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Applications of conditional nonlinear optimal perturbation to the studies of climate predictability and sensitivity analysis

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Conditional nonlinear optimal perturbation (CNOP) is the initial perturbation whose nonlinear evolution attains the maximum value of the cost function , which is constructed according to the problems of interests with physical constraint conditions. CNOP can represent the optimal precursor of certain weather or climate event, or stand for the initial error which has largest effect on the uncertainties at the prediction time. In sensitivity and stability analysis of fluid motions, CNOP also describes the most unstable (or most sensitive) mode. This talk will give a brief review on the applications of CNOP to the following problems:

1. the optimal precursor for El Nino-Southern Oscillation (ENSO) events, the "spring predictability barrier" for ENSO, and the decadal variability of ENSO asymmetry,
2. the sensitivity of ocean's thermohaline circulation (THC) to the finite amplitude of initial perturbations and the passive mechanism of the decadal variability of THC,
3. the nonlinear instability and sensitivity of a theoretical grassland ecosystem to the finite-amplitude perturbations.

The results obtained by CNOP are compared to those derived by linear singular vector (LSV). It is shown that CNOP can reveal the effect of nonlinearity on climate predictability and sensitivity. Furthermore, CNOPs also demonstrate significant physical

characteristics that cannot be shown by LSV approach. All these results suggest that CNOP is one of useful tools in the studies of climate predictability and sensitivity analysis. The problem of reducing the computational cost of CNOP is also discussed.