

Couple Data Assimilation and ENSO Prediction

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El Niño-Southern Oscillation (ENSO), the most dominant climate variation of the couple ocean-atmospheric system on seasonal to interannual time scales, has world-wide economical and societal impacts. The current El Niño has caused over 10 billion (US) dollars in damages and many fatalities world wide. The damages would have been heavier were there not a timely advisory of the event. Improved prediction of ENSO, together with proper precaution procedure, could greatly alleviate the unfavorable impacts. With the global coverage, satellite data such as those from the TOPEX/Poseidon altimeter provide indispensable information for monitoring ENSO events. Assimilation of these data into dynamical model has advanced the predictive skill.

Conventionally, forecasts are initialized from an ocean state obtained by assimilating data into the ocean model alone. This could produce a "shock" to the couple model and thus limits the predictive skill. Here we made a first attempt to obtain an initial state that is consistent with couple model dynamics by assimilating coincident satellite and in-situ data in a couple context. Such an initial state, being a solution of the couple model rather than that of the ocean model alone, leads to dramatic improvement in forecasts.

An optimization system is developed to assimilate multi-channel data into an intermediate couple model of the Tropical Pacific using the adjoint method. The couple model consists of an ocean model modified from the Cane-Zebiak model and a statistical atmosphere. The adjoint of the couple model is generated largely through the Tangent Linear and Adjoint Model Compiler. The data assimilated include sea surface height anomalies (SSHA) derived from XBT and TOPEX data (before and after October 1992, respectively), sea surface temperature anomalies (SSTA) from the NOAA Climate Analysis Center, and FSU pseudo wind stress anomalies. The couple model is fitted to these data within various six-month intervals by optimally adjusting the initial SSTA, SSHA, zonal current, model parameters, and singular vectors of the statistical atmosphere.

Significant improvement is found in hindcasts/forecasts initialized from the end of couple assimilations. Starting from April 1997, in particular, the system successfully predicted the rapid warming, the peak amplitude and phase, and the initial decay of El Niño 97/98 through the spring of 1998. Similar improvement is also found in forecasting the 82/83 and 86/87 events. The attempt thus demonstrates the importance of couple data assimilation in forecasting ENSO events.

The system is also being used to assess impacts of various data to forecasts, to examine processes responsible for developments and decays of various ENSO events, and to evaluate the sensitivity of forecasts to the background seasonal cycle and various parameterizations.

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