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Stratosphere-troposphere coupling: The influence of the Quasi-Biennial Oscillation on the Arctic Polar vortex and troposphere in perpetual winter WACCM runs

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Idealized Experiments with the Whole Atmosphere Community Climate Model(WACCM) are used to explain the influence of the stratospheric tropical Quasi-Biennial Oscillation(QBO) on the Northern Hemisphere wintertime stratospheric polar vortex and troposphere. The zonally symmetric circulation in thermal wind balance with the QBO affects high frequency eddies throughout the extratropical troposphere. The influence of the QBO is strongest and most robust in the North Pacific near the jet exit region, in agreement with observations. Variability of the stratospheric polar vortex does not appear to explain the effect that the QBO has in the troposphere in the model, though it does contribute to the response in the North Atlantic. Anomalies in tropical deep convection associated with the QBO appear to damp, rather than drive, the effect of the QBO in the extratropical troposphere. The thermal wind response to QBO momentum anomalies interacting with tropospheric transient waves appears to be the crucial mechanism through which the QBO produces significant anomalies in the extratropical troposphere. Changes in the tropospheric circulation do not appear to be important for the polar stratospheric response however. Changes in Eliassen-Palm flux propagation and convergence solely within the stratosphere appear crucial for weakened vortex. Neither upper and mid-stratospheric shear associated with realistic QBO profiles, nor downward propagation of the QBO, appear important for understanding the effect of the QBO on the vortex. In fact, changes in wave propagation in the subtropical upper stratosphere in response to a realistic sheared EQBO profile are opposite to that expected from critical line arguments. Overall, the QBO modulates Rossby wave propagation and convergence in both the subtropical and polar stratosphere as predicted by linear theory, though not always as predicted by changes of the subtropical critical lines.