The counter-wind current in the northern South China Sea as seen from data assimilative modeling

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Introduction

The South China Sea Warm Current (SCSWC) flows peculiarly against the wind in winter, so that related studies have draw some attention in the past decades. However, insufficient continuous current observations made the direct description of the structure and the width of this counter-wind current very unconvincing apart from observational evidence that the SCSWC is noncontinouse in winter. Modeling studies of the SCSWC are usually limited by coarse resolution, unrealistic wind forcing, artificial bathymetry, and incomplete dynamic processes in the model. So the features of the SCSWC in winter are still unclear and motivate modern data assimilative, high-resolution modeling approach.

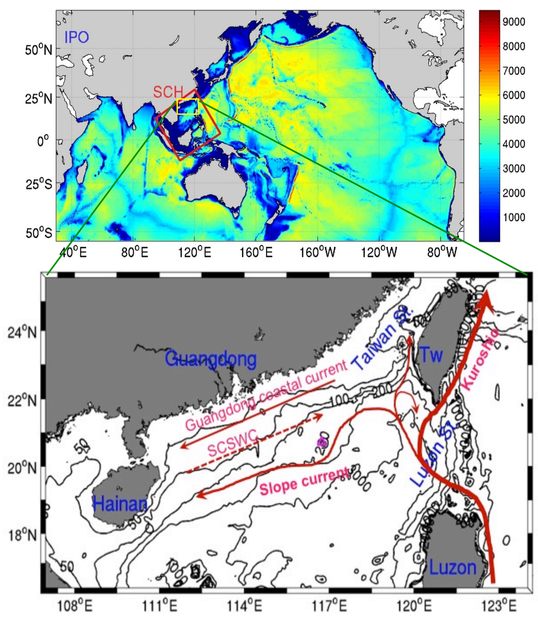

Fig. 1. Bathymetry of the nested model domain in the South China Sea with its northern part highlighted, and the three adjacent currents near the coast in winter are denoted schematically.

Motivation

- Based on a high-resolution Hybrid Ocean Model (HYCOM) with tidal forcing and an advanced data assimilation method, the assimilative simulations in January of 2004 and 2005 are investigated on monthly and on daily.
- The features of the SCSWC about its location, width and the vertical structure can be obtained, and further try to understand why it is difficult to be observed in general.

Model and data assimilation scheme

- Using two-level nesting way, the high-resolution HYCOM model was set-up with approximate 5 km horizontal resolution and 30 layers in vertical. The model topography is interpolated by GEBCO 1′. Considering the tide impact on the coastal current system, the main eight main constituents of tides (K1, O1, P1, Q1, M2, N2, S2 and K2) from FES2004 act on the boundary as a barotropic pressure forcing. And the model is driven by high resolution atmospheric forcing from ECMWF interim reanalysis.
- There are many successful cases to assimilate sea level anomaly (SLA) data from AVISO global products into ocean general circulation model, but in which the model do not include tides forcing. Based on Ensemble Optimal Interpolation (EnOI), Xie et al. (2011) proposed a computationally cheap assimilation scheme as formula (1), to deal with this issue.

$$\psi^a_{t_0} = \psi^f_{t_0} + \sum_{t_0-6\le t\le t_0} A'_{t_0}(HA')^T_{t_0}[(HA')_{t_0}(HA')^T_{t_0} + (\frac{N-1}{\alpha})R_t]^{-1}(d_t - H\overline{\psi}^f_t), \qquad (1)$$

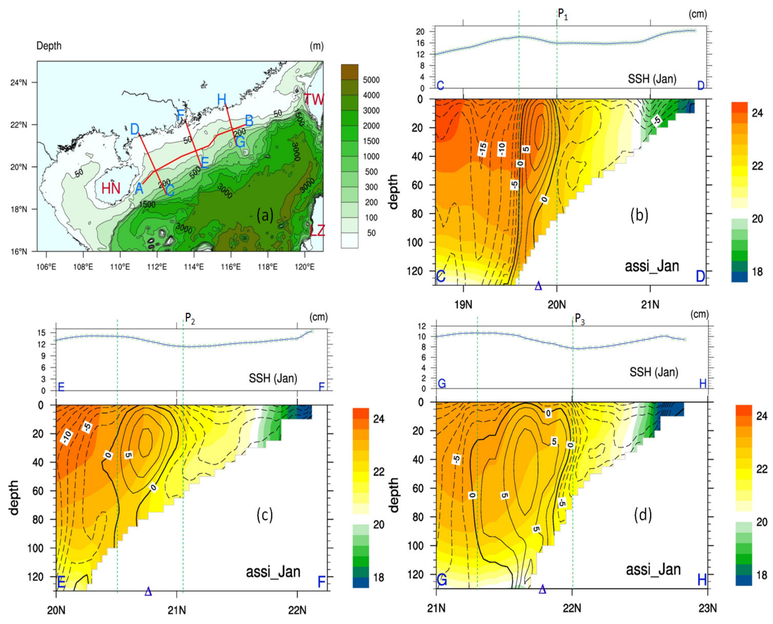

Fig. 4.(a) Positions of three orthogonal sections across the section AB with topography (shading). Panels (b-d) show the temperature and the current through sections CD, EF, and GH respectively.

Fig.5.Comparison of eddy kinetic energy (EKE) and mean kinetic energy (MKE) in January 2004 and 2005 at 30m depth. The blue line denotes the location of section AB as showing in Fig.2. (a) MKE (units: cm^2s^{-2}); (b) EKE (units: cm^2s^{-2}); (c) rate of logarithm between EKE and MKE.

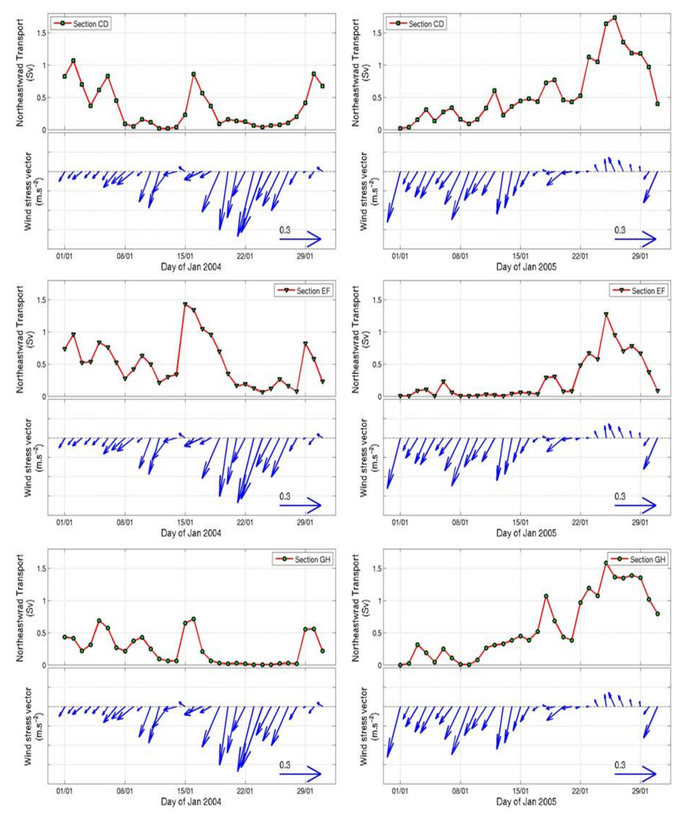

Fig. 6 Daily northeastward volume transports in January from the surface to 50 m deep and the nearby wind stress vectors at the three points P_1, P_2 and P_3 shown in Fig. 4.

Features of the counter-wind current in winter

- The counter-wind current almost is following 100 m isobath from east of Hainan island to near 117°E, its width is varied about 55-85 km form west to east.
- The strongest speed center nearly to 10 cm/s appears from 10 m to 30 m depth in vertical, and the sea water accumulation at south of this current well contributes to that.
- The evolution of the daily circulation shows the most counter-wind current isn`t so stable and strong like in past studies, and appears rather transient features.

Discussion

- In this study, the SCSWC mostly follows 100m isobath with less 100 km width which may increase the difficulty to be observed. Guan (1978) proposed that the SCSWC is mostly confined between the 200 m and 400 m isobath with 160–300 km width . In fact, an more studies generally agree that the 50 m and 200 m isobaths can be viewed as the boundaries of the SCSWC.
- The analysis of the kinetic energy shows that the SCSWG has more mesoscale variability than mean current.
- Further, the comparison of wind stress and current transports suggest that the current develops only during the wind relaxation.

  They increase the transient feature of the SCSWC.

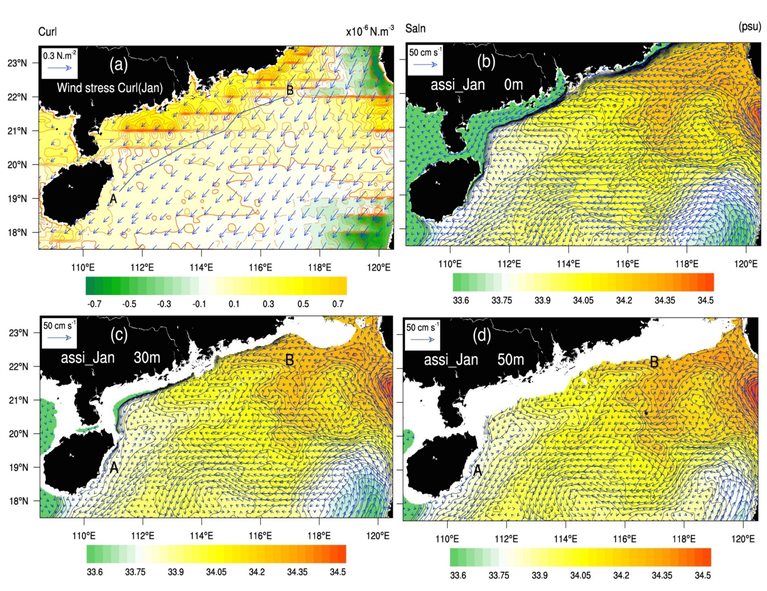

Fig.2. Wind stress and current fields at different depths averaged in January 2004 and 2005 with salinity (shading in lower and upper-right plot.

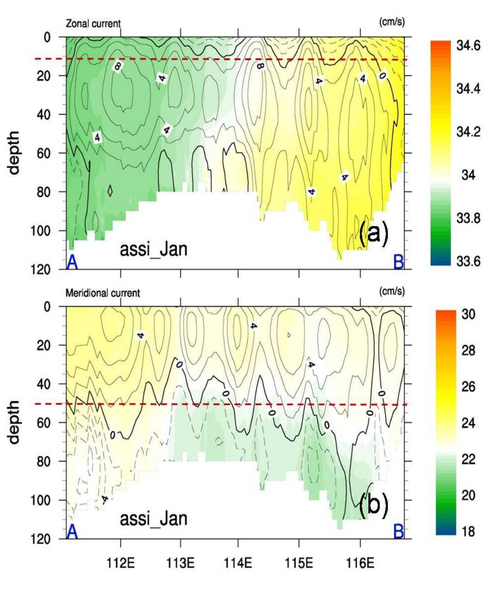

Fig. 3.Averaged U and V components in January along the section AB [shown in Fig.2] (units: cms^{-1}; interval: 2 cms^{-1}).

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