

# Progress towards CESM3 ocean model and workflows



Gustavo Marques  
gmarques@ucar.edu

&

Elena Romashkova  
eromashkova@ucar.edu

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

**CESM Workshop, June 13th 2023**

# New and revised global configurations

## Revised workhorse configuration; 2/3° resolution (tx2\_3):

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

## New configurations:

- **Eddy-permitting**; 1/4° resolution (tx1\_4). This will be used to leverage work done by the CPT
- **Eddy-resolving**; 1/12° resolution (tx1\_12), coming soon!
- **Ultra-high**; 1/36° resolution (tx1\_36), coming soon!

Many thanks to Frank Bryan and Fred Castruccio!

Configurations will be fully documented on GitHub



Supergrid  
Topography generation  
Generate an ESMF mesh  
Runoff mapping files  
Introduction  
Wave Dissipation dataset

The screenshot shows the GitHub repository page for Supergrid. The page title is "Supergrid" and the sub-page is "About". The "About" section contains the following text: "The supergrid is created using ORCA\_gridgen which relies on the NEMO ocean modelling framework to generate tripolar grids for MOM6. For a complete description of the code, please check [this user guide](#). The original code has been modified to create an supergrid (ocean\_hgrid.nc), in addition to the defaults files for NEMO (coordinates.nc and coordinates\_north.nc)."

The "Usage" section contains the following text: "File param.f90 has the modifications needed to generate the nominal 2/3 degree resolution grid (tx2\_3); The original (default) configuration used for ORCA1 is also included for comparison (file param.f90.ori and trop.f90.ori). A simple [diff](#) of the files can be used to check what has been changed to create tx2\_3:"

```
diff param.f90 param.f90.ori
```

The code is intended to compile under any compliant Fortran 90 compiler. It must be compiled with a flag that promotes reals to 8 bytes. It must be linked with the NetCDF F90 library. To compile ORCA\_gridgen on Casper, load the following modules:

```
module load intel/19.1.1
module load netcdf/4.8.1
```

Then type:

```
cd ORCA_gridgen
make clean
make
```

This should create an executable called "tripole.exe". Next, type the following:

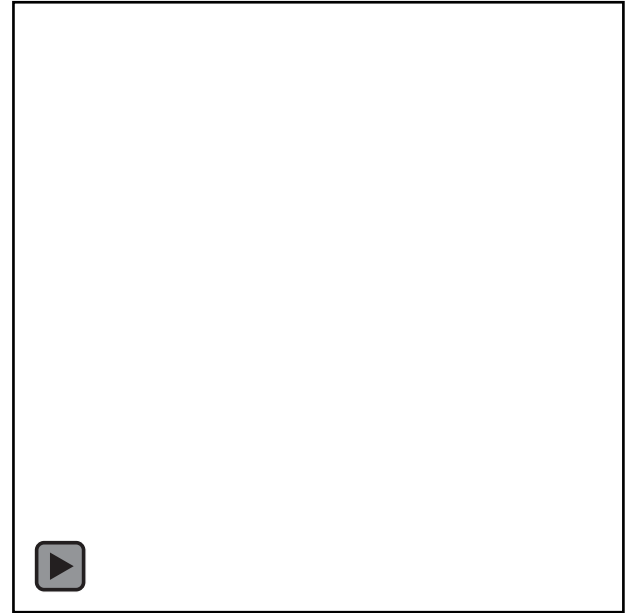
[ncar.github.io/tx2\\_3/](https://ncar.github.io/tx2_3/)



# CESM/MOM6 global 1/4° configuration

- Ocean (MOM6) and sea ice (CICE5) components;
- Nominal 1/4° 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).

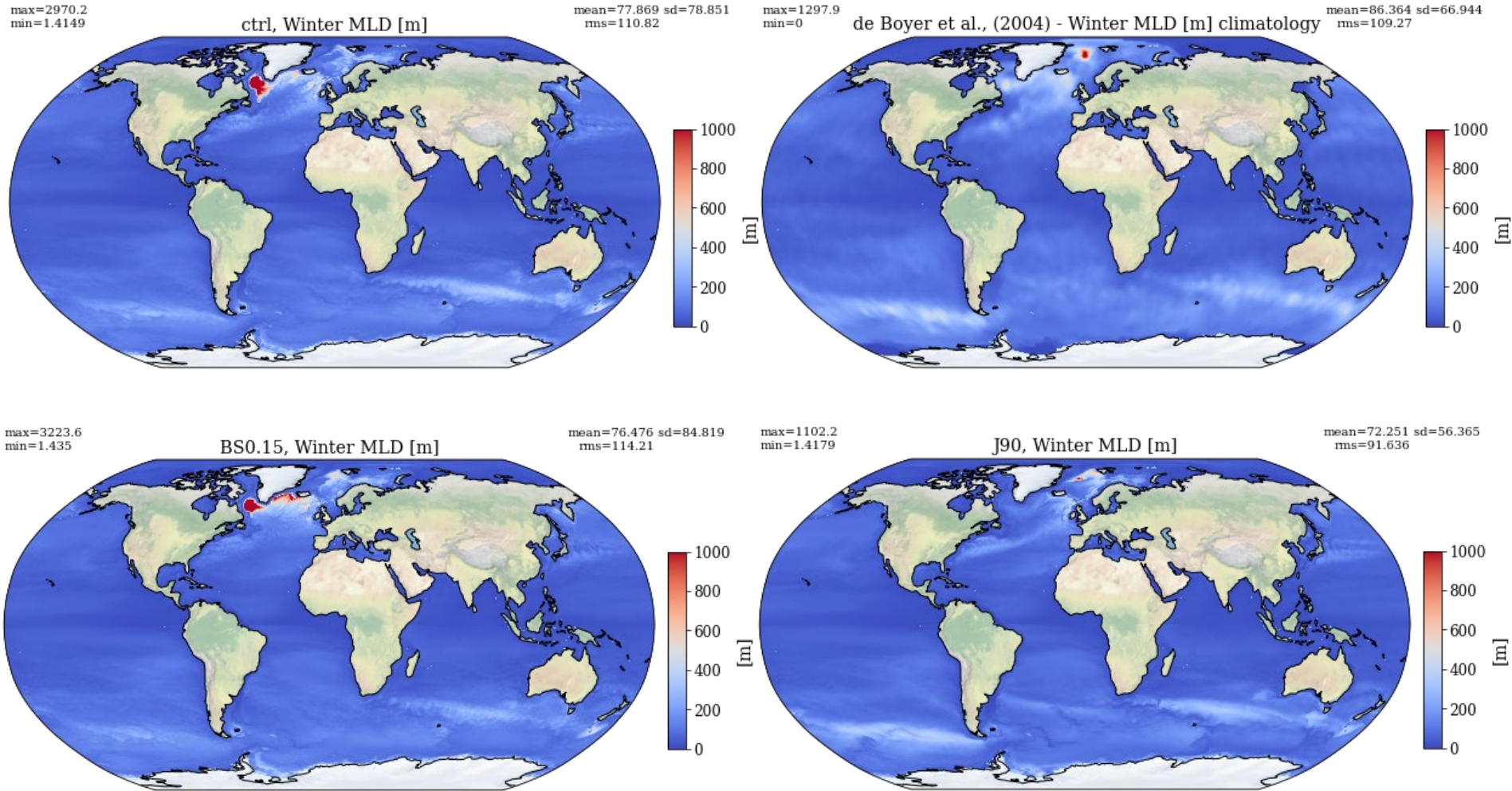
[https://github.com/NCAR/tx1\\_4](https://github.com/NCAR/tx1_4)



# Surface velocity (m/s) comparison against backscatter schemes



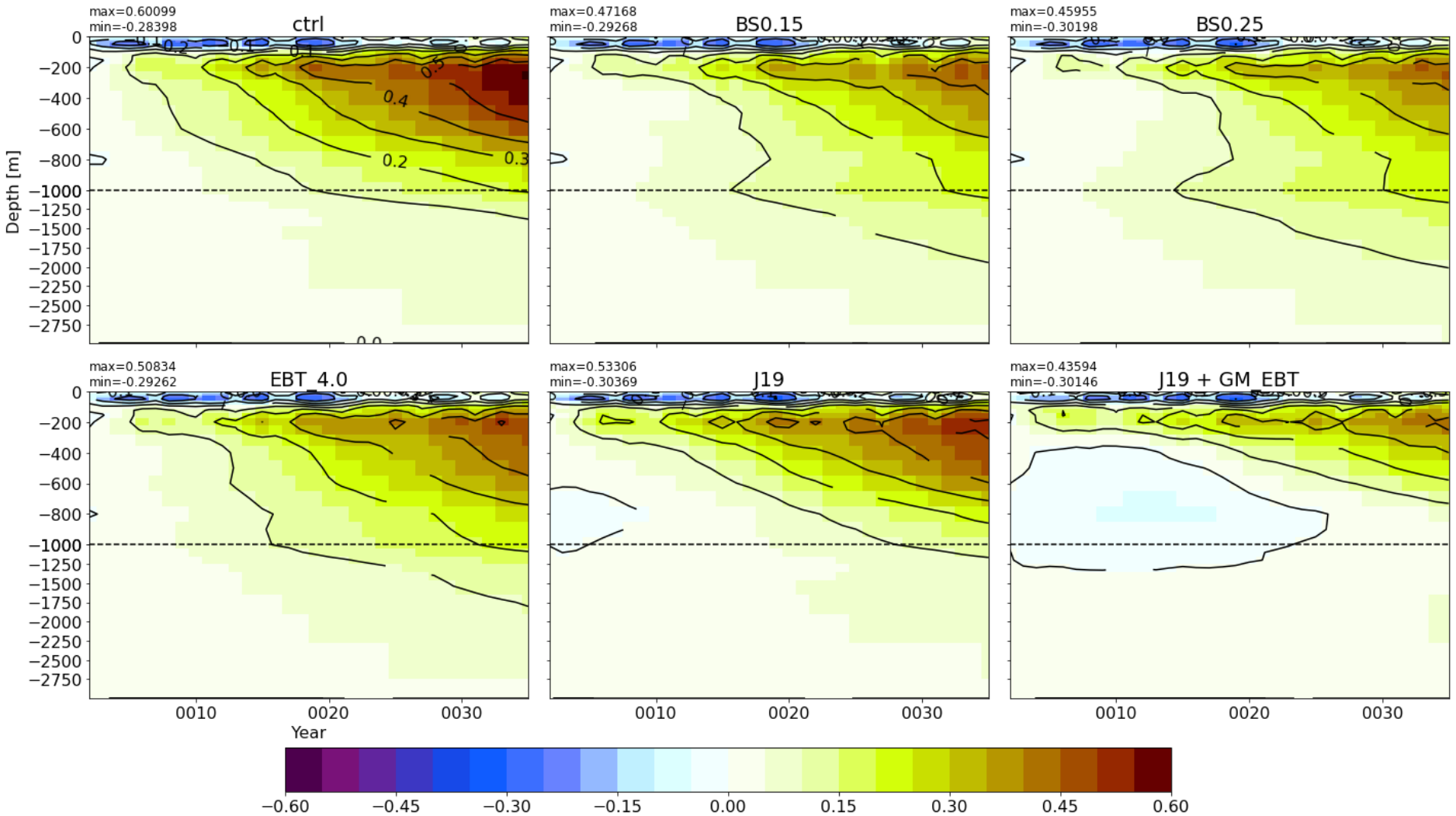
# Winter Mixed Layer Depth (MLD), 0.03 kg/m<sup>3</sup> density criteria



Averaged between years 30-35.

# Global temperature drift

Global potential temperature drift [°C], (model - woa18)



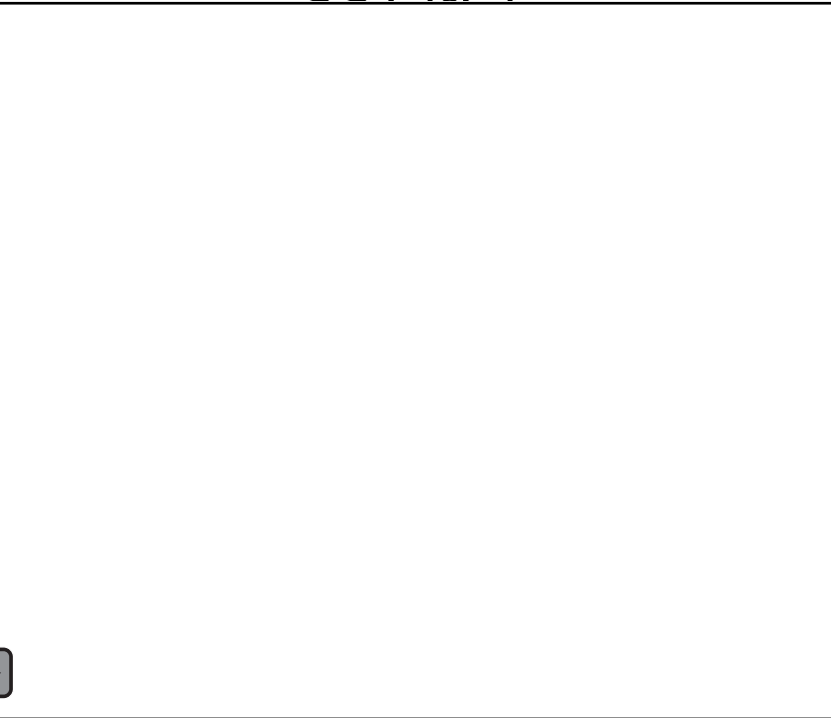
Overall bias reduction is all cases.

# Regional applications with CESM/MOM6

## Eastern tropical Pacific

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

CST 1001

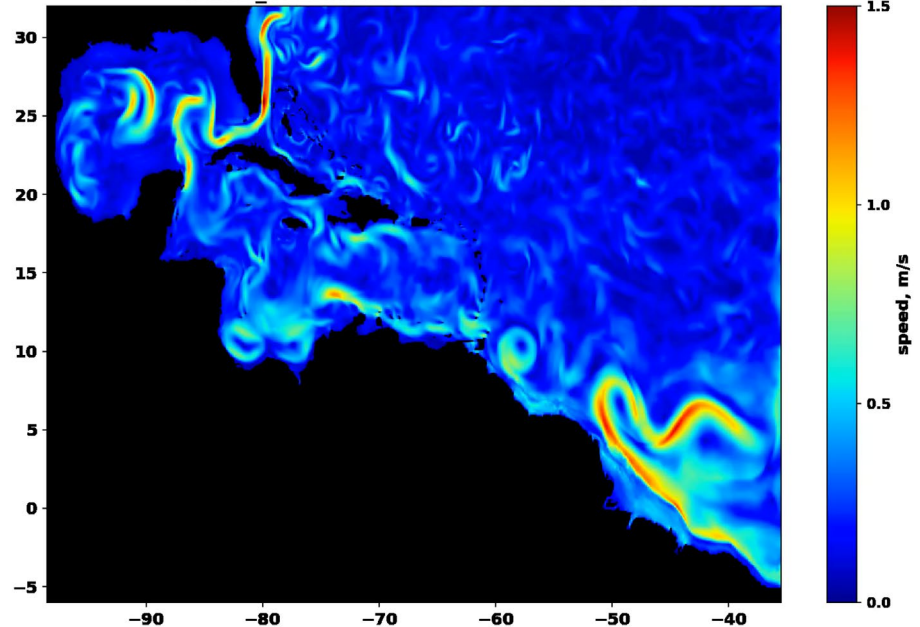


## Caribbean Sea and Gulf Mexico

1/12°, driven by JRA-55 (1/4°)

Surface vel. (m/s)

CARIB\_012.001.2 - 1999-12-30T12:00:



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

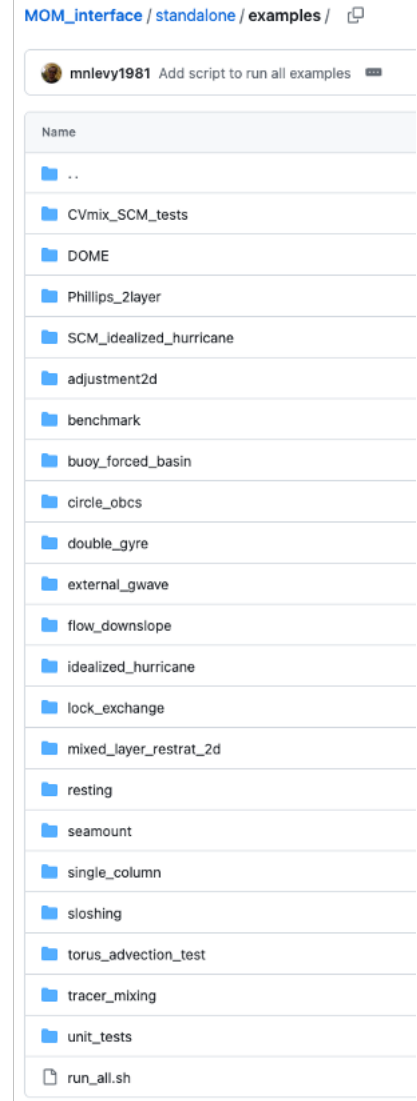
- Actionable science applications, e.g., coral, fisheries, Marine Protected Areas

# 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.

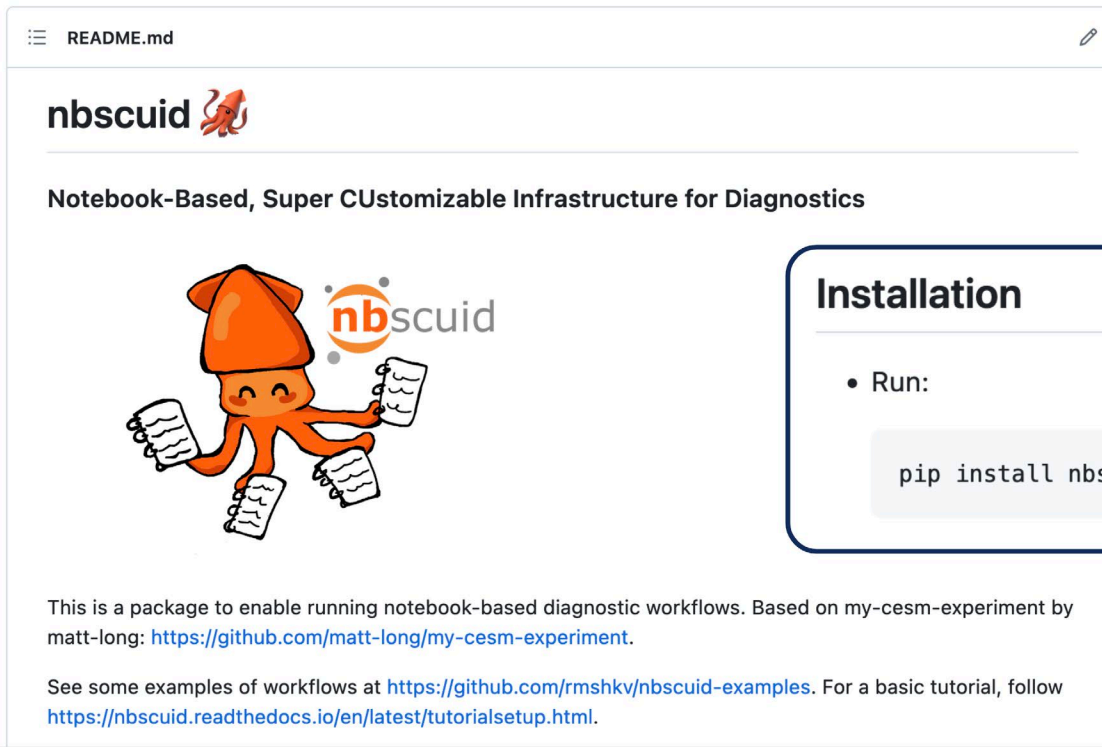
21 idealized test cases are currently supported 

[https://github.com/ESCOMP/MOM\\_interface/tree/main/standalone/examples](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



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>.

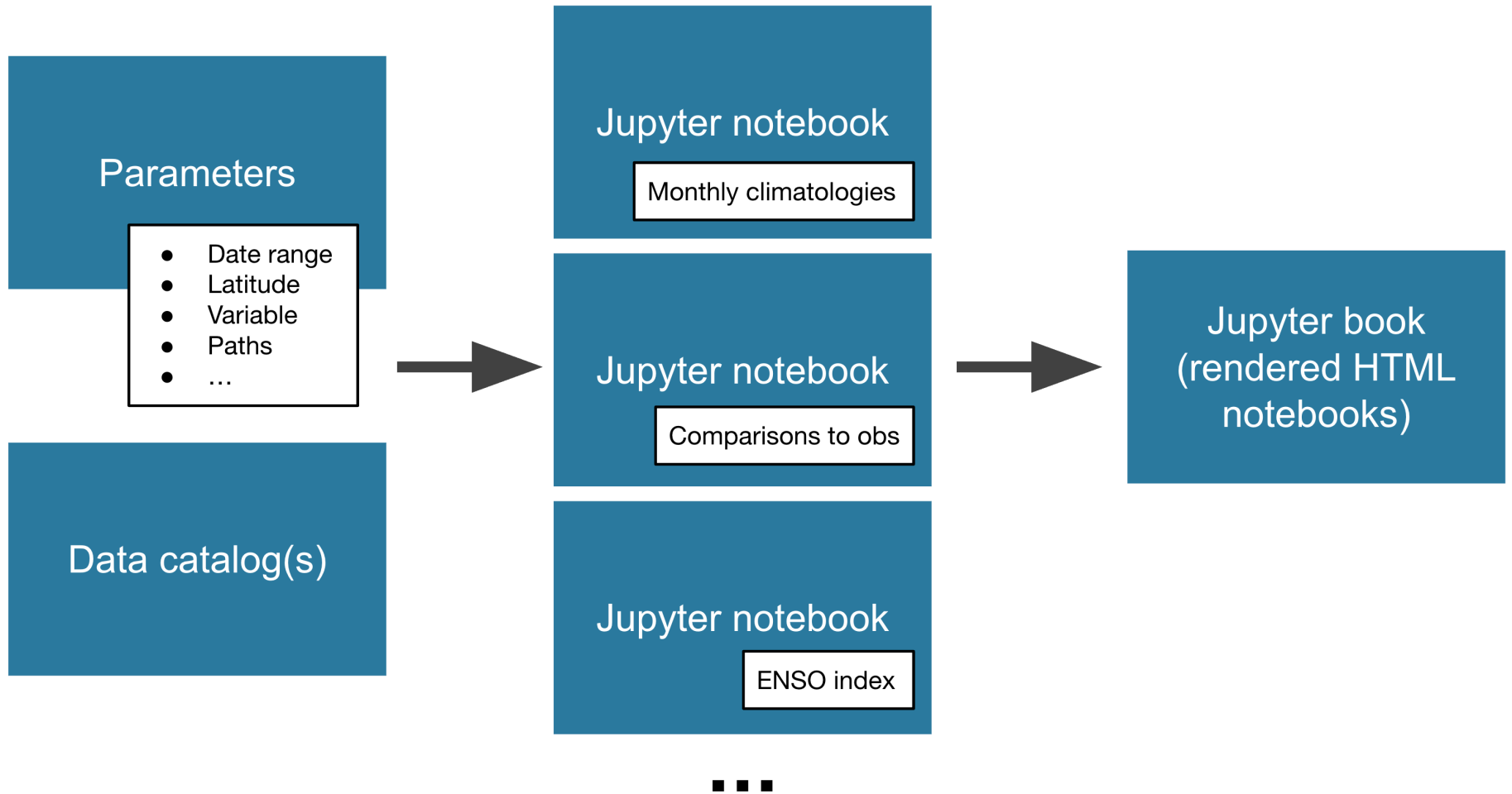
### Installation

- Run:

```
pip install nbscuid
```



# 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

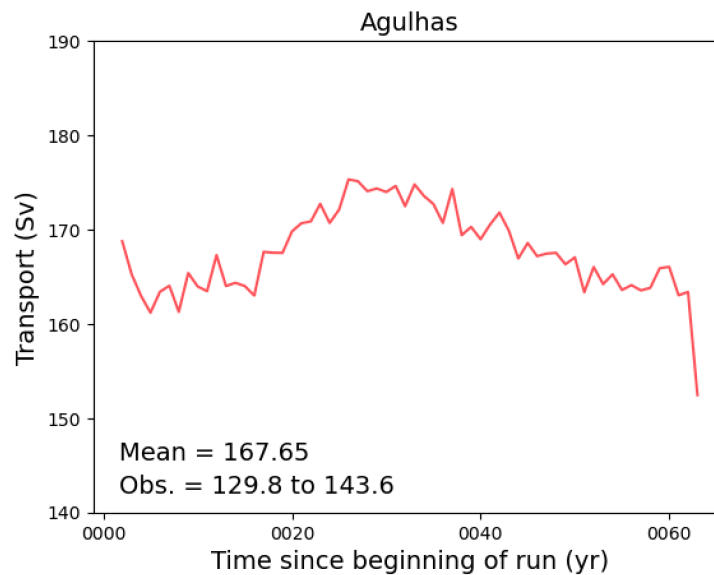
#### Transport across sections

Temperature and Salinity biases at selected 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', ylim=(140,190)
plotSections.append(bab)
plotPanel(bab, observedFlows=observedFlows)
```

### Contents

#### Connecting to cluster

This is the only cell that needs to be modified

#### Agulhas Section

Bab al mandeb Strait (Red Sea)

Bering Strait

Barents opening

Davis Strait

Denmark Strait

Drake Passage

English Channel

Florida Bahamas

Fram Strait

Gibraltar Strait

Hormuz Strait (Persian Gulf or Arabic Sea)

Iceland Norway

Indonesian Throughflow

Mozambique Channel

Pacific undercurrent

Taiwan Luzon

Windward Passage

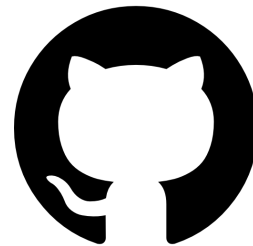
Save netCDF file with transports

**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](mailto:eromashkova@ucar.edu)



# Summary

- Improved the workhorse global  $2/3^\circ$  grid and land/sea mask. Preliminary tests look good. New set of fully-coupled simulations are underway;
- New global eddy-permitting ( $1/4^\circ$ ) configuration  $\longrightarrow$  test kinetic energy backscatter schemes informed by Ocean Transport and Eddy Energy Climate Process Team;
- High-resolution regional modeling  $\longrightarrow$  enable actionable science applications;
- New package for notebook-based diagnostics in progress.  
(<https://github.com/rmshkv/nbscuid>)

Thank you! [gmarques@ucar.edu](mailto:gmarques@ucar.edu) & [eromashkova@ucar.edu](mailto:eromashkova@ucar.edu)