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Does model parameter error in the Zebiak-Cane model cause a significant spring predictability barrier in its El Niño prediction?

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Within the frame of the Zebiak-Cane model, we used the approach of conditional nonlinear optimal perturbation (CNOP) to study the effect of model parameter errors on 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. And their resultant prediction errors were investigated in depth. It is demonstrated that the CNOP-P errors neither cause a noticable prediction error of the Niño-3 sea surface temperature anomaly (SSTA) nor present an obvious season-dependent evolution of the prediction errors. Then the CNOP-P errors could not cause a significant SPB for El Nino events. In contrast, the initial errors that have the largest effect on the results of the predictions, referred to as the CNOP-I errors, tend to have an obvious season-dependent evolution with the largest error growth rate in spring, and also cause a large prediction error, thus yielding a significant SPB. The initial errors, compared to the parameter errors, may play a much more important role in yield a significant SPB for El Nino events. To further validate this result, we investigated the situation that the CNOP-I and CNOP-P errors are simultaneously superimposed in the model, which may be a much plausible case because initial errors and model parameter errors simultaneously exist in realistic predictions. The results illustrated that the combined mode of CNOP-I and CNOP-P errors tend to have almost the same significant season-dependent evolution similar as that of CNOP-I errors, and also yield a large prediction error, consequently inducing a significant SPB. The inference, therefore, is that initial errors, rather than model parameter errors, may be the dominant source of uncertainties that cause a significant SPB for El Niño predictions of the Zebiak-Cane model. Our results help in clarifying the role of the initial error in SPB, which may provide a clue for explaining why SPB can be reduced largely by improving initial conditions. The results also illustrate a theoretical basis for improving data assimilation in ENSO prediction.