3rd International Conference on Earth System Modelling
Vol. , 3ICESM-231-1, 2012
3rd International Conference on Earth System Modelling

Solar signal propagation: The role of gravity waves and stratospheric sudden warmings

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We use a troposphere-stratosphere model of intermediate complexity to study the atmospheric response to an idealized solar forcing in the subtropical upper stratosphere during Northern Hemisphere (NH) early winter. We investigate two conditions that could influence poleward and downward propagation of the response: (1) the representation of gravity wave effects and (2) the presence/absence of stratospheric sudden warmings (SSWs). We also investigate how the perturbation influences the timing and frequency of SSWs. Differences in the poleward and downward propagation of the response within the stratosphere are found depending on whether Rayleigh friction (RF) or a gravity wave scheme (GWS) is used to represent gravity wave effects. These differences are likely related to differences in planetary wave activity in the GWS and RF versions, as planetary wave redistribution plays an important role in the downward and poleward propagation of stratospheric signals. There is also remarkable sensitivity in the tropospheric response to the representation of the gravity wave effects. It is most realistic for GWS. Further, tropospheric responses are systematically different dependent on the absence/presence of SSWs. When only years with SSWs are examined, the tropospheric signal appears to have descended from the stratosphere, while the signal in the troposphere appears disconnected from the stratosphere when years with SSWs are excluded. Different troposphere-stratosphere coupling mechanisms therefore appear to be dominant for years with and without SSWs. The forcing does not affect the timing of SSWs, but does result in a higher occurrence frequency throughout NH winter. Quasi-Biennial Oscillation effects were not included in our model experiments.