RECONSTRUCTION OF SATELLITE-DERIVED SEA SURFACE TEMPERATURE OF THE SOUTH CHINA SEA IN 2003-2009

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Abstract

The South China Sea (SCS) is a large marginal sea in the tropical region where the percentage of missing data of the daily Advanced Very High Resolution Radiometer (AVHRR) sea surface temperature (SST) is very high. Here we use a relatively new technique, DINEOF (Data INterpolating Empirical Orthogonal Functions), to reconstruct the SST of the SCS in 2003-2009. Furthermore, a comparison between the reconstructed data and daily Tropical rainfall Measuring Mission Microwave Imager (TMI) SST is implemented.

South China Sea

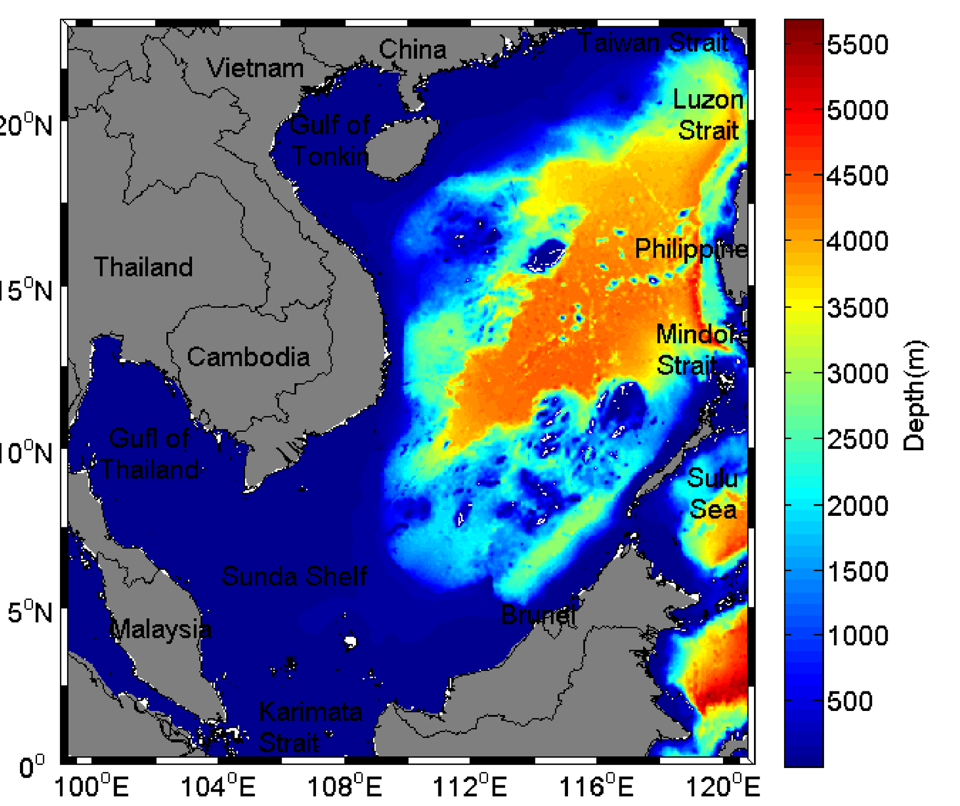


Figure 1. Geography and bathymetry of the South China Sea.

The SCS is a large tropical marginal sea (Figure 1), extending from 0ºN - 23ºN and 99ºE - 121ºE, the total area of 3.5x10^6 km^2, average depth over 2000 m (maximum depth reaching more than 5000 m). It is connected to the East China Sea through the Taiwan Strait, the Pacific Ocean through the Luzon Strait, and to the Indian Ocean through the Malacca Strait. The SCS is influenced under the East Asian monsoon system: northeasterly in winter (~ 9 m/s) and southwesterly in summer (~ 6 m/s).

Data

An AVHRR SST data set spanning from 2003 to 2009 (2557 images) with a horizontal resolution of 4 km is used. Night-time data are used to avoid skin temperature problems. The percentage of missing data is very high in space and time (Figure 2). Average missing data is 88%.

Only images containing at least 2% of data are used and pixels which are missing more than 95% information of the time are masked as land points. The number of images is reduced to 2087 (82% of the initial data), with the mean cloud coverage is about 85%.

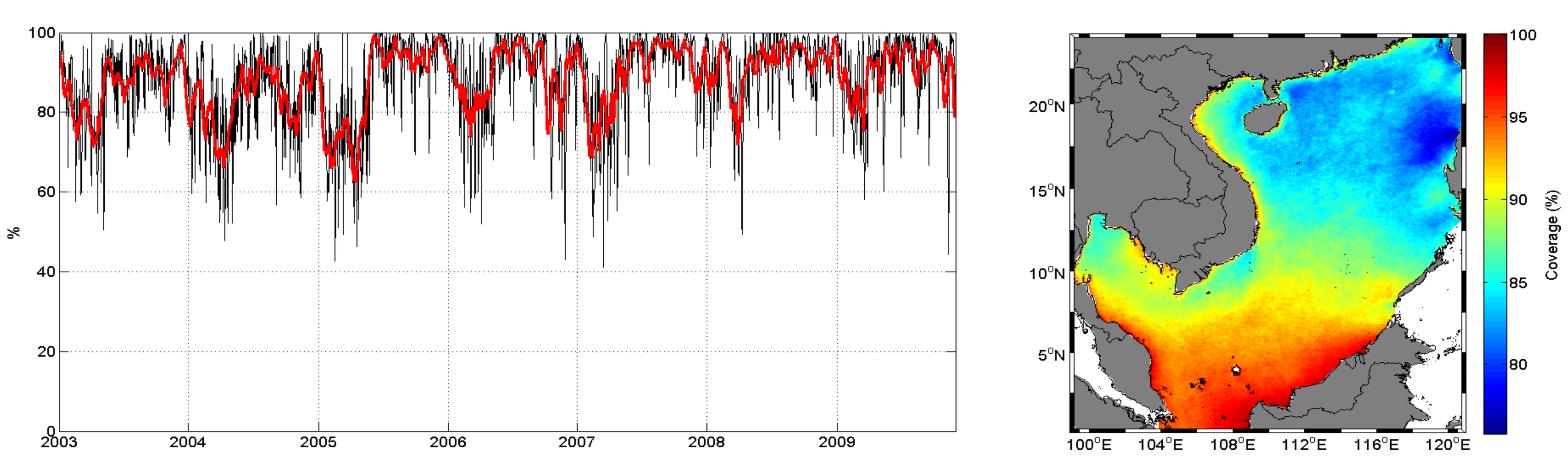


Figure 2. Temporal (left) and spatial (right) variation of cloud cover percentage in the South China Sea in 2003 – 2009.

Method

To reconstruct cloud-covered satellite images, we use DINEOF (Data INterpolating Empirical Orthogonal Functions) described in Beckers et al. (2003), Alvera-Azcárate et al. (2005). A filtering of temporal covariance matrix is used following Alvera-Azcárate et al. (2009). Firstly, the initial data input **X** is obtained by subtracting the temporal mean and setting the missing data to 0. Secondly, a Singular Value Decomposition (SVD) of **X** is performed, which is used to calculate the missing data by the equation:

$$\mathbf{X}_{ij} = \sum_{p=1}^{k} \rho_p \left(\mathbf{u}_p\right)_i \left(\mathbf{v}_p^T\right)_j$$

where i, j are temporal and spatial indexes, respectively, k is the number of EOFs mode, **u** and **v** are the p*th* spatial and temporal functions of EOF, and ρ_p is the corresponding singular value. Step 2 is repeated until convergence. Thirdly, a cross-validation technique determines the optimal number of EOF modes retained in the reconstruction. Finally, the optimal number of EOFs is used to reconstruct the whole matrix.

Here we did not run DINEOF until obtaining the optimal number of EOFs.

Results

We use 3 first EOFs explaining 98,88% of initial variance to reconstruct the whole data set. A comparison between the reconstructed SST by DINEOF and the TMI SST with the horizontal resolution of 25 km is implemented (Figure 3). The maximum root mean square (RMS) error is about 1ºC.

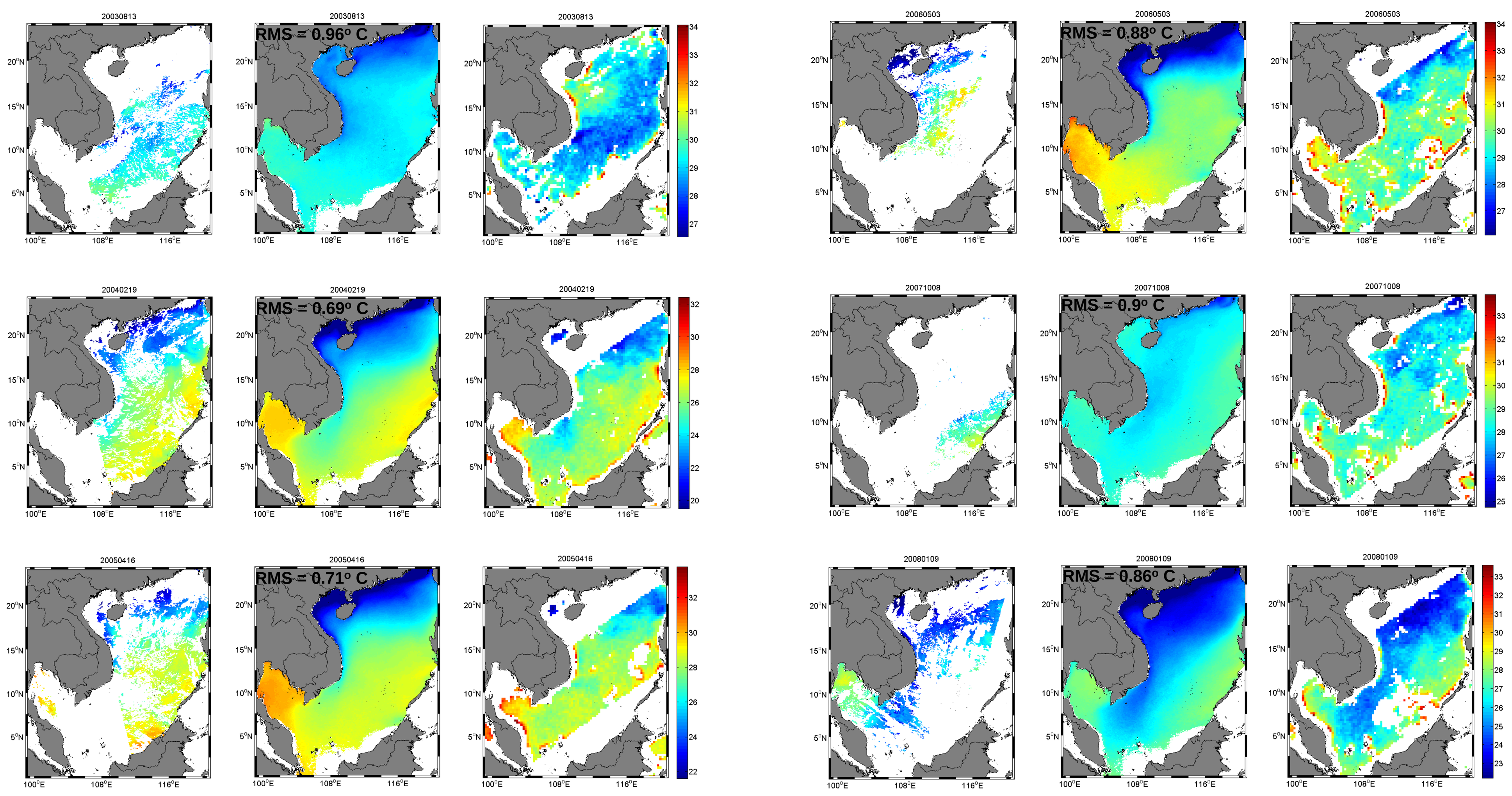
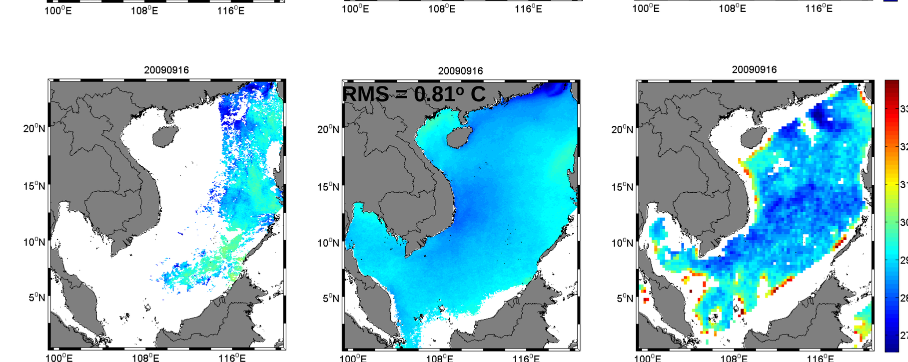


Figure 3. Comparison between the reconstructed SST by DINEOF and the TMI SST in 2003-2009: observed AVHRR SST (left), DINEOF SST (middle), and TMI SST (right). The maximum RMS error is about 1º C.



Mode 1 and 2 account for 68.81% and 28.91 % of variability respectively. They might be related to a seasonal cycle of northeasterly and southwesterly monsoon. Mode 3 accounts for 1.12% of variability. It also exhibits a seasonal cycle. It might be related to the variability of SST in the period of the transition from northeasterly and southwesterly monsoon and vice versa. Further study with wind data is necessary to understand better these patterns.

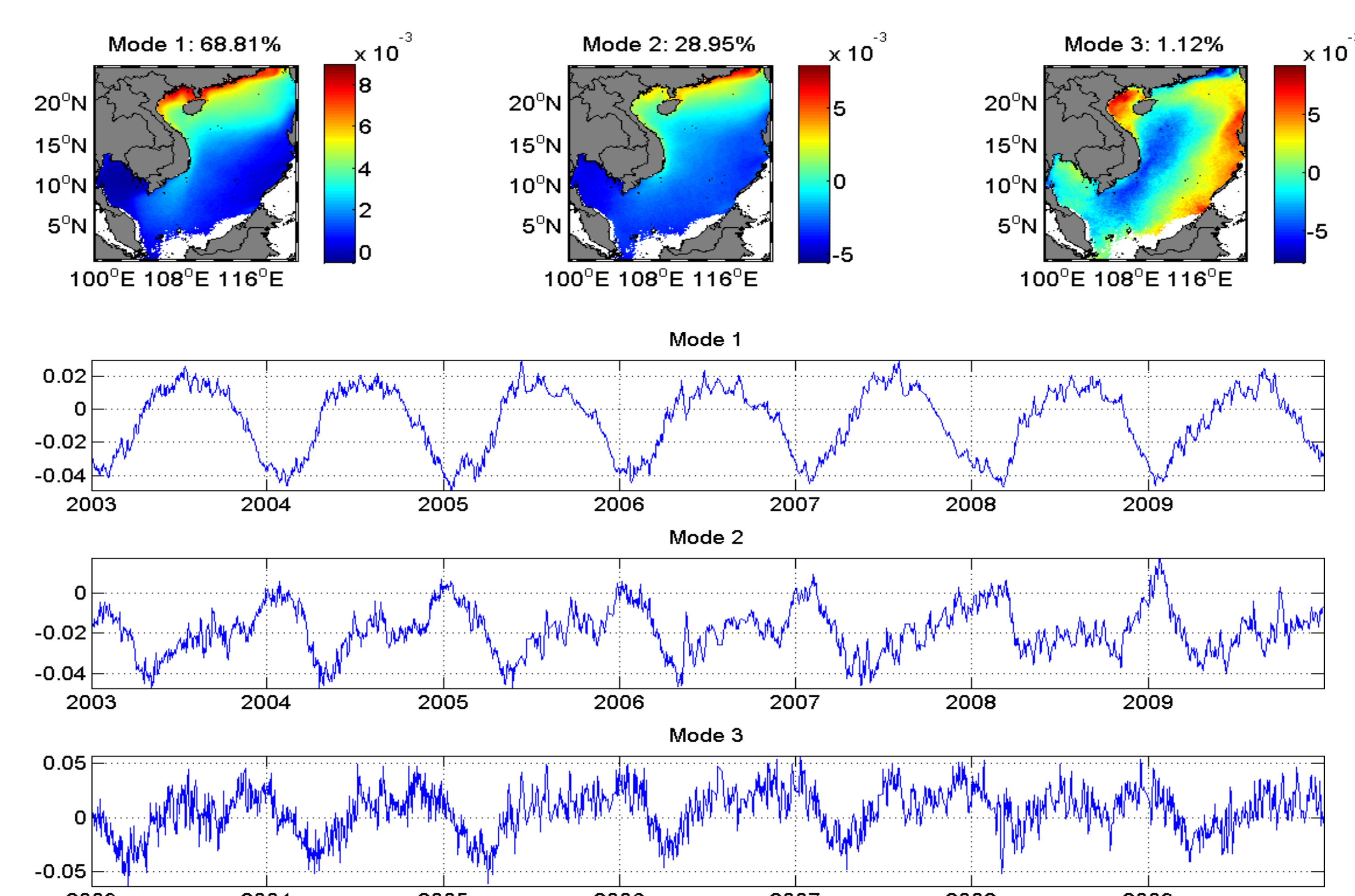


Figure 4. Spatial and temporal EOF of modes 1-3.

Acknowledgments

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