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Excitation of SST anomalies in the eastern equatorial Pacific by oceanic optimal perturbations

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A generalized stability analysis is used to explore the excitation of sea surface temperature anomalies in the eastern equatorial Pacific by optimal initial perturbations in temperature and salinity within an ocean general circulation model. We find perturbations that can efficiently modify the SST of the Nino3 region with an approximately 9-month delay. The time interval between the end of March and mid-April is particularly favorable for these perturbations to cause subsequent changes in the eastern equatorial Pacific. This sensitivity is related to two critical factors: during the boreal spring Equinox the heat content of the western equatorial Pacific reaches its seasonal maximum, whereas the zonal winds along the equator relax.

The optimal initial anomalies in temperature and salinity have a complex spatial structure extending between 20°S and 20°N. This large meridional extent of the anomalies allows for a strong focusing effect - signals from different locations reach the eastern equatorial Pacific simultaneously thus generating a strong transient warming in a relatively small region. Ocean adjustment to the optimal perturbations involves a basin-size Rossby wave that propagates westward and induces a large-scale anomalous eastward advection along the equator, which acts on the mean east-west temperature gradient and gradually warms SST in the east. At the same time, a continuum of Kelvin waves are being excited, which reduce the thermocline slope along the equator and deepen the thermocline in the eastern equatorial Pacific. Thus, the Rossby wave and Kelvin waves work constructively to generate the transient warming of the Nino3 SST. An idealized model with two variables is formulated to illustrate these ideas and, in particular, show the importance of zonal advection feedback for the amplitude and duration of the transient warming. Ultimately, this study highlights the importance of non-normal dynamics for generating an efficient transient growth of SST anomalies in the tropical Pacific even in the absence of coupled ocean-atmosphere interactions.