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The dynamics of eddy-driven North Atlantic Oscillation explored by using conditional nonlinear optimal perturbation

Z.N. Jiang (1), M. Mu (2), and D.H. Luo (3)

(1) State Key Laboratory of Severe Weather (LaSW), Chinese Academy of Meteorological Sciences, Beijing ,China (jzn@cams.cma.gov.cn), (2) Key Laboratory of Ocean Circulation and Wave, Institute of Oceanology, Chinese Academy of Sciences, Qingdao (mumu@qdio.ac.cn), (3) RCE-TEA and LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing,China(ldh@mail.iap.ac.cn)

In this paper, conditional nonlinear optimal perturbation (CNOP) method is used to acquire the initial perturbations which could develop into the North Atlantic Oscillation (NAO) anomaly pattern with a triangular T21, three-level, quasi-geostrophic global spectral model from the synoptic view. With a three-dimensional winter climatological flow as the basic state, two kinds of initial perturbations corresponding to developing into the positive and negative phases of NAO anomaly are found respectively, both of which are wave trains upstream of the climatological Atlantic jet.

Analysis reveals that in the evolution of perturbations, the role played by the nonlinear process in the onset of the negative NAO phase is stronger than that in the onset of the positive NAO phase. The perturbation/basic state interaction and perturbation self-interaction both determine whether the negative phase of NAO happens, whereas the nonlinearity term in the positive NAO onset only appears to modulate the structure of perturbation to have a dipole mode over the north Atlantic at the optimization time, and meanwhile cause this dipole mode to become zonally extended. That is to say, the nonlinear processes play an inevitable role during the onset of NAO.

In addition, a low-over-high zonal wind anomaly exists in the midlatitude for the negative-phase NAO. Whereas, a high-over-low zonal wind anomaly exists in the midlatitude for the positive-phase NAO. This is also consistent with the analysis of observational data. All the above calculations reveal that CNOP method is a useful tool to explore the onset of NAO teleconnection pattern.