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Characteristic of initial errors that cause a significant spring predictability barrier for El Nino events

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In this paper, the characteristic of the initial errors that cause a significant "spring predictability barrier" (SPB) for El Nino events is described by discussing three previous works associated with applications of the conditional nonlinear optimal perturbation (CNOP) in an ENSO predictability study. The CNOP is superimposed onto the El Niño events and acts as the initial error with the biggest affect on the uncertainties of the predictions. The evolution of the CNOP-type errors has an obvious seasonal dependence and yields a significant SPB for the El Nino events. Its linear counterpart, the linear singular vector (LSV)-type errors, has a much more localized region in comparison to the CNOP-type errors and causes a smaller prediction error that yields a less significant SPB. Other initial errors, whenever the predictions start, either cause a weak SPB or do not yield a SPB for the El Niño events. The occurrence of a significant SPB may be closely related to particular initial error patterns. In the Zebiak-Cane model, the CNOP-type errors were classified into two types: one possessing an SSTA pattern with negative anomalies in the equatorial central-western Pacific, positive anomalies in the equatorial eastern Pacific, and a thermocline depth anomaly pattern with positive anomalies along the equator; and another with patterns almost opposite to those of the former type. These two kinds of CNOP-type errors are most likely to cause a significant SPB. In the hindcasts of the predetermined model El Nino events, two kinds of initial errors were also found. The two patterns of initial errors have opposite signs and, consequently, opposite growth behaviors, which may demonstrate two dynamical mechanisms of error growth that are related to SPB: in one case, the errors grow in a manner similar to El Niño, while in the other, the errors develop with a tendency that is opposite to El Niño. These two types of initial errors have localized regions and may be most likely to provide the information regarding the "sensitive area" of the ENSO predictions. If these types of initial errors exist in the realistic ENSO predictions and if a target method or a data assimilation approach can filter them, the ENSO forecast's skill may be improved.