Coupled assimilation of both atmospheric and oceanic observations for ENSO prediction using an intermediate coupled model

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Overview

THE initial surface and subsurface temperature fields are important for ENSO prediction due to the ocean's long memory. As a result, most ENSO predictions are initialized by ocean data assimilation.

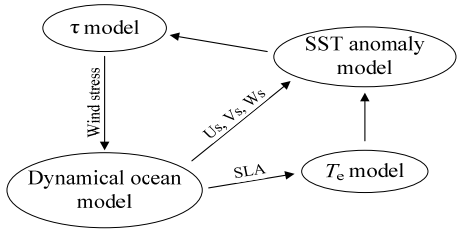
ANOTHER key for the development of an ENSO event is the wind anomalies in the western Pacific associated with air-sea coupled tropical convection systems. Therefore the assimilation of both atmospheric and oceanic observations should be taken into account for ENSO prediction.

HOWEVER one difficulty is that the atmosphere has relative short memory on its initial conditions. This can be even worse if one uses the intermediate coupled models (ICM) in which the atmospheric components are statistical and slavery to ocean components. In this case, the atmospheric models do not have any memory on its initial conditions and the adjustment of the atmospheric state made by assimilation cannot impact on model forecast.

IN this study we use the coupled covariance to assimilate both atmospheric and oceanic observations based on ensemble Kalman filter with an intermediate coupled model. The coupled covariance enables the assimilation of atmospheric observations to adjust the ocean states and can overcome the above mentioned difficulty technically.

Model structure and assimilation schemes

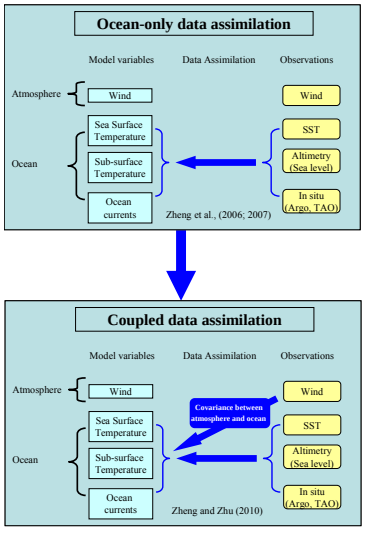
1. Model coupling schematic



The ICM consists of a dynamical ocean model, an SST anomaly model with an empirical parameterization for T_e in terms of SLA, and a statistical atmospheric wind stress (τ) model.

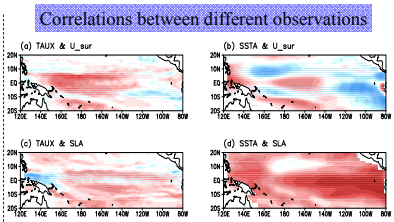
Adopted from Zhang et al., (2005).

2. Assimilation schemes

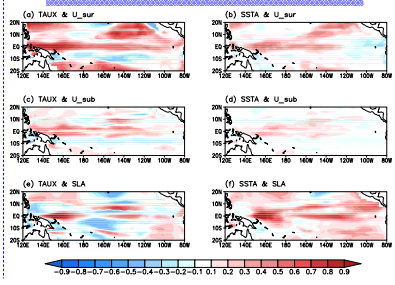


3. Physical support

Correlations between different observations



Correlations between ensemble members



- Surface winds over the tropical Pacific dominate the surface currents. The observed zonal wind stress anomalies more strongly correlate with the zonal surface current compared to the observed SST anomalies over the equatorial Pacific.
- Ensemble-forecasted members during the ensemble assimilation process can successfully capture this nature aspect. This is the motivation on developing the coupled data assimilation scheme.

Related References

1. Zhang, R.H., S.E. Zebiak, R. Kleeman, and N. Keenlyside, 2005: Retrospective El Niño forecast using an improved intermediate coupled model. *Mon. Wea. Rev.*, **133**, 2777–2802.
2. Zheng, F., J. Zhu, R.H., Zhang, and G.Q. Zhou, 2006: Ensemble hindcasts of SST anomalies in the tropical Pacific using an intermediate coupled model. *Geophys. Res. Lett.*, **33**, L19604, doi: 10.1029/2006GL026994.
3. Zheng, F., J. Zhu, R.H. Zhang, 2007: Impact of altimetry data on ENSO ensemble initializations and predictions. *Geophys. Res. Lett.*, **34**, L13611, doi: 10.1029/2007GL030451.
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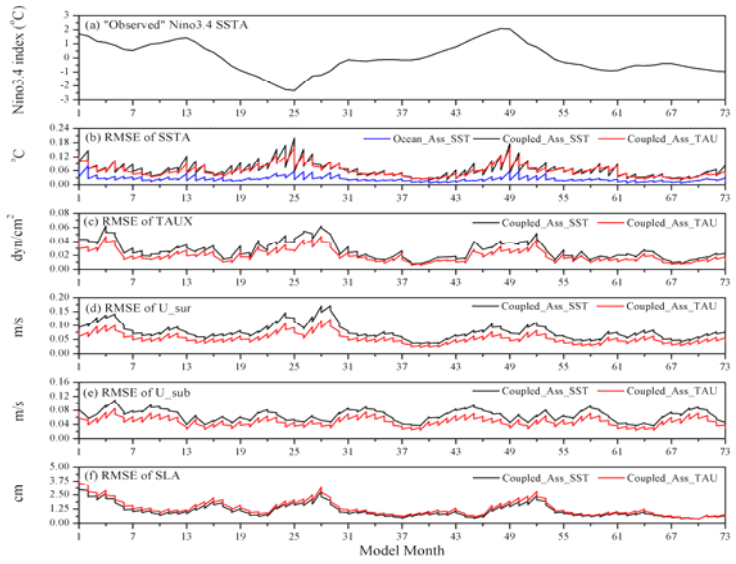
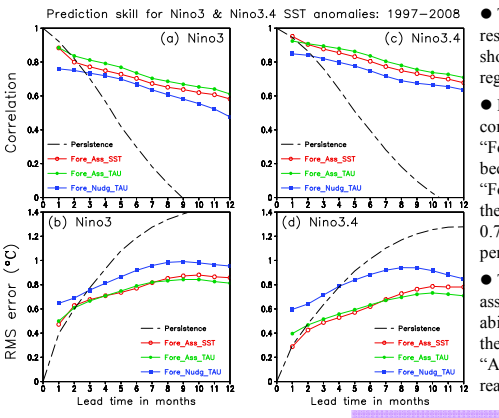
Idealized assimilation experiments: Understanding



- The RMS errors of the SSTA in the "Ocean_Ass_SST" experiment are smallest in the three experiments, and those in the "Coupled_Ass_TAU" experiment are smaller than those in the "Coupled_Ass_SST" experiment.
- The better performance of the "Coupled_Ass_TAU" experiment at reducing the errors of the SSTA can be explained by the better assimilation results of the zonal wind stress during the assimilation process. At the same time, better analyzed/corrected zonal currents at both the surface and subsurface layers obtained in the "Coupled_Ass_TAU" experiment can also improve the accuracy of the prediction of the SSTA.
- Besides of surface and subsurface thermal states, the accuracy of the currents in upper oceans are also important issues on initializing a better forecast through affecting the advection terms of SST.

Real retrospective forecast experiments



- The two ensemble-mean hindcast results have particularly good skills at short lead times over the Niño3.4 region.
- Beyond the 3-month lead time, the correlation coefficient of the "Fore_Ass_TAU" ensemble mean becomes 0.05 higher than that of the "Fore_Ass_SST" ensemble mean, and the correlation coefficient is still above 0.78 over the 12-month prediction period.
- The coupled "Ass_TAU" assimilation scheme has more effective ability of controlling and depressing the error growth than the ocean-only "Ass_SST" assimilation scheme in realistic forecast.

2007/08 La Nina case

Assimilation | Prediction