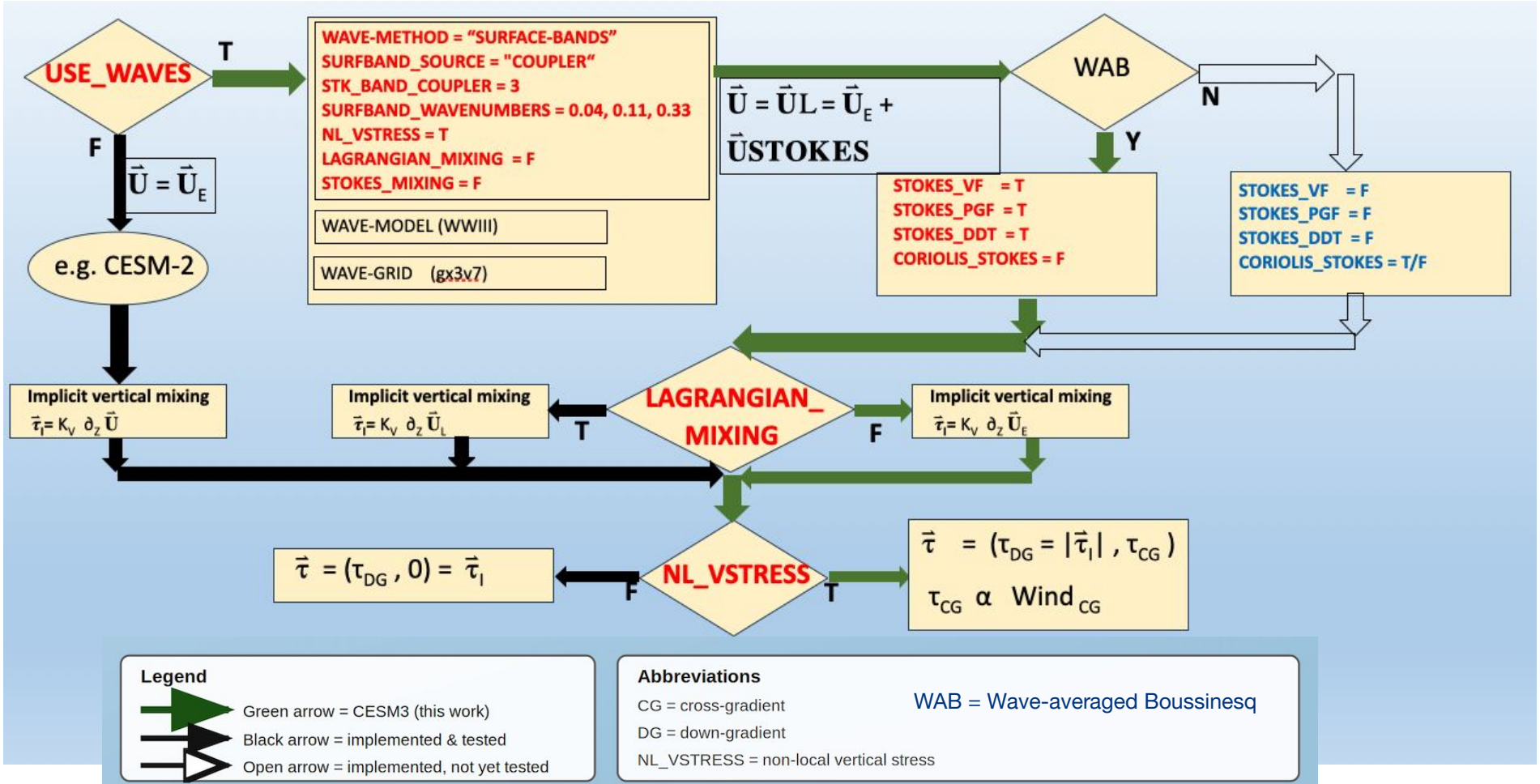
Ice shelf - ocean interactions



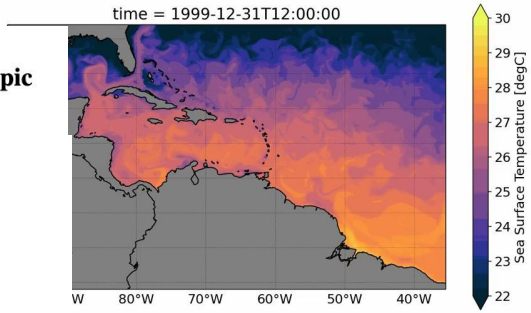
- This MOM6 simulation is described in Yung et al, (2026) - Results of the second Ice Shelf–Ocean Model Intercomparison Project (ISOMIP+)

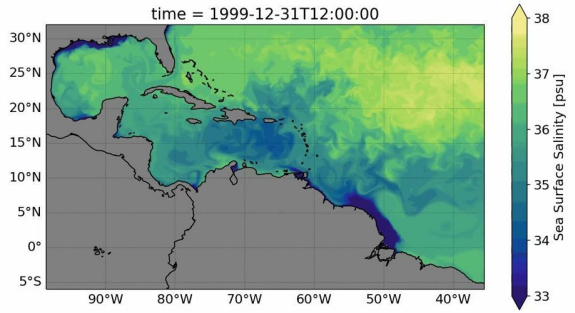
- Some centers are starting to explore ice-shelf/ocean interactions in regional and global models

Vertical Mixing with and without surface gravity waves



Growing Ecosystem of Regional MOM6 Applications





Impact of vertical coordinate systems on simulations of barotropic and baroclinic tides in the Yellow Sea using a regional MOM6 configuration for the Northwest Pacific

Inseong Chang[1,2], Young Ho Kim[1], Young-Gyu Park[2], Hyunkeun Jin[2], Gyundo Pak[2], Andrew C. Ross[3], and Robert Hallberg[3]

[1]Division of Earth & Environmental System Sciences, Pukyong National University, Busan, Republic of Korea
[2]Ocean Circulation and Climate Research Department, Korea Institute of Ocean Sciences and Technology, Busan, Republic of Korea
[3]NOAA OAR Geophysical Fluid Dynamics Laboratory, Princeton, NJ, USA

A high-resolution physical–biogeochemical model for marine resource applications in the northwest Atlantic (MOM6-COBALT-NWA12 v1.0)

Andrew C. Ross[1], Charles A. Stock[1], Alistair Adcroft[1], Enrique Curchitser[2], Robert Hallberg[1], Matthew J. Harrison[1], Katherine Hedstrom[3], Niki Zadeh[1], Michael Alexander[4], Wenhao Chen[5], Elizabeth J. Drenkard[1], Hubert du Pontavice[5], Raphael Dussin[1,6], Fabian Gomez[7,8], Jasmin G. John[8], Dujuan Kang[9,2], Diane Lavoie[10], Laure Resplandy[11,12], Alizée Roobaert[13], Vincent Saba[14], Sang-Ik Shin[4], Samantha Siedlecki[15], and James Simkins[2]

Assessing vertical coordinate system performance in the Regional Modular Ocean Model 6 configuration for Northwest Pacific

Inseong Chang[1,2], Young Ho Kim[1], Young-Gyu Park[2], Hyunkeun Jin[2], Gyundo Pak[2], Andrew C. Ross[3], and Robert Hallberg[3]

[1]Division of Earth Environmental System Science, Pukyong National University, Busan, Republic of Korea
[2]Ocean Circulation and Climate Research Department, Korea Institute of Ocean Sciences and Technology, Busan, Republic of Korea
[3]NOAA OAR Geophysical Fluid Dynamics Laboratory, Princeton, NJ, USA

JGR Oceans

Research Article | Open Access

Geoscientific Model Development | Open Access | EGU

A Link Between U.S. East Coast Sea Level and North Atlantic Subtropical Ocean Heat Content

Jacob M. Steinberg, Stephen M. Griffies, John P. Krasting, Christopher G. Piecuch, Andrew C. Ross

First published: 04 December 2024 | https://doi.org/10.1029/2024JC021425 | VIEW METRICS

Accessibility issue? Request accessibility update.

arth System Model/Modular Caribbean Sea

Giovanni Seijo-Ellis[1], Donata Giglio[1], Gustavo Marques[2], and Frank Bryan[2]

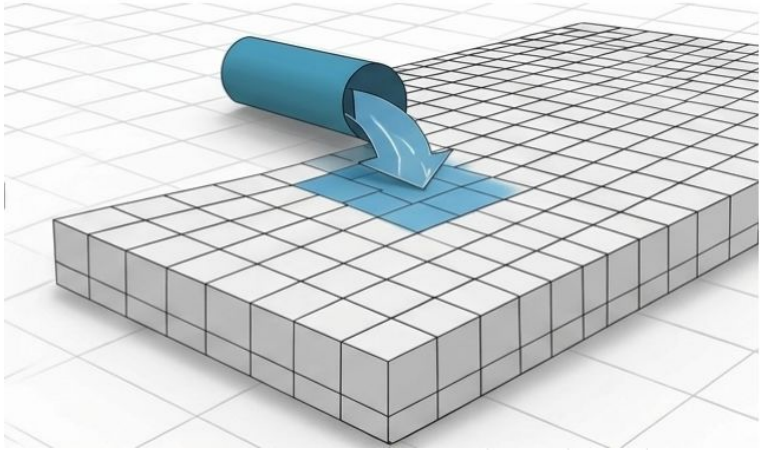
[1]Department of Atmospheric and Oceanic Sciences, University of Colorado, Boulder, Boulder, CO, USA
[2]Climate and Global Dynamics Laboratory, U.S. National Science Foundation National Center for Atmospheric Research, Boulder, CO, USA

Enabling actionable science applications, e.g., coral, fisheries, sea level, Marine Protected Areas, etc.

Estuary Box Model (EBM) in MOM6

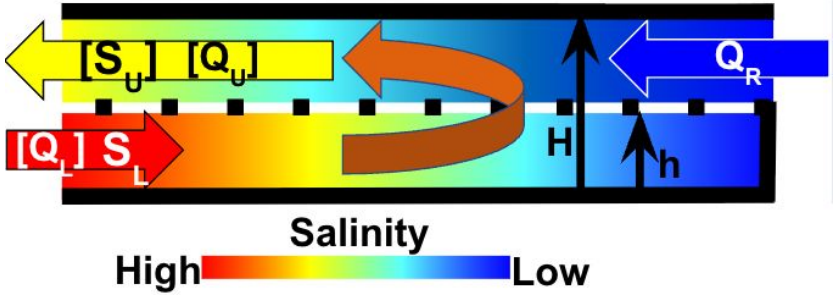
Current Models

River discharge is often introduced *ad hoc*; either as "augmented precipitation" over some prescribed area or injected into a single grid cell → failing to represent estuary mixing and transport processes



Work to implement the EBM in MOM6, supported by NOAA, is underway

Goal: Improve representation of riverine freshwater in MOM6 → reduce coastal salinity and stratification biases



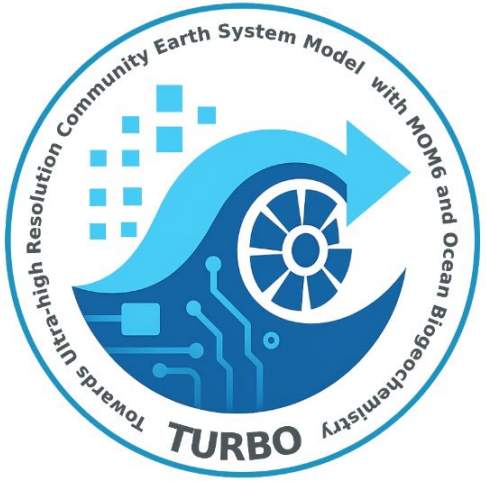
Schematic courtesy of Qiang Sun

MOM6 and GPUs

TURBO: Towards Ultra-High Resolution Community Earth System Model (CESM) with MOM6 and Ocean Biogeochemistry

Enable faster code to exploit modern HPC

- **TURBO will be valuable for predictability across timescales allowing higher res ocean through exploiting GPUs**



Parallel effort at GFDL and ACCESS to port MOM6 to GPUs

An NSF Cyber Infrastructure Project (CSSI)

Community Resources and Training Opportunities

Interested in learning CESM?

NCAR/CGD organizes a CESM Tutorial every year (normally held during early July)

More information at: https://www.cesm.ucar.edu/events/tutorials/

Models and Training for the Community: CROCODILE –An NSF Cyber Infrastructure Project (CSSI)

CROCODILE: Regional Ocean and Carbon Cycle Modeling and Data Assimilation with the Community Earth System Model

- Tools to aid researchers to easily configure regional domains using MOM6 ocean model within the CESM framework
- Connects models and observations using DART/JEDI data assimilation
- Projections at regional and local scales (needed by decision makers)

Upcoming workshop (CROCODILE + MOM6)

2026 Regional Ocean Modeling with MOM6 in the Community Earth System Model Framework

Sep. 28 to Oct. 2, 2026

CROCODILE has a strong community building and training component

Helpful resources for the MOM6 model

- CESM/MOM6 webpage offers quick start guides, tutorials, and an overview CESM/MOM6 GitHub Wiki.
- MOM6 webinar tutorial series (2020) covers theory, how-to, and use-cases MOM6 2020 Webinar Series.
- Expanding documentation is open for community contributions MOM6 Read the Docs.
- Post-processing analysis packages: mom6_tools (mom6_tools GitHub) and om4labs (om4labs GitHub).
- MOM6 forum is available for technical and scientific questions MOM6 CESM Forum.
- Regional MOM6:
  - https://github.com/CROCODILE-CESM/CrocoDash
  - https://github.com/NOAA-CEFI-Regional-Ocean-Modeling
  - https://github.com/COSIMA/regional-mom6

Obrigado! gmarques@ucar.edu