EGU22-6993
https://doi.org/10.5194/egusphere-egu22-6993
EGU General Assembly 2022

Quantification of oblique orographic gravity wave propagation deduced from a mountain wave model

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Observations and high resolution models suggest a high potential for gravity waves (GW) to propagate horizontally, which is usually not considered in current parameterizations of general circulation models (GCM). For a quantification of the oblique propagation of orographic GWs and their transport of momentum throughout the atmosphere, we present a mountain wave model (MWM) that describes the terrain induced GW sources, propagation and momentum flux. Being aware of horizontal wind gradients, the model also allows for GW refraction which leads to a turning of the wave vector.

The MWM we present here is a simplified model identifying orographic GW sources from topography data. It is similar to the one presented in Bacmeister et.al. (1994). First, the topography is smoothed using a Gaussian bandpass filter, which allows to consider the different scales of generated MWs separately. This smoothed topography is afterwards reduced to the inherent ridge structure (i.e. to the arêtes of mountains) by employing edge and line detection algorithms from computer vision. Using this underlying arête structure in combination with a fit of idealized Gaussian-shaped mountain ridges to the topography gives us a straightforward way of determining MW parameters for launching a ray, i.e. source location, orientation and size of the wave vector as well as the displacement amplitude. These parameters are then used to calculate the propagation in space and time in given atmospheric backgrounds (determined from smoothed ERA5 (European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis 5th Generation) data) with the ray tracer GROGRAT. The results can then be binned in terms of momentum flux and drag or used for a reconstruction of 3D temperature perturbations for a given time.

The MWM presented here has been validated against global satellite data as well as local measurements to a new quality compared to previous studies. The validation has been performed by applying an instrument-specific observational filter to the model data before considering global maps of momentum flux distributions and horizontal cross-sections of temperature perturbations. Comparisons of these to satellite data and limb measurement retrievals respectively will be shown in this presentation.