Modeling the Observed Solar Cycle Variations of the Quasi-biennial Oscillation (QBO)

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In several papers, the solar cycle (SC) effect in the lower atmosphere has been linked observationally to the Quasi-biennial Oscillation (QBO) of the zonal circulation, which is generated primarily by small-scale gravity waves (GW). Salby and Callaghan (2000) in particular analyzed the QBO, covering more than 40 years, and discovered that it contains a large SC signature at 20 km. We discuss the results from a recent 3D study, in which the QBO was simulated under the influence of the SC. For a SC period of 10 years, the relative amplitude of radiative forcing is taken to vary exponentially with height, i.e., 0.2% at the surface, 2% at 50 km, 20% at 100 km and above. Applying spectral analysis to filter out and identify the SC signature, the model produces a relatively large modulation of the QBO, which reproduces the observations qualitatively. The modulation of the QBO, with constant phase relative to the SC, is shown to persist at least for 60 years. The same model run generates in the seasonal variations a hemispherically symmetric Equatorial Annual Oscillation (EAO, with 12-month period), which is also confined to low latitudes like the QBO, and it is modulated by the SC. Under the influence of the GWs, the EAO propagates down into the lower stratosphere, as does the QBO. The amplitude of the EAO is relatively small, but its SC modulation is large, and it is in phase with that of the QBO. The SC modulated EAO is evidently the pathway and pacemaker for the solar influence on the QBO. Induced by the EAO, the SC influence on the QBO is apparently amplified and transferred to lower altitudes by tapping the momentum from the upward propagating GWs. The QBO and EAO are partially redistributed by the meridional circulation and planetary waves presumably, to generate in the temperature at high latitudes measurable SC signatures near the tropopause. Although the variations in the Polar Regions are comparable or even larger than those near the Equator, the phase progressions indicate that the oscillations originate at low latitudes where most of the energy resides. The modeled EAO may be involved in generating the Arctic Oscillation (Thompson and Wallace, 1998), which represents a mode of variability that appears to be sensitive to SC influence and seems to propagate down from the stratosphere.