The effects of ocean data assimilation on prediction of North Pacific marine heatwave

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Motivation

Background:

(1) Marine heatwaves (MHWs) are prolonged, extremely warm water events over the upper ocean that can make substantially ecological and socioeconomic impacts. The 2013-2015 North Pacific marine heatwave was the strongest and most famous MHW, called *The Blob* in the scientific literature and media.

(2) Many studies focus on the physical drivers of MHWs, but there are relatively few studies on improving the prediction skill of MHWs.

(3) Ocean data assimilation improves the seasonal and interannual prediction skill of climate models.

Science question:

Whether ocean data assimilation can effectively increase the prediction skill of MHWs?

Data and methods

Table 1 Data used in this article

Data type	Period	References	Data usage
SST	1982.02-2018.12	NOAA (Reynolds et al, 2002)	Data assimilation and results analysis
SLA	1993.01-2018.12	ARMOR3D (Guinehut et al, 2012)	Data assimilation
In situ temperature and salinity profiles	1982.02-2018.12	Hadley (Gouretski et al, 2010)	Data assimilation
Reanalysis temperature profiles	1982.02-2018.12	Hadley (Gouretski et al, 2010)	Results analysis

We employ the deterministic ensemble Kalman filter (DEnKF) to assimilate SST, altimeter satellite gridded sea level anomalies, in situ temperature and salinity profiles into NUIST-CFS1.0 (i.e., previously SINTEX-F) that had used coupled SST-nudging initialization method. We assess the initial conditions and prediction skills with and without the ocean data assimilation over the Blob region (40°-50°N, 150°-135°W) at lead times of up to 24 months.

Conclusions

Ocean data assimilation improves the prediction skill of SSTA in the Blob region and significantly enhances the prediction skill of subsurface temperature in the region, which helps increase the prediction skill of MHWs.

Results

◆Differences in the analysis

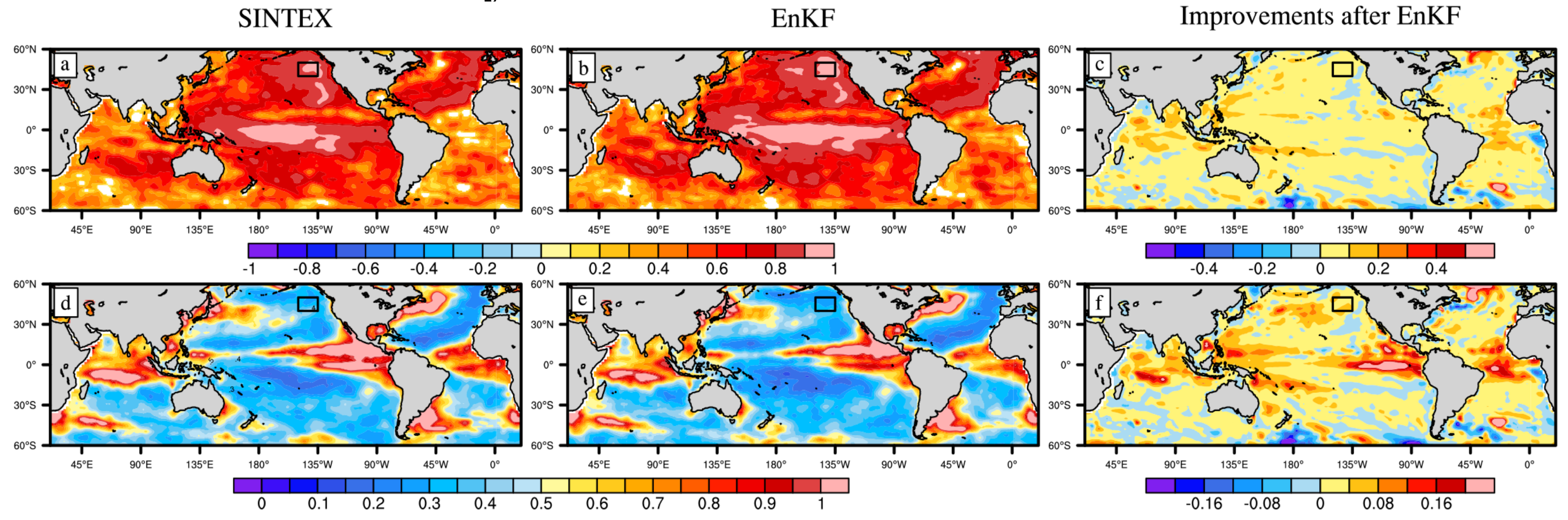

Fig. 1 Impacts of ocean data assimilation on global upper 100m temperature (T100) initial conditions: a, Anomaly correlation coefficient (ACC) for monthly T100 without ocean data assimilation during1985-2014. Colored shading indicates values of 99% significance. The black box in **a** denotes *the Blob* region (40°-50°N, 150°-135°W). **b**, As in **a**, but for the ACC with ocean data assimilation. **c**, The ACC improvement by ocean data assimilation. Warm (cold) colors represent improvements (degradations). **d-f**, As in **a-c**, but for the results based on root mean square error (RMSE, °C). The black box in a denotes region

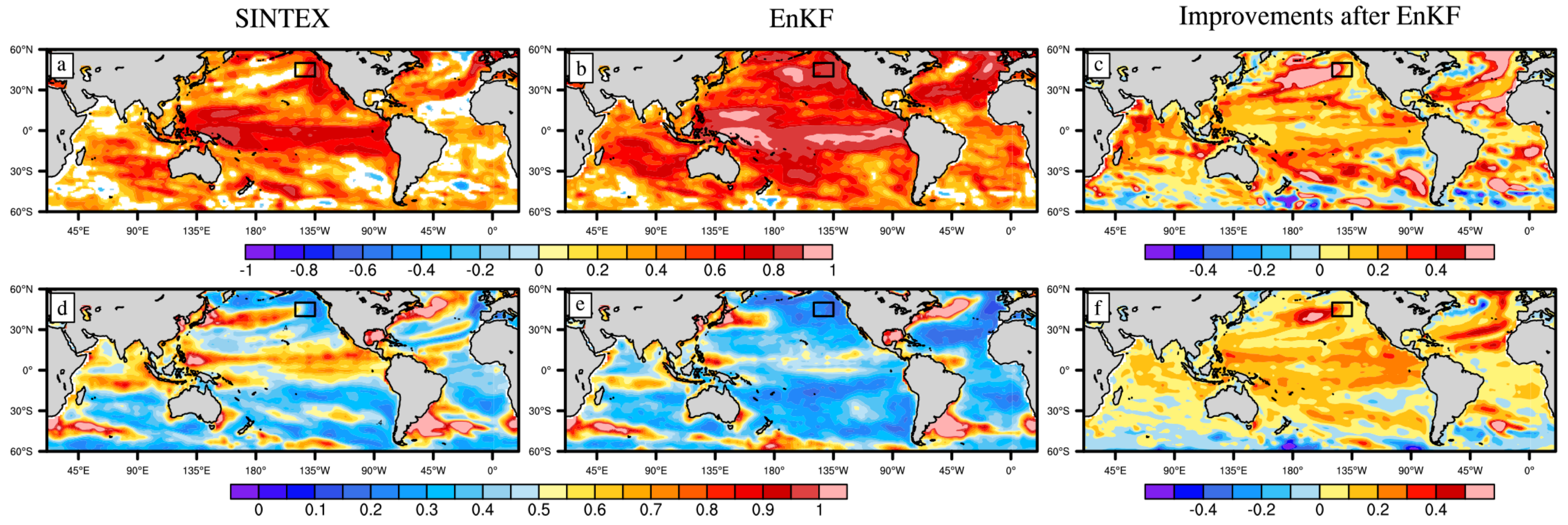

Fig. 2 As in Fig.1, but for the results of upper 300m temperature (T300)

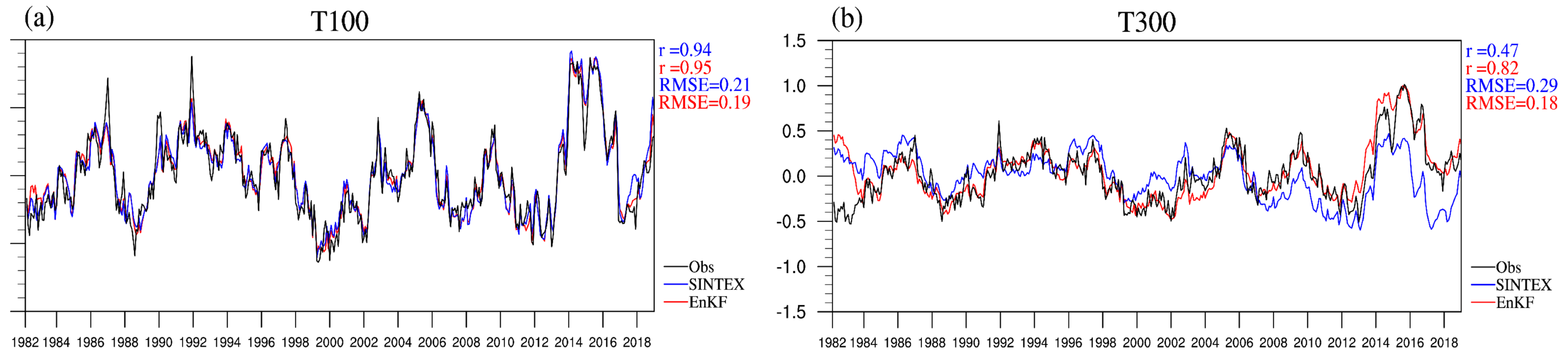

Fig. 3 Impacts of ocean data assimilation on the initial conditions of upper ocean temperature in the Blob region: a, The monthly T100 anomaly averaged over the Blob region (40°-50°N, 150°-135°W) over the period of 1985-2014. Black solid line denotes the observation, and the blue (red) solid line denotes the simulation without (with) ocean data assimilation. R and RMSE indicate the correlation coefficient and root mean square error, respectively. **b,** As in **a**, but for the T300 anomaly.

◆Differences in the prediction

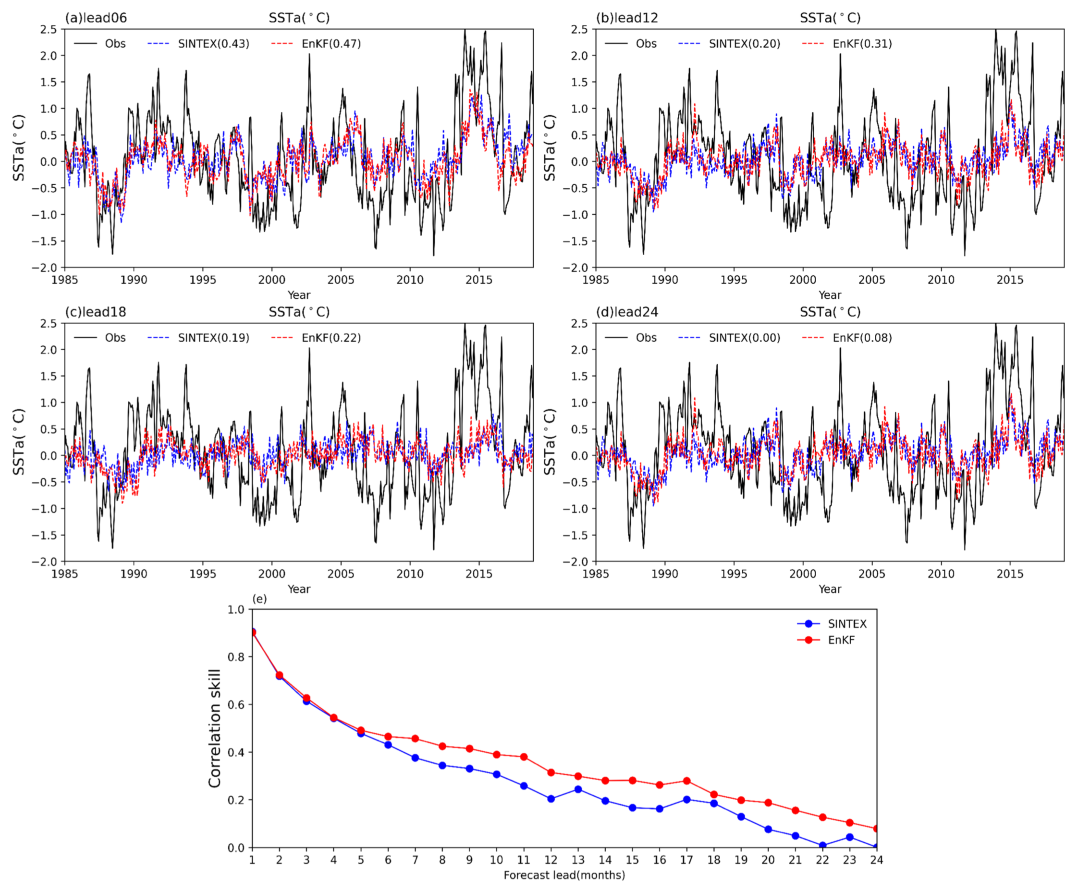

Fig. 4 Impacts of ocean data assimilation on the prediction skill of monthly SSTA averaged over the Blob region: Monthly SSTA anomaly averaged over the Blob region over the period of 1985-2014. Black solid line denotes the observation, and the blue (red) solid line denotes the predicted SSTA without (with) ocean data assimilation at (**a-d**) 6, 12, 18 and 24 months lead. **e**), Blue (red) solid lines denote the ACC skill in predicting the SSTA averaged over the Blob region as a function of the forecast lead month without (with) ocean data assimilation.

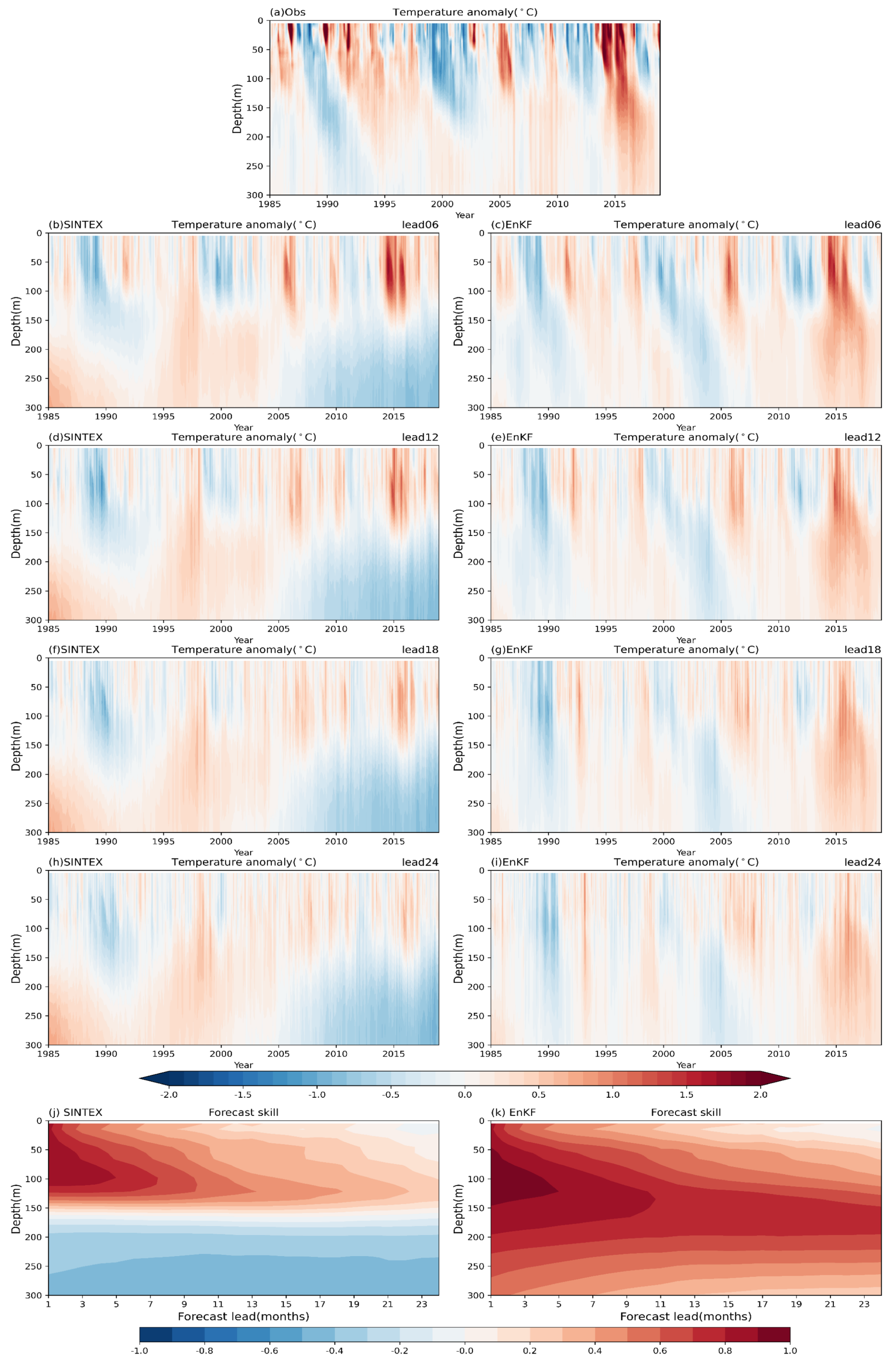

Fig. 5 Impacts of ocean data assimilation on the prediction skill of monthly upper ocean temperature anomaly in the Blob region: a, Observed monthly temperature anomaly from surface to 300m deep averaged over the Blob region over the period of 1985-2014. (Left column) Predicted upper ocean temperature anomalies without ocean data assimilation at (**b, d, f, h**) 6, 12,18, and 24 months lead. (**c, e, g, i**) As in left column, but for the predictions initialized from the conditions with ocean data assimilation. (**j, k**) ACC skill in predicting the monthly upper ocean temperature anomaly averaged over the Blob region as a function of the forecast lead month without and with ocean data assimilation.