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Searching for Optimal Precursors of ENSO by Using Conditional Nonlinear Optimal Perturbation of a Coupled Ocean-Atmosphere Model

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With a coupled ocean-atmosphere ENSO model of Zebiak and Cane (1987), the problem of optimal precursors for ENSO is explored by using conditional nonlinear optimal perturbation (CNOP). For the different optimization time intervals, we compute the CNOPs of a predetermined annual cycle for the coupled system. It is shown that there exist not only CNOPs of the annual cycle, but also local CNOPs. These CNOPs and local CNOPs have respectively the robust patterns qualitatively, which are quite different from those of linear singular vector (LSV) quantitatively. Extensive numerical experiments demonstrate that the nonlinear evolutions of CNOPs (local CNOPs) are significantly larger than those of the corresponding LSVs for the same amplitudes of initial perturbations. Physically we find that these CNOPs (local CNOPs) with proper magnitude of norm have the potential for evolving to El Nino (La Nina) events for the constraint condition. Further compared with LSV, CNOPs (local CNOPs) also tend to be the optimal patterns for El Nino (La Nina) events. These facts therefore inspire us to regard CNOPs (local CNOPs) of annual cycle as the optimal precursors for El Nino (La Nina). Further studies demonstrate that the amplitudes of these model El Nino (La Nina) events induced by CNOPs (local CNOPs) are highly sensitive to the optimization time intervals. All these above results support the view of Mu et al. (2003) and Duan et al. (2004) and verify the results derived from theoretical model of Wang and Fang (1996).

Keywords: ENSO model; nonlinear; optimal perturbations;

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