Geophysical Research Abstracts, Vol. 9, 07466, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-07466

3-D normal mode analysis of the northern stratospheric polar vortex

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The variability of the stratospheric polar vortex is related with the energy variability of the forcing planetary waves. The analysis relays on a 3-Dimensional normal mode expansion of the atmospheric general circulation that allows partitioning the Total (i.e. Kinetic + Available Potential) atmospheric energy into the energy associated with Rossby and inertio-gravity modes with barotropic and baroclinic vertical structures. The use of the 3-Dimensional normal mode expansion also allows the study of the effects of both zonal and meridional scales.

This analysis scheme was applied to the NCEP/NCAR reanalysis. Our approach mainly departs from traditional ones in what respects to the wave forcing, which is here assessed in terms of Total energy amounts associated with the waves instead of heat and momentum fluxes.

Positive (negative) anomalies of the energy associated with the first two baroclinic modes of the planetary Rossby wave with zonal wavenumber 1 are followed by downward progression of negative (positive) anomalies of the vortex strength. A signature of the vortex vacillation is also well apparent in the lagged correlation curves between the wave energy and the vortex strength. The analysis of the correlations between individual Rossby modes and the vortex strength further contributed to confirm the result from linear theory that the waves which force the vortex are those associated with the largest zonal and meridional scales.

Separated analysis was made on stratospheric sudden warming (SSW) events of the displacement and split types. Two composite analyses of SSW events of the displacement and split types have revealed different dynamics. SSWs of displacement type are forced by positive anomalies of the energy associated with the first two baroclinic modes of planetary Rossby waves with zonal wavenumber 1; SSWs of the split type are in turn forced by positive anomalies of the energy associated with the planetary Rossby wave with zonal wavenumber 2, and the barotropic mode appears as the most important component. In what respects to stratospheric final warming (SFW) events, obtained results suggest that the wave dynamics is similar to the one in SSW events of the displacement type.

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Liberato, M. L. R., J. M. Castanheira, L. da la Torre, C. C. DaCamara and L. Gimeno, 2007: Wave energy associated with the variability of the stratospheric polar vortex. J. Atmospheric Sciences, in press.