UFS-R2O Progress & Year 3 Plan

Marine Components
Development Cross Cutting Team

6&7 December 2021

EMC, PSL, GSL, CSL, NSSL, ARL, NESDIS

Marine Components - Description and Goal

Goal: Coordination of all marine components (ocean, ice, wave) for UFS applications:

- Configurations of global marine components for GFS, GEFS, and SFS
  - High resolution 1/12° ocean & sea-ice model for RTOFS applications and short timescales
  - Med. resolution 1/4° ocean & sea-ice model for longer-timescales and larger ensembles
- Configure marine components for HAFS
  - High resolution regional MOM6 (to replace HYCOM in HAFS)

Marine Components - Progress and status: Active areas of development

UFS based applications being actively developed with focus on marine components:

Marine DA
Ocean ice coupled model to look at polar dynamics and for developing the Marine DA system

HAFS
Hurricane Analysis and Forecast System (ocean and wave)

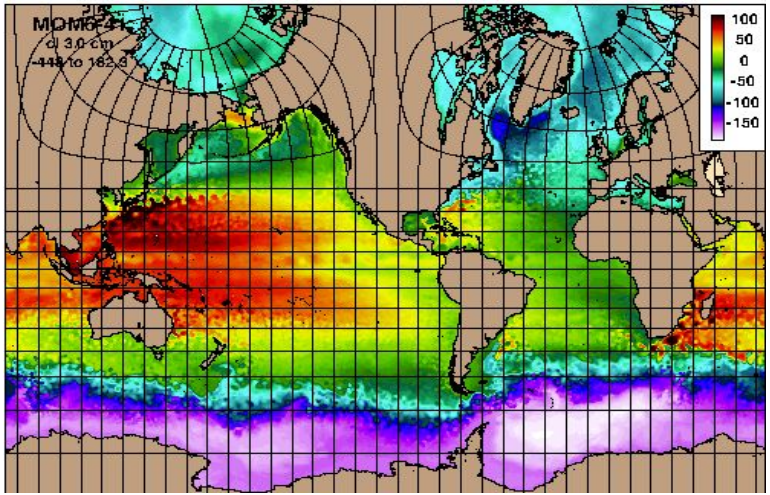
Future RTOFS
High resolution 1/12° global model for a future RTOFS

S2S
25 km atm, ¼° ocean and ice, and ½° waves for future GEFSv13 and SFSv1

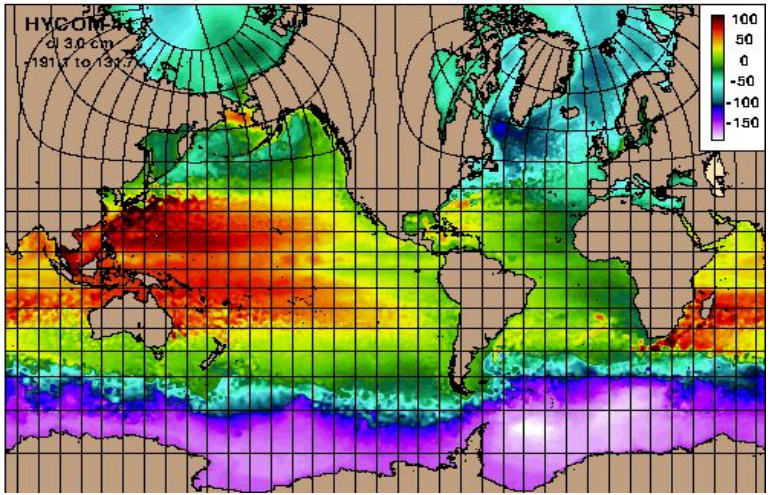
Marine Components - Progress and status: High resolution global MOM6

Global Mean SSH in RTOFS-like 1/12° Configurations

HYCOM



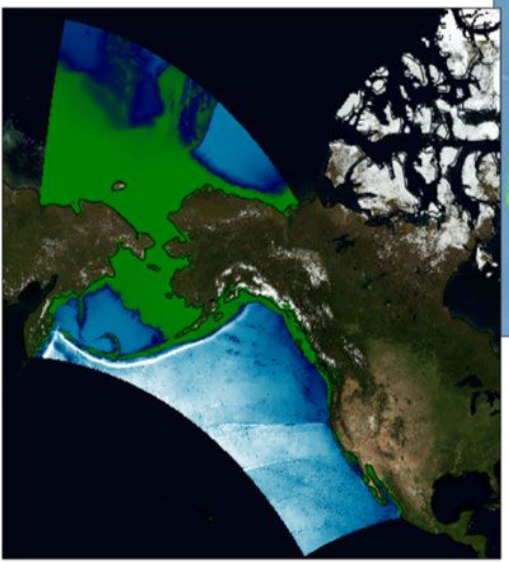
MOM6

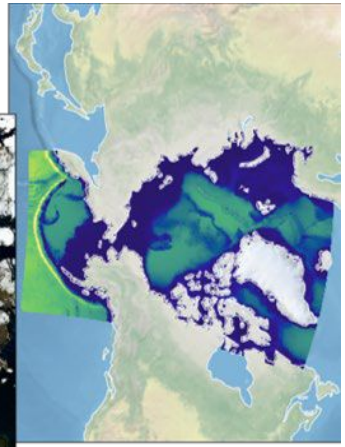


- Coordinated efforts among GFDL, EMC and FSU
- Extensive experiences from the HYCOM community are being ingested (e.g., incremental analysis update, boundary conditions, vertical coordinate definitions, etc.)
- Updating to OM4.1 Global Configuration

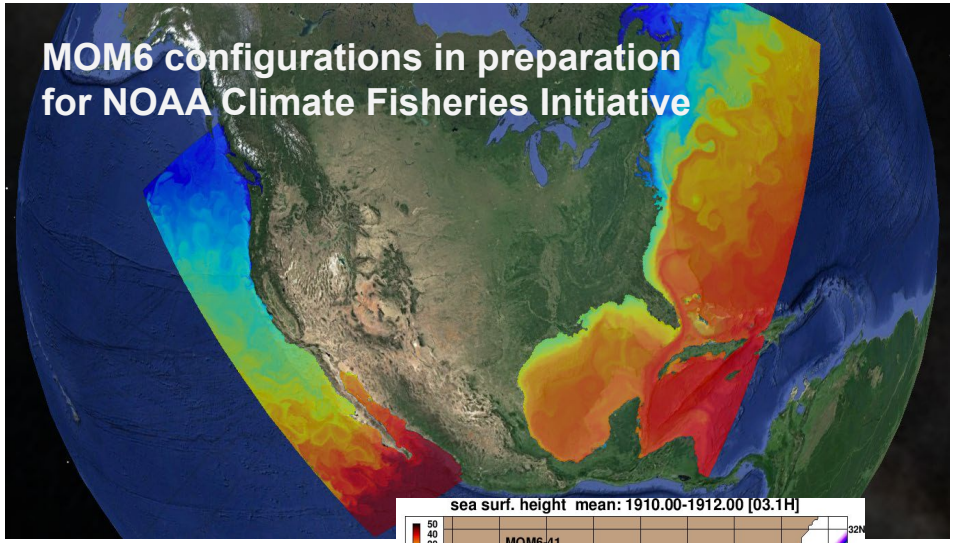
Marine Components - Progress and status: Regional MOM6 Applications

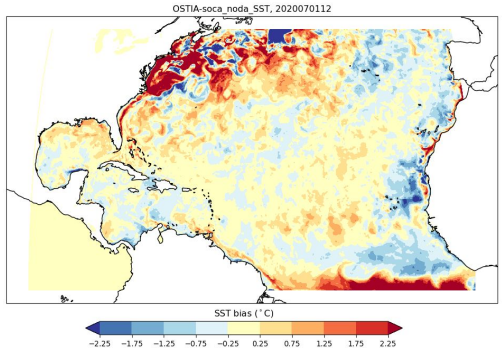
MOM6-NEP

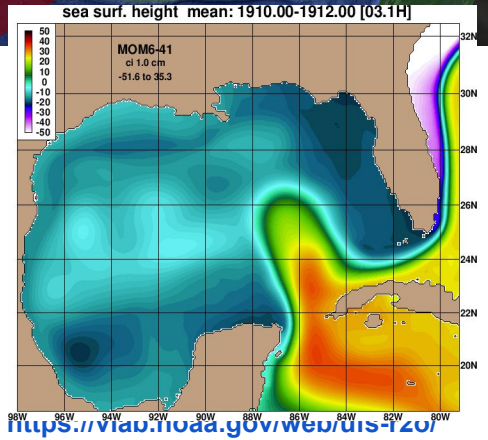




MOM6-Arctic



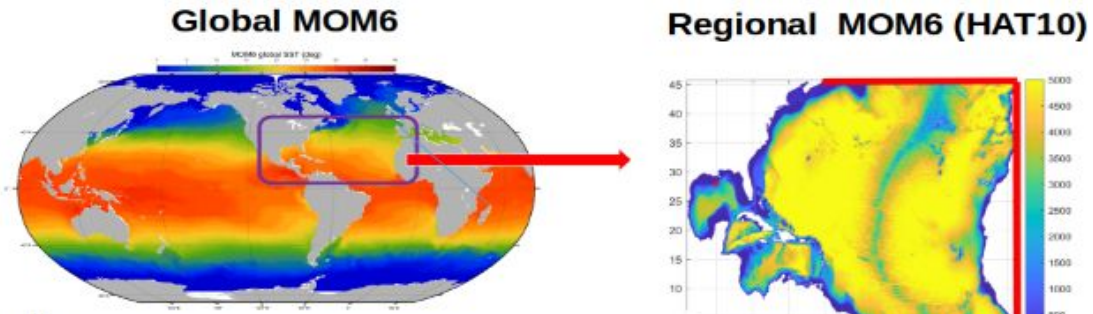




Collaborative efforts among GFDL, Rutgers, AOML, PMEL, EMC, U. Alaska, Others

Marine Components - Progress and status: Regional MOM6 for HAFS

- New domains setup is underway in collaboration with AOML/FSU-COAPS
- Cost effective sponge zone options are in consideration: on-going testing
- Open/closed boundaries (HAT10 domain): currently North, East, and South open, testing other combinations
- Absent/weak river discharge, warming in the GOM
- Gulf Stream position (drifts northward, warmer & saltier)
- Saltier waters
  - with intensified/isolated cold water north of the GS at surface
  - warmer conditions at 55 m



Goal:
provide best estimate ocean IC & BC for coupled Hurricane forecast system
Current Experiment configuration: 1/12-degree resolution

Marine Components - Major Accomplishments

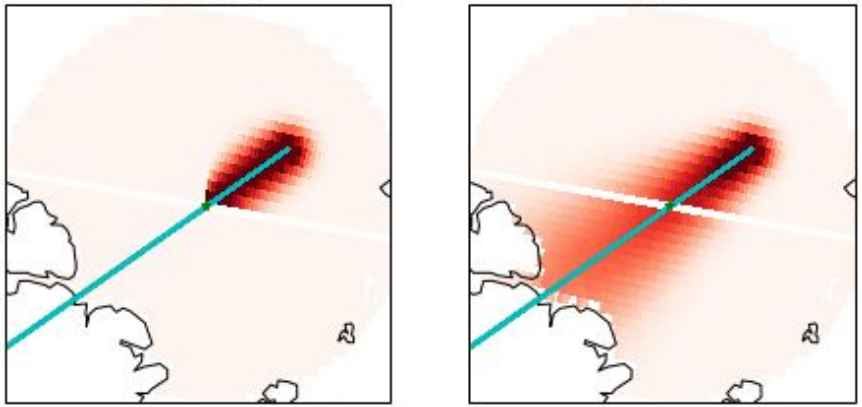
- Continued work on global 1/12° MOM6 ocean model for RTOFS/GFS
- Continued work on regional MOM6 for HAFS
- Coupled model prototypes were completed contributing to the operational targets for GEFSv13 (FY24) and SFSv1 (FY25/26)

Marine Components - Major Challenges

The wave component needs to be prepared for a future ice free summertime Arctic.

Currently, the wave model cannot propagate waves in a potential ice-free arctic due to a singularity caused by defining directions relative to the North Pole.

Existing WW3 | Development WW3

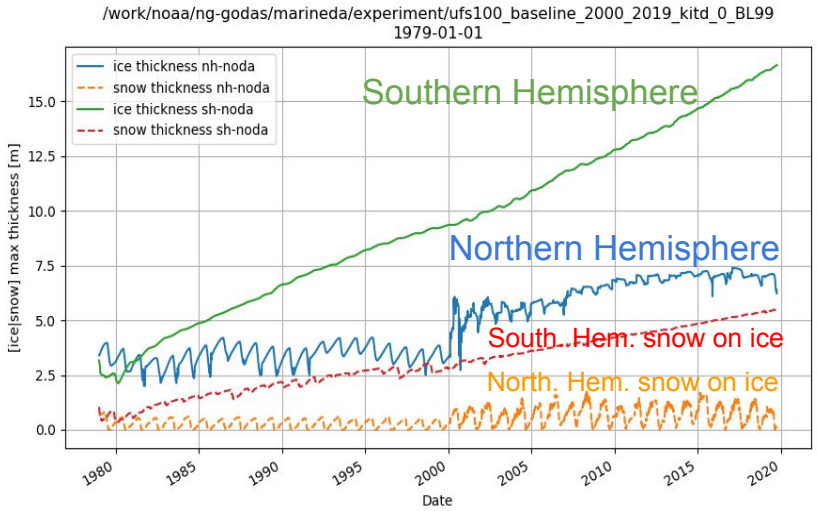


Collaboration between EMC & GFDL

This figure shows waves propagating along a great circle (marked in green) across an ice free Arctic. On the left is the current WW3, which has issues with the singularity at the North Pole. The right uses a recently developed version of WW3 with a grid local definition of directions. This work needs to be extended to higher order geographic propagation schemes and to address computational efficiency issues.

Marine Components - Major Challenges

Issues with excessive sea-ice thickness in isolated points in long runs



Maximum Sea Ice and Snow Thicknesses
From 40-year Long Free-run Using DATM

GFDL/CMIP suggested solutions

- Use of C-grid dynamics for sea-ice in CICE v.6?
- Fill in single point bays and channels in land-mask (until CICE C-grid is available)
- Include Lagrangian model for icebergs to redistribute calving and melt

Marine Components - Year 3 Priorities

- [MRW SFS]: Configuration of ocean, sea ice and wave components for GFSv17, GEFSv13 and SFSv1.
  - Ensure wave model is capable of propagating waves in an ice-free arctic
- [MRW SFS]: Investigation of coupling strategies for marine components for GFSv17, GEFSv13, and SFSv1.
  - A lack of funding will impact model skill of fluxes and biases. In addition, coupling strategies could be investigated for skill versus computational time which could lead to missed opportunities for increased model performance and/or skill.
- [MRM SFS]: Explore inclusion of ecological modeling
- [Hurricane]: Configuration of ocean and wave components for coupled HAFS, including replacement of HYCOM with MOM6.
  - Lack of funding will also lead to delays with RTOFS and merging of RTOFS with a future GFS.
- [SRW]: Inclusion of FVCOM for Great Lakes in RRFSv1.

Marine Components - Major Challenges

- Improving ocean model circulation patterns
  - Gulf stream separation and deep western boundary current / AMOC structure
  - Gyres and sufficient eddy shedding
- Using generalized vertical coordinates with open boundary conditions for regional MOM6
- Ice-ocean-wave coupling physics and strategies
  - Want to obtain the best fluxes to improve model skill
  - Reduce model bias and drift, and improve stability
- Coupled DA
  - DA for each marine component
  - Regional HAFS DA
  - High resolution global ocean DA
  - Coupled DA

Marine Components - Work Plan

- Waves:
  - Wave physics configuration to best capture high sea events
  - Coupling feedback to ATM and OCN
  - Design new grid configurations for HAFS, GFS, GEFS, SFS, considering:
    - Capturing high sea-events
    - Coupled system and feed-back to other components
    - Prepare for ice-free Arctic summers
    - Modeling appropriate wave spread for ensembles
    - Risk: Might require infrastructure upgrades
- Ocean:
  - Continue development for high resolution regional and global MOM6
  - Continue HYCOM / MOM6 Comparisons & Importing HYCOM capabilities to MOM6
  - Explore inclusion of BCG modules
- Ice
  - Test new physics available from CICE Consortium (Icepack)
  - Test new C-grid configuration of CICE6 being implemented by CICE Consortium
  - Include icebergs
- Ocean-Ice-Wave Coupling Strategies
  - Focusing on fast time scale (< ~1 hour) physical interactions

Marine Components - Compute Requirements

Development of the marine components and coupling strategies will be done both independently and in collaboration with the appropriate UFS-R20 application teams. In addition to the compute resources associated directly with in-kind projects, dedicated marine component compute per month are:

Hera (marine-cpu, EMC): 1.4 M core hours/month
Orion (marine-cpu, EMC): 1.4 M core hours/month
Gaea: 1M core hours/month

Marine Components - Anticipated in kind effort: Ecological Modeling

- NOAA Climate Fisheries Initiative
  - Regional ocean modeling will use MOM6
  - This initiative will also be interested in solving challenges related to boundary and initial conditions for regional ocean modeling.
  - This initiative will investigate regional ecological issues
- JPSS-PGRR:
  - “Implementation of ocean biogeochemical modeling and ocean color data assimilation in the Unified Forecast System in support of NCEP’s weather, subseasonal-to-seasonal, and ecological predictions”
    - PI: Avichal Mehra
    - Team: Daryl Kleist, Jong Kim, Xiao Liu, Hae-Cheol Kim, Eric Bayler
    - Organizations: NOAA/NCEP, NOAA/OAR, NOAA/NESDIS

Marine Components - Anticipated NOFOs in kind effort

- Development of High Resolution MOM6 for NGGPS
  - PI: Eric Chassignet (FSU)
  - Team: FSU: Alan Wallcraft, Alexandra Bozec, NOAA/NCEP: Avichal Mehra, Hae-Cheol Kim, Jong Kin, Hyun-Sook Kim, Zuleman Garraffo, Shastri Paturi, NOAA/GFDL: Robert Halberg, Alistair Adcroft, NCAR: Gokhan Danabasoglu, Gustavo Marques
  - Organizations: FSU, NOAA/NCEP, NOAA/GFDL, NCAR
- Developing Regional Ocean Modeling Capabilities with MOM6 for use in the Unified Forecast System
  - PI: Enrique Curchitser (Rutgers), Alistair Adcroft (NOAA/GFDL), Robert Halbert (NOAA/GFDL), Avichal Mehra (NOAA/NCEP)
  - Organizations: Rutgers, NOAA/GFDL, NOAA/NCEP

Note, these projects are expected to persist as funded projects during UFS-R20 Y3.

Marine Components - Anticipated in kind effort

- Sea Ice Data Assimilation
  - Funded by WPO/STI FY22-23
  - Joint effort between GFDL and EMC to advance sea ice data assimilation for UFS (at EMC) and for SPEAR (at GFDL) with a post doc at GFDL (already hired) and UMD/CISESS (in process of hiring)
- Extending Maritime Hazard Information to Week Two and Beyond
  - Funded by CPO/CTB
  - Collaboration between EMC, OPC, and AOML
  - Research scientist at University of Miami's University of Miami Cooperative Institute for Marine and Atmospheric Studies (CIMAS)
  - Project will generate a 15-20 year wave reforecast forced by the GEFSv12 reforecast and develop probabilistic tools for forecasters for weeks two and beyond for GEFSv13.
- Improving Lake-Effect Snow Forecasting Capabilities via Advanced Coupling Techniques in NOAA's Unified Forecast System (UFS)
  - Funded by 2019 WPO (OWAQ) High Impact Weather Testbeds
  - GLERL, University of Michigan

Marine Components - Summary & Closing Remarks

Anything you want to convey to reviewers and POs as takeaways for this development area