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The QBO as potential amplifier and conduit to lower altitudes of solar cycle influence

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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. Salby and Callaghan (2000) in particular analyzed the QBO wind measurements, covering more than 40 years, and discovered that they contain a large SC signature at 20 km. We report here the results from a study with our 3D Numerical Spectral Model (NSM), which relies primarily on parameterized gravity waves (GW) to describe the QBO 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 identify the SC signature, the model generates a relatively large modulation of the QBO, which reproduces the observations qualitatively. The numerical results demonstrate that the QBO modulation, closely tracking the phase of the SC, is robust and persists at least for 70 years. The question is what causes the effect, and our analysis shows that four interlocking processes are involved in the modeled SC mechanism: (1) In the mesosphere at around 60 km, the variations in the UV generate in the zonal winds a SC modulation of the 12-month annual oscillation, which is hemispherically symmetric and confined to equatorial latitudes like the QBO. (2) Although the amplitude of this equatorial annual oscillation (EAO) is relatively small, its SC modulation is large and extends into the lower stratosphere under the influence of, and amplified by, wave forcing. (3) For the entire time span of the model simulation, the amplitude modulations of the EAO and QBO are essentially in phase with the imposed SC heating. This indicates that, due to positive feedback in the wave mechanism, the EAO apparently provides the pathway and pacemaker for the SC modulation of the QBO. (4) Our

analysis demonstrates that the SC modulation of the QBO is then amplified by tapping the momentum from the upward propagating gravity waves. Influenced and amplified by wave processes, the QBO thus acts as conduit to transfer to lower altitudes the larger SC variations in the UV absorbed in the mesosphere. Our model produces in the temperature variations of the QBO and EAO measurable SC modulations at polar latitudes near the tropopause. The effects are apparently generated by the meridional circulation, and planetary waves presumably, which redistribute the energy from the equatorial region where the waves are very effective in amplifying the SC influence.