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Response of baroclinic wave lifecycles to stratospheric flow conditions

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The dynamical coupling between the stratosphere and troposphere is of great interest and has consequences for tropospheric predictability and climate change. In particular, the importance of the direct influence of the lowermost stratospheric flow on tropospheric synoptic scale systems for stratosphere-troposphere coupling has been suggested by several recent observational and modelling studies. In order to systematically investigate this influence two sets of model simulations are carried out.

Idealised nonlinear baroclinic wave lifecycles are performed using a dry primitive equation model (PUMA) on the sphere. Different lifecycle experiments with increasing cyclonic shear about a baroclinically unstable mid-latitude jet show a distinct shift from anticyclonic (LC1) to cyclonic (LC2) lifecycle behaviour, consistent with previous studies. It is found that the critical strength of the shear increases with increasing strength of a stratospheric jet, which is placed on the poleward side of the tropospheric jet. Thus, a strong (weak) stratospheric jet prefers anticyclonic (cyclonic) lifecycle behaviour, associated with a zonal flow forcing and a change of surface pressure resembling the high (low) phase of tropospheric low-frequency variability modes like the AO or NAO, which agrees with the observed stratospheric influence on these modes.

A simple algorithm for detecting anticyclonically and cyclonically breaking synoptic scale waves from tropospheric daily isentropic potential vorticity maps is applied to two forced-dissipative simulations with the same model, differing in the strength of the thermally forced stratospheric polar vortex. In the strong (weak) polar vortex case the number ratio of anticyclonic to cyclonic wavebreaking events is increased (decreased) and is associated with a poleward (equatorward) shift of the tropospheric jet, both of which is consistent with the results from the idealised lifecycle experiments.