EGU 2020

The improvements to the numerical model of South China Sea ocean circulations

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Outline

- **Introduction**
- Model settings and validation
- Tracer advection schemes comparison
- Changing of surface forcing
- Conclusion

Introduction

- The SCS is semi-enclosed marginal sea, connected with the adjacent seas through several straits

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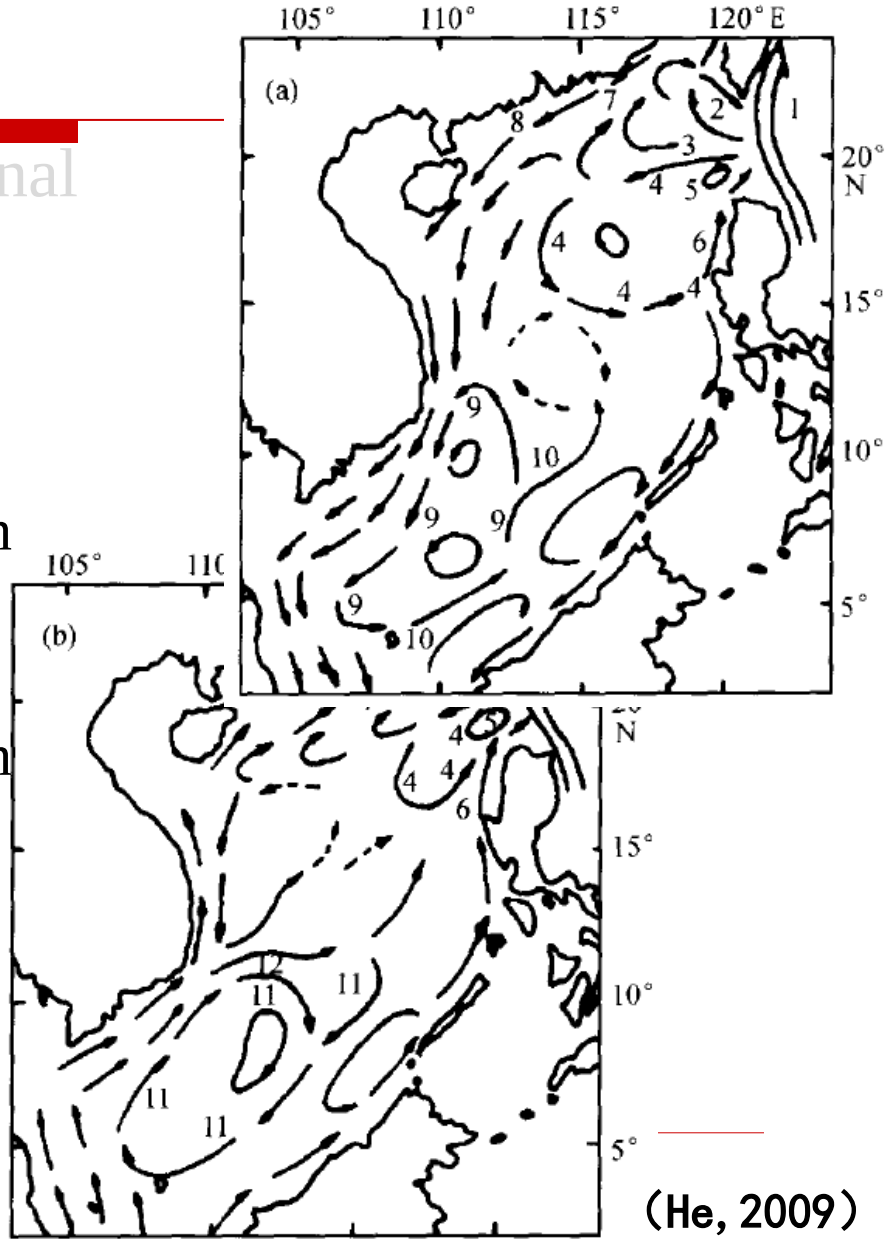
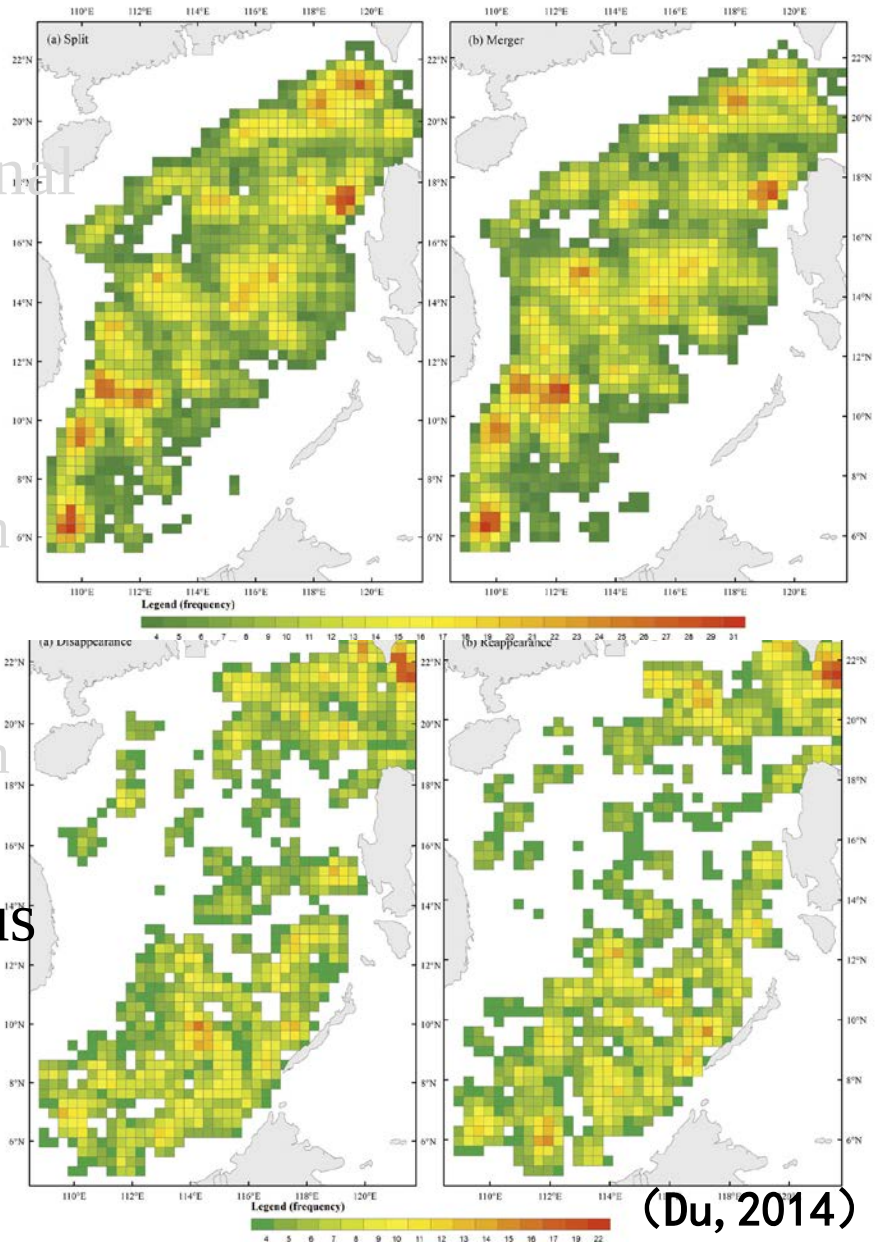
- Basin-scale circulations
  - Cyclonic in winter, anti-cyclonic in summer
  - Persistent cyclonic in the NSCS, Cyclonic in winter, anti-cyclonic in summer in the SSCS



(He, 2009)

Introduction

- The SCS is semi-enclosed marginal sea, connected with the adjacent seas through several straits
- Basin-scale circulations
  - ✓ Cyclonic in winter, anti-cyclonic in summer
  - ✓ Persistent cyclonic in the NSCS, Cyclonic in winter, anti-cyclonic in summer in the SSCS
- Mesoscale eddy activities obvious



(Du, 2014)

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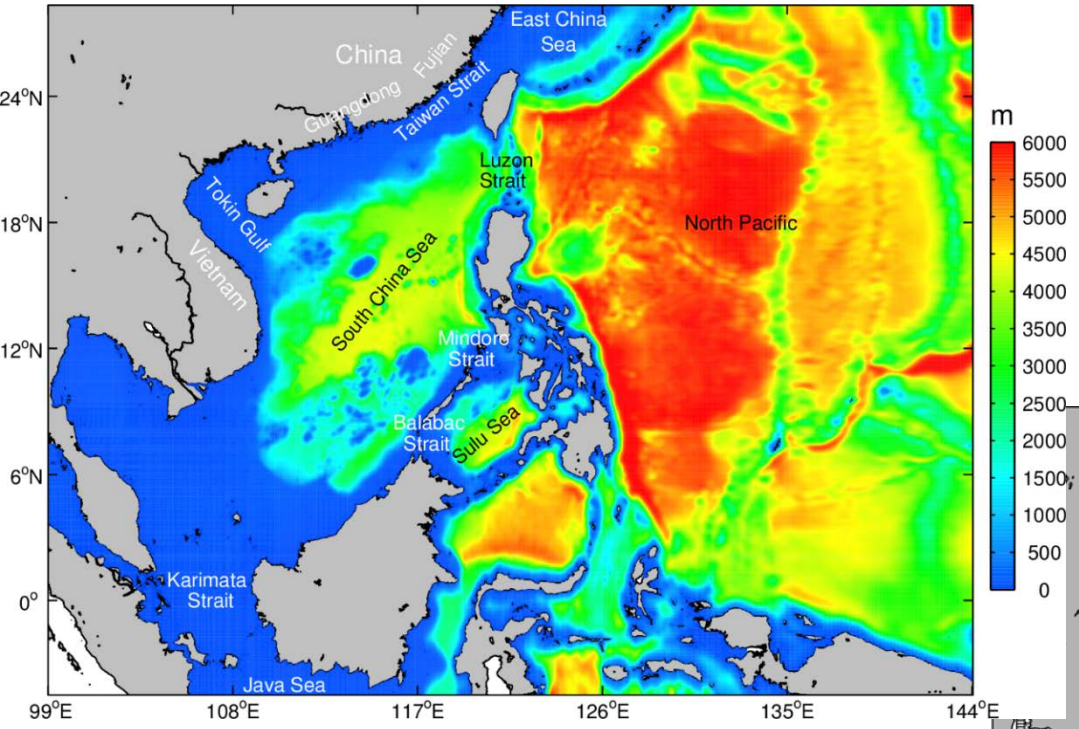
Model settings

- Based on ROMS **Version 3.7**
- **Domain**
  - ✓ -4.5°S~28.4°N, 99°~145°E
- **Horizontal Resolution**
  - ✓ 1/12°～1/30°, Grid NO.: 985×793
- **Vertical Resolution**
  - ✓ 30 Layers
- **Bathymetry data**
  - ✓ GEBCO（0.5′×0.5′）
  - ✓ ETOPO1（1′×1′）
- **Initial Condition**
  - ✓ GDEMV3（0.25° ×0.25° ）

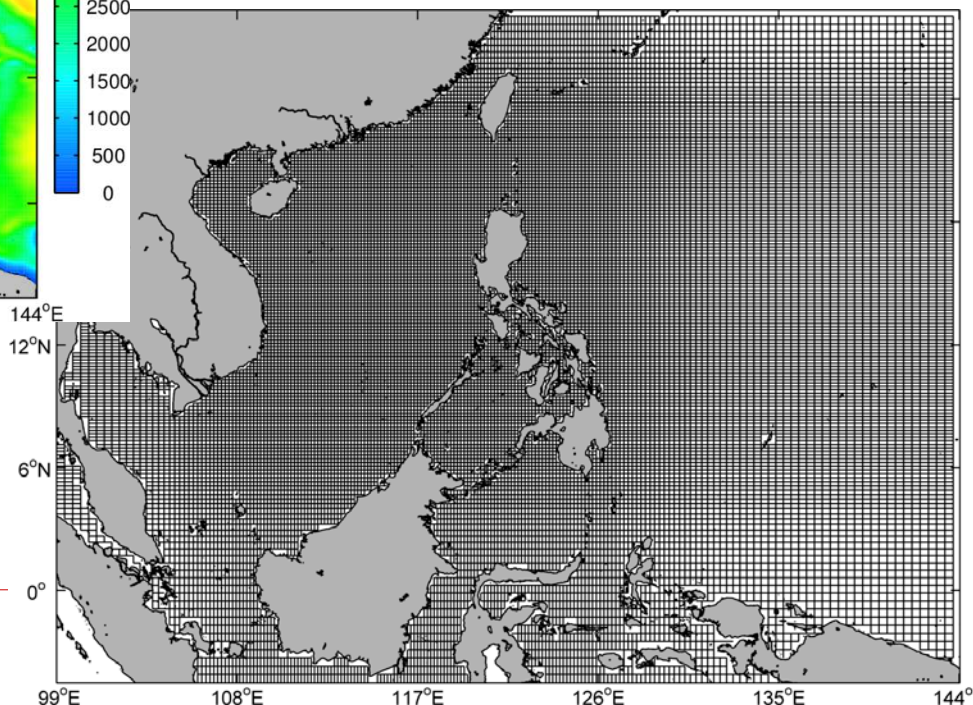
- **Forcing**
  - ✓ **Surface**: CFSR 6-hourly
  - ✓ **Open Boundary**: SODA monthly
  - ✓ **River**: Pearl, Mekong monthly
- **DA**
  - ✓ Qcorrection (AVHRR)
  - ✓ EnOI： AVISO SLA
- **Time step**
  - ✓ External: 6s
  - ✓ Internal: 180s

Model settings



Domain & bathymetry

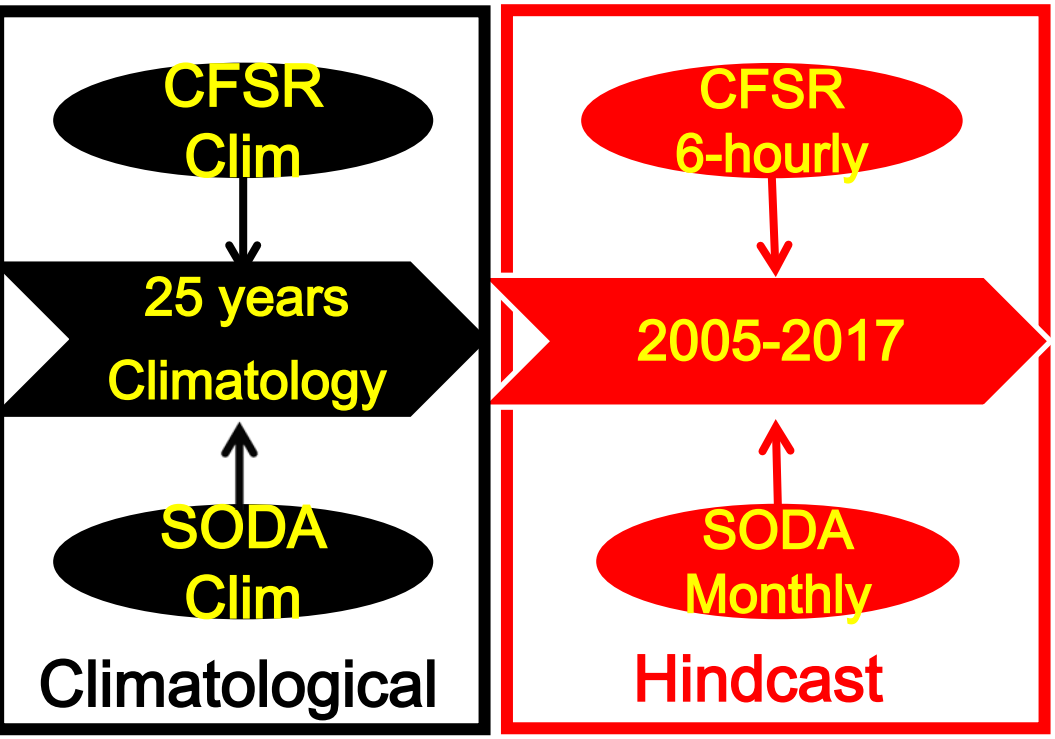
grid distribution



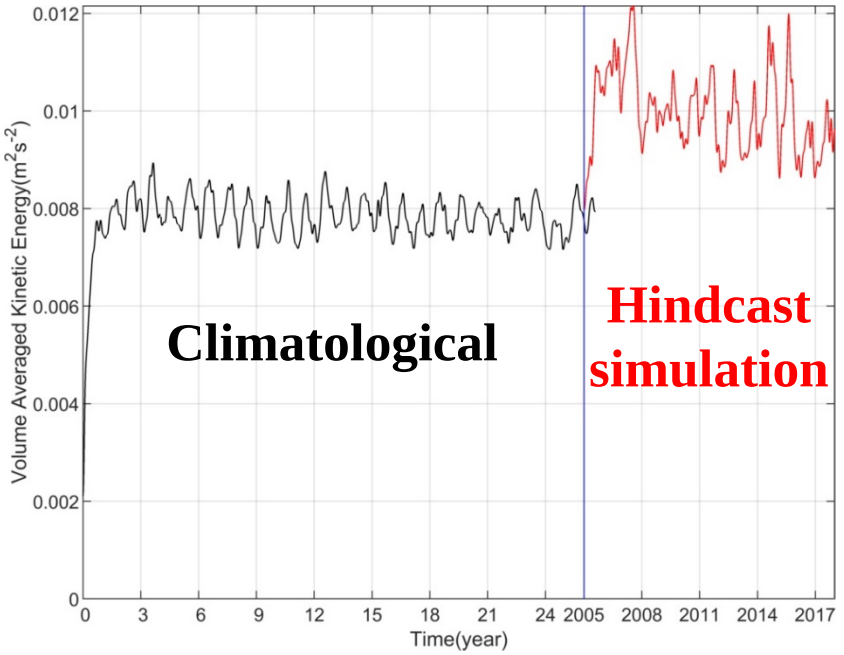
Model settings

Model run & stability

Surface forcing

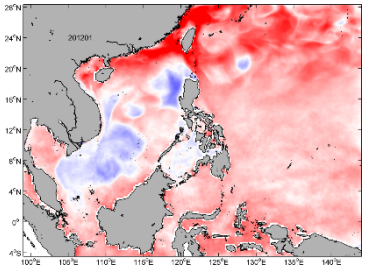
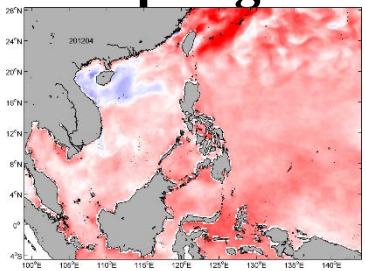
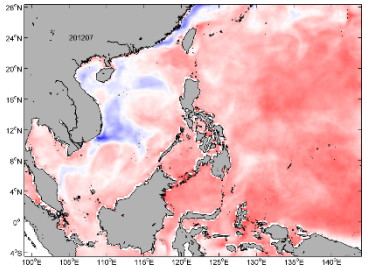
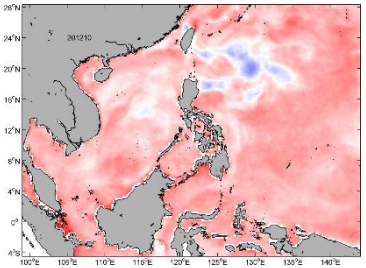
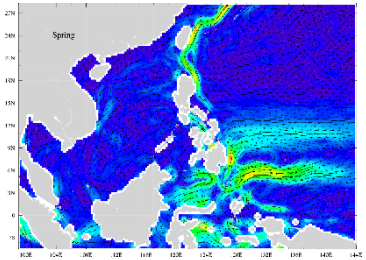
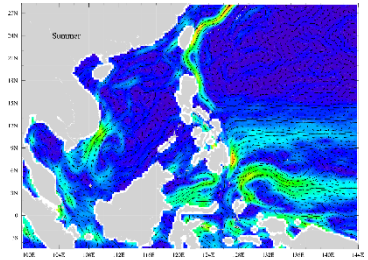
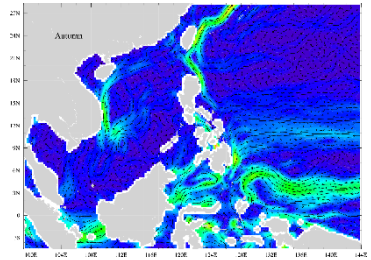
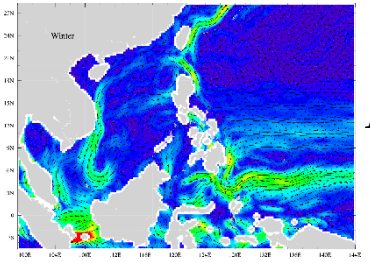
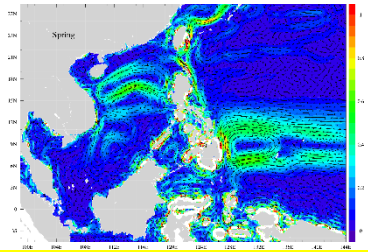
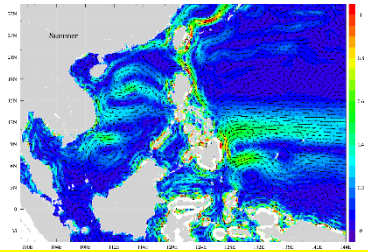
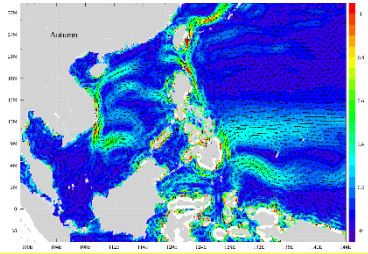
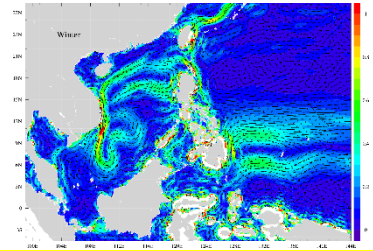


Domain averaged kinetic energy



Open boundary

Model validation

Winter	Spring	Summer	Autumn
			
RMSE=1.07	RMSE=0.98	RMSE=0.86	RMSE=0.84
			
			

AVISO

Model

The spatial pattern and seasonal variations for the geostrophic currents are good agreement with Aviso observations.

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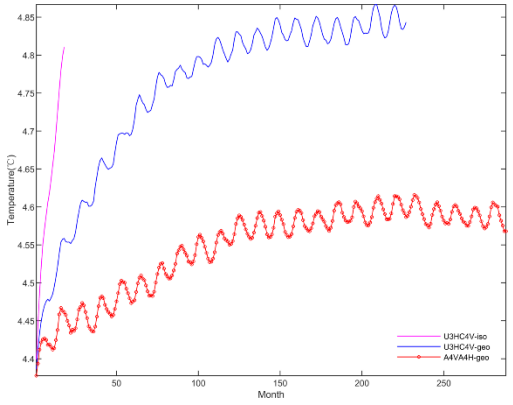
Tracer advection schemes comparison

Tracers' horizontal mixing problem—Spurious Diapycnal Mixing

Experiments Settings

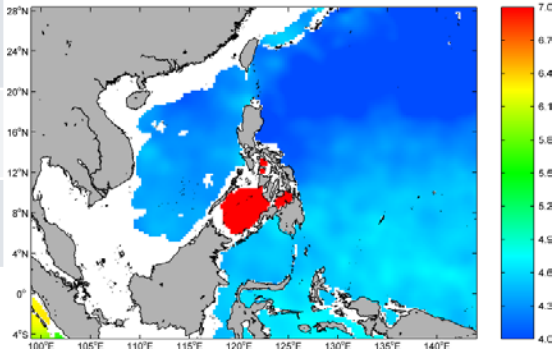
Exp.	Hori. Adv.	Vert. Adv.	Hori. Mixing
1	U3 3rd upstream	C4 4th Centered	iso-cons. rho
2	U3 3rd upstream	C4 4th Centered	geo-cons. z
3	A4 4th Akima	A4 4th Akima	geo-cons. z

Domain averaged Temp. on the 1000m layer

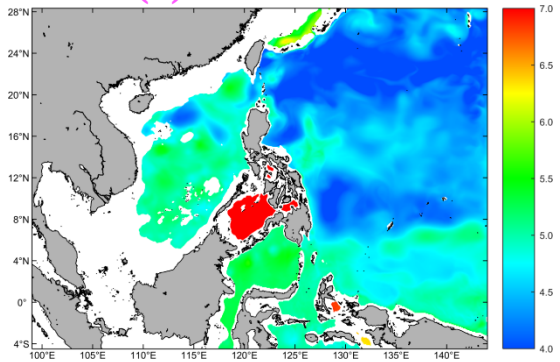


Monthly mean Temp. on the 1000m layer in the 18th month

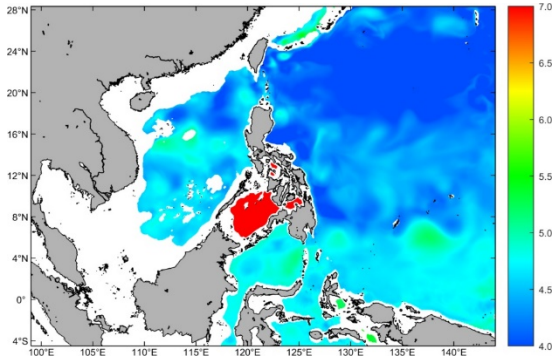
Initial GDEM



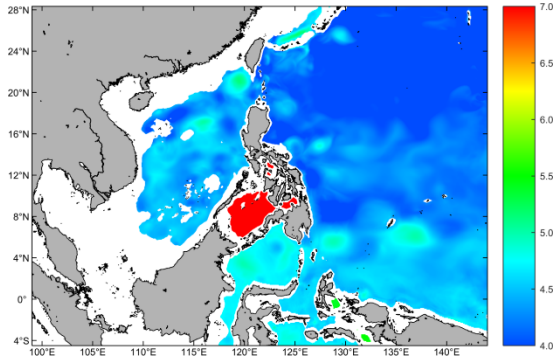
(1) U3HC4V-iso



(2) U3HC4V-geo



(3) A4HA4V-geo



The Iso should be better in theoretically, but not in fact, especially for σ coordinate system.
The 3rd experiment is the best to limit the spurious diapycnal mixing of tracers for long-term running.

Tracer advection schemes comparison

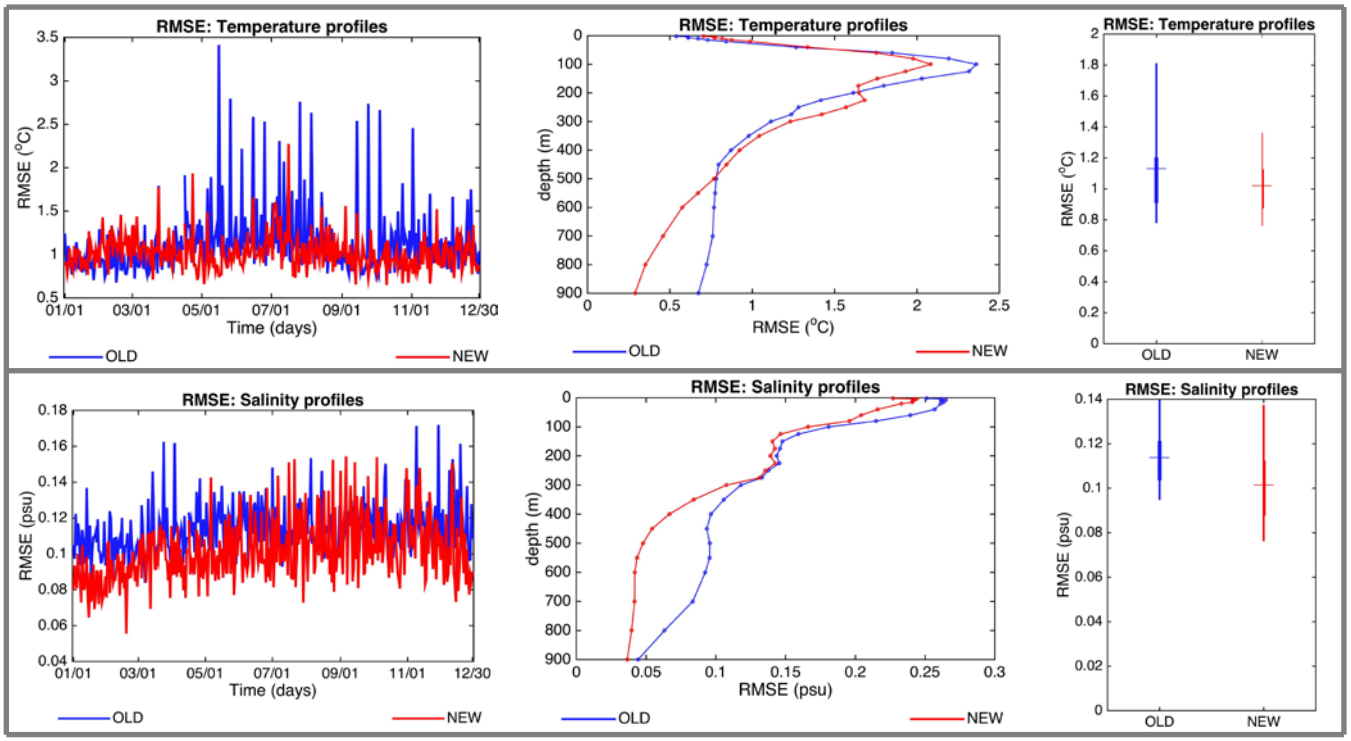
Results validation

In the new(A4HA4V-geo) version, RMSE of T and S decreases largely than the old (U3HC4V-geo) version, especially in the layer of deeper than 500m.

- IVTT-Class 4 metrics, 2017/01/01-12/30
- Observation: Argo T/S profile
- Interpolation the model data to time and location of the obs.
- Calculate the RMSE

T Profile

S Profile



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Changing of surface forcing

Directly Forcing

- Shortwave radiation
- Net heat flux
- Momentum stress
- Freshwater flux(EMP)

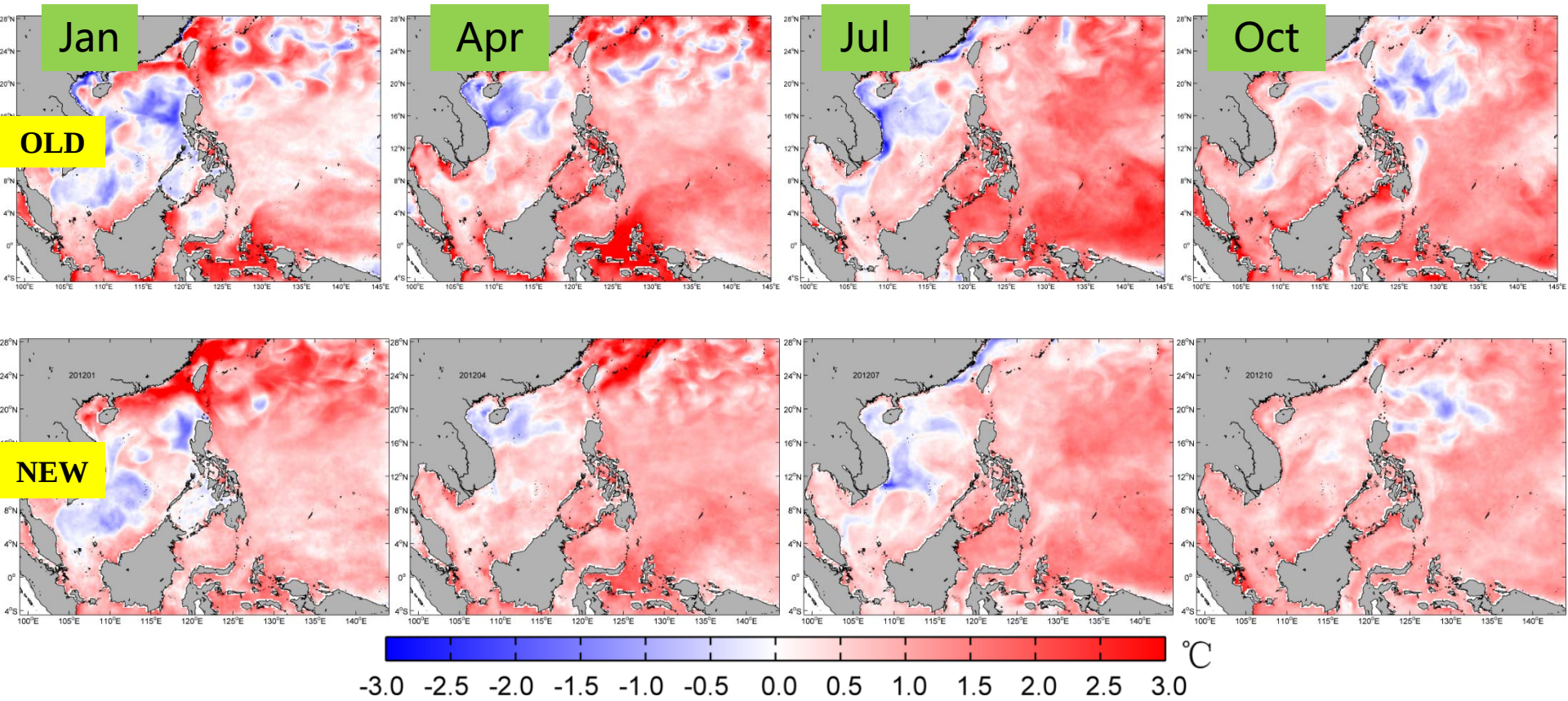
Net heat flux = short-long-sensible-latent

Bulk flux （COARE3.0） ← Models' SST

- Shortwave radiation
- Down-welling longwave radiation
- Air pressure
- Relative humidity
- Wind speed
- Rain fall rate

Changing of surface forcing

Monthly mean Model's SST RMSE with OSTIA in 2017



Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Old	0.99	0.97	0.86	1.12	1.36	1.12	1.15	1.00	1.09	1.01	1.00	0.95
New	1.07	0.95	0.85	0.98	1.03	0.81	0.86	0.80	0.81	0.84	0.79	0.90

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Conclusion

- The improvements to the model skill can be achieved by changing the model setting and numerical schemes.
- The combination of 4th Akima for both horizontal and vertical advection and horizontal mixing of tracers on geopotential surfaces is the best to reduce the errors from the spurious diapycnal mixing in terrain-following coordinate models.
- Employing bulk formula to introduce the negative feedback effects between ocean and atmosphere to sea surface atmospheric forcing, can improve the model skill of sea surface temperature significantly.

Thanks for your time!