Progress towards CESM3 ocean model and workflows

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In collaboration with: Keith Lindsay, Frank Bryan, Gokhan Danabasoglu, Alper Altuntas, Scott Bachman, Ian Grooms, Matt Long, Deepak Cherian, Fred Castruccio, Cecile Hannay, David Bailey, Jim Edwards + many others

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New and revised global configurations

Revised workhorse configuration;
2/3º resolution (tx2_3):

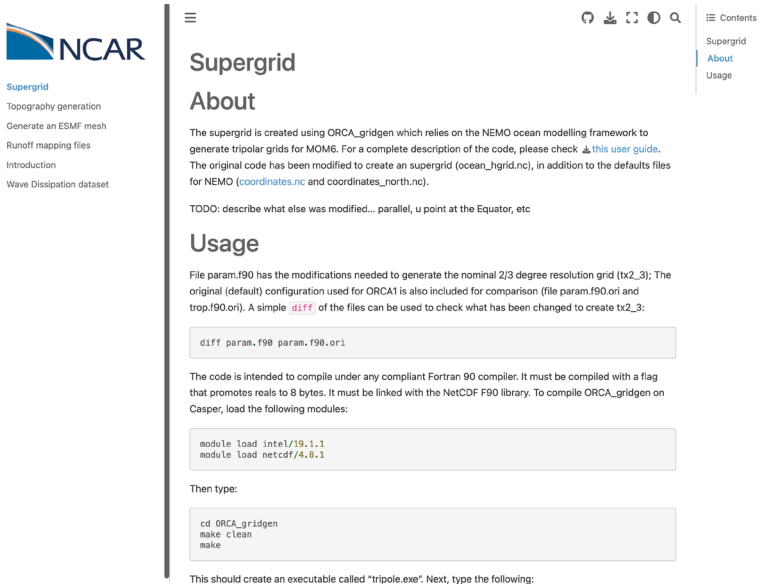
- Shifted zonal velocity point to be @ Equator
- Revisited topography and land/sea masking
- Change domain size to optimize grid decomposition

Many thanks to Frank Bryan and Fred Castruccio!

New configurations:

- **Eddy-permitting**; 1/4º resolution (tx1_4). This will be used to leverage work done by the CPT
- **Eddy-resolving**; 1/12º resolution (tx1_12), coming soon!
- **Ultra-high**; 1/36º resolution (tx1_36), coming soon!

Configurations will be fully documented on GitHub

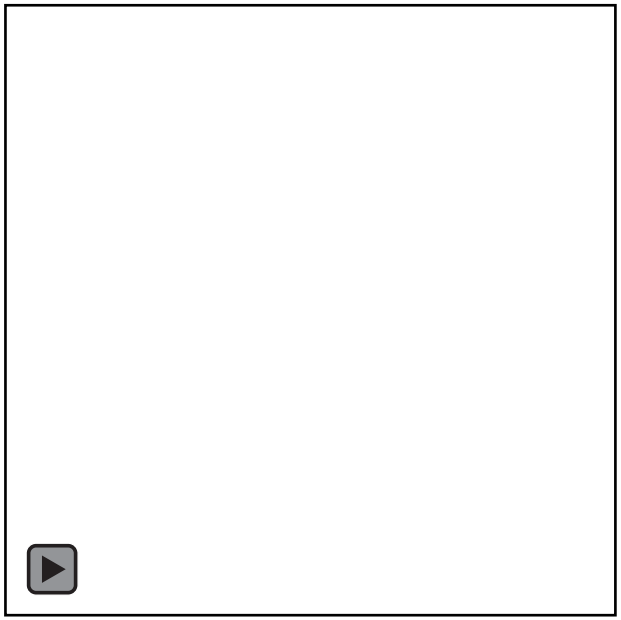


ncar.github.io/tx2_3/

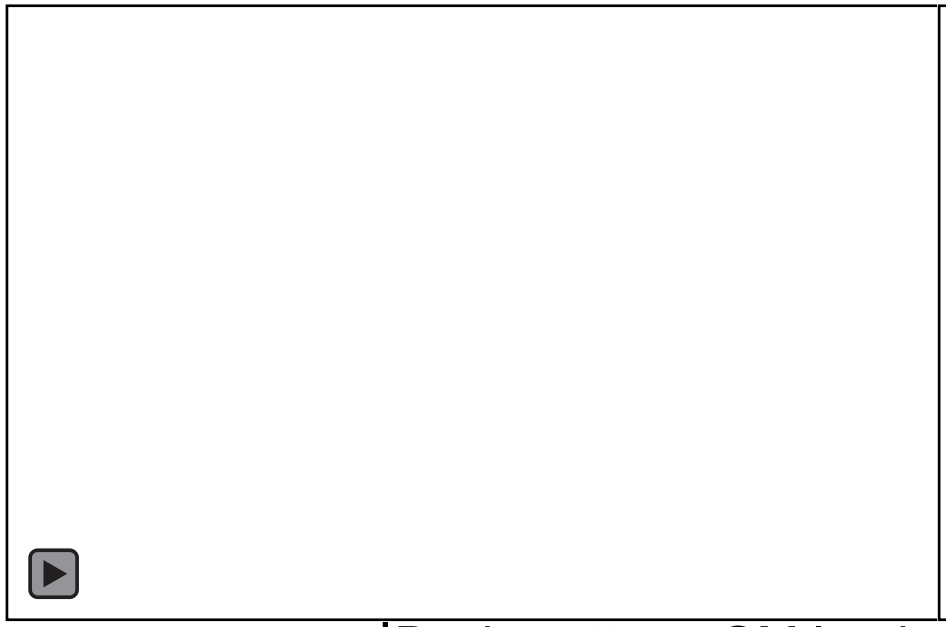
CESM/MOM6 global 1/4º configuration

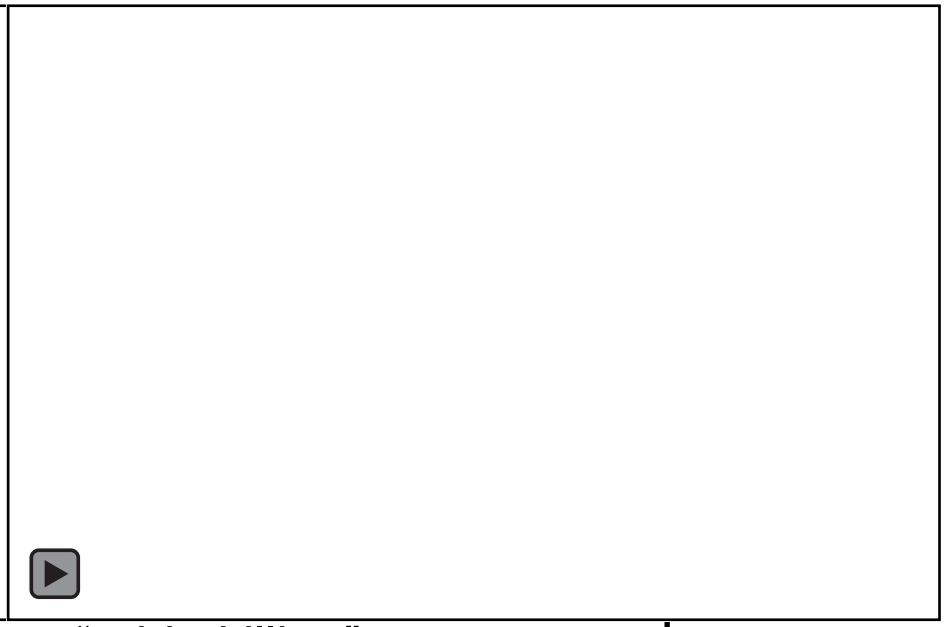
- Ocean (MOM6) and sea ice (CICE5) components;
- Nominal 1/4º horizontal resolution in a tripolar grid. Grid built using modified ORCA grid generation;
- Bathymetry and land/sea mask are derived from the Shuttle Radar Topography Mission (SRTM) dataset;
- IC's and SSS restoring from WOA18;
- Vertical grid is z* with 65 layers;
- NCAR vertical physics package via CVmix;
- Mixed-layer eddies parameterization (Fox-Kemper et al., 2011);
- Control has no mesoscale parameterizations (like OM4_025, Adcroft et al., 2019). Biharmonic dissipation is the maximum of i) dynamic (Griffies & Hallberg, 2000) and ii) static (background) contributions;
- Forcing via JRA-55 dataset (1958-2018).

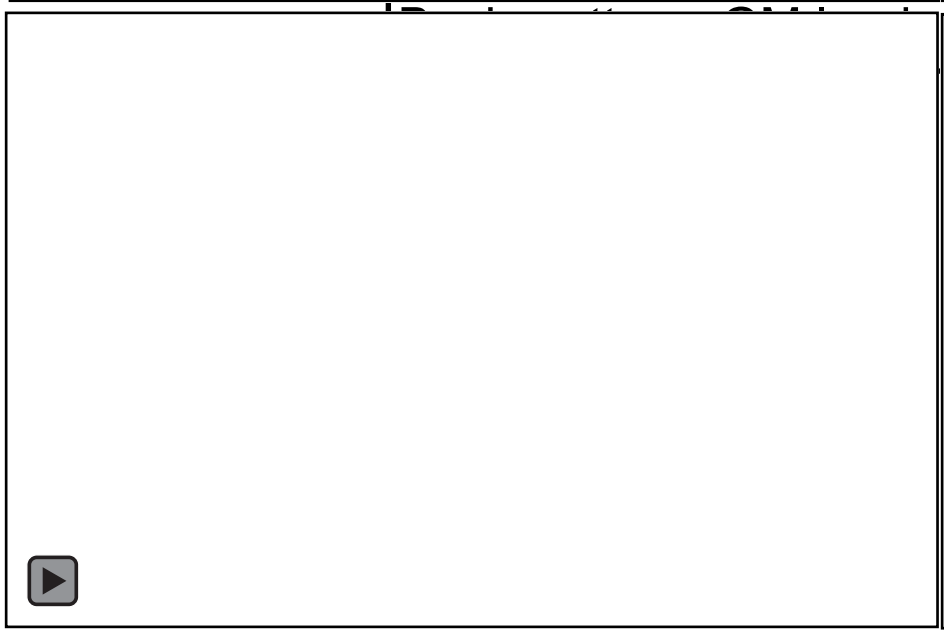
https://github.com/NCAR/tx1_4

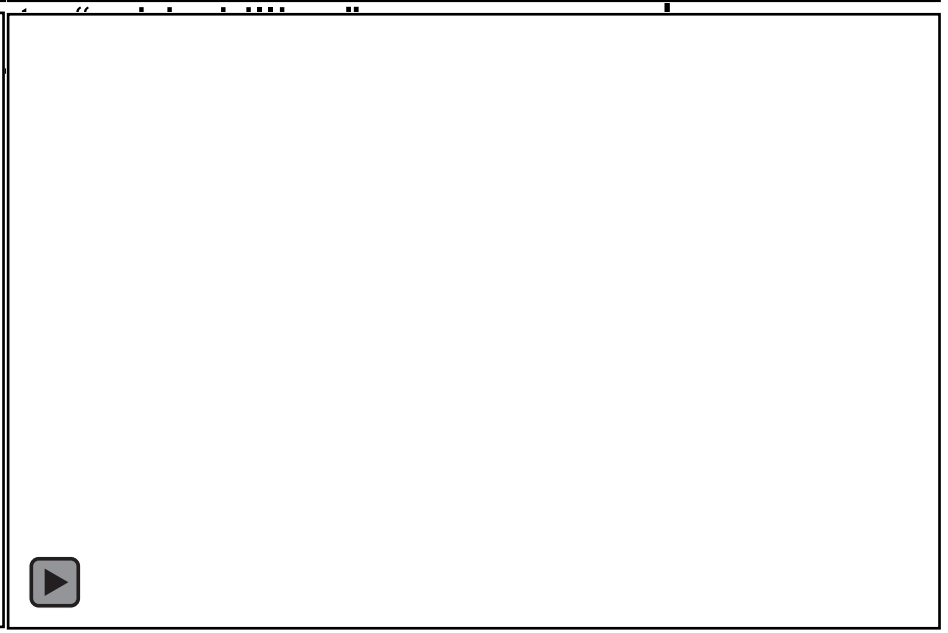


Surface velocity (m/s) comparison against backscatter schemes

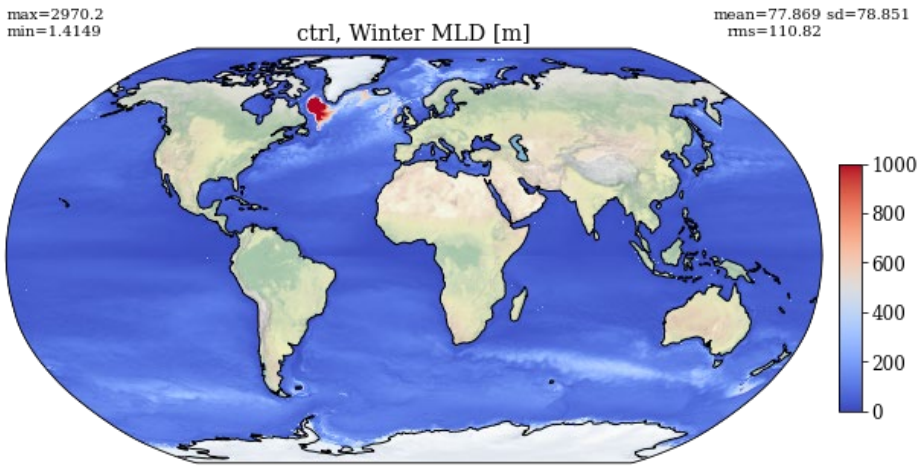


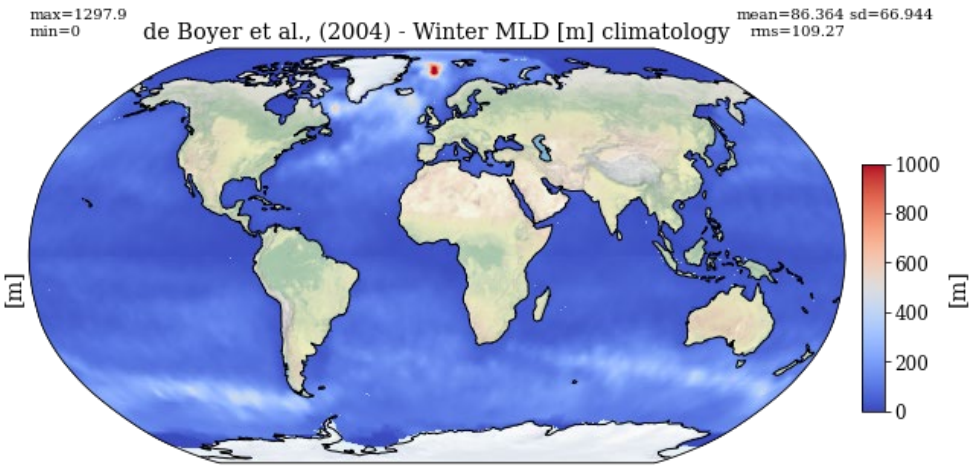


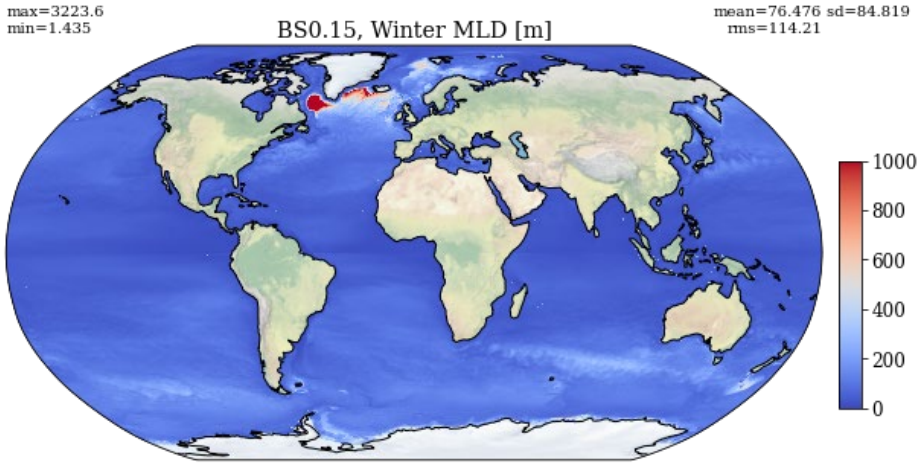


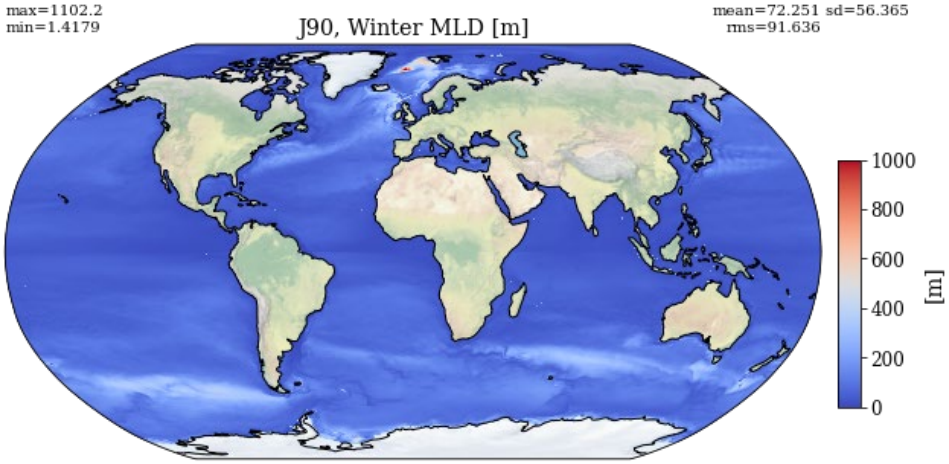


Winter Mixed Layer Depth (MLD), 0.03 kg/m^3 density criteria



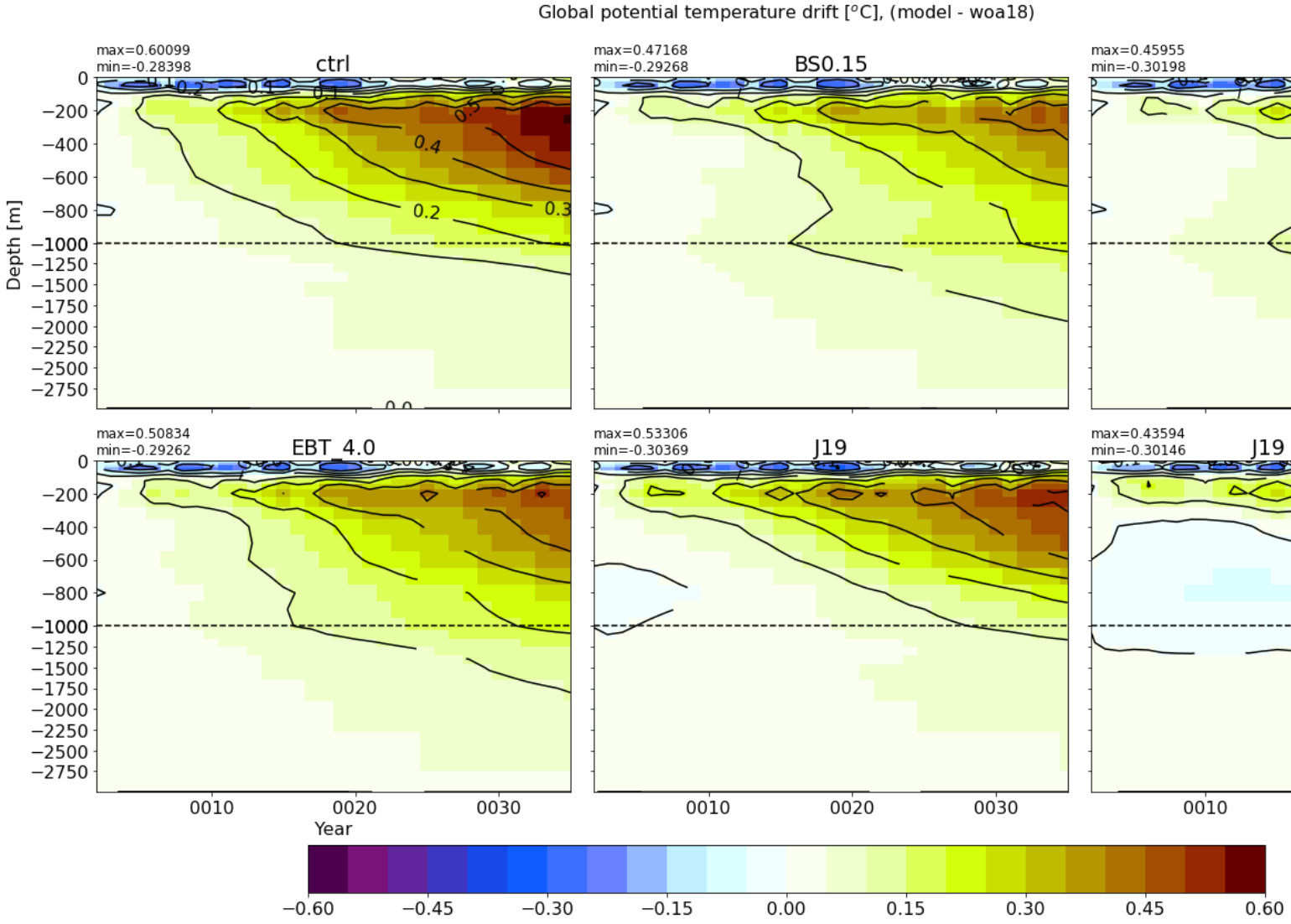






Averaged between years 30-35.

Global temperature drift



Overall bias reduction is all cases.

Regional applications with CESM/MOM6

Eastern tropical Pacific

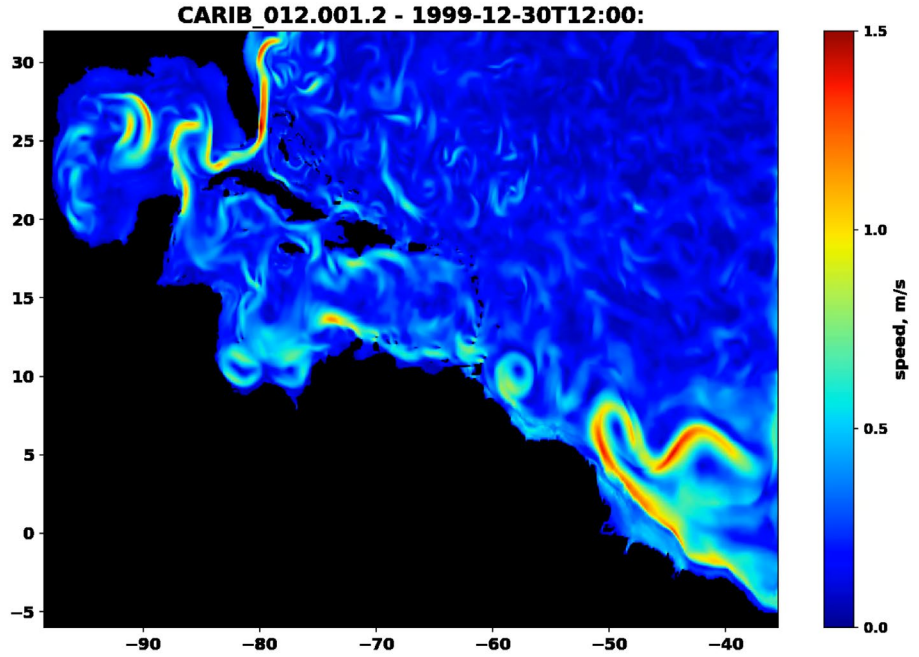
1 km, driven by MPAS-A (3 km)

SST [ºC]

Caribbean Sea and Gulf Mexico

1/12º, driven by JRA-55 (1/4º)

Surface vel. (m/s)



Led by Giovanni Seijo (grad. student, CU Boulder/ASP)

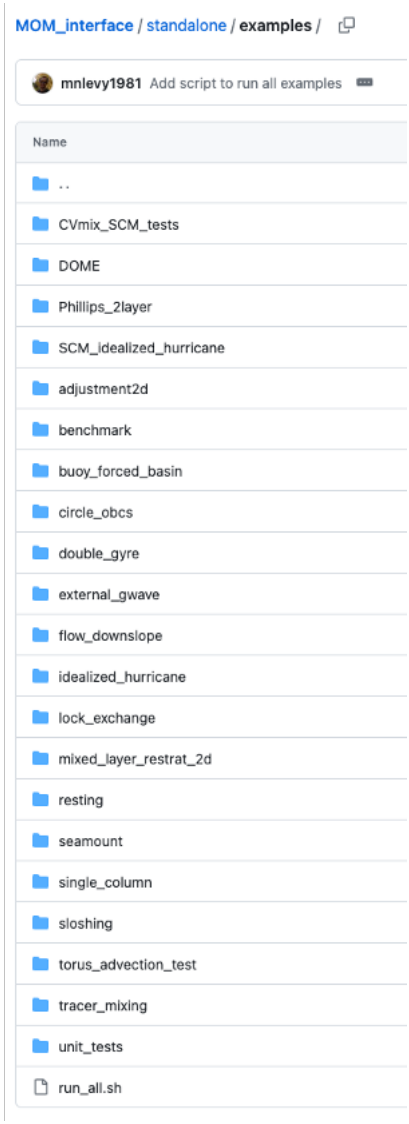
- Actionable science applications, e.g., coral, fisheries, Marine Protected Are

Option to run standalone MOM6 simulations within CESM

Idealized test cases provide simplified scenarios for studying fundamental processes, developing/testing parameterizations, benchmarking the model, and facilitating educational purposes.

21 idealized test cases are currently supported →

https://github.com/ESCOMP/MOM_interface/tree/main/standalone/examples



Notebook-based diagnostics

- Notebook-based for easy sharing and annotating, with support for scripts for back-compatibility
- Flexible diagnostic framework - run out of the box or customize
- Catalog-friendly for simpler data access
- Multiple options for computational resources

README.md

nbscuid

Notebook-Based, Super CUstomizable Infrastructure for Diagnostics

Installation

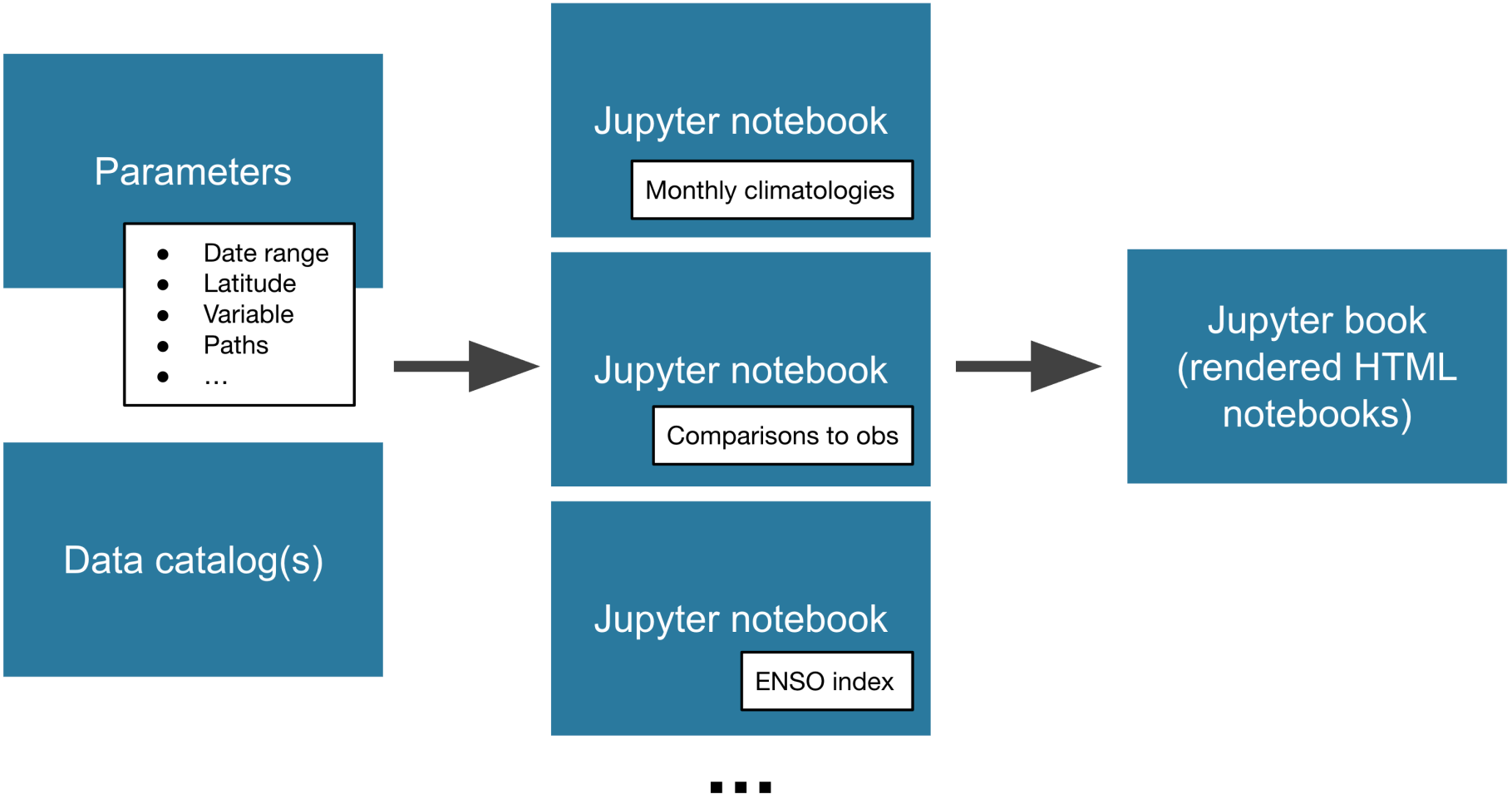
- Run:

```
pip install nbscuid
```

This is a package to enable running notebook-based diagnostic workflows. Based on my-cesm-experiment by matt-long: https://github.com/matt-long/my-cesm-experiment.

See some examples of workflows at https://github.com/rmshkv/nbscuid-examples. For a basic tutorial, follow https://nbscuid.readthedocs.io/en/latest/tutorialsetup.html.

Workflow overview



Experimenting with MOM6 diagnostics

- Current workflow:
  - Diagnostic functions: **mom6-tools**
  - Series of python scripts configured by a yaml file and submitted via bash script through **qsub**
  - Create output files that are displayed through notebooks in **mom6_solutions**
- Goal: converting these diagnostics to be compatible

Example of a mom6-tools diagnostics Jupyter book

Example project

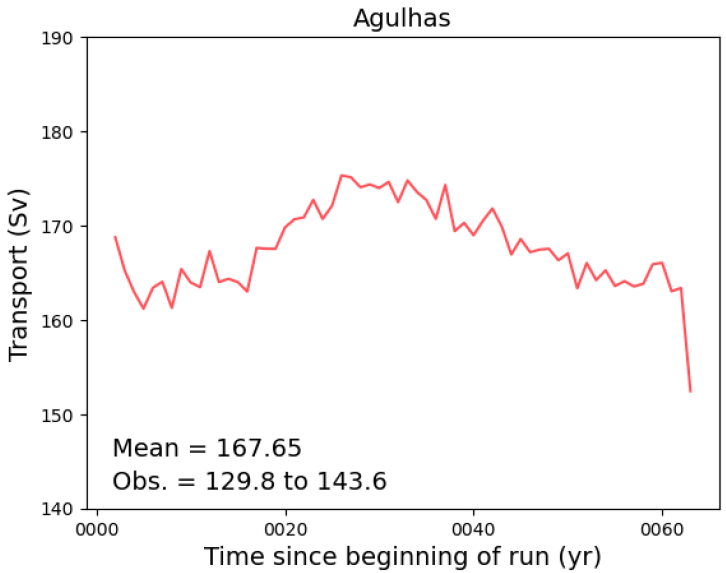
mom6 notebooks

Transport across sections

Temperature and Salinity biases at slected depth Levels

Agulhas Section

```
agulhas = Transport(args,'agulhas_section','umo',label='Agulhas',ylim=(140,190.
plotSections.append(agulhas)
plotPanel(agulhas, observedFlows=observedFlows)
```



Bab al mandeb Strait (Red Sea)

```
bab = Transport(args,'Bab_al_mandeb_Strait','umo',label='Bab al mandeb Strait',yli
plotSections.append(bab)
plotPanel(bab, observedFlows=observedFlows)
```

Contents

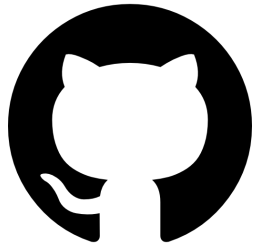
Links

Main repo: https://github.com/rmshkv/nbscuid

Docs: https://nbscuid.readthedocs.io

Usage examples: https://github.com/rmshkv/nbscuid-examples

Contact me: eromashkova@ucar.edu



Summary

- Improved the workhorse global 2/3^{o} grid and land/sea mask. Preliminary tests look good. New set of fully-coupled simulations are underway;

- New global eddy-permitting (1/4^{o}) configuration ⟶ test kinetic energy backscatter schemes informed by Ocean Transport and Eddy Energy Climate Process Team;

- High-resolution regional modeling ⟶ enable actionable science applications;

- New package for notebook-based diagnostics in progress. (https://github.com/rmshkv/nbscuid)

Thank you! gmarques@ucar.edu & eromashkova@ucar.edu