A new mechanism for spontaneous imbalance exciting large-area gravity waves

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In order to improve global atmospheric modelling, the trend is towards including source-specific gravity waves (GWs) in general circulation models. In a case study, we search for the source of a GW observed over Greenland on 10 March 2016 using the Gimballed Limb Observer for Radiance Imaging of the Atmosphere (GLORIA) onboard the German research aircraft HALO. GLORIA is a remote sensing instrument where the measured infrared radiances are converted into a 3D temperature field through tomography.

We observe a GW packet between 10 and 13km that covers ∼1/3 of the Greenland mainland. GLORIA observations indicate a horizontal (vertical) wavelength of 330km (2km) and a temperature amplitude of 4.5K. Slanted phase fronts indicate intrinsic propagation against the jet but the GW packet propagates (ground-based) with the wind. To find the GW source, 3D GLORIA observations, GROGRAT raytracer, ERA5 data, and an ECMWF numerical experiment are used. The numerical experiment with a smoothed topography indicates virtually no GWs suggesting that the GW field in the full model is caused by the orography. However, these are not mountain waves. A favourable area for spontaneous GW emission is identified within the jet exit region by the cross-stream ageostrophic wind speed, which indicates when the flow is not in geostrophic balance.

Backtracing experiments (using GROGRAT) trace into the jet and imbalance regions. The difference between the full and the smooth-topography experiment is the change in wind components by the compression of air above Greenland. These accelerations and decelerations in the jet cause the jet to become out of geostrophic balance, which excites GWs by spontaneous adjustment. We present, to the best of our knowledge, the first observational evidence of GWs by this topography-jet mechanism.