



# Design assessment of an on going in-situ ocean observing system in Chinese marginal seas



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## Abstract

Chinese Academy of Sciences is now developing a sustainable ocean observing system in the Chinese marginal seas (including Yellow Sea, East China Sea and South China Sea). This observing system includes three coastal stations, four offshore buoys and regular cruise sections that will be carried out by its research vessels. The locations of these buoys and cruises are now determined. Implementations of this observing system will be carried out in the following years (2008-2011). In this paper a design assessment of this observing system in the context of monitoring large scale interseasonal and interannual variability is discussed using an existing Kalman theory based method. This approach examines the error reductions made by assimilation of observations from the given buoy and cruise sections according to the Kalman filter theory. The background error covariance is calculated by ensemble of model based results. Two sets of ensemble are used from which the stationary background error covariance matrices can be calculated. One is from an assimilation run of a coarse resolution (0.5° by 0.5°) ocean model. Another is from a higher resolution (0.12° by 0.12°) model simulation. The results from the two datasets are similar. We found that the SST observations from the three coastal stations and four offshore buoys can effectively reduce the SST analysis error in Bohai Sea, Yellow Sea, East China Sea and northern and middle parts of South China Sea. However, in the regions east of Viet Nam and east of Taiwan and Philippine, the percentages of error reductions are relative small.

## Method and data

This method is based on Kalman Filter theory (Sakov and Oke, 2008), the well-known formula is  $P = [I - PH^T(H^T H + R)^{-1} H^T] P$ , and the background error covariance is calculated by  $P = \frac{1}{m-1} A A^T$ , by updating the background ensemble  $A^k \rightarrow A^{k+1}$ . We get the analysis error covariance  $P^a = \frac{1}{m-1} A^a A^{aT}$ . Here, we use percentage reduction of the analysis error to quantify how much the analysis error can be reduced after assimilating observation. The standard deviations before assimilating observation and after assimilating observation are denoted by  $\sigma_{\text{before}}$  and  $\sigma_{\text{after}}$ . So the percentage reduction formula of the analysis error can be given as follows  $\text{Per} = \frac{\sigma_{\text{before}} - \sigma_{\text{after}}}{\sigma_{\text{before}}} \times 100\%$ .

**Datasets:** Two model datasets are used in this study. The first is from 12-year (1982.1-1993.12) assimilation run of a regional vertical eta-coordinate ocean model (You *et al.*, 2003). Another dataset is from a 10-year (1996.1-2005.12) simulation run of a hybrid-coordinate ocean model (HYCOM) (Xiao, 2007).

### Impact of a single observation at (125°E, 32°N)

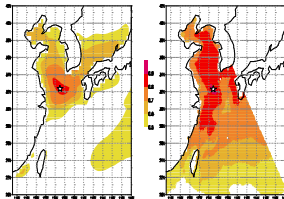


Figure 1. The stationary background error standard deviation of SST field (unit: °C) calculated from the two datasets. (a) from the 1/2° assimilation run; (b) from the 1/8° HYCOM simulation run; (c) from the NCEP SST reanalysis data; (d) the mean surface current from (You *et al.*, 2003). They show similar patterns of large scale interseasonal/ interannual variability of the SST fields.

Figure 2. The Per values that measures the percentage of the uncertainty decrease after assimilation of a single observation in the East China Sea (marked by the star). The (a) from the 1/2° assimilation run; (b) from the 1/8° HYCOM simulation run. The vector fields are the mean surface current fields from the two datasets respectively.

## Assessment of the observing system

This figure shows the locations of the on-going CAS observing system. The main idea behind this design is to enhance CAS's capability of monitoring large scale ocean variability of marginal seas around China by having two long-term off-shore observation platforms and one coastal station in the Yellow Sea/East China Sea operated by the Institute of Oceanology and the similar facility in the South China Sea operated by the South China Sea Institute of Oceanology. The coastal stations are based on their existing facility there.

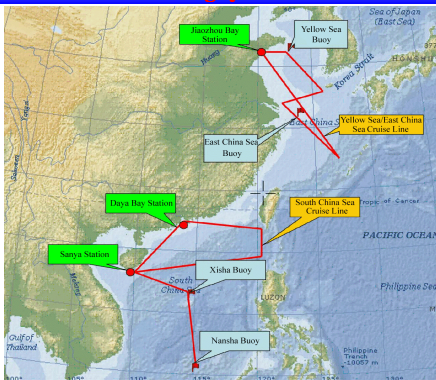


Figure 3. The sketch of the ocean observing system (including three coastal stations, four offshore buoys and regular cruises) in Chinese marginal seas (This is the initial layout, maybe there are some difference in the actual station layout according to the actual instance)

The following Figures show the distribution of the Per. Results from two datasets by assimilating different observing manner are consistent that the analysis error of SST could be effectively decreased after assimilating observations at these stations.

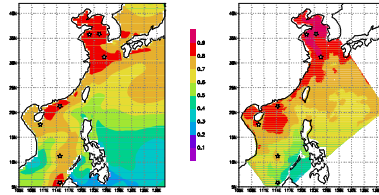


Figure 4. The Per values after assimilation of the SST observations at the seven fixed locations. The (a) from the 1/2° assimilation run; (b) from the 1/8° HYCOM simulation run. The vector fields are the mean surface current fields from the two datasets respectively.

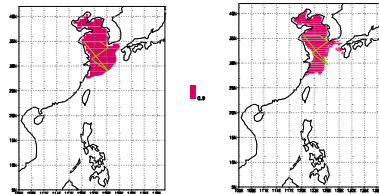


Figure 5. the percentage (Per) of uncertainty reduction of SST analysis error by assimilating section observations in East China Sea and Yellow Sea are presented, the green dashed denotes section location. Left result is from the 1/2° assimilation run, the right one is from HYCOM.

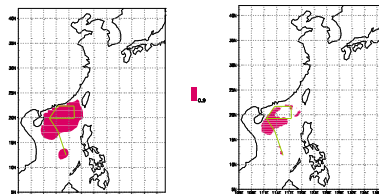


Figure 6. The same to the fig. 5, selected region is in South China Sea.

## Conclusions and discussions

In this paper, ensemble-based observing system simulation experiments (OSSE) method is used to assess an ocean observing system in the Chinese marginal seas. In this study we focus on the assessment of the observing system's ability in monitoring the large scale, inter-annual and inter-seasonal variability. The main results are as follows:

- (1) The percentage of uncertainty reduction of SST analysis error is close to 80-90%, and the large impact areas are in Bohai Sea, Yellow Sea, East China Sea, South China Sea and coastal sea area. However, the observing system seems to under-sample some areas such as the east of Taiwan and Philippine, and the south part of the South China Sea.
- (2) The Nansha buoy at the middle of the South China Sea seems to have a limited yield comparing to other stations due to the low variability in the middle of the South China Sea.
- (3) When turn to the cruise sections in the East China Sea, uncertainty reduction of SST analysis error is more than 90% in East China Sea and Yellow Sea, and affected areas include Bohai Sea and even east of Taiwan and Japan. The cruise sections in the South China Sea can reduce uncertainty.

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