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Downward influence of dynamical signals in the middle atmosphere

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There is now lots of evidence to suggest that the dynamics of the stratosphere influence the dynamics of the troposphere. Several papers have investigated the mechanisms for this downward influence. However, there is much that remains not well understood. In this talk the downward propagation through the stratosphere of the response to an imposed stratospheric perturbation is considered. The interaction between the lower stratosphere and the troposphere that would follow this downward propagation is not considered.

Experiments are carried out using a 1D Holton–Mass type wave mean-flow model in which a dynamical perturbation is imposed in the zonal wind field in the upper stratosphere. The Holton–Mass model supports steady and vacillating equilibria which gain or lose stability depending on the amplitude of the lower boundary Rossby wave forcing, Φ_0. It is found that no simple downward propagating dynamical signal is supported by the zonal mean-flow dynamics, $\Phi_0 = 0$. This is also true for low values of Φ_0. However, at high values of Φ_0 the strongly non-linear nature of the dynamics are sensitive to the imposed perturbation and the resulting change caused by this perturbation occurs over the whole depth of the stratosphere, thus enabling a large downward influence. The amount of downward influence caused by the perturbation is greatest when multiple stable equilibria exist.

This work extends in a natural way to more realistic 3D models. Evidence of the existence of multiple stable equilibria in 3D models has already been demonstrated in several papers, manifested in one by the time evolution of dynamical fields showing sensitivity to initial conditions. Here, using the Reading 3D spectral model IGCM, it is found that the downward influence of a stratospheric perturbation is greatest when

the magnitude of lower boundary wave forcing, Φ_0, is such that the time evolution is sensitive to small changes in initial conditions.

The amount of Rossby wave momentum flux (the Eliassen–Palm or EP flux) that enters the stratosphere, has been shown to be dependent on the state of the stratosphere. Therefore, it is demonstrated here that a perturbation at high altitudes can, by altering the state of the stratosphere, significantly alter the amount of EP flux entering the stratosphere. This in turn will have an affect on the dynamics of the troposphere.