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A test of the gravity wave polarization relations based on 3D-GLORIA and in situ data

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During the POLSTRACC/SALSA/GW-LCycle campaign in winter 2015/2016, several research flights of the German research aircraft HALO targeted gravity wave (GW) events. The waves were observed by several instruments simultaneously, i.e. the Gimballed Limb Observer for Radiance Imaging of the Atmosphere (GLORIA), on-board in-situ sensors for winds and temperature, and, where this was possible, dropsondes. The GLORIA measurements allow to reconstruct the 3D temperature structure of mesoscale GW events. This 3D structure was used to determine the amplitude and wave vector of the wave using a 3D sinusoidal wave analysis in small, overlapping volumes. Based on the space-dependent wave vector, amplitude and phase, the wind perturbation due to the GWs can be reconstructed from temperature via the polarization relations.
When planning the HALO flights we gave special attention to the comparison of GLORIA observations with in situ measurements. The flight plans were designed in a way that GLORIA limb views in certain flight sections matched regions sampled by in situ measurements in other flight sections, which in this way were in the center of the GLORIA observation volume. For these parts of the flights the inferred GW wind perturbations can directly be compared to the measurements from the in situ basis sensor system of the airplane. We focus on two flights, a complex superposition of mountain waves observed over Iceland on 25 January 2016 and a superposition of waves from orography and spontaneous imbalance observed on 28 January 2016.
In a first step, we test our approach of GW analysis and reconstruction based on analysis data of the European Centre for Medium Range Weather Forecast - Integrated Forecast System (ECMWF-IFS). These data are self-consistent and contain only mesoscale GWs. The influence of the background removal and the sinusoidal fit method is assessed. In a second step, we use real observations from GLORIA and in situ instruments. The influence of the different scales to which the methods are sensitive is discussed. We find that background removal is more robust for temperatures and vertical winds and more difficult for horizontal winds. Vertical winds measured by in situ observations are dominated by small scale GWs. Overall we find confirmation of the polarization relations, but for vertical winds only when small scale waves can be removed by low-pass filtering.