Modelling of Circulation, Tides, and Thermohaline Structures of the Southern Region of the South China Sea using Regional Ocean Modelling System (ROMS)

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Outline

- Motivation and Goals

- Dynamical Structure of the Sea off the East Coast of Peninsular Malaysia (Daryabor et al. 2014, Ocean Dynamics)

- Numerical Modelling of Tides in the Southern Region of the South China Sea (Daryabor et al. 2014, Submitted, Earth and Planetary Science Letters)

Motivation and Goals

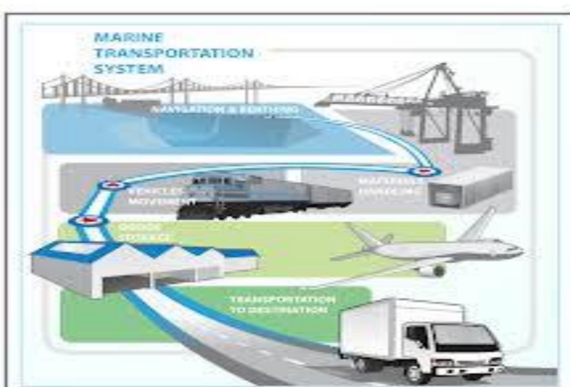
Forecasting and prevention of marine hazards

Economics and Marine Resource Management

Development and prosperity of the country

Development of maritime transportation

Coastal engineering and management



Dynamical Structure of the Sea off the East Coast of Peninsular Malaysia

Numerical model and Configuration

- ROMS AGRIF (IRD), Bathymetry ETOPO2,
- Shared 30 S-layers for the both domain.
- Horizontal resolution 50 and 9 Km for parent and child, respectively.

Forcing and Initialization

- Wind stress, net surface freshwater and heat fluxes from COADS.
- Model initialized at 15th of January, with temperature and salinity fields from the WOA2005.
- Time steps 18 and 3 minutes for the parent and child domains, respectively.
- Ten years in total for the model integration.

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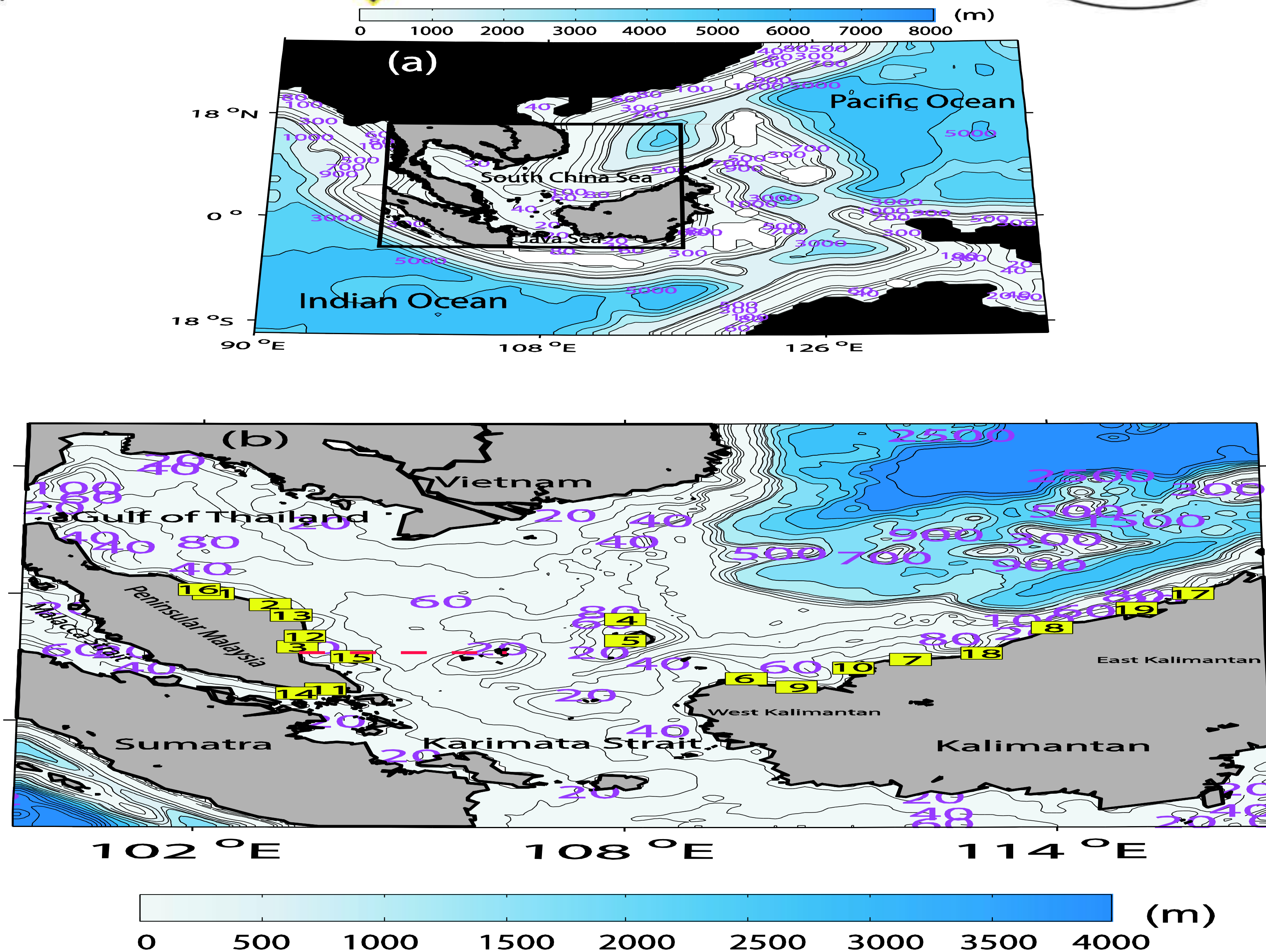
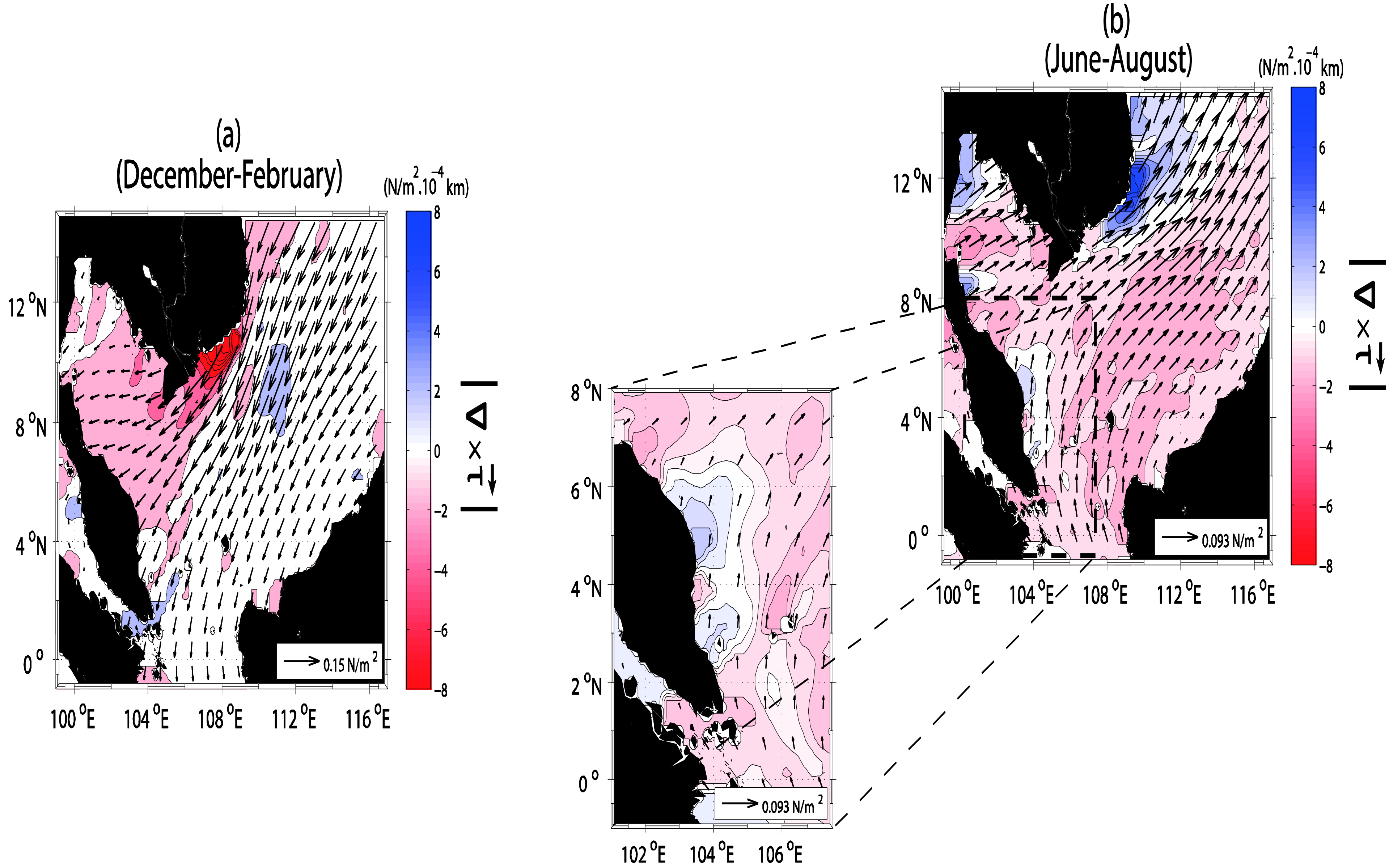
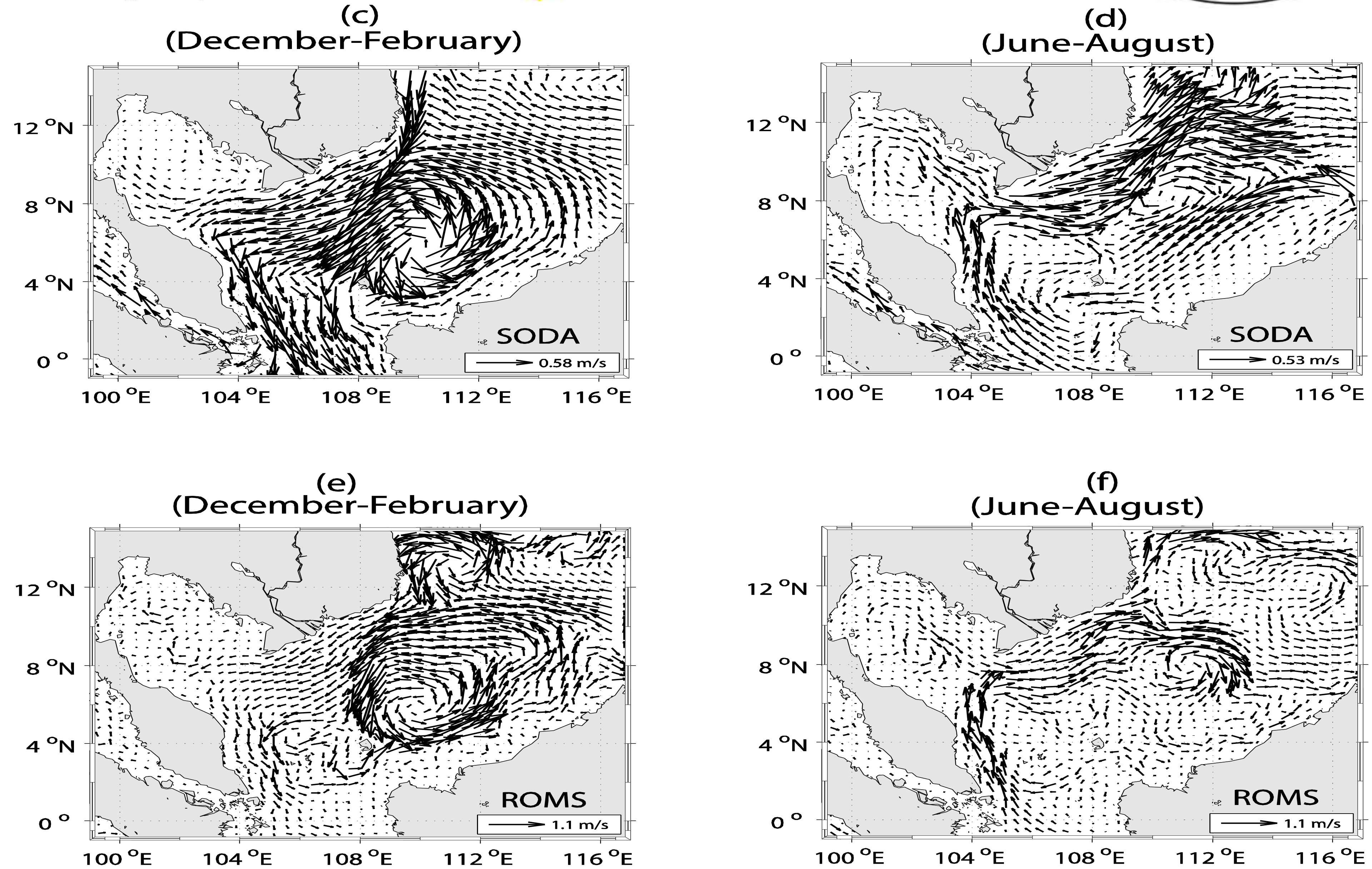



(a)
(December-February)
(N/m².10⁻⁴ km)
0.15 N/m²
(b)
(June-August)
(N/m².10⁻⁴ km)
0.093 N/m²
0.093 N/m²
12 °N
8 °N
4 °N
0 °
6 °N
2 °N
100 °E
104 °E
108 °E
112 °E
116 °E
102 °E
106 °E
8
6
4
2
0
−2
−4
−6
−8


(c)
(December-February)
SODA
0.58 m/s
(d)
(June-August)
SODA
0.53 m/s
(e)
(December-February)
ROMS
1.1 m/s
(f)
(June-August)
ROMS
1.1 m/s
12 °N
8 °N
4 °N
0 °
100 °E
104 °E
108 °E
112 °E
116 °E

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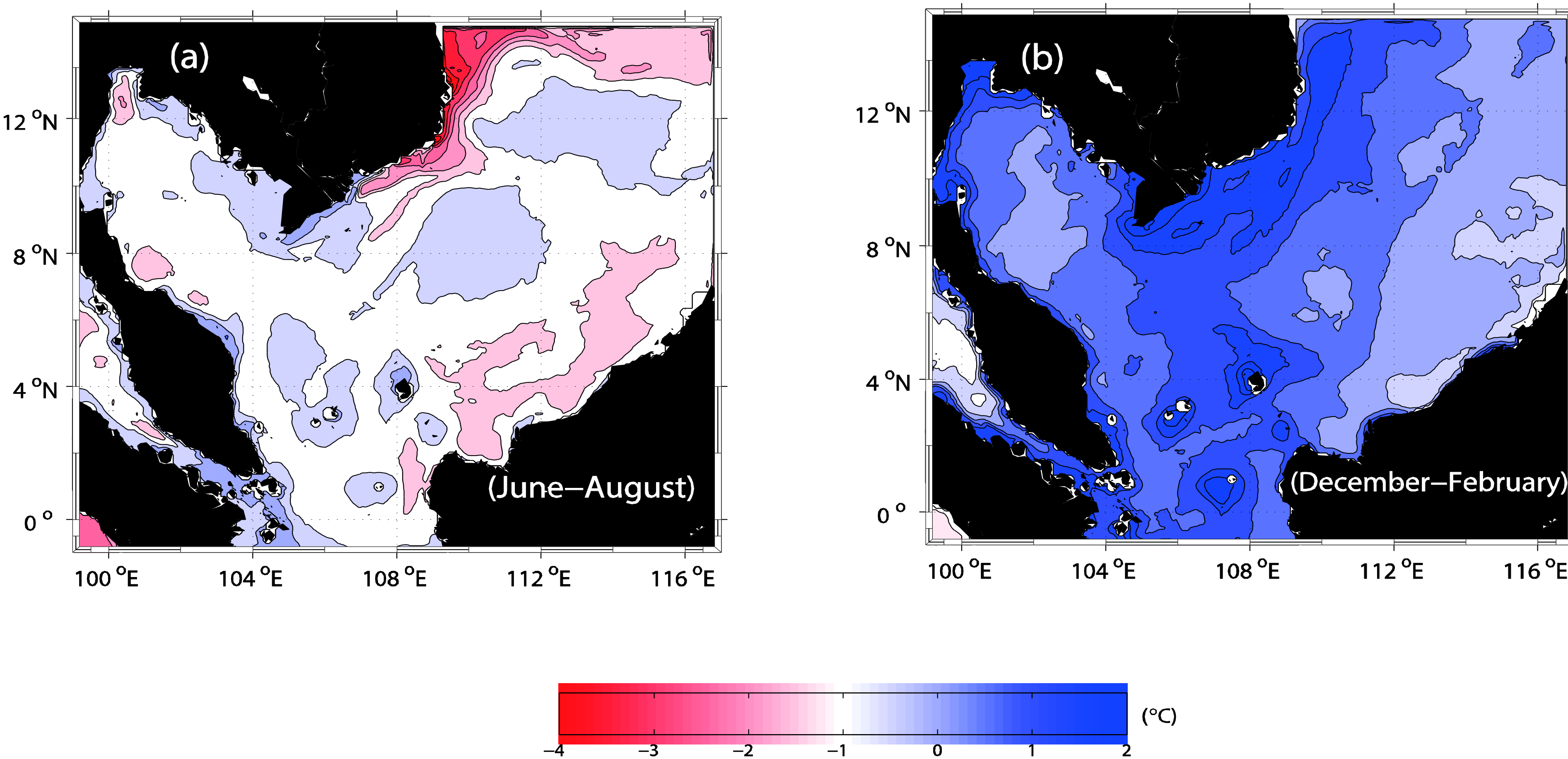
Model SST minus Pathfinder SST show occurred upwelling, the positive values (i.e., warm biases) and the negative values (i.e., cold biases) represented the regions with cooler and warmer SSTs, respectively.



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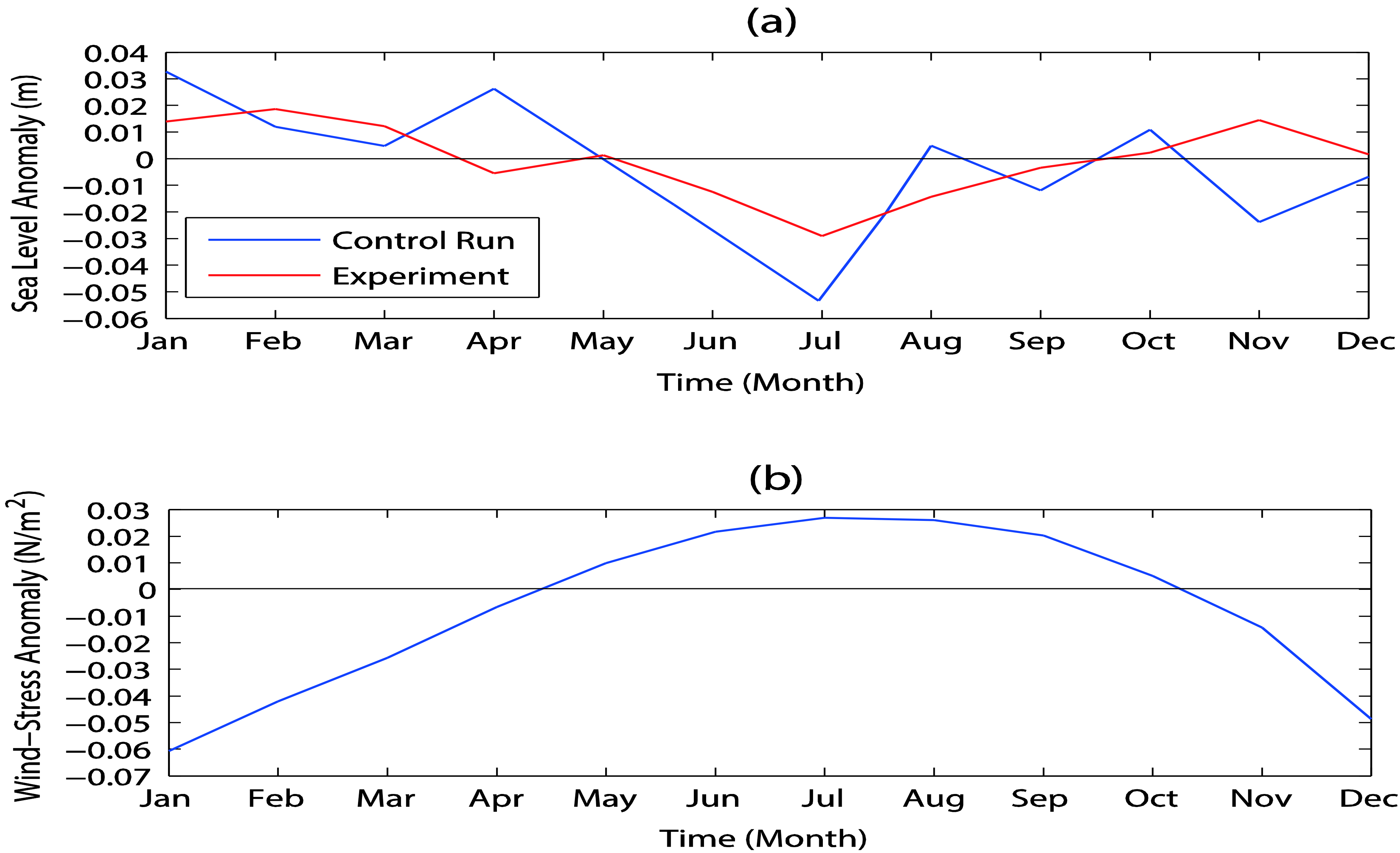

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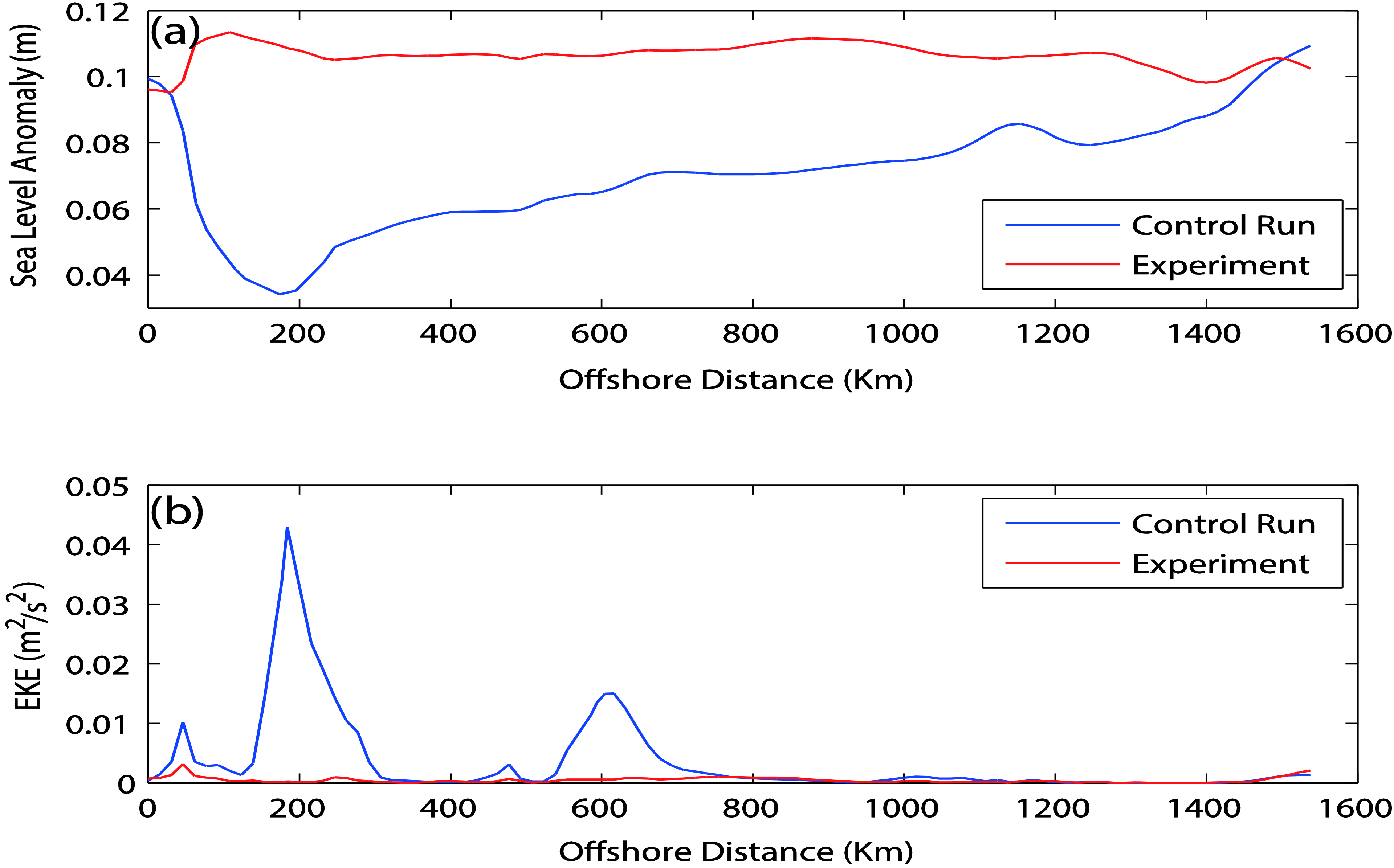

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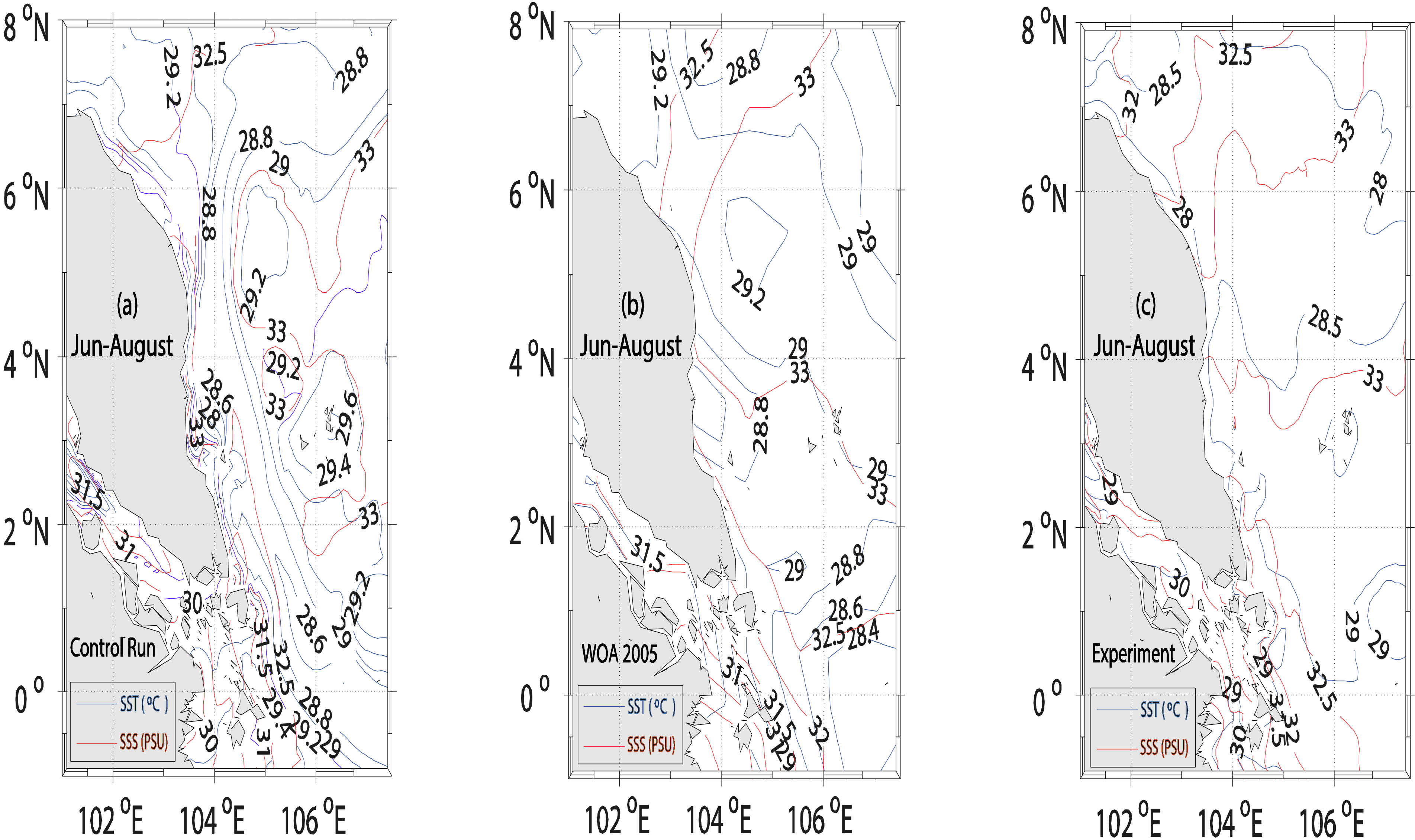

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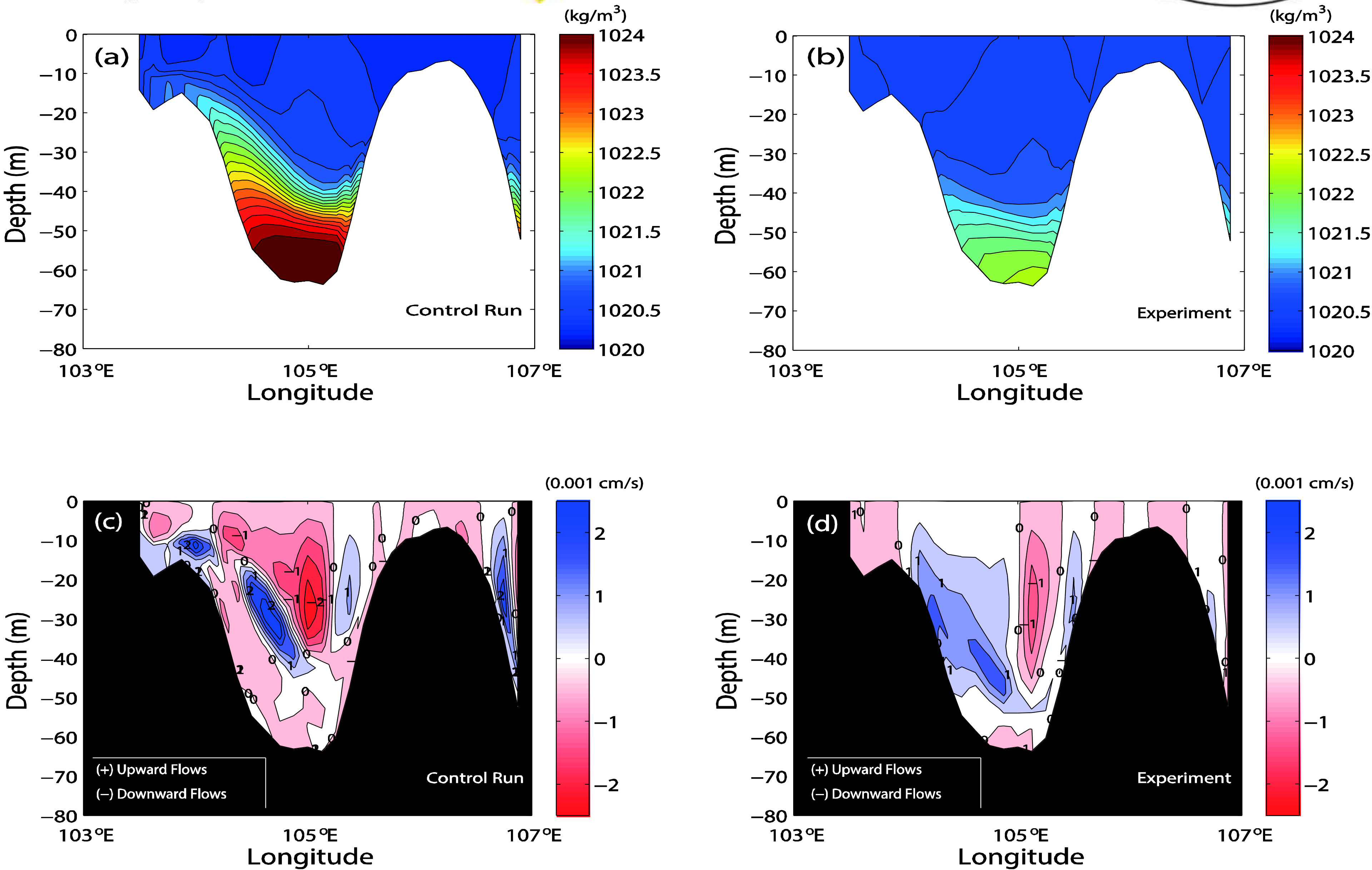

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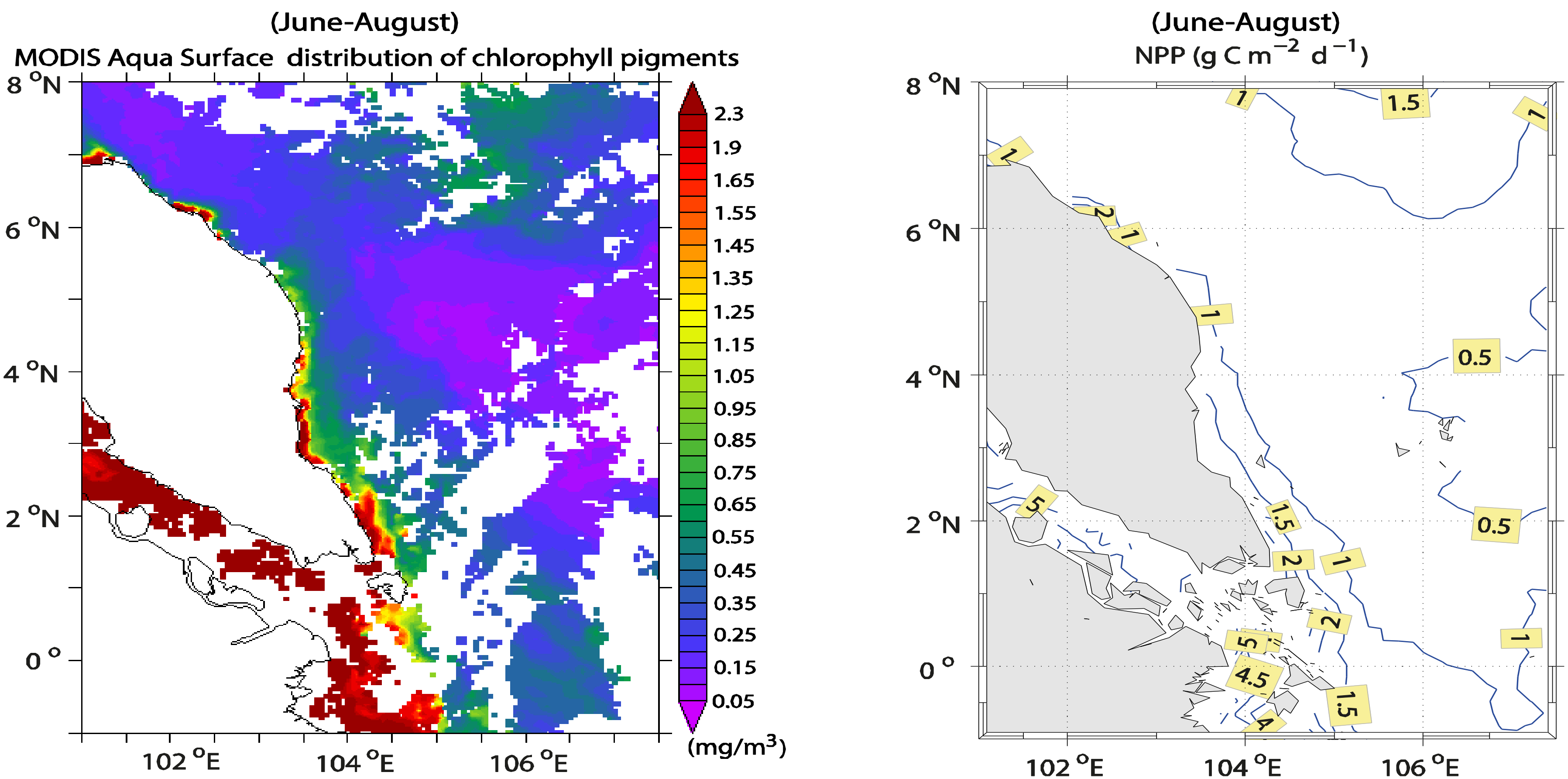
(a) (b)



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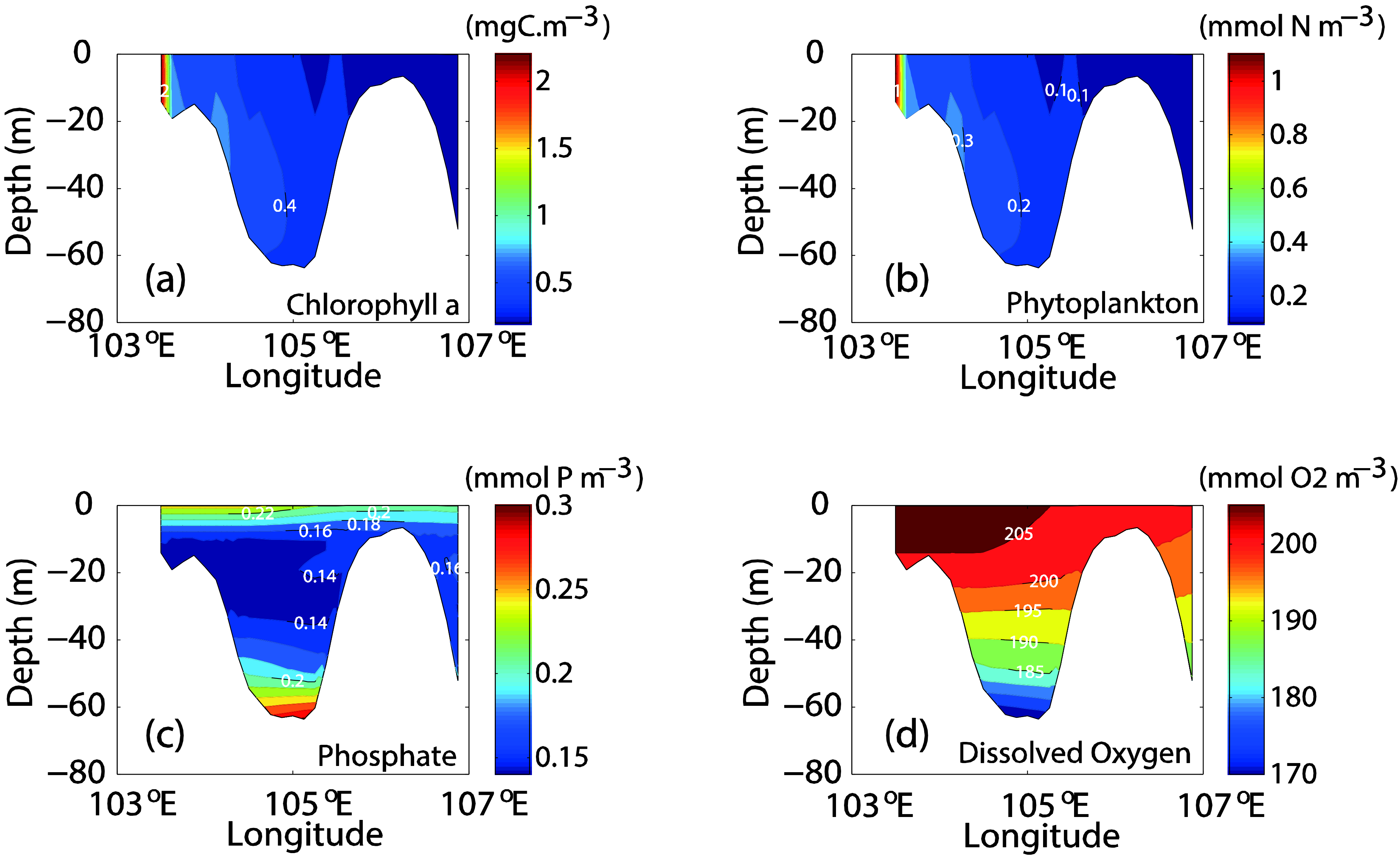

- **Numerical Modelling of Tides in the Southern Region of the South China Sea**

- **Numerical model and Configuration**

- ✓ ROMS AGRIF (IRD), Bathymetry ETOPO2,
- ✓ Shared 30 S-layers for the both domain.
- ✓ Horizontal resolution 25 and 9 Km for parent and child, respectively.

- **Forcing and Initialization**

- ✓ Wind stress, net surface freshwater, heat fluxes from COADS, and TPXO7 (M2, S2, K1, O1, N2, K2, P1, and Q1)
- ✓ Model initialized at 15th of January-15th of March, with temperature and salinity fields from the WOA2005.
- ✓ 1 hourly model integration for the parent and child domains, respectively.

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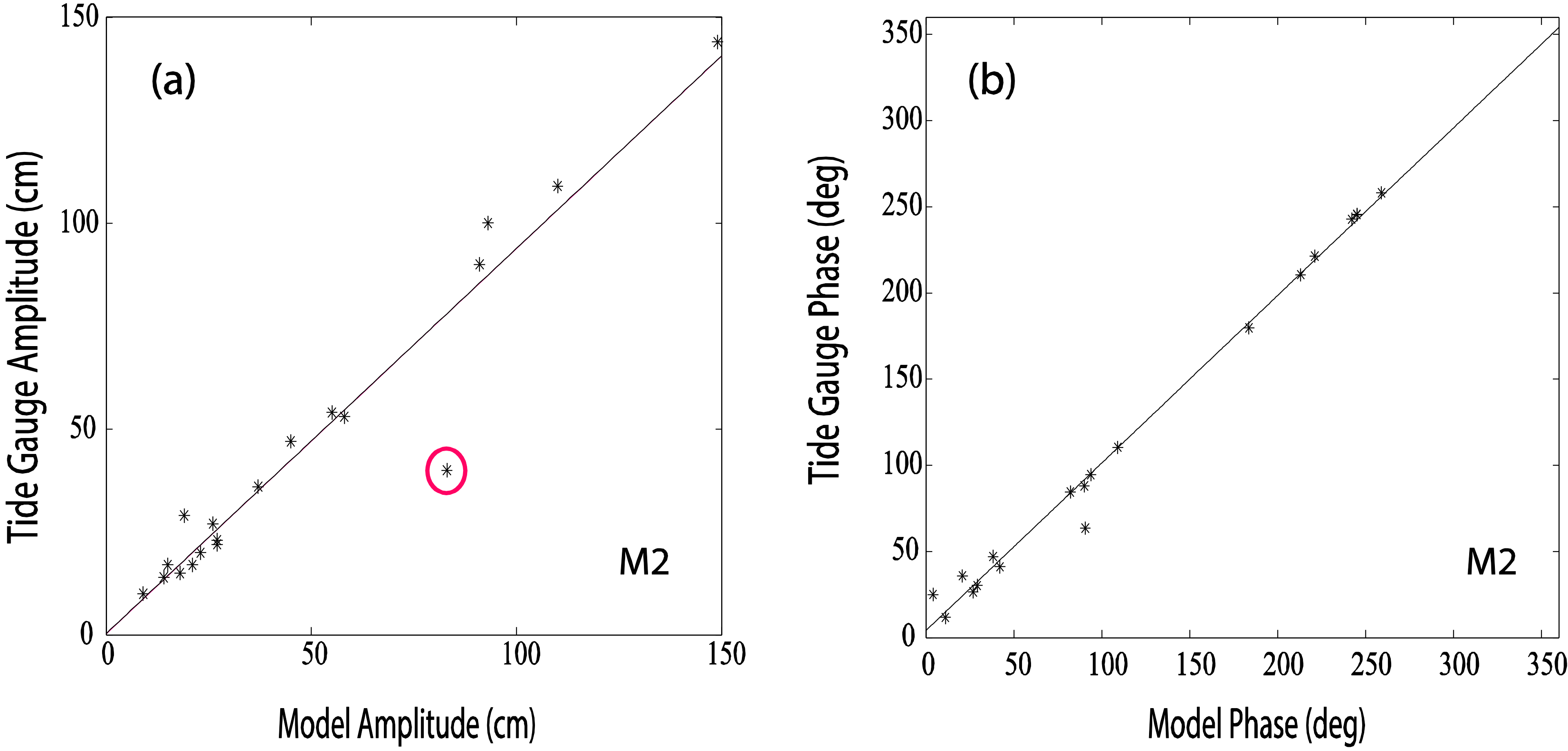

The red circle indicates relatively large error for the Johor Bahru station. This station is located at the southern end of Peninsular Malaysia and within the vicinity of the Malacca Straits.

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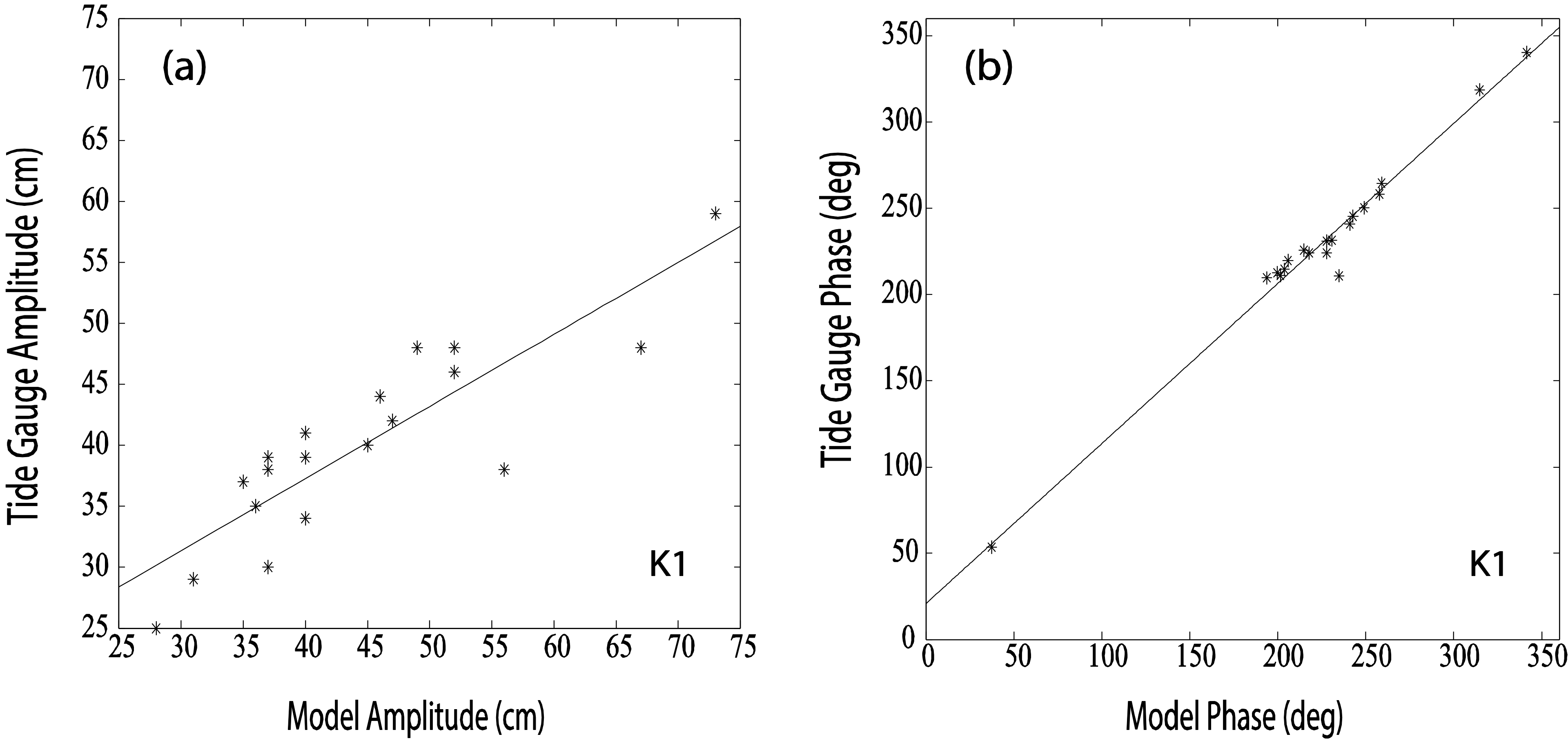

Similarly, relatively large errors for the simulated K1 amplitudes could belong to the stations near the areas with steep topography (Robertson, 2005).

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$$RMS = \sqrt{\frac{\sum_{i=1}^{N} |C_{Mi} - C_{Oi}|^2}{2N}}$$

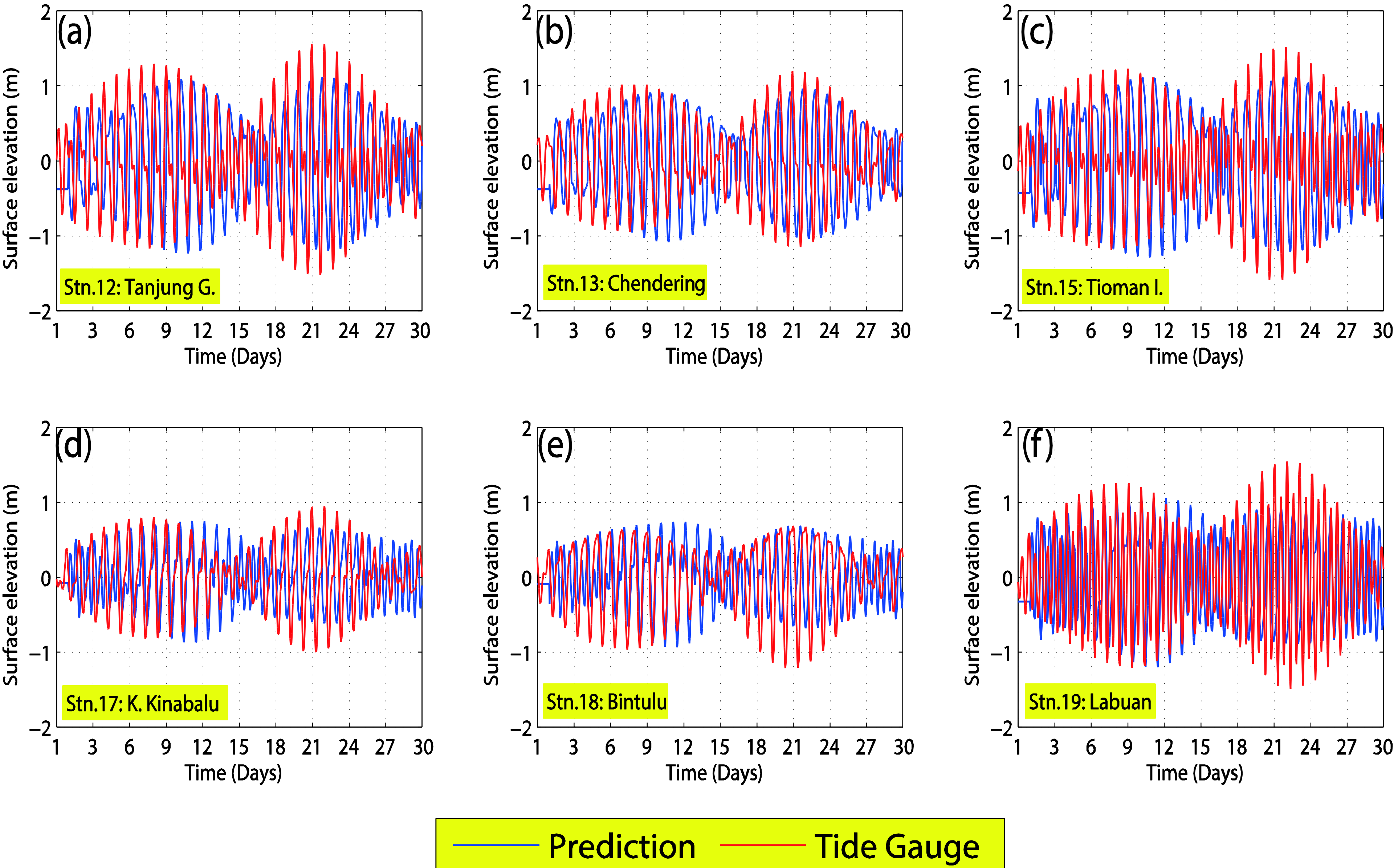
	M2		K1	
	Amp. (cm)	Phase (UT degrees)	Amp. (cm)	Phase (UT degrees)
TPXO	15.0	20.4	8.0	17.2
Parent	14.8	15.8	6.0	16.3
Child	7.5	9.0	5.4	10.0

- ✓ Table shows that the simulated tidal amplitudes and phases are more accurate than those of the TPXO7. Similarly, the corresponding values were more accurate for the child (i.e. the fine resolution domain) than those of the parent domain (i.e. the coarse resolution domain).

- ✓ The high RMS values suggest that the global and coarse models are not appropriate for small scale features in analogy with the regional nested structure.

- ✓ the results represented show that in the SSCS with complex bathymetry and coastlines, a high resolution model is required for better simulations. According to Janekovic and Powell (2012), complex bathymetry may lead to the non-linear interaction between neighbouring tidal frequencies and the baroclinic instability, which can inject more energy to the upper layers and cause changes in the surface tidal signals.

- ✓ Also, a study by Simmons et al. (2004) pointed out that in areas with complex bathymetry and strong tidal baroclinicity, the application of a 3D model is much more accurate than that of a 2D model and may improve the results.


(a)
Stn.12: Tanjung G.
(b)
Stn.13: Chendering
(c)
Stn.15: Tioman I.
(d)
Stn.17: K. Kinabalu
(e)
Stn.18: Bintulu
(f)
Stn.19: Labuan
Surface elevation (m)
Time (Days)
Prediction
Tide Gauge

- ✓ The comparison between the TGs surface elevations and the predicted elevations shows that the spring-neap and diurnal and semidiurnal of the simulated model are reasonably reproduced by the model at all stations. This implies that the boundary conditions are accurately specified.

- ✓ However, a small difference between the TGs and the predicted results can be expected due to the complex bathymetry.

- ✓ At the Labuan Station, the sea levels were almost predicted reasonably well in terms of phase and particularly the tidal range.

- ✓ Results indicate that the highest tidal range occurred at Tanjung G. (Station 12), Tioman I. (Station 15) at the ECPM and Labuan (Station 19) at northern Kalimantan.

- ✓ However, the tidal range at K. Kinabalu (Station 17) and Bintulu (Station 18) were reduced. The high tidal range stations suggest that there exist an interaction between these coastal regions interacted with the high tides.

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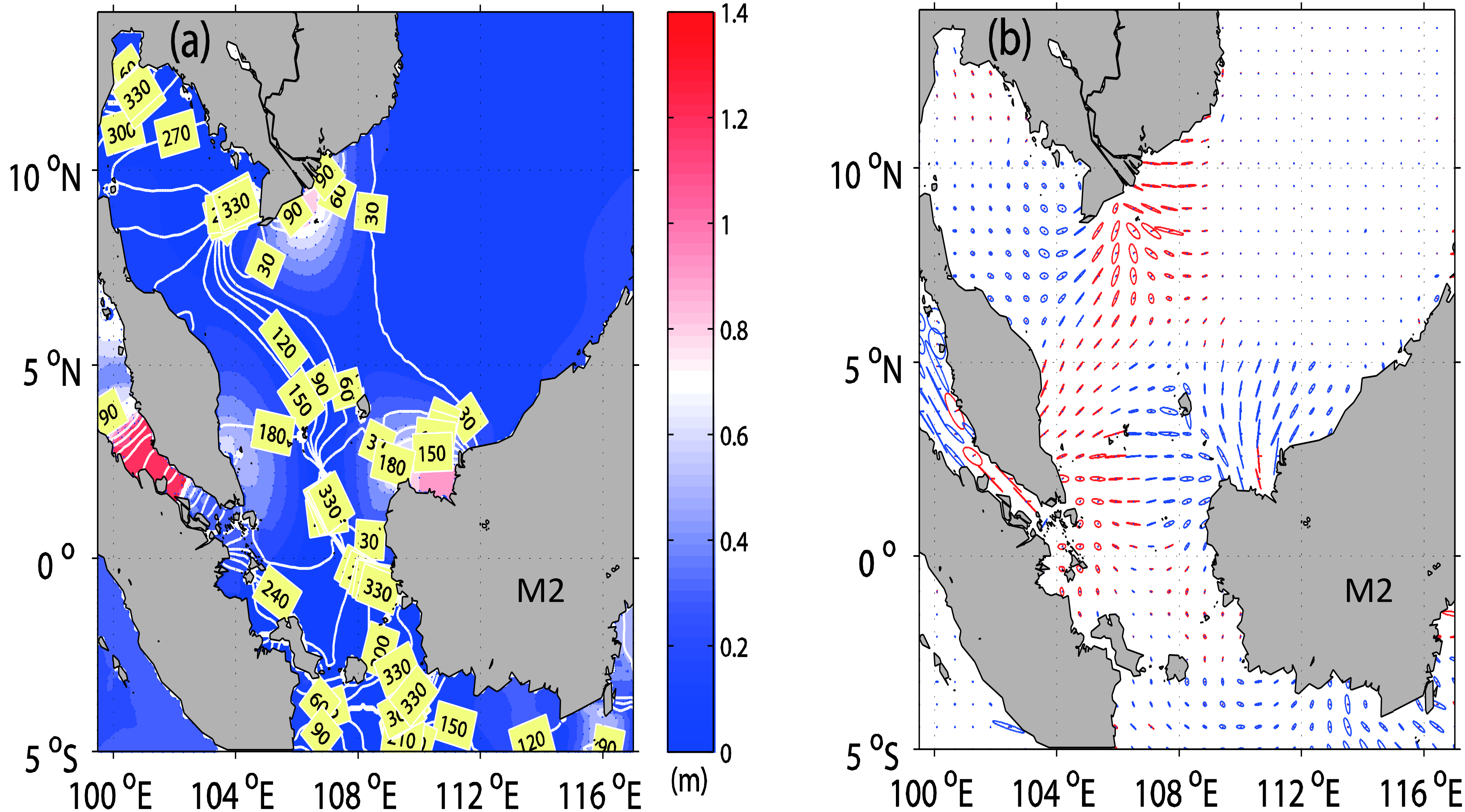

The maximum current with the largest major semi axis is 0.7 m/s.

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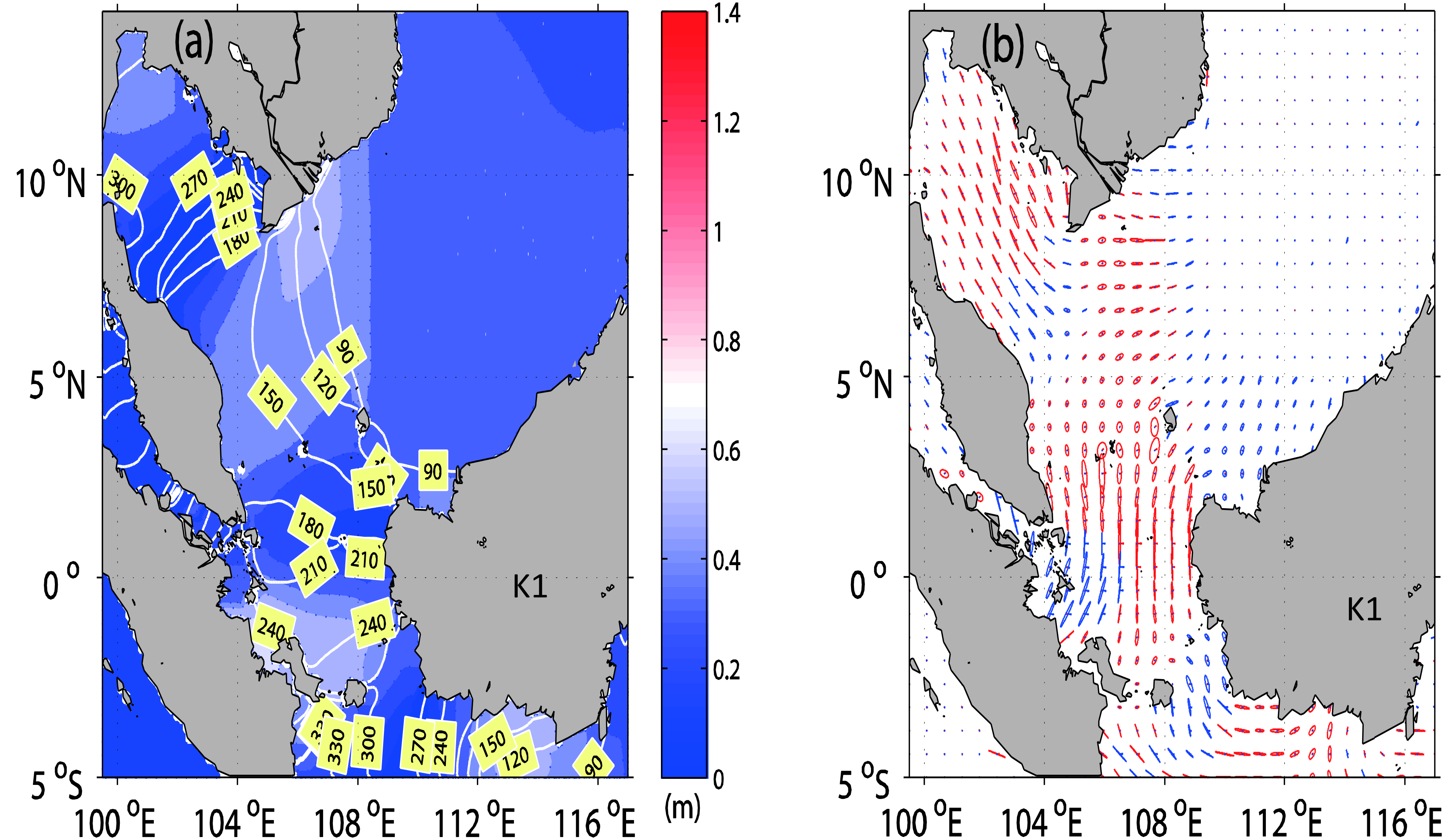

The maximum current with the largest major semi axis is 0.43 m/s.

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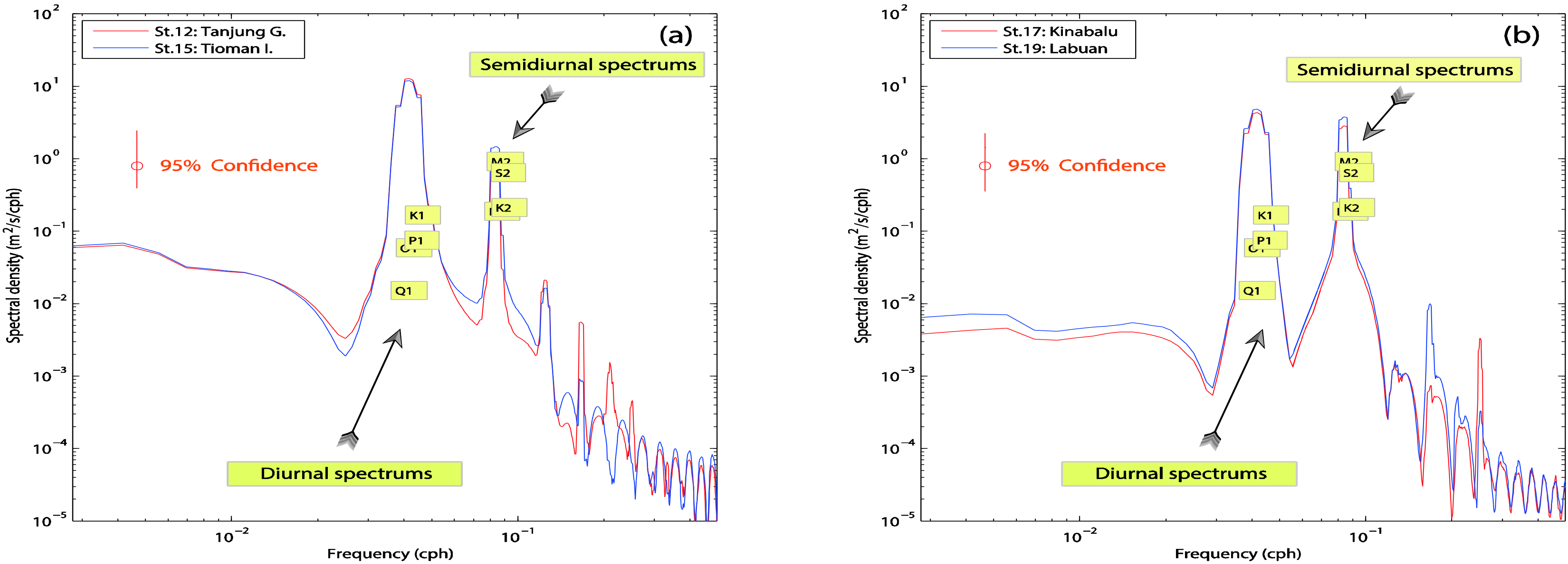

- ✓ The percentage of the mean average power energy spectrum (m2/s/cph) for diurnal tides at Labuan (Station 19) is approximately 43% less than at Tanjung G. (Station 12), whilst the mean average power energy is greater for the semidiurnal tides by approximately 24.4% at the Labuan (Station 19) than Tanjung G. (Station 12).
- ✓ This comparison indicated that the diurnal and semidiurnal tides are more energetic at the ECPM and the coasts of north Kalimantan at East Malaysia, respectively.

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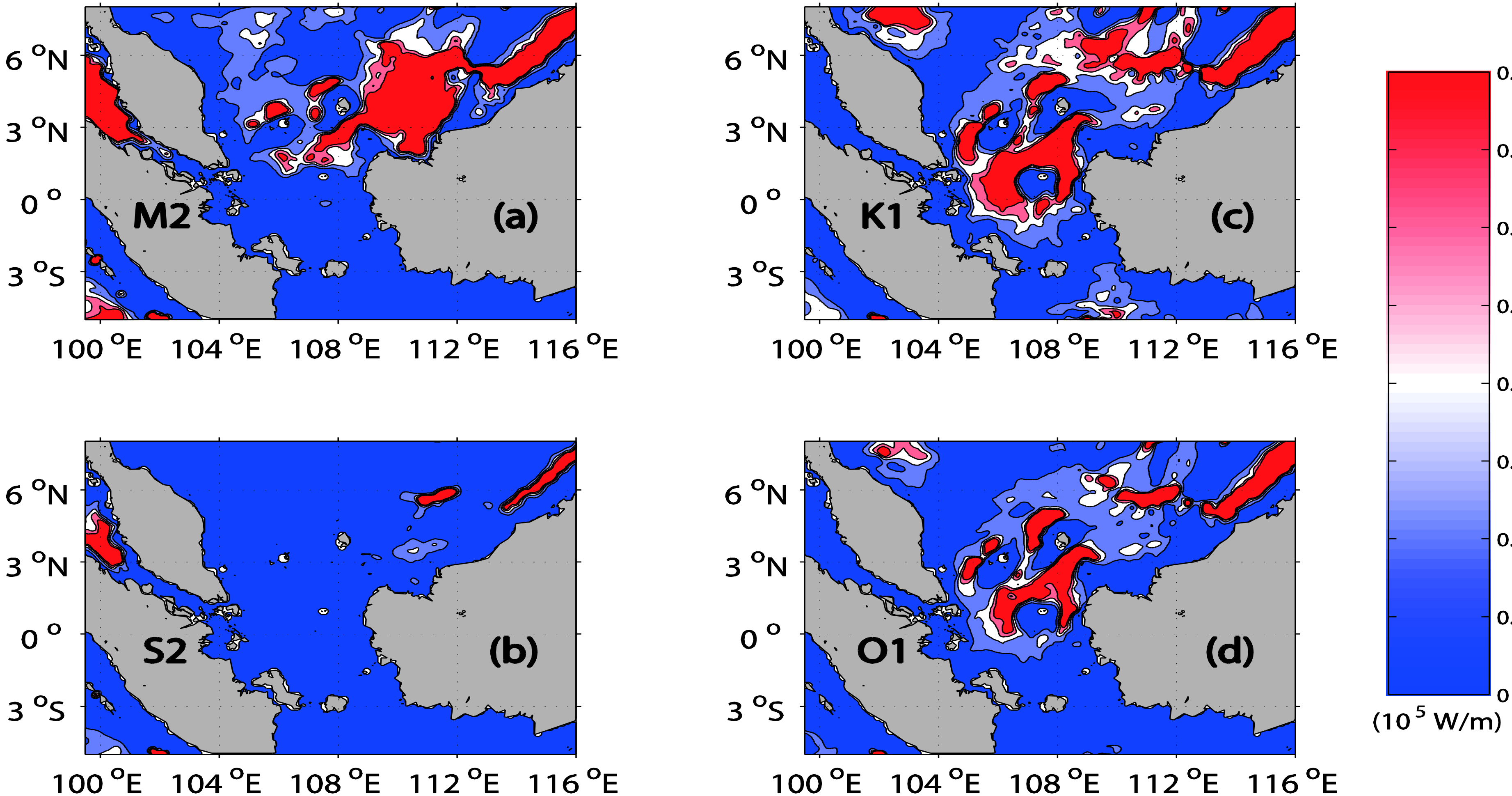

- ✓ Result demonstrated that the diurnal tidal energy flux is 59.4% greater than that of the semidiurnal tides over at the SSCS. It shared 5.5% of the diurnal tidal energy flux into the Java Sea through the SSCS and the Karimata Straits.

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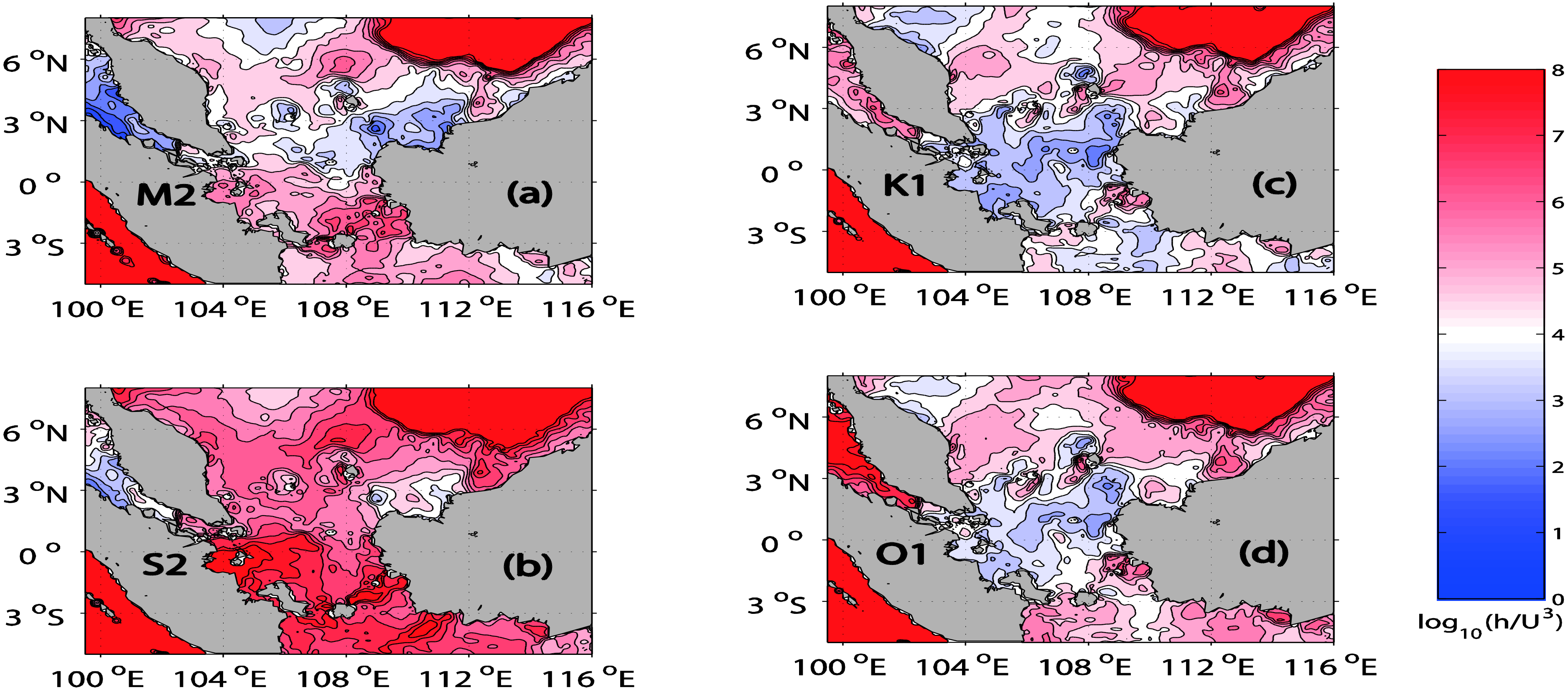

- ✓ Important criterion namely the mixing parameter (proposed by Simpson and Hunter, 1974) is used for the investigation of such processes in the region.
- ✓ The region with small values of approximately less than 3 is defined as the location of the tidal mixing zone (Yanagi et al., 2001; Hu et al., 2003; Yao et al., 2012).

- ✓ From Figure, the coastal regions of Tanjung Datu (Station 6), Kuching (Station 9) and Kuala Paloh (Station 10) located at Sarawak are known as the location of tidal mixing zone due to the existence of the strong M2 tide.

- ✓ For the diurnal tides, a correlation is clearly shown between the distribution of the maximum tidal currents and the pattern of the strong energy flux in the region between the southern tip of the ECPM and west Kalimantan, but with a weak effect for the O1 tidal constituent.

- ✓ Overall, the SSCS is heavily influenced by the diurnal tides, specifically the K1 tide, which is a major contributor to tidal mixing.

Acknowledgments

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