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QBO Modulation of Transient Planetary Waves during Northern Winter

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It has been suggested that the stratospheric Quasi-Biennial Oscillation (QBO) may influence the Northern Hemispheric (NH) winter stratospheric vortex via a modulation of planetary wave propagation. However, previous studies on the QBO modulation of quasi-stationary planetary waves have given inconclusive results.
In this study, a space-time spectral analysis is applied to geopotential height data from the ERA-40 and ERA-Interim reanalyses for the period of 1958-2009 in order to provide some new insights on the QBO modulation of transient planetary waves. In the stratosphere and during the extended NH winter (Oct-Mar), the waves of zonal wavenumbers 1-3 with periods of 22.5-30 days and 45-60-days are found to be significantly stronger at the latitude range of 35-65 [U+F0B0] N when the QBO at 50hPa is in its westerly phase than when it is in its easterly phase. In the troposphere, significant QBO modulation is only detected in planetary waves at zonal wavenumber 2 with a period of 22.5-30 days in early winter (Oct-Dec). Overall, the modulation is noticeably stronger for eastward propagating waves in the stratosphere while it is stronger for westward propagating waves in the troposphere. Consistent results in the stratosphere can be obtained using the temperature data from the Sounding of the Atmosphere using Broadband Emission Radiometry/Thermosphere-Ionosphere-Mesosphere-Energetic and Dynamics (SABER/TIMED). The SABER data also show that the QBO effect on the eastward propagating 23-day waves extends into the mesosphere ($\sim$70 km) for wavenumber 1 and only up to the stratopause ($\sim$45km) for wavenumbers 2 and 3.
We speculate that the eastward propagating 22.5-30 day waves are generated a nonlinear interaction between zonal-mean intra-seasonal oscillations (ISO) with a periodicity of 1.7 to 2 months and the well-known 16-day planetary waves. The QBO modulation of 22.5-30 day waves is likely due to a QBO modulation of the ISO. Further studies are needed to prove this conjecture.