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Synoptic responses to breaking mountain gravity waves at turning critical levels

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The synoptic scale responses of a stratified rotating shear flow to small scale mountain gravity waves (GWs) encountering turning critical levels is analysed. To quantify the significance of the momentum deposit by the moutain GWs onto the large-scale flow, these responses are compared to those produced by large scale mountains.

For this purpose, we use a semi analytical model based on a linear Boussinesq semi-geostrophic f-plane version of the Eady model of baroclinic instability, and force it by two independent processes. Both processes result from a large scale complex mountain that consists of a finite size ensemble of small scale ridges embedded within a large scale enveloppe, the horizontal scale of the enveloppe being significantly different from that of the individual ridges. Under this hypothesis, a first mountain forcing is due to the mountain GWs which are generated by the small-scale ridges.They interact with the large scale flow at turning critical levels, where they produce a dipolar potential vorticity (PV) anomaly advected and steered by the shear in the mid-troposphere. The second forcing is due to the large scale enveloppe, which produces a vertical velocity at the ground but no inflow PV.

We show that, under a geometrical configuration such that the majority of the mountain GWs encounter critical levels, the potential vorticity they produce can force steady boundary Eady waves as substantial as those produced by the corresponding large scale mean orography. Furthermore, we find that the GWs can reinforce (i) the anticyclonic circulation and (ii) the downslope low which are produced by the mean orography.

These calculations are essentially analytical, but can help to appreciate the needs to parametrize mountain gravity waves turning critical levels.