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The initial errors that induce a significant "spring predictability barrier" for El Niño events and their implications for target observation: results from an earth system model

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The National Center for Atmospheric Research (NCAR) Community Earth System Model (CESM) is used to study the "spring predictability barrier" (SPB) problem for El Niño events from the perspective of initial error growth. By conducting perfect model predictability experiments, we obtain two types of initial sea temperature errors, which often exhibit obvious season-dependent evolution and cause a significant SPB when predicting the onset of El Niño events bestriding spring. One type of initial errors possesses a sea surface temperature anomaly (SSTA) pattern with negative anomalies in the central-eastern equatorial Paci[U+FB01]c, plus a basin-wide dipolar subsurface temperature anomaly pattern with negative anomalies in the upper layers of the eastern equatorial Pacific and positive anomalies in the lower layers of the western equatorial Pacific. The other type consists of an SSTA component with positive anomalies over the southeastern equatorial Pacific, plus a large-scale zonal dipole pattern of the subsurface temperature anomaly with positive anomalies in the upper layers of the eastern equatorial Pacific and negative anomalies in the lower layers of the central-western equatorial Pacific. Both exhibit a La Niña-like evolving mode and cause an under-prediction for Niño-3 SSTA of El Niño events. For the former initial error type, the resultant prediction errors grow in a manner similar to the behavior of the growth phase of La Niña; while for the latter initial error type, they experience a process that is similar to El Niño decay and transition to a La Niña growth phase. Both two types of initial errors cause negative prediction errors of Niño-3 SSTA for El Niño events. The prediction errors for Niño-3 SSTA are mainly due to the contribution of initial sea temperature errors in the large-error-related regions in the upper layers of the eastern tropical Pacific and/or in the lower layers of the western tropical Pacific. These regions may represent "sensitive areas" for El Niño – Southern Oscillation (ENSO) predictions, thereby providing information for target observations to improve the forecasting skill of ENSO.