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The vertical gradient of gravity wave momentum flux in global observations and modeling

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In their recent review paper Geller et al. (2013) compared climatologies of gravity wave momentum flux (GWMF) from various global models with GWMF inferred from different observation techniques. They find a generally good agreement in the global distributions in the lower stratosphere, but a strong difference in the vertical gradient of GWMF profiles: observations from various satellite data sets show a strong decrease of GWMF with a scale height of 9-12km while parametrized GWMF in ECHAM decreases only slowly with a scale height of 24km. The authors hint that this may be caused by the fact that observations see only part of the wave spectrum. In particular, gravity waves (GWs) with short horizontal scales are not seen by the infrared limb sounders. Is the horizontal scale the major reason? Are there other effects responsible for the different vertical gradients? We here consider this question using the GROGRAT ray-tracing model and GWs that are, in principle, visible to infrared limb sounding instruments. For this we analyze GWs in high resolution ECMWF analysis fields at 25km altitude and determine wave amplitudes and the 3D wave vector. The horizontal distribution of GWMF from these ECMWF-resolved waves matches observed distributions well. The inferred wave parameters are used as launch parameters and the GWs are propagated upward with GROGRAT up to 90km altitude. GROGRAT is here used as a 3D ray-tracer with wave action flux conservation and a Fritts and Rastogi saturation scheme, i.e. it is similar to a GW parametrization but can handle 3D propagation in addition. The GROGRAT results also display a very weak decrease of GWMF in the stratosphere and lower mesosphere, similar as the GW parametrization, and are thus an interesting test-bed for searching reasons for the difference between observed and modeled vertical gradients as they were seen in Geller et al. (2013). Using the GROGRAT simulations we investigate the following potential reasons for the difference in the vertical gradient between model results and observation: 1. the difference between vertical (1D) and 3D propagation, 2. details of the saturation scheme, 3. the launch amplitudes and 4. the influence of the observational filter. We find indication that GW amplitudes in the ECMWF-resolved wave fields are too low and thus GWs reach saturation in the GROGRAT simulation only above the stratopause. Also the influence of the observational filter is substantial. While reasonable agreement in the polar night jet is found mitigating a combination of different effects, larger differences remain in the subtropics where GWs in ECMWF are not fully realistic.