Optimum Interpolation Analysis for Sea Surface Temperature Using the oriented elliptic correlation scales

Zhihong Liao, Bin Xu, Lei Zhang

National Meteorological Information Centre, China Meteorological Administration, Beijing, China

Abstract

Optimum Interpolation (OI) analysis is made for the Sea Surface Temperature (SST) product of Fengyun-3C (FY-3C) Visible and Infrared Radiometer (VIRR), and a novel oriented elliptic correlation scales are used in the SST analysis in comparison with the traditional rectangular correlation scales, then the results are evaluated against the measurements of in-situ SST and OISST products. Statistical results for 2015 indicates that the SST results by using the oriented elliptic correlation scales is more effective than those using the rectangular correlation scales, which decrease the value of RMSE from 0.4194℃ to 0.3816℃, but it is much larger than the OISST products with the RMSE of 0.2780℃. It demonstrates that it still have a lot of errors in the SSTs of FY-3C VIRR, which makes the poor quality of these SST analysis products, while the oriented elliptic correlation scales for SST has a better performance than the rectangular correlation scales in OI analysis.

Data and Method

The SST products of FY-3C VIRR from the National Satellite Meteorological Center (NSMC) of China are selected, which record daytime SST (VIRRD) and nighttime SST (VIRRN), and the in-situ SSTs are used from the in situ SST quality monitor (iQuam) system. The experiment resampled these SST data to a spatial resolution of 0.25° after quality control and bias correction, and reconstructed the SST field using the OI analysis with the initial parameters in Table 1. Then the dataset of SST incremental field based on the initial analysis is obtained, and the values of data to guess error ratios for each type of SST are re-estimated, and the spatial correlation scales including the rectangular correlation scales and the oriented elliptic correlation scales are calculated as shown in Table 2.

Table 1 Initial values of data to guess error ratios and spatial correlation scales

	$\varepsilon_{In-situ}$	ε_{VIRRD}	ε_{VIRRN}	λ_x	λ_y
Assumptions	0.50	0.50	0.50	151km	155km

The rectangular correlation scales

Assuming that the correlation coefficient between the SST increments at the target location (x_i, y_i) and those in the surrounding neighborhoods (x_j, y_j) follows the Gaussian distribution (Reynolds and Smith 1994),

$$F_{xy} = A\exp\left[\frac{-(x_i-x_j)^2}{\lambda_x} + \frac{-(y_i-y_j)^2}{\lambda_y}\right] \quad (1)$$

λ_x and λ_y is the maximum latitudinal and longitudinal distances of the associated neighborhoods, respectively. A is the coefficient of association. And these parameters determine the effective region of the target location, which are estimated by using the Least Squares Estimation.

The oriented elliptic correlation scales

The correlation scale of the oriented ellipse is established as the basic shape unit for OI analysis, and its correlation with distance is modeled as follows,

$$F_{d,\theta} = \exp\left[\frac{-d}{D(\theta)}\right] \quad (2)$$

$F_{d,\theta}$ is a function with the distance d and the azimuth θ in polar coordinates. The elliptic equation $D(\theta)$ express the shape of correlation scales, which can be described as

$$D(\theta) = \frac{L_{max}L_{min}}{\sqrt{L_{max}^2\sin^2(\theta-\varphi) + L_{min}^2\cos^2(\theta-\varphi)}} \quad (3)$$

φ is the rotation angle for the ellipse. L_{max} and L_{min} stand for the semi-major axis and semi-minor axis of the ellipse, and the global distribution of them are separately shown in Figure 1 and 2, which are calculated by using the Gauss-Newton iteration method.

Using the updated parameters of spatial correlation scales and the values of data to guess error ratios, the SST fields are re-calculated by OI analysis. The OI results from using the rectangular correlation scales (OI_{rect}) and using the oriented elliptic correlation scales ($OI_{ellipse}$) between 60° S and 60° N are evaluated by the in-situ SST, and compared with the OISST products. It demonstrates that the performance of the $OI_{ellipse}$ is quite better than the OI_{rect}, as the global distributions of SST Biases and Standard Deviations (SDs) shown in Figure 3 and the statistic results in Table 3.

Results

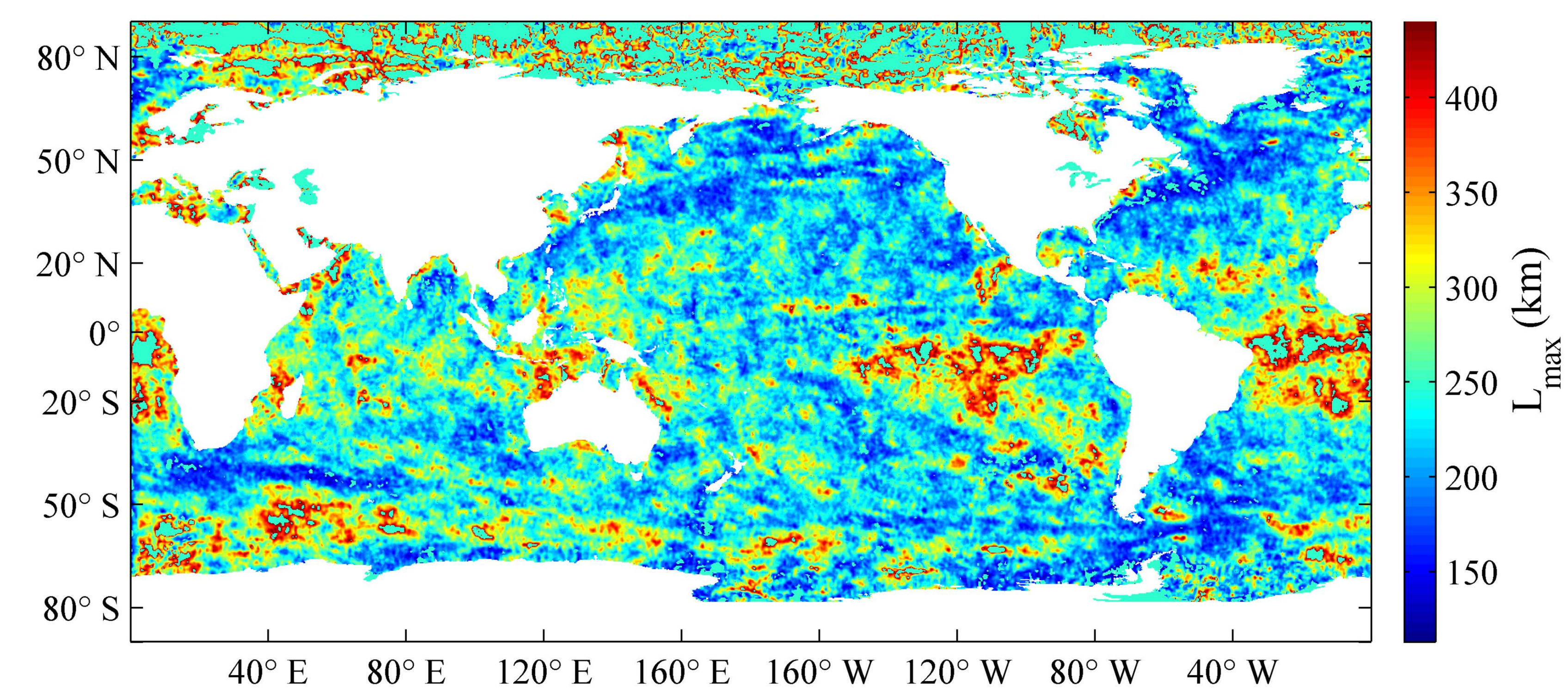

Figure 1 Global distribution of the parameter L_{max} that estimated by the initial SST analysis data

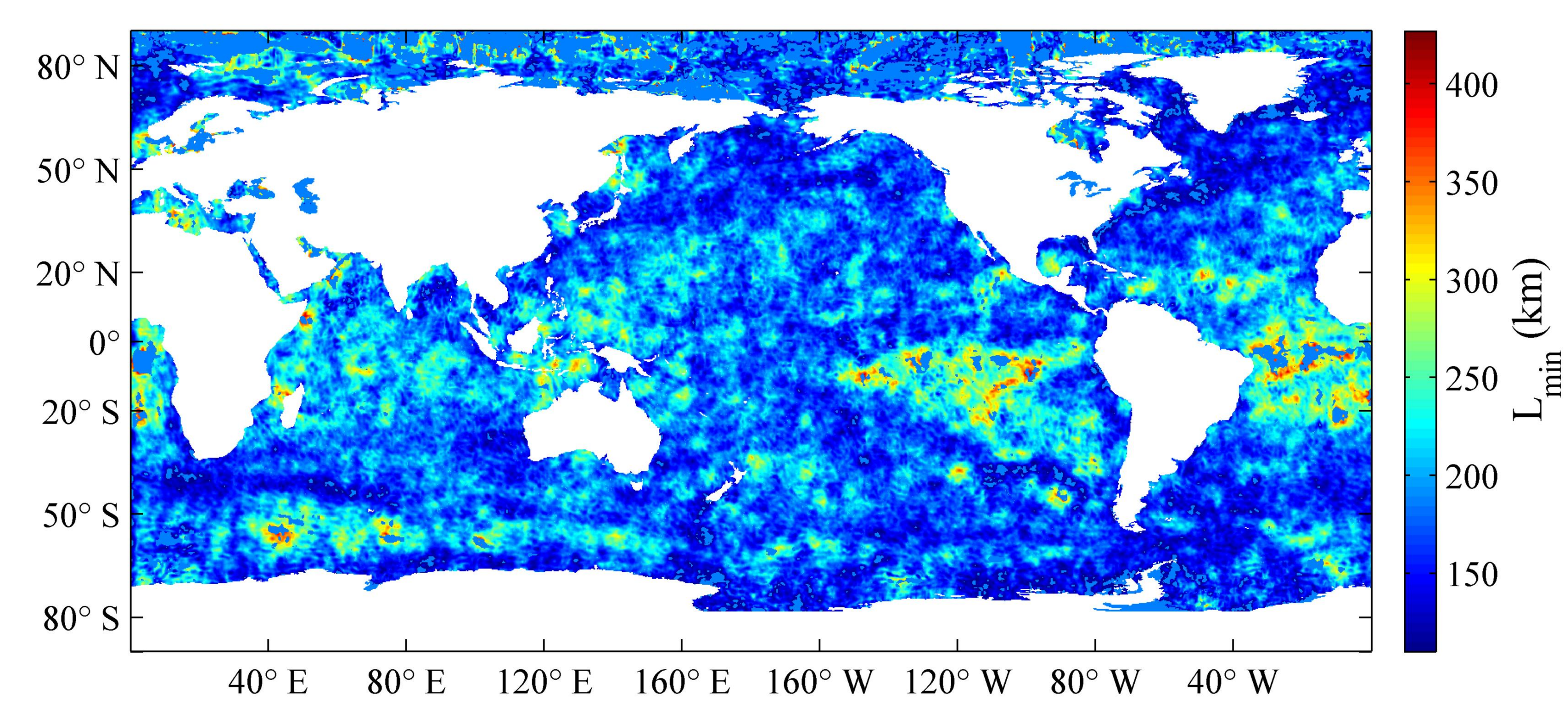

Figure 2 Global distribution of the parameter L_{min} that estimated by the initial SST analysis data

Table 2 Average values of data to guess error ratios and spatial correlation scales

	$\varepsilon_{In-situ}$	ε_{VIRRD}	ε_{VIRRN}	λ_x	λ_y	L_{max}	L_{min}	ϕ
Statistics	0.14	0.45	0.43	189km	169km	250km	185km	1.30

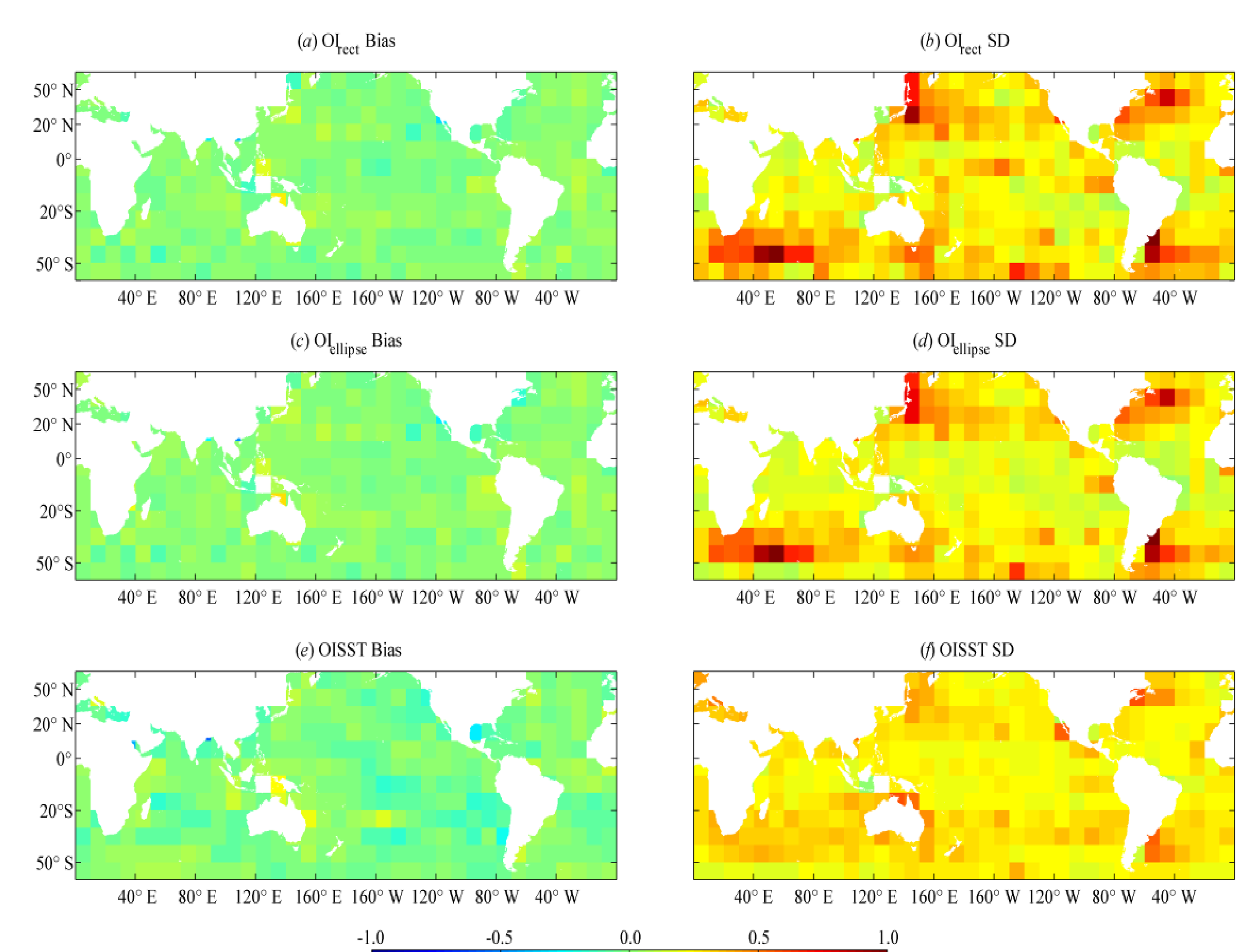

Figure 3 The distributions (60° S - 60° N) of the average Biases and SDs from (*a*), (*b*) OI_{rect}, (*c*), (*d*) $OI_{ellipse}$ and (*e*), (*f*) OISST within 10° ×10° rectangles.

Table 3 Statistic results of 2015 from original SST and SST analysis (60° S - 60° N) using OI method

	RMSE (℃)	SD (℃)	R	SNR
Original SST	0.4775	0.3279	0.9980	18.2370
OI_{rect} SST	0.4194	0.2762	0.9988	21.0360
$OI_{ellipse}$ SST	0.3816	0.2528	0.999	23.0428
OISST	0.2780	0.2045	0.9995	31.5503