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The relative influence of wind and stability on gravity wave distributions in the middle atmosphere

Peter Preusse and Manfred Ern
Forschungszentrum Jülich GmbH, IEK-7, Juelich, Germany (p.preusse@fz-juelich.de)

Gravity waves (GWs) and their momentum flux exhibit a pronounced annual cycle in the stratosphere and mesosphere. This behaviour is caused by a complex interplay of GW sources and the modulation of the propagation condition for GWs by the background atmosphere. Modulation of the GW spectrum and critical level filtering by the background winds as well as modulation by the background stability (buoyancy frequency) all contribute. We perform GW ray-tracing experiments based on a climatological background atmosphere and a launch distribution tuned to match satellite observations. The launch distribution is kept constant in order to isolate the effects of the background atmosphere. We find that for the total momentum flux the global shape is almost entirely generated by the background winds which filter different phase speeds and different directions as GWs encounter critical levels. In particular, at mid and high latitudes the potential of GWs to enter the stratosphere in winter and strong filtering due to the wind reversal in summer generates a strong contrast between summer and winter. The situation is different, if only short vertical wavelength waves are considered. This mimics measurements where the background atmosphere is removed by vertical filtering. The short vertical wavelength part of the spectrum is, to a large degree, saturated and the buoyancy frequency directly influences the maximum GW momentum flux. We find strong sensitivity in particular in the mesosphere, where temperature gradients are already negative and temperature variations may cause also larger variations of the buoyancy frequency.