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Does model parameter error cause a significant "spring predictability barrier" for El Nino events in the Zebiak-Cane model?

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Within the framework of the Zebiak–Cane model, we used the approach of conditional nonlinear optimal perturbation (CNOP) to study the effect of model parameter errors on El Niño–Southern Oscillation (ENSO) predictability. We obtained the optimal model parameter errors within a reasonable error bound (i.e. CNOP-P errors), which have the largest effect on the results of El Niño predictions. The resultant prediction errors were investigated in depth. The CNOP-P errors do not cause a noticeable prediction error of Niño-3 SSTA (the sea surface temperature anomaly averaged over the Niño-3 region) and do not show an obvious season-dependent evolution of the prediction errors. Consequently, the CNOP-P errors do not cause a significant spring predictability barrier (SPB) for El Niño events. In contrast, the initial errors that have the largest effect on the results of the predictions (i.e. the CNOP-I errors) show a season-dependent evolution, with the largest error increase in spring, and also cause a large prediction error, thereby generating a significant SPB. The initial errors play a more important role than the parameter errors in generating a significant SPB for El Niño events. To further validate this result, we investigated the situation in which CNOP-I and CNOP-P errors are simultaneously superimposed in the model, which may be a more credible approach because the initial errors and model parameter errors coexist under realistic predictions. The combined mode of CNOP-I and CNOP-P errors shows a similar season-dependent evolution to that of CNOP-I errors and yields a large prediction error, thereby inducing a significant SPB. The inference, therefore, is that initial errors play a more important role than model parameter errors in generating a significant SPB for El Niño predictions of the Zebiak–Cane model. This result helps to clarify the roles of the initial error and parameter error in the development of an SPB, and highlights the role of initial errors, which demonstrates that the SPB could be markedly reduced by improving the initial conditions. The results provide a theoretical basis for improving data assimilation in ENSO predictions.