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The Vertical Connection of the QBO-Modulated 11-year Solar Cycle Signature during NH Early Winter

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It has been previously found that the 11-year solar cycle signal in the polar stratosphere during Northern Hemispheric (NH) winter is modulated by the equatorial Quasi-Biennial Oscillation (QBO). However, the vertical connection of the signal under different QBO phases and the dynamic reasoning of the modulation remain unclear. In this study, we analyzed observational geopotential height data to provide some new insights on this topic with a focus on the early winter signature. The signals are strongest in the upper stratosphere. When the QBO is in its easterly phase (QBOe), they appear to move gradually eastward and poleward, resulting in a predominantly positive signal over the pole, with a weaker vertically connected negative signal over the Icelandic Low. When the QBO is in its westerly phase (QBOw), the polar stratospheric signal is mainly negative, and appears connected to a negative anomaly in the troposphere over the Aleutian Low.

A spectral analysis of the stratospheric response in planetary waves showed a reduction of wavenumber 2 power under QBOe and an enhancement of wavenumber 3 under QBOw. These responses are characterized by an overall increase/decrease in wave activity at mid- to high latitudes rather than a latitudinal shift of wave activity. There is no clear stratosphere-troposphere connection under QBOe, but under QBOw there is a vertically coherent increase in wave power at wavenumbers 1-3 with a period of 5.6-6.9 days.

We suggest that the differences in response under QBOe and QBOw can be explained through differences in initial vortex strength, resulting in either a stronger influence from the low-latitude upper stratosphere (QBOe) or from the troposphere (QBOw) on the polar stratosphere.