Research on Geophysical Data Processing and Regional Marine Science

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Introduction

The internationally shared gravity data is an economical source for data collection. However, due to some reasons, there may be quality problems in it. Therefore, it is necessary to carry out quality control before further research work.

Data

International underway gravity and bathymetry data were downloaded from the National Oceanic and Atmospheric Administration (NOAA). A rectangular region (164.9 ~ 163.7 ° W, 6.4 ~ 7.0 ° N) was selected as the study area. The distance between survey lines is about 11 km (Fig. 1). The water depth is measured by multi-beam and the range of water depth is 4116 ~ 4987 m.

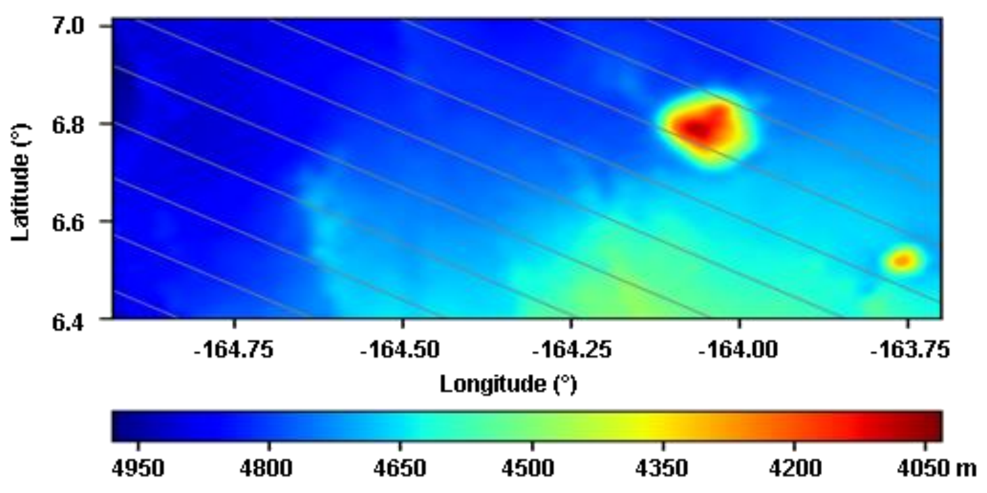


Fig. 1 Survey lines and water depth map in the study area

The range of gravity anomaly is -2.1 ~ 29.4 mGal and most are positive. There are linear high and beaded anomalies along the the survey lines which may be caused by e.g. the regular surge at sea, the failure of the instrument itself or the improper handling. Due to the lack of crossing points, a satellite altimeter-derived gravity model of DTU21 is selected for comparison here.

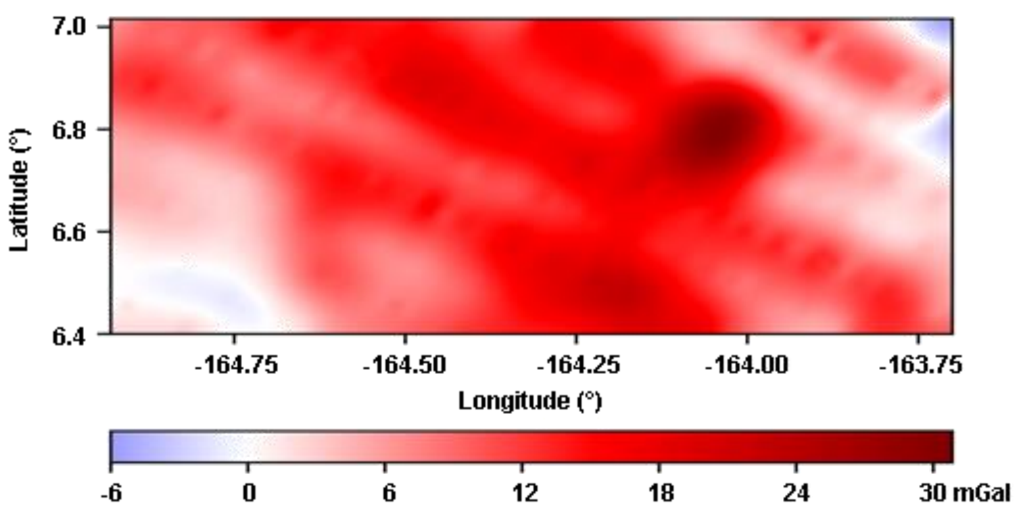
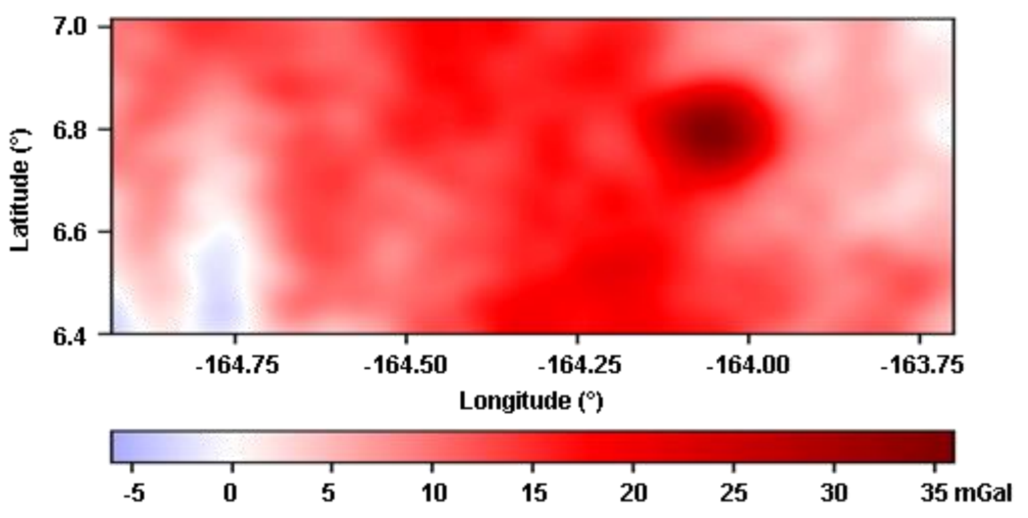


Fig. 2 Map of measured gravity anomaly

Fig. 3 Map of DTU21 gravity anomaly



Method

Wavelet transformation is a method based on Fourier Transform for localized time-frequency analysis. The multi-scale wavelet transforms the approximate and detailed signals back to the spatial domain to ensure that their dimensions are consistent with the input signals. In this way, signal reconstruction can be achieved by simple addition.

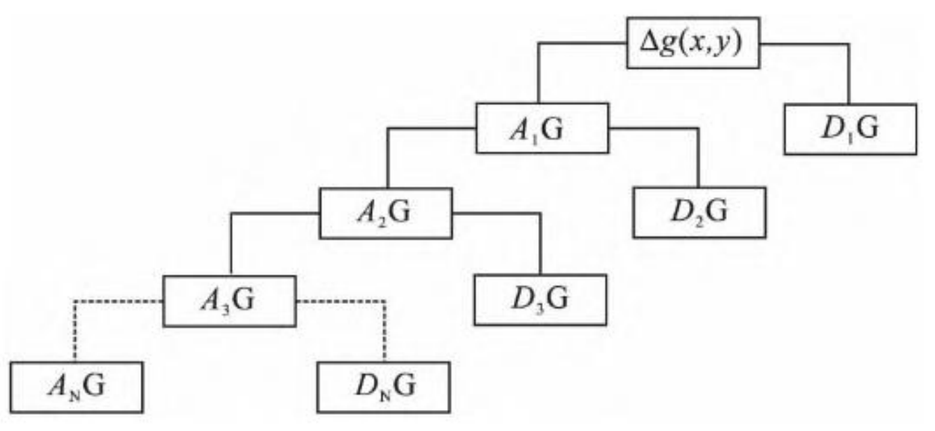


Fig. 4 Schematic diagram of multi-scale wavelet transformation

In certain frequency bands, the gravitational field is highly coherent with the water depth. Researchers use this as a reference for gravity inversion of topography. Here we apply the **radially symmetric coherence analysis** for noise detection and the calculation formula is:

$$C_{ab}(w) = |P_{ab}(w)|^2 / \left(P_{aa}(w) P_{bb}(w)\right)$$

The process of **multi-scale coherence analysis** includes:
(1) Decompose the input data into multi-scale components with the wavelet transformation;
(2) Determine the noise layers by analyzing the coherence of each gravity component with water depth;
(3) Suppress the noise layers by means of total or partial elimination;
(4) Reconstruct the processed components to obtain the result data.

Result

Here, we performed wavelet decomposition of 8 orders. By carrying out the coherence analysis of each component with water depth, we found the result of the second-order detail vertical component and the third-order detail horizontal component is the lowest and their sum (Fig. 5) is the noise to eliminate.

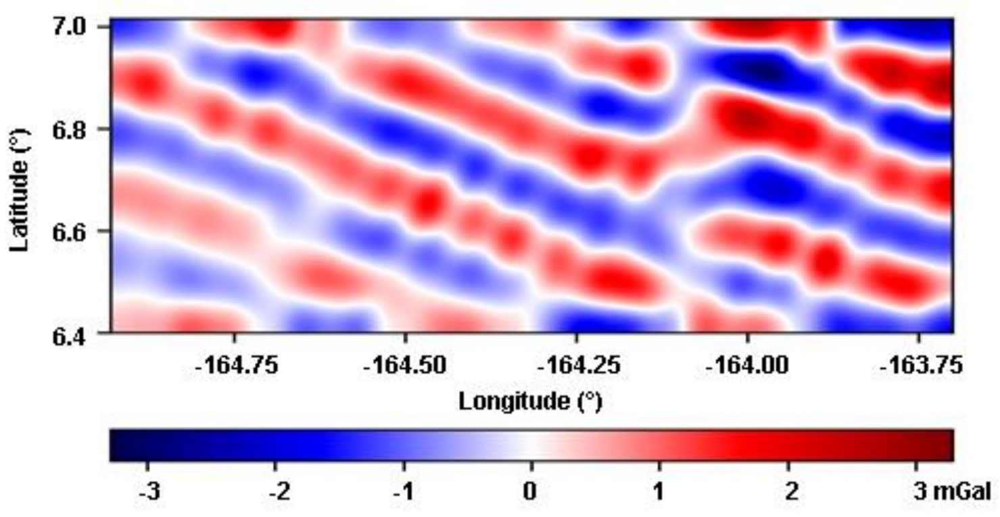
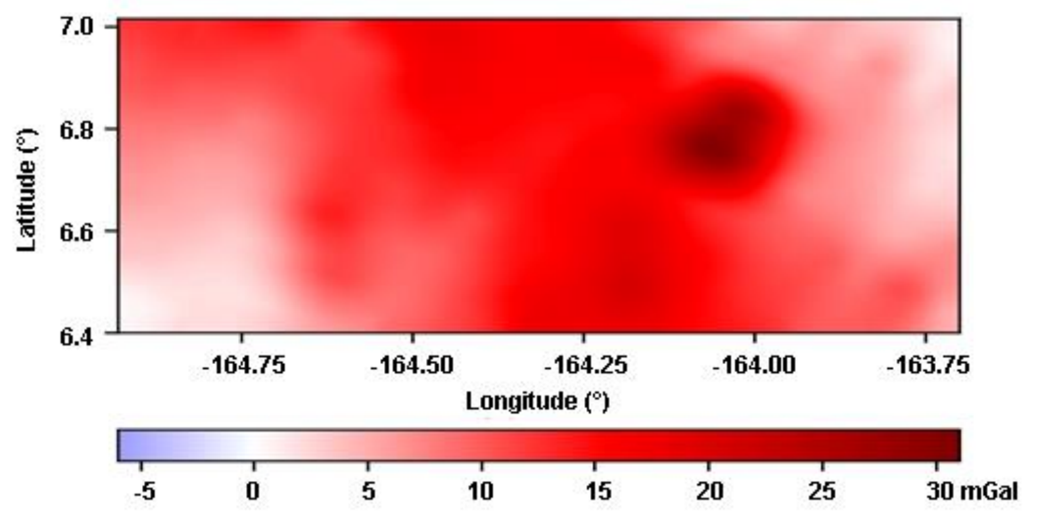


Fig. 5 Sum of second-order detail vertical component and third-order detail horizontal component

After processing the noise components, we obtain the final result (Fig. 6). Comparing it with DTU 21 (Fig. 3), It's obvious that the quality of gravity data has been greatly improved and the result is convincible.

Fig. 6 map of processed gravity anomaly

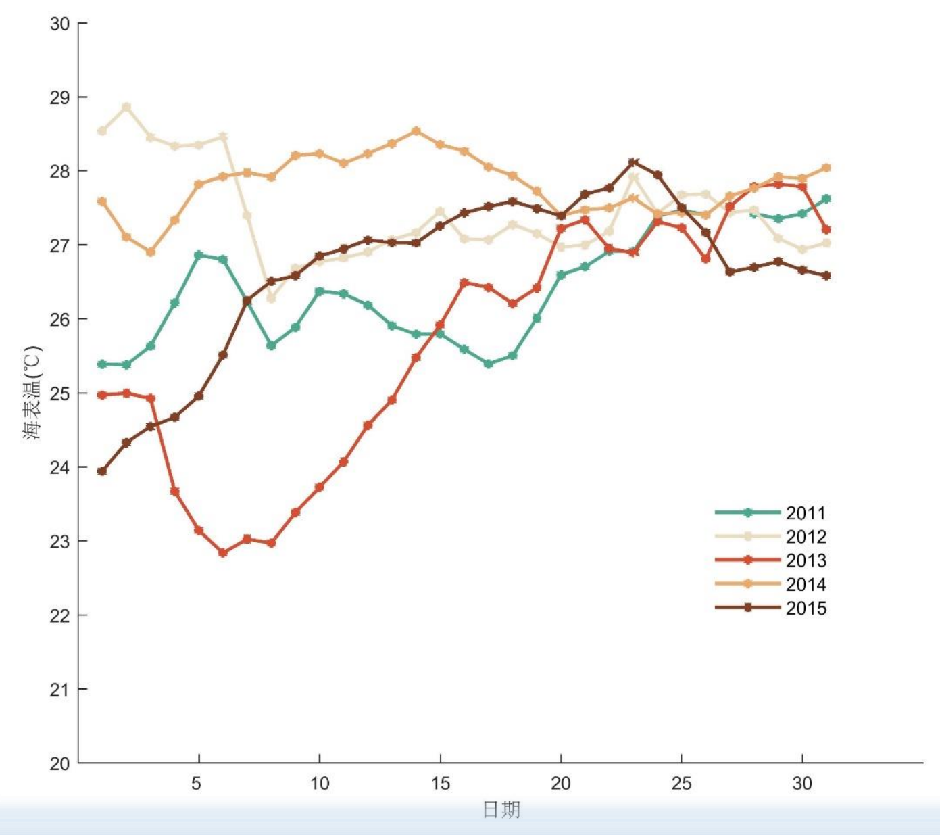


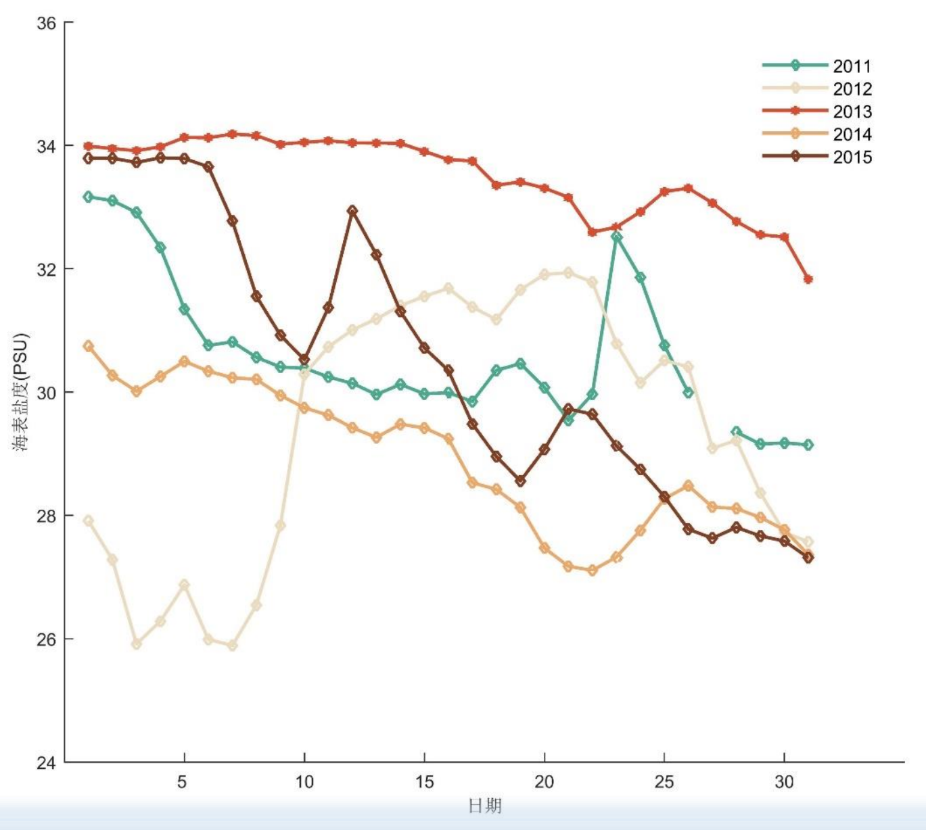
Conclusion

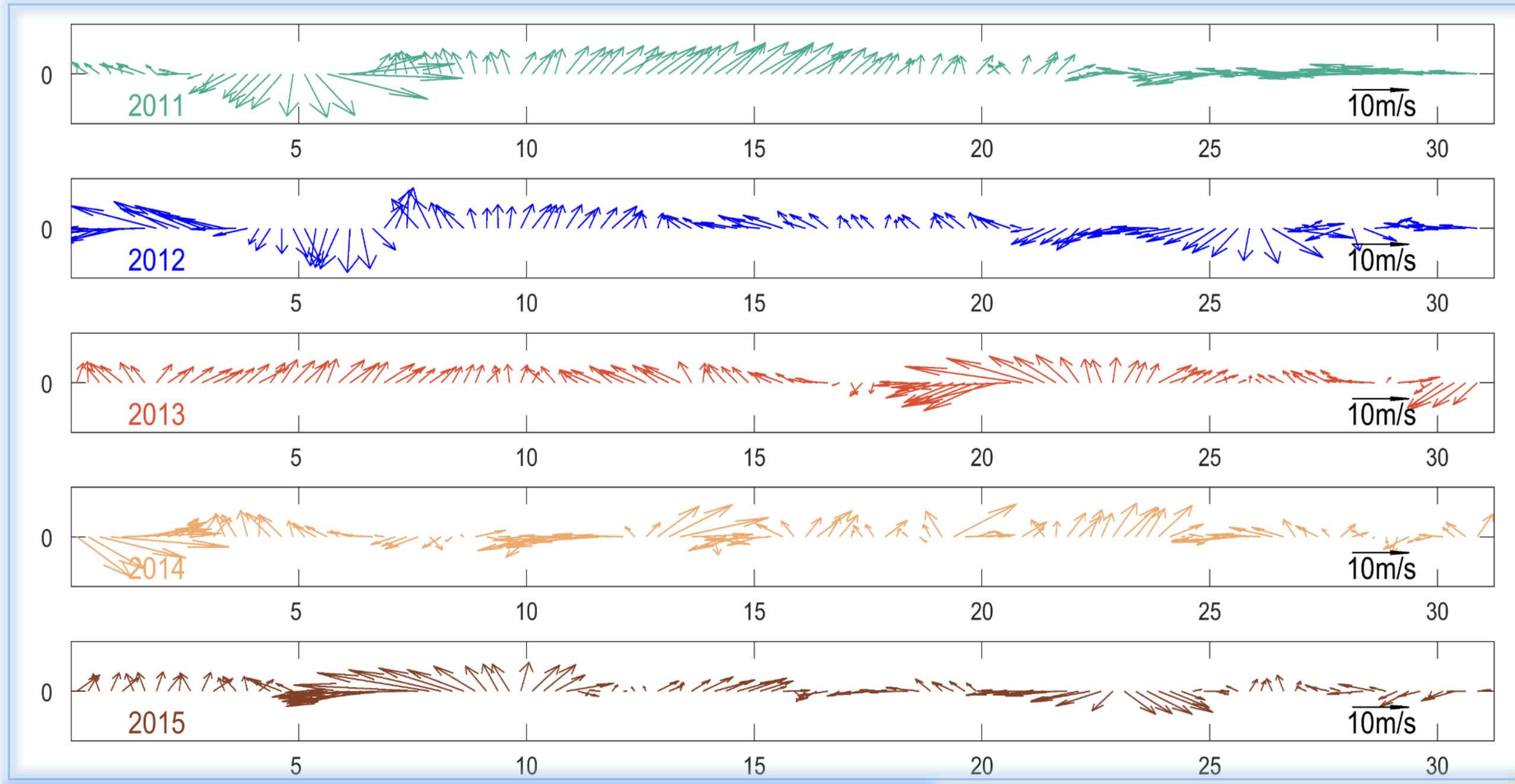
The experimental results show that the multi-scale coherence analysis can effectively find and suppress the systematic noise, and also can be used for judging the quality of underway gravity data.

Temperature and Salinity

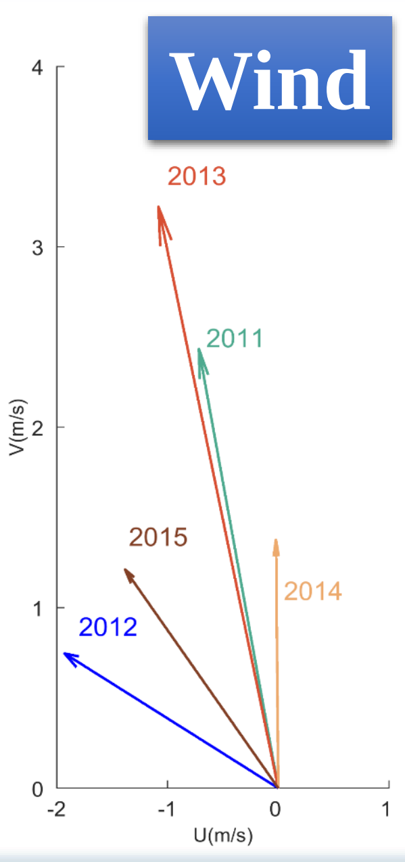
Data collocated from Dachenzhen Ocean Station show that the highest salinity in August 2013 was 34.30, the lowes temperature in August 2013 was 22℃, consider all the possible water masses in this region, only the Kuroshio subsurface water has such hydrological characteristics.





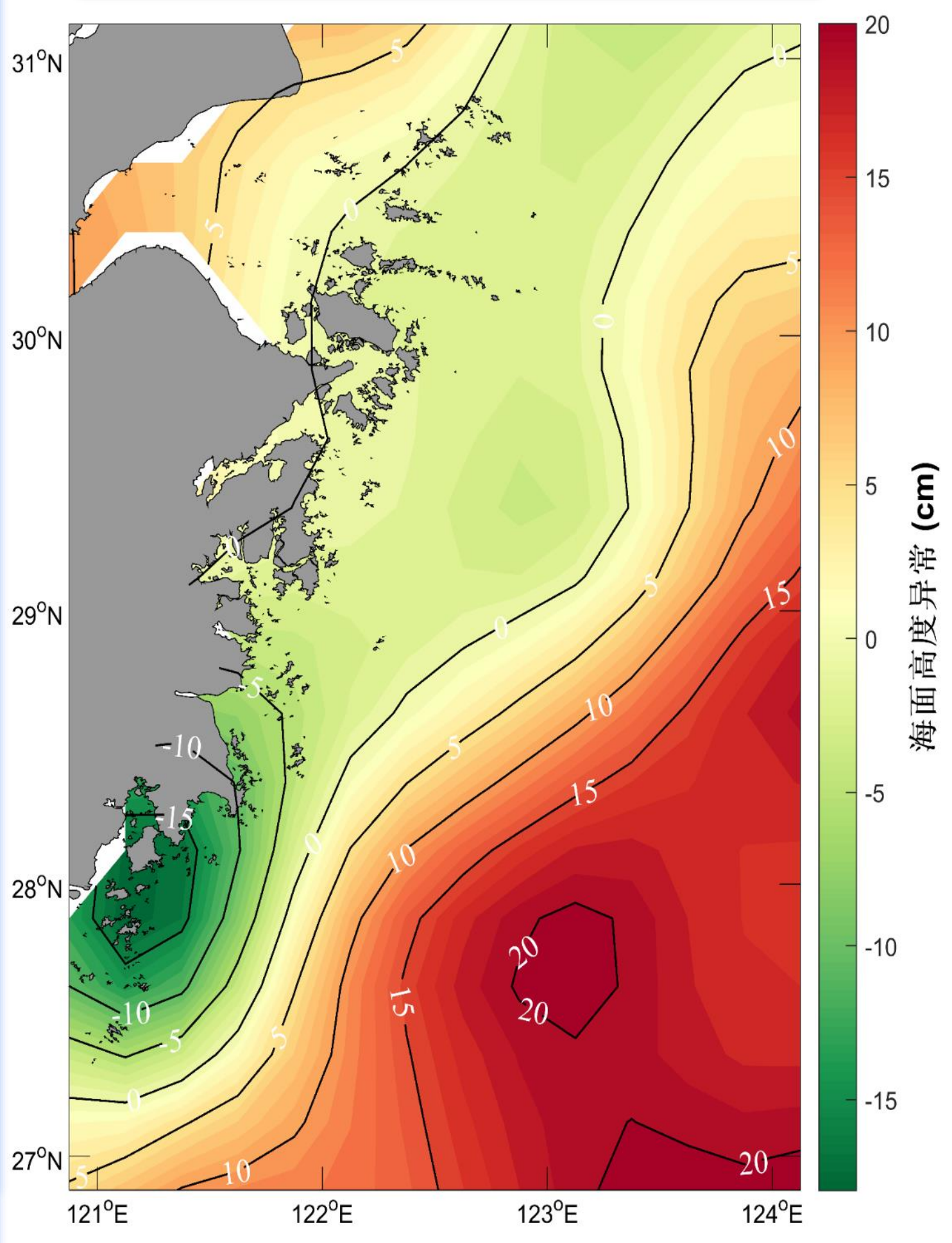


Wind

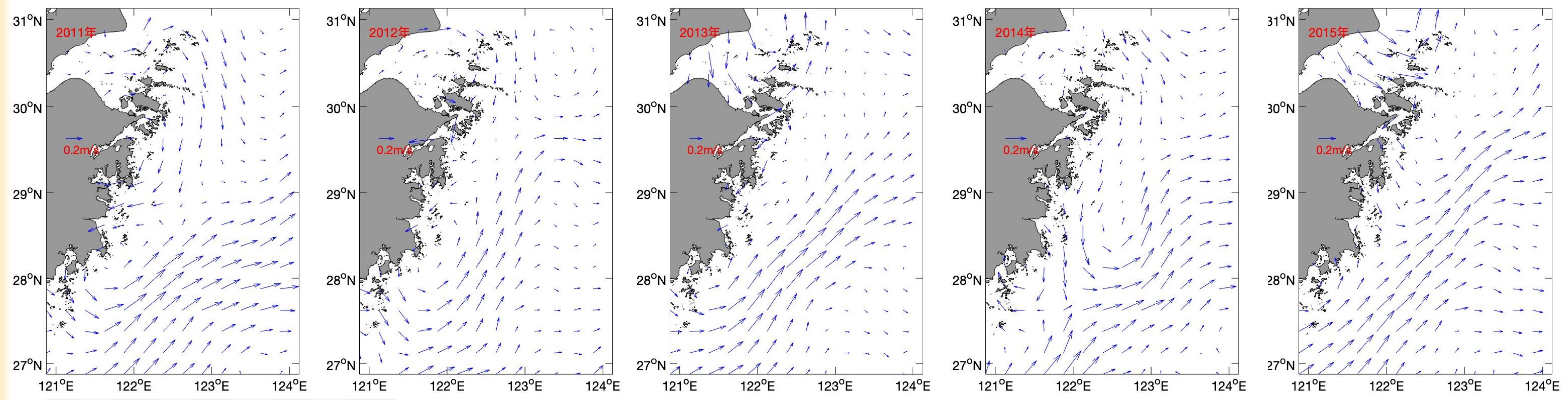


The wind data shows that the average wind in August of these five years was northwest wind, and the average wind speed in August of 2013 was the highest of 3.40 m/s, and the meridonal wind component was 3.22m/s. In August 2013, compared with other August years, the wind direction was basically southeast or southwest throughout the month, only a brief northeast wind around the 19th and 30th.

Sea Level Anomaly

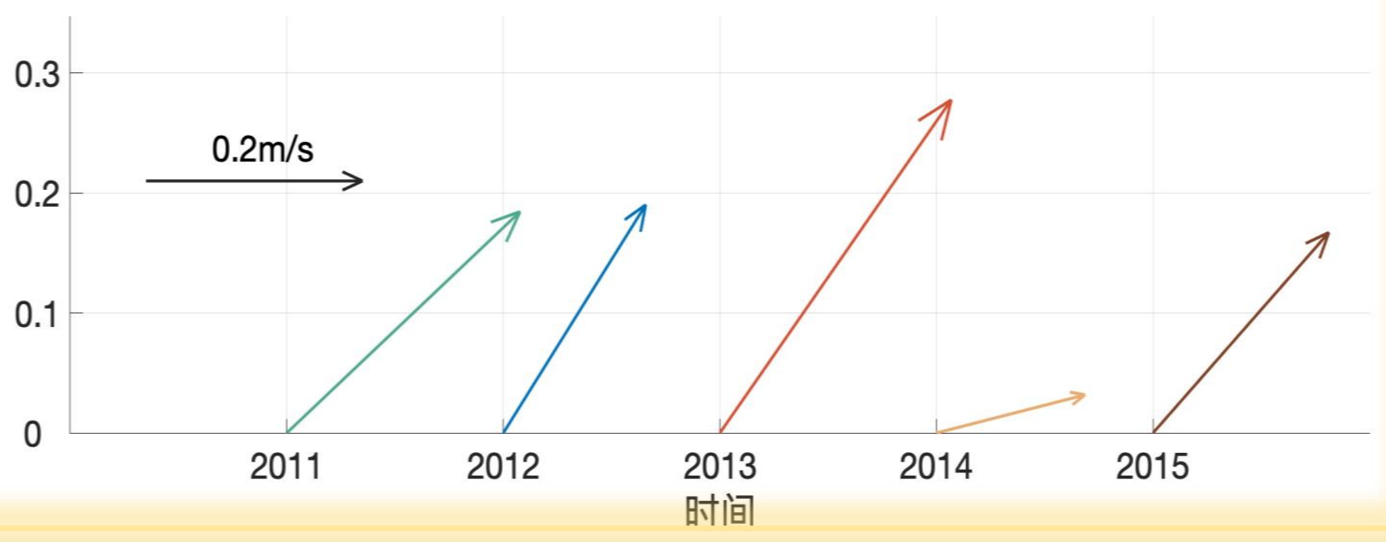


The monthly mean sea level anomaly distribution of ECS in August 2013 showed that there was a negative area centered around (121.12° E, 28.12° N), and the extreme value was about -18 cm. In the area with the center of (123.12° E, 27.62° N), there is a positive anomaly in the sea surface height, with the extreme value of 20 cm. The maximum difference in sea surface height from the outer sea to the nearshore is about 38cm.



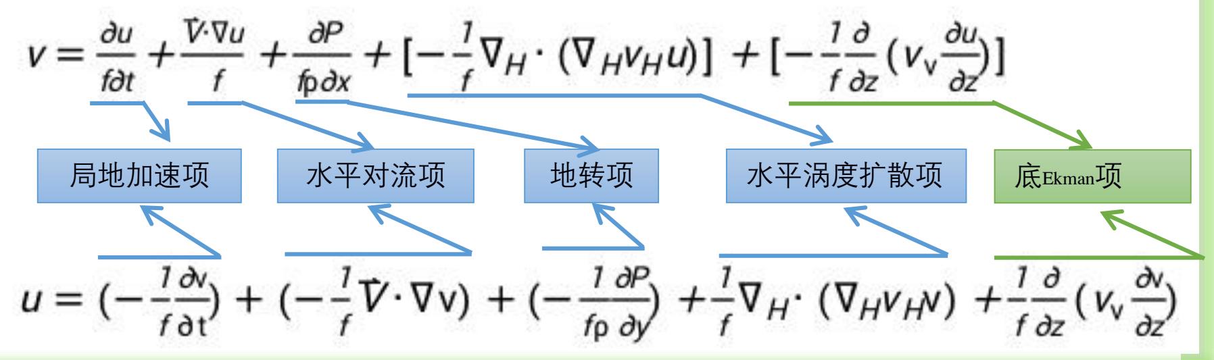
Geostrophic Flow

In August 2013, the geostrophic flow in Zhejiang offshore was parallel to the shoreline and flowed to the northeast, which was obviously stronger than that in other August years. Compared with the adjacent years, the geostrophic current of Zhejiang in August 2013 flows to the northeast from nearshore to offshore.



Theory

The bottom Ekman flow is the main driving force supporting the invasion of subsurface Kuroshio water to shore, and the bottom Ekman flow intensity is positively correlated with the velocity of the geostrophic flow.



$$v = \frac{\partial u}{f\partial t} + \frac{\vec{V}\cdot\nabla u}{f} + \frac{\partial P}{f\rho\partial x} + \left[-\frac{1}{f}\nabla_H\cdot(\nabla_H v_H u)\right] + \left[-\frac{1}{f}\frac{\partial}{\partial z}\left(v_v\frac{\partial u}{\partial z}\right)\right]$$

$$u = \left(-\frac{1}{f}\frac{\partial v}{\partial t}\right) + \left(-\frac{1}{f}\vec{V}\cdot\nabla v\right) + \left(-\frac{1}{f\rho}\frac{\partial P}{\partial y}\right) + \frac{1}{f}\nabla_H\cdot(\nabla_H v_H v) + \frac{1}{f}\frac{\partial}{\partial z}\left(v_v\frac{\partial v}{\partial z}\right)$$

Conclusion

The surface exposure mechanism of Kuroshio subsurface water could be concluded as:

Long time northeastward wind → Strengthen the offshore Ekman flow → Increase the SSH difference from offshore to inshore → Strengthen the geostrophic flow → Strengthen the onshore bottom Ekman flow → the Kuroshio Subsurface water builds up to shore and exposed to the surface