Evaluation of a mesoscale eddy resolving North Pacific Ocean model forced by JRA55-do

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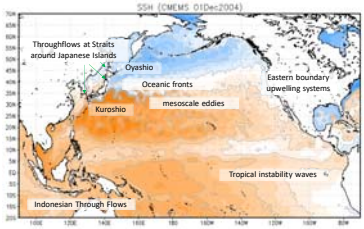
Abstract. An OMIP-BGC-like simulation is conducted for a mesoscale eddy resolving model for the North Pacific Ocean. The North Pacific Ocean model has a nominal horizontal resolution of 10 km and is embedded within a lower resolution (nominal 1-degree) global ocean model by a two-way nesting method. In the experiment, the global ocean model with the bio-geochemistry and the inert chemistry has been run for 360 years (1658-2017) by repeating the 60-year JRA55-do surface dataset (1958-2017) for six times by following the OMIP-BGC protocol. Next, the global model with the embedded 10-km North Pacific Ocean model is branched off from the spun-up state of the global model in 1936 and is run until 2017. In this poster, we are presenting the overall evaluation on the simulation result of the North Pacific Ocean model. The impact of the high resolution on the mean physical and geochemical tracer fields, the simulated long-term regional sea level variability, and the mesoscale eddy fields, are mainly assessed.

1. Why high-resolution ocean models for the North Pacific?

- Kuroshio and Oyashio (western boundary currents)
- Throughflows at Straits around the Japanese Islands
- Oceanic fronts, mesoscale eddies
- Eastern boundary upwelling systems along the western coast of North American Continent
- Tropical instability waves
- Indonesian thorough flow

High-res ocean models are beneficial not only to the ocean but also to coupled atmosphere – ocean system.



2. 10-km North Pacific model embedded within a global model

Ocean model source code

MRI.COM v4 (Tsujino et al. 2017)

- z* vertical coord. Partial step topog.
- B-grid (tracer at corners), generalized orthogonal curvilinear coord.
- Second Order Moment for T&S advection
- PPM for passive tracer advection

Vertical mixing

- Umlauf and Burchard (2003)
- Decloedt and Luther (2010)

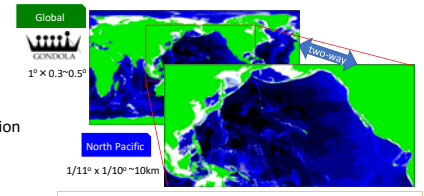
Horizontal mixing

Global

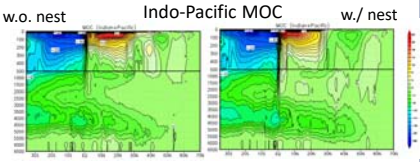
- Tracer: Redi isopycnal & Gent McWilliams
- Momentum: Smagorinsky harmonic, anisotropic

North Pacific (see also "Tuning" (left side))

- Tracer: Biharmonic
- Momentum: Biharmonic Smagorinsky



Mass of water and tracers are conserved for the Global + North Pacific System by the flux adjustment at the surface/side boundaries.
By applying a sponge layer, models are connected smoothly (below).

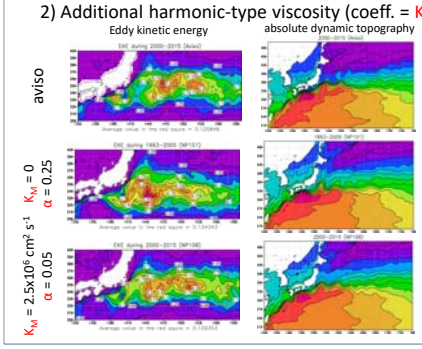


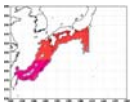
3. "Tuning" of the North Pacific model

EKE is "tuned" by the two parameters

1) $\boldsymbol{\tau} = \rho_a C_d(|\boldsymbol{U}_{10} - \alpha \boldsymbol{u}_o|) * (\boldsymbol{U}_{10} - \alpha \boldsymbol{u}_o)$ - α = 1: EKE too low, underdeveloped recirculation gyres; - α = 0: too energetic mesoscale eddies

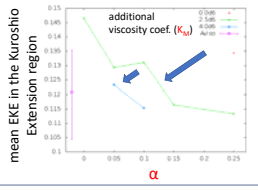
2) Additional harmonic-type viscosity (coeff. = K_M) on the Kuroshio along the boundary





Additional viscosity is necessary to regulate too energetic Kuroshio.

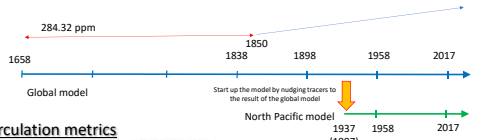
Summary of sensitivity experiments



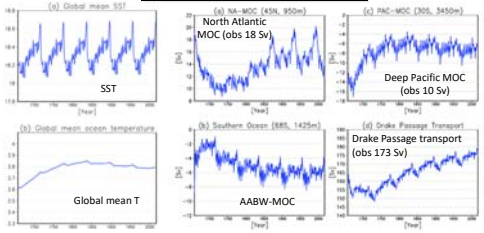
4. OMIP-BGC simulation (spin-up of the global model)

OMIP-BGC-like experiment forced by JRA55-do

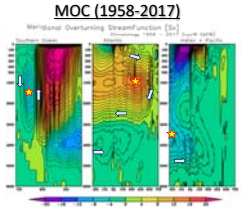
The ocean component of MRI-ESM2 (developed for CMIP6) has been slightly tuned for this experiment



Global ocean circulation metrics

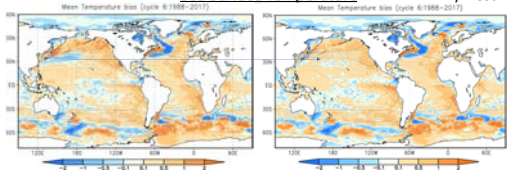


MOC (1958-2017)



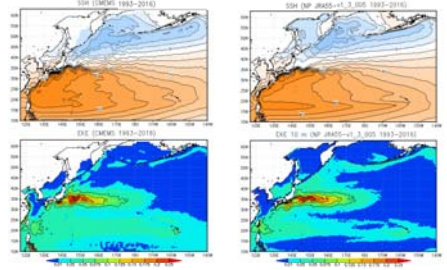
5. Evaluation of Physical Fields

w.o. nest — Sea Surface Temperature — w./ nest

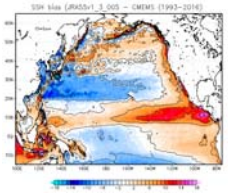


High resolution can significantly improve simulation of the North Pacific Ocean!

Altimeter — Sea Surface Height and EKE — Model



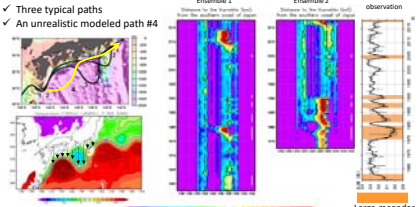
Altimeter – Model



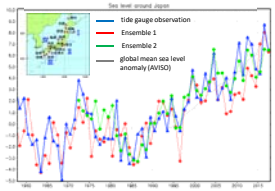
- ✓ Low ridge/trough of wind driven gyres → Wind stress is possibly weak.
- ✓ Methods to adjust wind vector around ITCZ in JRA55-do needs to be revised.

"Large Meander" of Kuroshio south of Japan

- ✓ Three typical paths
- ✓ An unrealistic modeled path #4



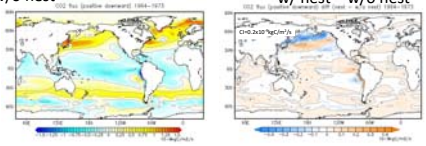
Coastal sea level of Japan



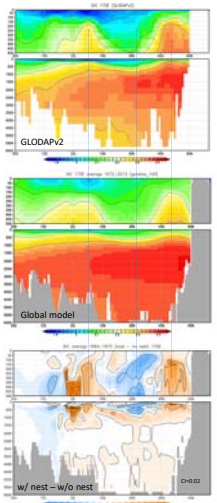
6. Evaluation of Biogeochemical Fields

Surface CO_2 flux (positive downward)

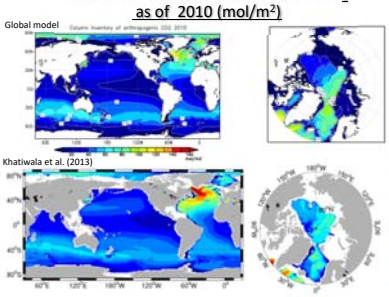
w/o nest — w/ nest – w/o nest



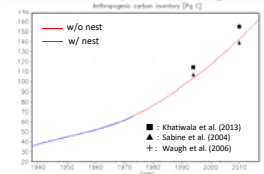
DIC (mol/m^3) @170°E (1972-2013)



Column inventory of anthropogenic CO_2 as of 2010 (mol/m^2)



Time series of globally integrated column inventory of anthropogenic CO_2



Northward intrusion of CFC11 into the bottom layer of the Pacific Basin