Validation of Wavewatch-III Using the TOPEX/POSEIDON Data

Peter C. Chu
Naval Postgraduate School
Yiquan Qi, Yuchun Chen, Ping Shi, and Qingwen Mao
Chinese Academy of Sciences
Email: pcchu@nps.edu
http://www.oc.nps.navy.mil/~chu

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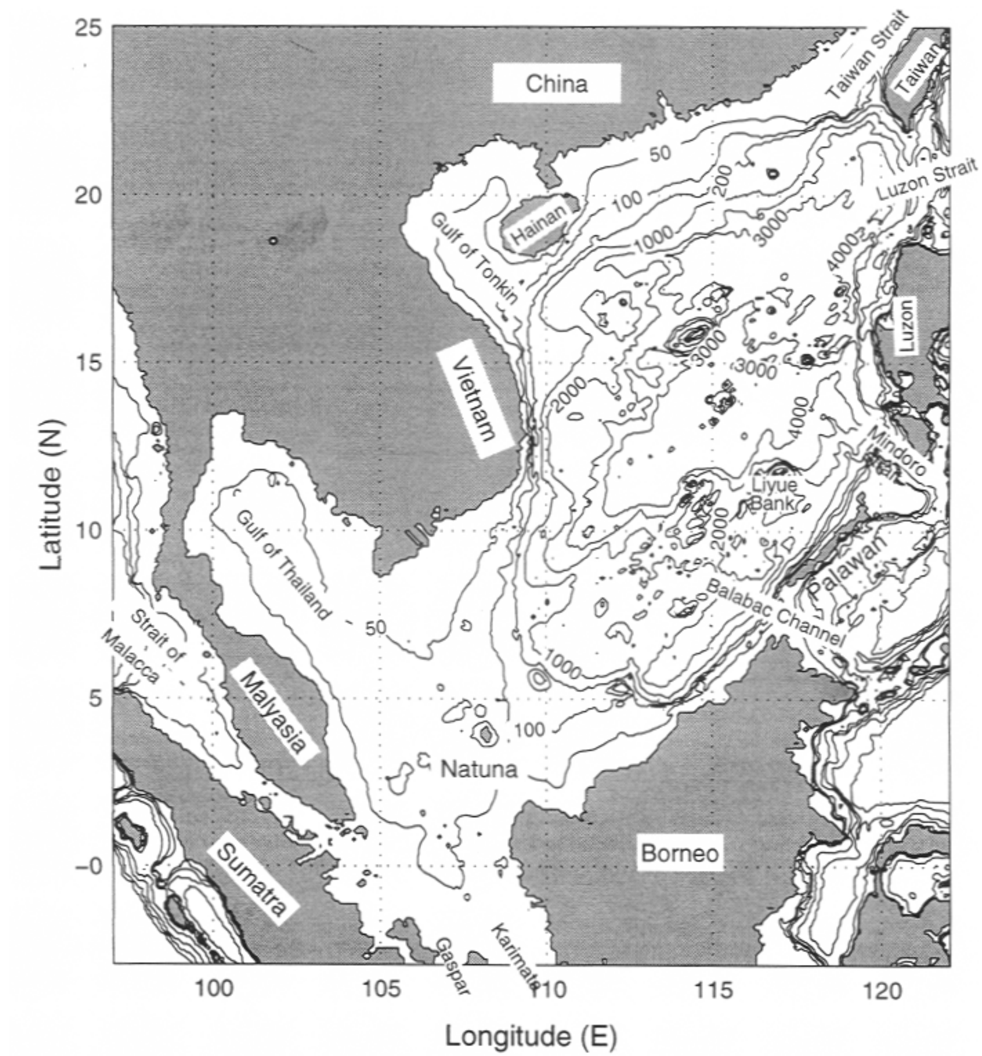
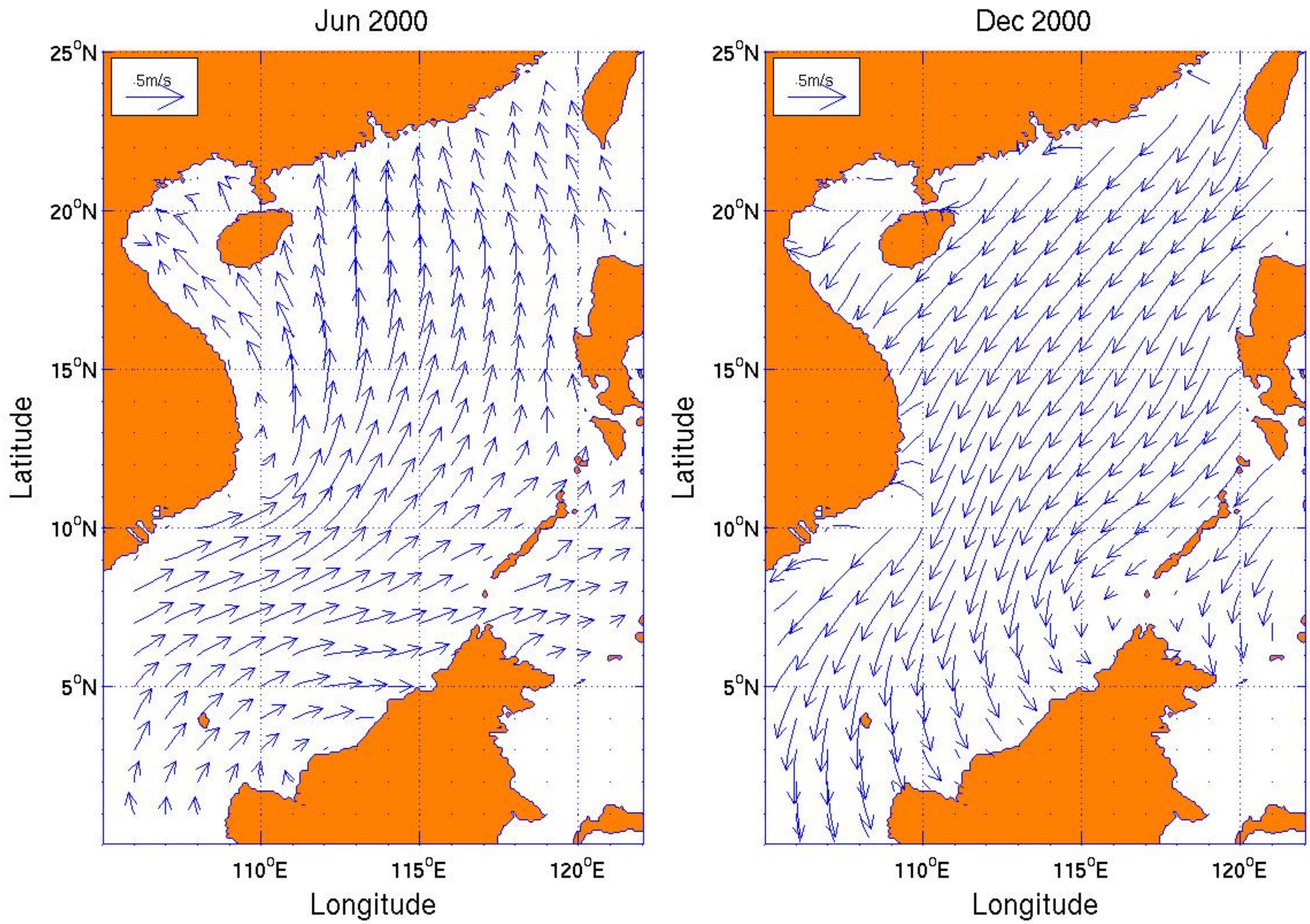
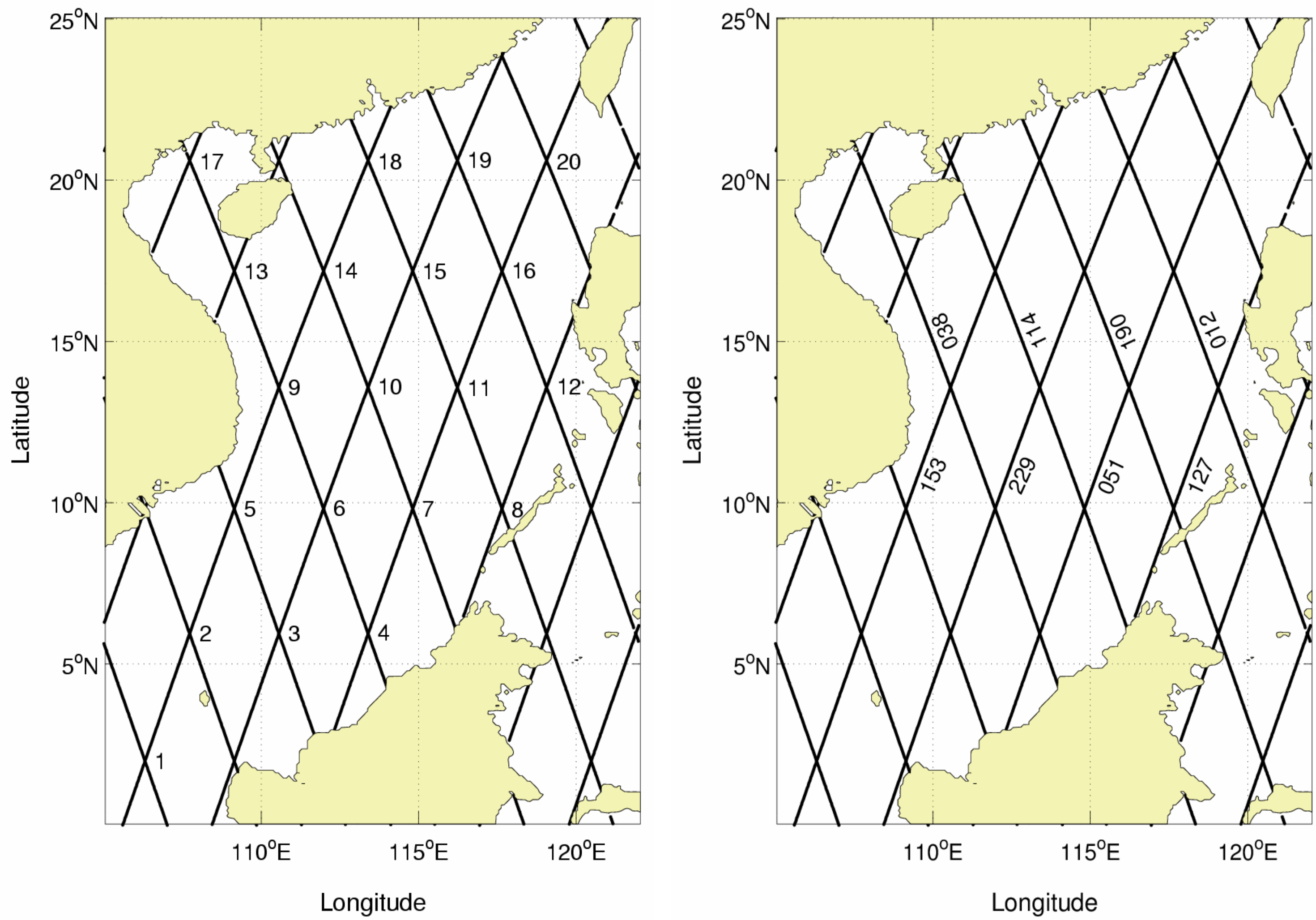
South China Sea



Monsoon Winds (from QuikScat Data)



T/P (a) crossover points and (b) tracks in the SCS.



Wave Spectrum *F*

- $F = F(k, \theta, \sigma, \omega; \mathbf{x}, t)$
- Phase Parameters
  - wave number k
  - direction θ
  - intrinsic frequency σ
  - and absolute frequency ω
- Space ($\mathbf{x}$)
- Time (t)

Doppler Effect

- $\omega = \sigma + \mathbf{k} \cdot \mathbf{U}$ $\quad\quad$ $\sigma^2 = gk \tanh kd$

- Water Depth (d)

- Depth-time averaged velocity (**U**)

NOAA WaveWatch-III Third Generation Wave Model (Tolman 1999)

, $$\frac{\partial N}{\partial t} + \frac{1}{\cos\phi}\frac{\partial}{\partial\phi}\dot{\phi}N\cos\theta + \frac{\partial}{\partial\lambda}\dot{\lambda}N + \frac{\partial}{\partial k}\dot{k}N + \frac{\partial}{\partial\theta}\dot{\theta}_g N = \frac{S}{\sigma}$$

, $$S = S_{in} + S_{nl} + S_{ds} + S_{bot}$$

$$\dot{\phi} = \frac{c_g\cos\theta + U_\phi}{R} \qquad \dot{\lambda} = \frac{c_g\sin\theta + U_\phi}{R\cos\phi}$$

$$\dot{\theta}_g = \dot{\theta} - \frac{c_g\tan\phi\cos\theta}{R}$$

- *N – Wave action spectrum*

- $N(k,\theta;\ \mathbf{x},\ t)$ ⌖ $F(k,\theta;\ \mathbf{x},\ t)/$♋

- $F = F(k,$ 💧$, \sigma, \omega;\ \mathbf{x},\ t)$

Wind Input

- The surface winds (***U***) for the year of 2000 are obtained from the NASA SeaWinds on twice daily QuikScat (QSCAT) Level-3 gridded ocean wind vectors with 0.25° horizontal resolutions.

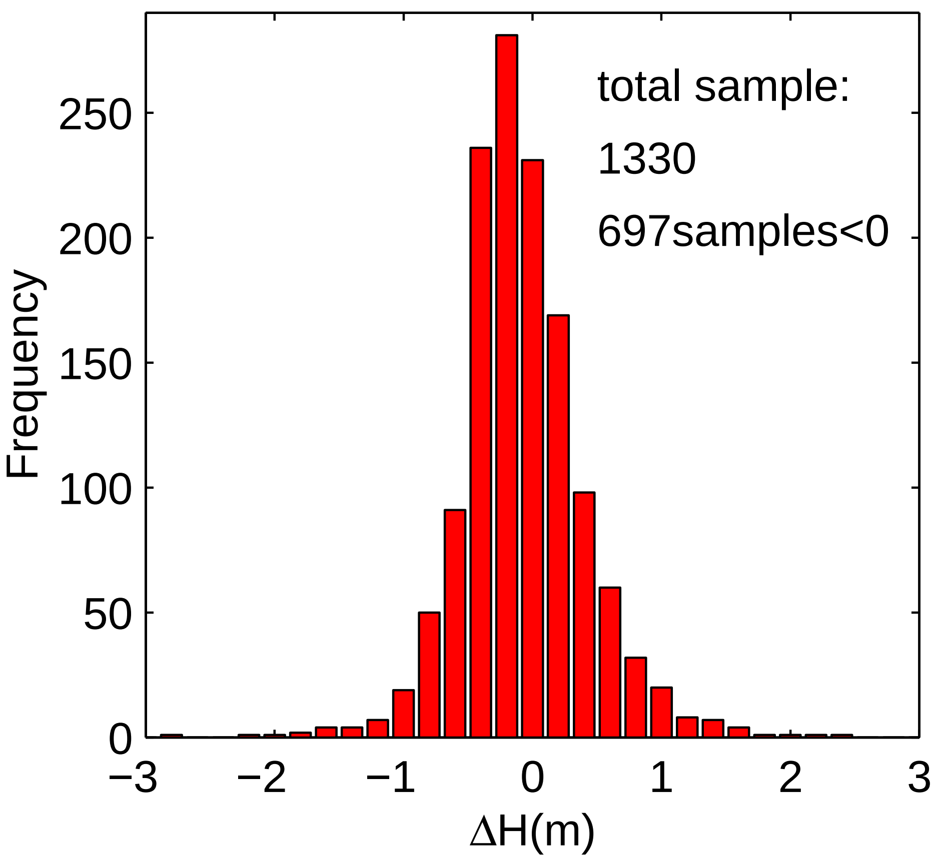
- In WWATCH, the friction velocity (u^*) is computed from the wind speed (U) at a given reference height z_r, in terms of a drag coefficient C_r (Tolman and Chalikov 1996).

Initial Condition

- JONSWAP 1973 wave spectra (Hasselmann et al. 1980) on January 3 (no sufficient wind data on January 1-2, 2000 for SCS), 2000.

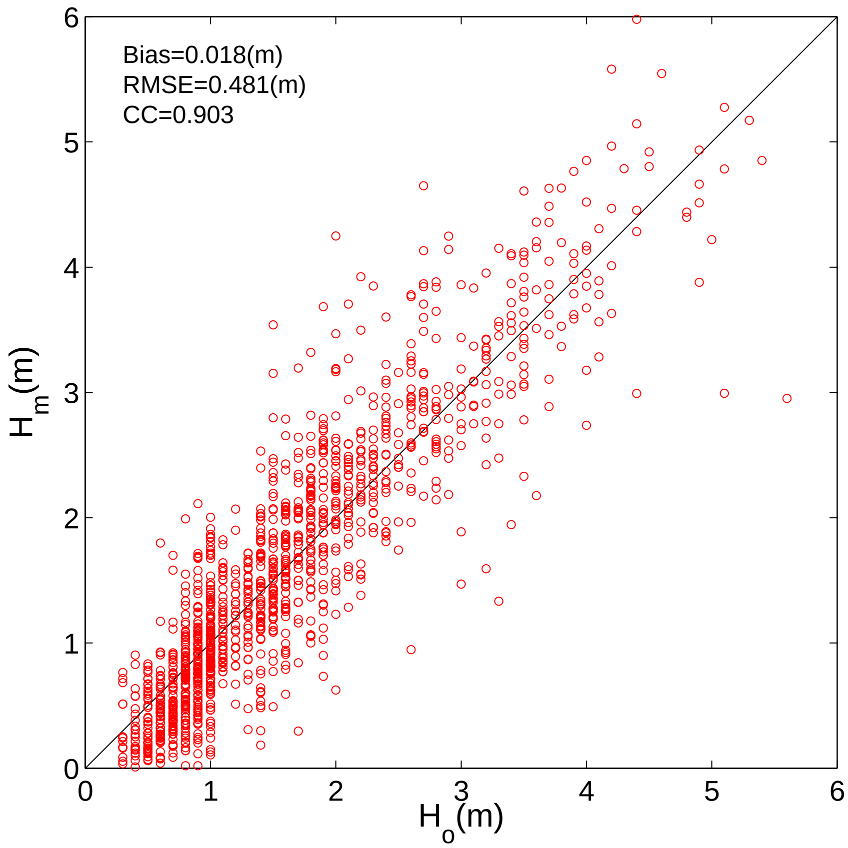
- The model SWH data are interpolated into the T/P crossover points, where the altimeter wave heights are compared. At each crossover point, there are M pairs (approximately 72) of modeled (H_m) and observed (H_o) SWH data in 2000 (around 2 pairs per 10 days).

STATISTICAL EVALUATION



- $\Delta H = H_m(x,y,t) - H_o(x,y,t)$

STATISTICAL EVALUATION



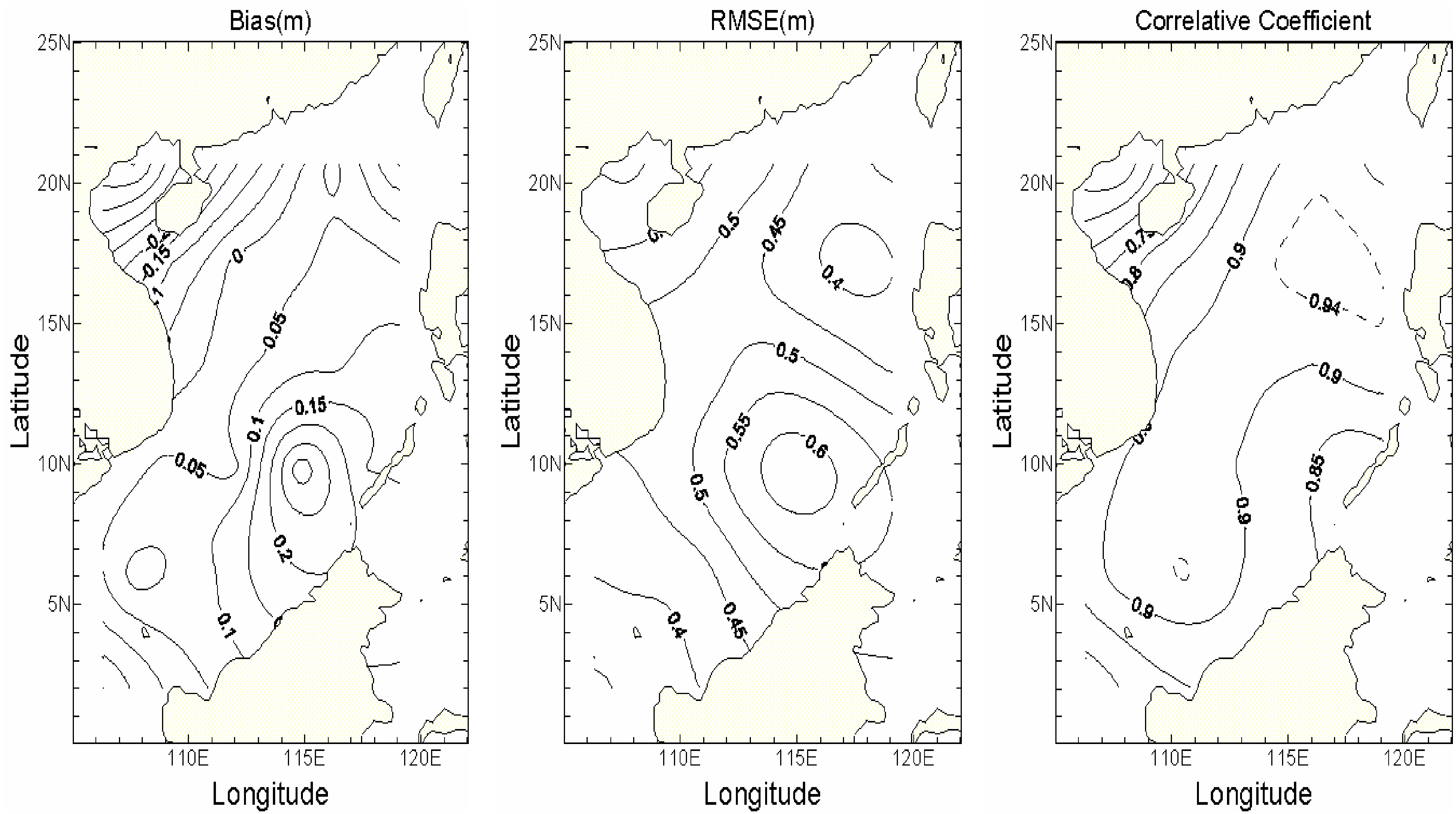
Verification at Crossover Points: BIAS, RMSE, Correlation Coefficient (cc)

$$\text{bias}(x,y) = \frac{1}{M}\sum_{i=1}^{M} \Delta H(x,y,t_i)$$

$$\text{rmse}(x,y) = \sqrt{\frac{1}{M}\sum_{i=1}^{M} \left[\Delta H(x,y,t_i)\right]^2}$$

$$\text{cc}(x,y) = \frac{\sum_{i=1}^{M}\left[(H_m(x,y,t_i) - \bar{H}_m(x,y)\right]\left[(H_o(x,y,t_i) - \bar{H}_o(x,y)\right]}{\sqrt{\sum_{i=1}^{M}\left[(H_m(x,y,t_i) - \bar{H}_m(x,y)\right]^2}\sqrt{\sum_{i=1}^{M}\left[(H_o(x,y,t_i) - \bar{H}_o(x,y)\right]^2}}$$

BIAS, RMSE, CC

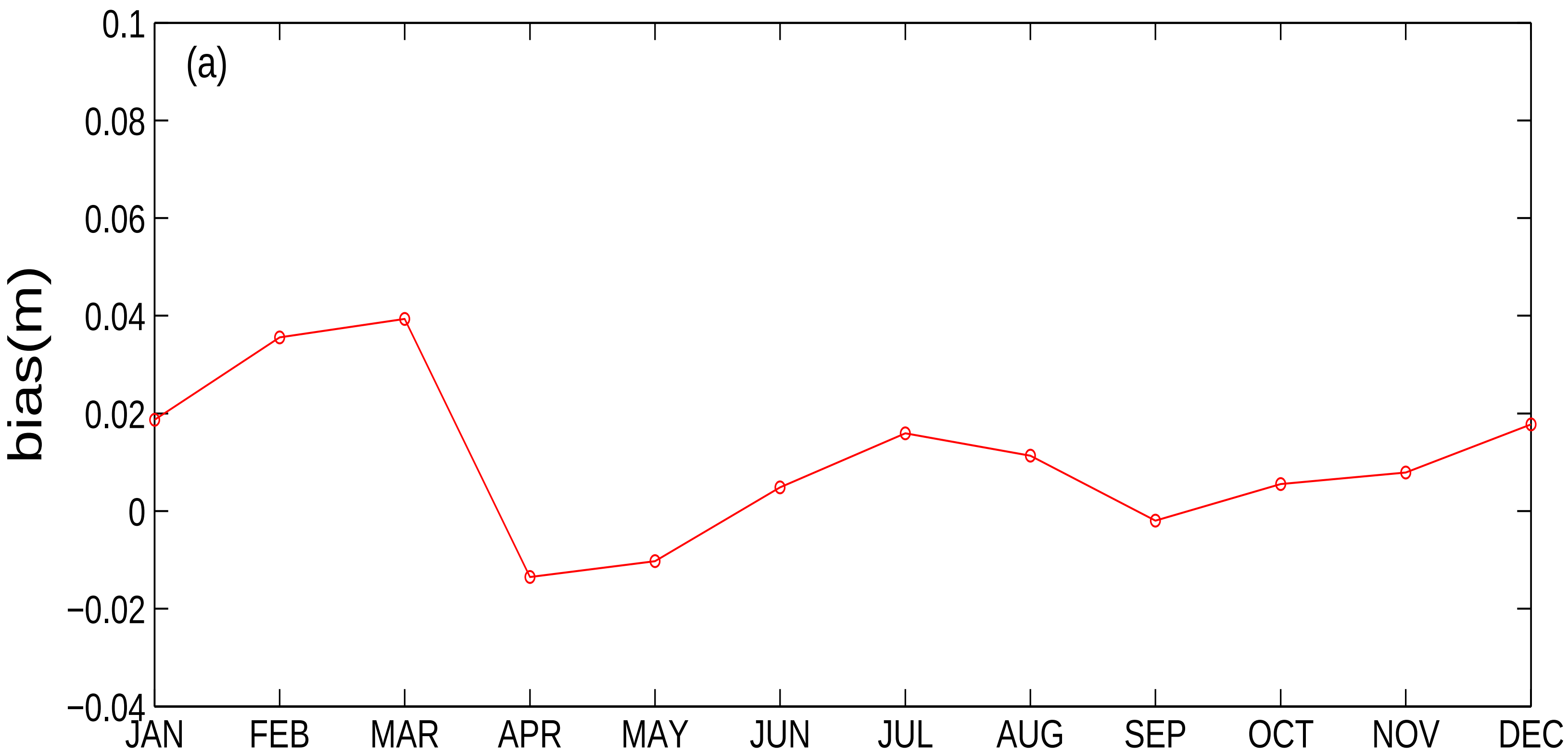

Bias(m)
RMSE(m)
Correlative Coefficient
25N
20N
15N
10N
5N
110E
115E
120E
Latitude
Longitude
0
0.05
0.1
0.15
0.2
0.4
0.45
0.5
0.55
0.6
0.8
0.85
0.9
0.94

Verification at Time Instance: BIAS, RMSE,

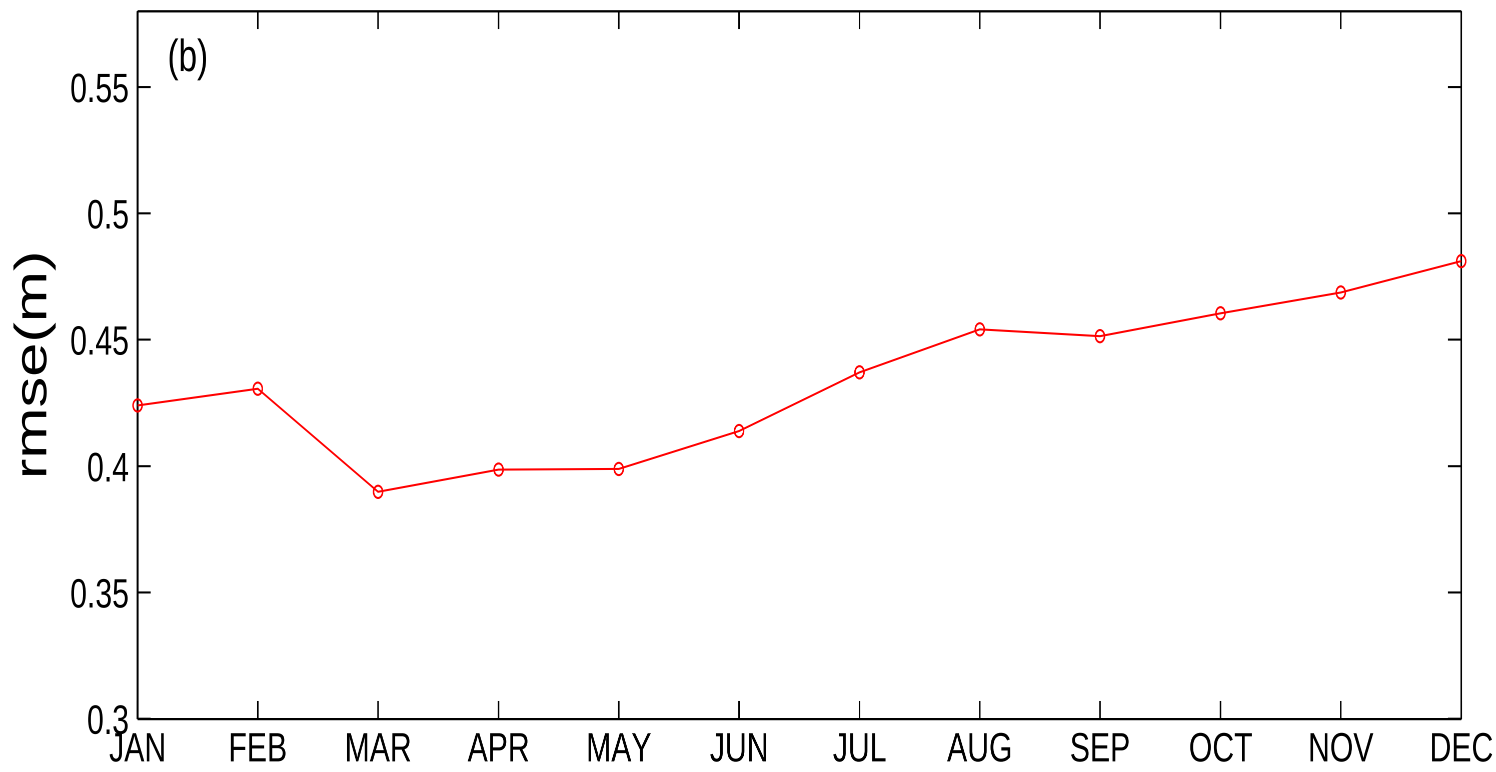
$$\text{bias}(t) = \frac{1}{N}\sum_{j,k} \Delta H(x_j, y_k, t)$$

$$\text{rmse}(t) = \sqrt{\frac{1}{N}\sum_{j,k} \left[\Delta H(x_j, y_k, t)\right]^2}$$

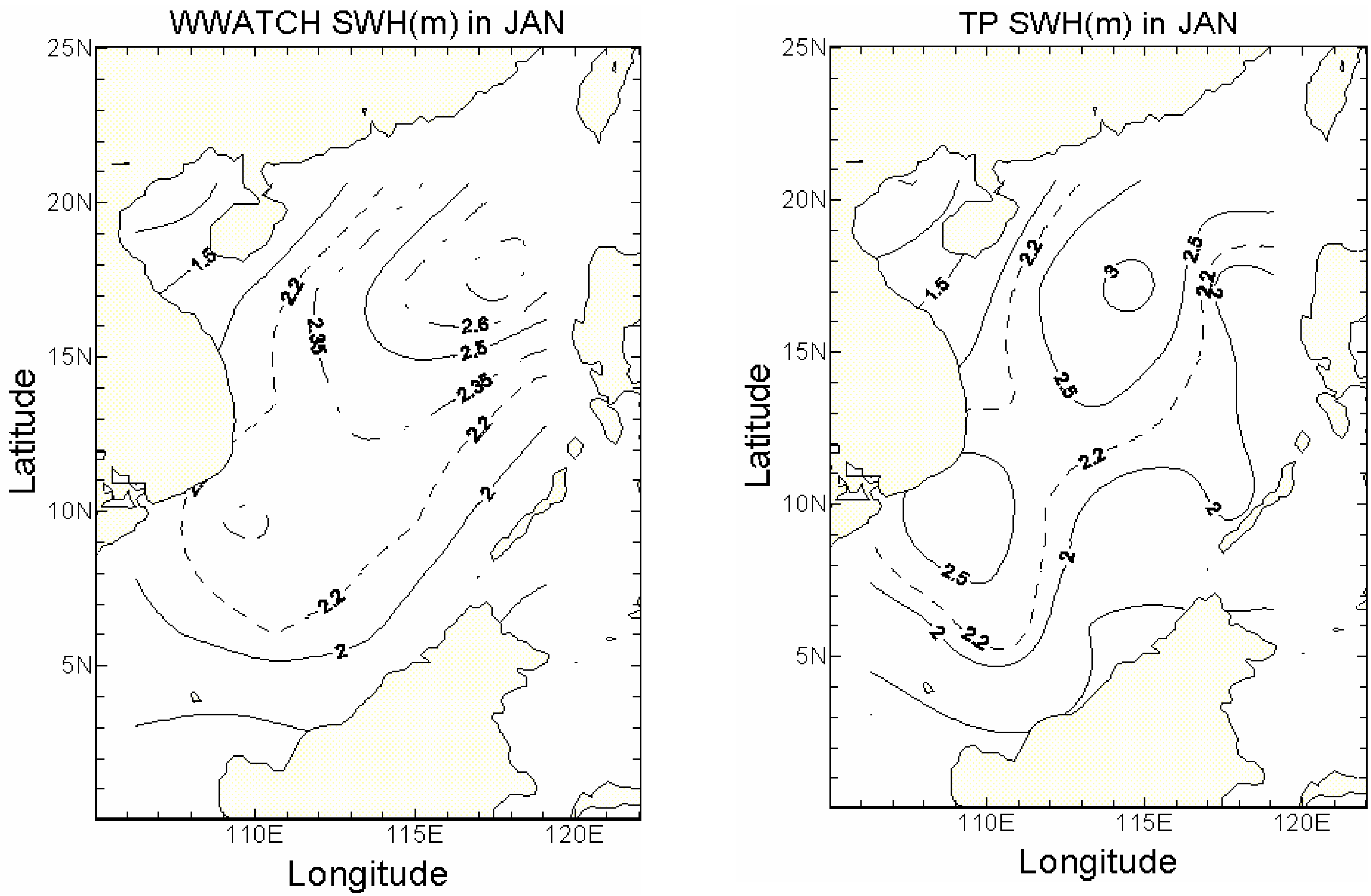
Temporal Evolution of BIAS



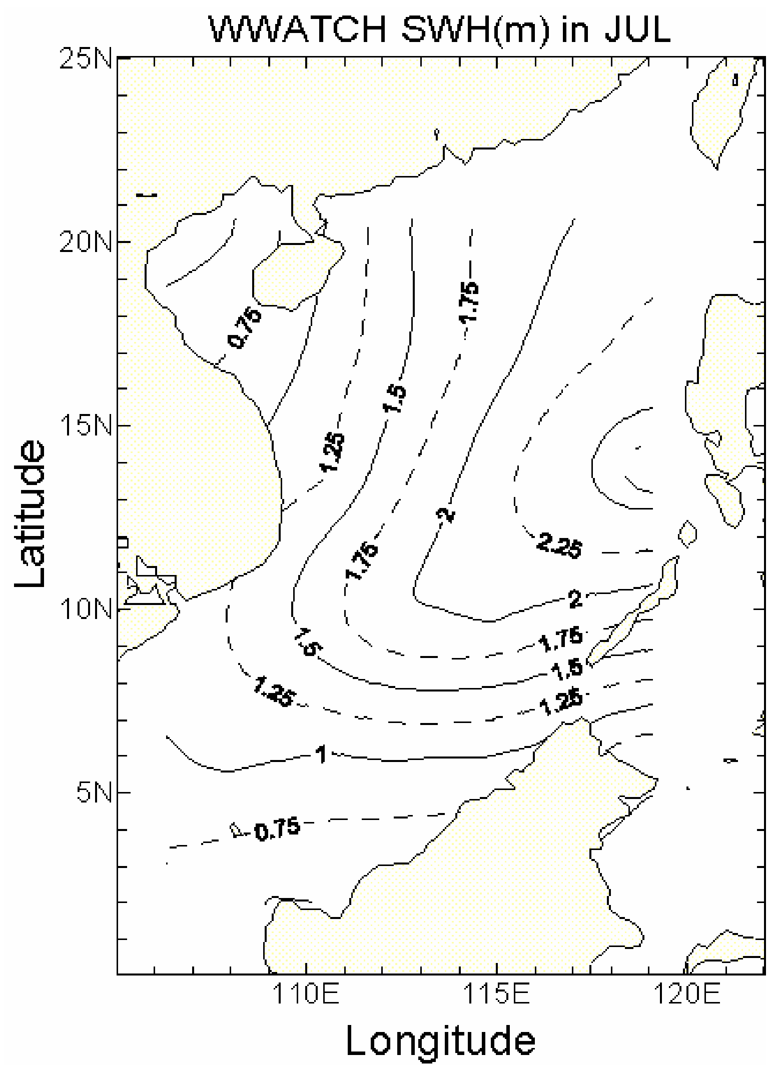
Temporal Evolution of RMSE

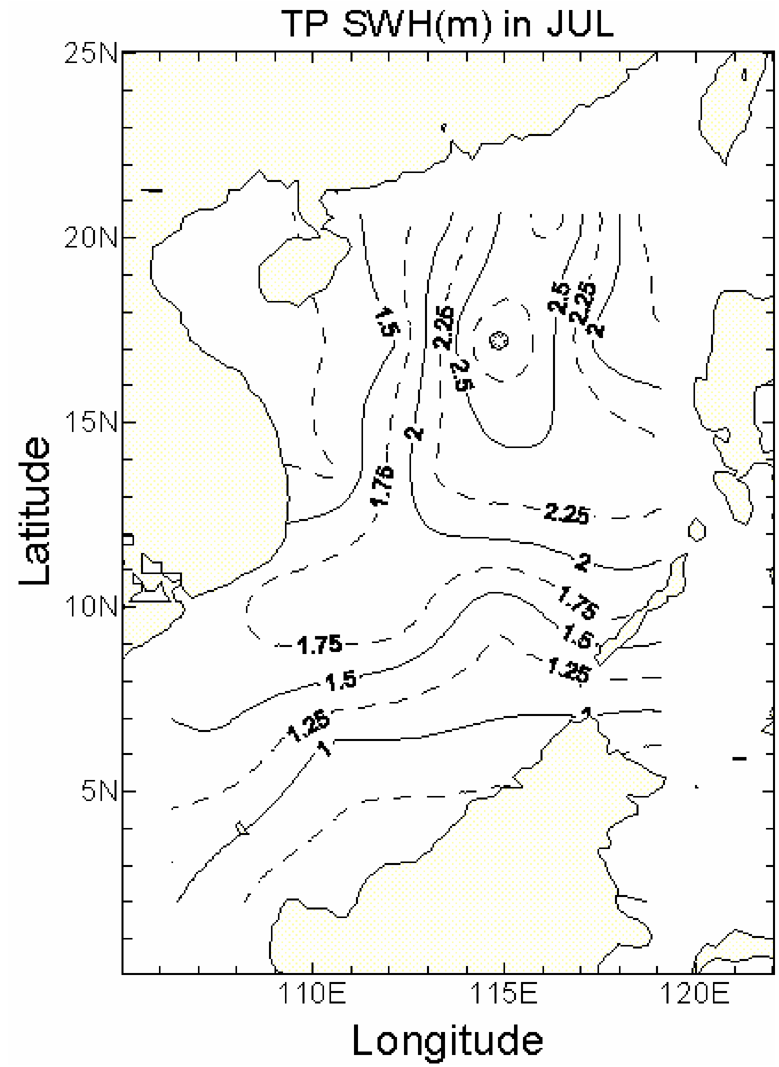


Monthly mean (Jan 2000) Significant Wave Height (SWH)



Monthly mean (July 2000) Significant Wave Height (SWH)





Conclusions

- (1) Wavewatch-III simulates the seasonal variability of SWH reasonably well comparing to the T/P SWH data.

- (2) The model errors for SWH hindcast have Gaussian-type distribution with mean values of 0.02 m and with slightly more sample number on the negative side (697) than on the positive side (633).

- (3) The root-mean-square error and correlation coefficient between modeled and observed significant wave heights are 0.48 m and 0.90.

- (4) Over the whole SCS, WWATCH has very low bias (-0.01 to 0.04 m). RMSE has a minimum value of 0.39 m in March and a maximum value of 0.48 m in December.