



Influence of horizontal resolution on mean state of tropical Indo-Pacific Oceans in OGCM simulations

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Motivation

- A high resolution ocean model is needed to simulate heat transport by mesoscale eddies and current structure associated with complex geometry, which may impact on the mean state of tropical Indo-Pacific Oceans.
- However, a long-term integration of the high resolution model requires vast computer resources, and thus it is still difficult to use it as a climate model.
- In this study, we explore a high resolution tropical model nested to a low resolution global model, which mitigates the limitation of computer resources.

Question

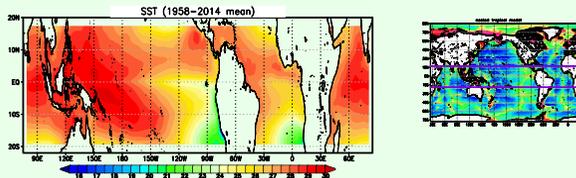
- What benefit does a high resolution ocean model provide for the mean state of the tropical Indo-Pacific Oceans, compared to a low resolution ocean model?

Methods

- MRI-JMA is developing three ocean models for the climate study, which are called **GONDOLA** (Global Ocean model as a Nucleus of Dynamically-Organized Large-scale Application).



Ocean Model	Resolution	Domain	Computational cost
<i>GONDOLA_100</i>	1° x 0.5° x 60 levels	global	1
<i>GONDOLA_010</i>	1/11° x 1/10° x 60 levels	global	376
<i>TP_NEST</i>	0.2° x 0.1° x 60 levels	tropical nested to GONDOLA_100	12.3



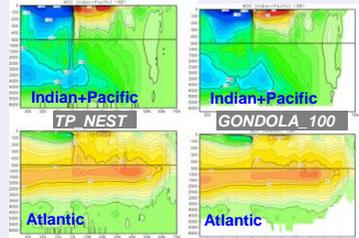
TP_NEST Configuration

- High resolution tropical ocean model embedded into a global model
- Resolution: 0.2° x 0.1° horizontal grid, 60 vertical levels
- Model domain: 19°S-17°N, 0°E-360°E
- Global model : 1°x0.5°, 60 vertical levels (the same as GONDOLA_100)
- Nesting: 2-way nesting
- Surface boundary conditions : modified JRA-55
- Initial condition: The 58 year of GONDOLA_100(1958/01/01)
- Integration period: 1958-2014 (57 years)

Validation

Meridional Stream Function

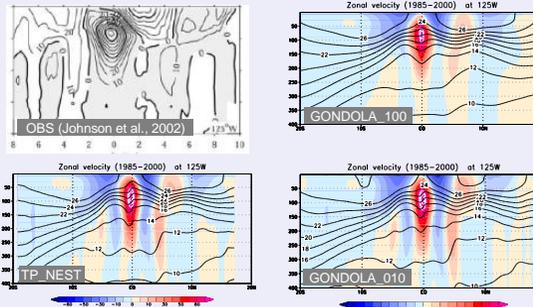
✓ In TP_NEST, a high resolution tropical model is smoothly connected to a low resolution model, indicating that the two-way nesting approach is at work.



Indonesian Throughflow (Sv)

	ITF	Lombok	Ombai	Timor
<i>OBS</i> (Sprintall et al. 2009)	15	2.6	4.9	7.5
<i>GONDOLA_100</i>	12.7	4.4	4.8	0.75
<i>TP_NEST</i>	13.1	4.0	4.3	2.7

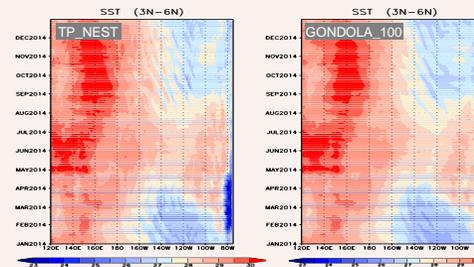
Zonal current at 125°W



✓ The higher resolution model shows a larger horizontal current shear between South Equatorial Current and North Equatorial Countercurrent north of equator.

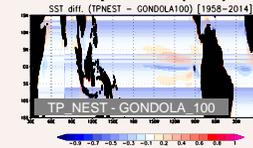
Influence of horizontal resolution

Tropical Instability Waves (TIWs)

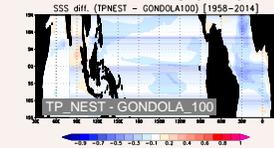


✓ Tropical instability waves, which are associated with a wave like structure in the eastern equatorial Pacific with a duration of 100 days, are well simulated in the higher resolution model.

Sea surface temperature (SST)

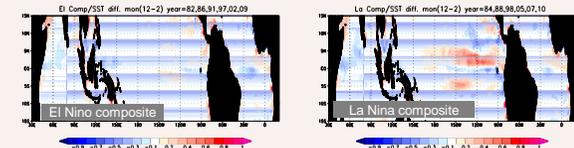


Sea surface salinity (SSS)



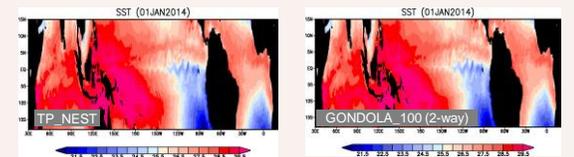
✓ Meridional heat and fresh water exchange by TIWs result in the warming and low salinity north of equator, whereas enhanced upwelling in the higher resolution model leads to the cooling and high salinity along the equator and the eastern coast of South America

Impact of high resolution on SST during El Nino and La Nina



✓ Impact of high resolution on SST is more significant during the La Nina period than during the El Nino period, reflecting larger horizontal current shear during the former period.

Comparison between 1-way and 2-way nesting



✓ The 2-way nesting model captures the features of TIWs better than the 1-way nesting model, suggesting that the 2-way nesting approach has benefit for the coupled modeling.

Summary

- A high resolution ocean model is capable to simulate tropical instability waves (TIWs) better than a low resolution model, because the former can more appropriately represent the horizontal current shear than the latter.
- The higher resolution model results in the warming and freshening north of equator, where TIWs enhance meridional heat and salt exchange.
- Two-way nesting global model represents TIWs better than one-way nesting global model. This suggests that the two-way nesting approach has benefit for the coupled modeling