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Contrasting the initial errors most likely to cause a spring predictability barrier for the tropical Pacific sea surface temperature anomalies associated with two types of El Niño events

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In this paper, the spring predictability barrier (SPB) problem for two types of El Niño events is investigated from the perspective of initial error evolution. This is enabled by tracing the evolution of a conditional nonlinear optimal perturbation (CNOP), superimposed on an observing system simulation of two types of El Niño events that act as the initial error with the biggest negative effect on the El Niño predictions. We show that the evolution of CNOP-type errors for CP-El Niño events can be classified into two types: the first are CP-type-1 errors possessing a sea surface temperature anomaly (SSTA) pattern with negative anomalies in the equatorial central western Pacific, positive anomalies in the equatorial eastern Pacific, and accompanied by a thermocline depth anomaly pattern with positive anomalies along the equator. The second are, CP-type-2 errors presenting an SSTA pattern in the central eastern equatorial Pacific, with a seesaw structure of negative anomalies in the east and positive anomalies in the west, and a thermocline depth anomaly pattern with a slight deepening along the equator. CP-type-1 errors grow in a manner similar to an EP-El Niño event and grow significantly during boreal spring, leading to a significant SPB for the tropical SSTA associated with the CP-El Niño. CP-type-2 errors initially present as a process similar to a La Niña-like decay, prior to transitioning into a growth phase of an EP-El Niño-like event. They do not present an evident season-dependent evolution and fail to cause a SPB. For the EP-El Niño events, their CNOP-type errors are also classified into two types: EP-type-1 errors and 2 errors. The former is similar to a CP-type-1 error, while the latter present with an almost opposite pattern. Both EP-type-1 and 2 errors exhibit obvious season-dependent evolution and yield a significant SPB for the tropical SSTA associated with EP-El Niño events. For both CP-El Niño and EP-El Niño, the CNOP-type errors that cause a prominent SPB are concentrated in the central and eastern tropical Pacific. This may indicate that the prediction uncertainties of both types of El Niño events are sensitive to the initial errors in this region. It is implied that the errors in this region mainly influence the amplitude of EP-El Niño events and the spatial structure of CP-El Niño events. This region may represent a sensitive area for the targeted observation of the two types of El Niño events.