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Simulations of two types of El Niño events by an optimal forcing vector approach

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In this paper, an optimal forcing vector (OFV) approach is proposed. The OFV offsets tendency errors and optimizes the agreement of the model simulation with observation. We apply the OFV approach to the well-known Zebiak-Cane model and simulate several observed eastern Pacific (EP) El Niño and central Pacific (CP) El Niño events during 1980-2004.

It is found that the Zebiak-Cane model with a proper initial condition often reproduces the EP-El Niño events; however, the Zebiak-Cane model fails to reproduce the CP-El Niño events. The model may be much more influenced by model errors when simulating the CP-El Nino events. As expected, when we use the OFV to correct the Zebiak-Cane model, the model reproduces the three CP-El Niño events well. Furthermore, the simulations of the corresponding winds and thermocline depths are also acceptable. In particular, the thermocline depth simulations for the three CP-El Niño events lead us to believe that the discharge process of the equatorial heat content associated with the CP-El Niño is not efficient and emphasizes the role of the zonal advection in the development of the CP-El Nino events. The OFVs associated with the three CP-El Niño events often exhibit a sea surface temperature anomaly (SSTA) tendency with positive anomalies in the equatorial eastern Pacific; therefore, the SST tendency errors occurring in the equatorial eastern Pacific may dominate the uncertainties of the Zebiak-Cane model while simulating CP-El Nino events. A further investigation demonstrates that one of the model errors offset by the OFVs is of a pattern similar to the SST cold-tongue cooling mode, which may then provide one of the climatological conditions for the frequent occurrence of CP-El Nino events. The OFV may therefore be a useful tool for correcting forecast models and then for helping improve the forecast skill of the models.