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Directional gravity wave momentum fluxes in the stratosphere derived from AIRS high-resolution temperatures

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Gravity waves are an important driver of atmospheric dynamics. Due to their small scales, gravity waves are poorly resolved in most general circulation models and chemistry climate models, and the effect of gravity waves on the background flow has to be parametrized. A key quantity of these parametrization schemes is the vertical flux of horizontal momentum due to gravity waves. Gravity wave parametrization schemes are poorly constrained, and for a further improvement global observations of gravity wave momentum fluxes from satellite are required. First attempts were based on absolute values of gravity wave momentum fluxes derived from satellite instruments having only one viewing direction. For a better comparison with parametrization schemes, however, directional momentum fluxes, i.e. momentum flux vectors, are needed.

We make use of 3D temperature distributions resulting from a dedicated high resolution temperature retrieval based on the 3D observations of the nadir scanning satellite instrument AIRS on board the EOS Aqua satellite. For January 2009 and an altitude of 36km as the first attempt, full 3D gravity wave wavenumber vectors are determined in small 3D fitting volumes, and global distributions of zonal and meridional gravity wave momentum fluxes are derived. Resulting global patterns of momentum fluxes are similar to those previously known from absolute momentum fluxes in the stratosphere: enhanced values are found in the polar jets and in the summertime subtropics. Momentum fluxes derived from AIRS are directed prevalently opposite to the background winds, i.e. eastward in the summertime subtropics, and prevalently westward in the polar jets. In addition, in the polar jets meridional momentum fluxes are opposite in their direction to the meridional winds induced by planetary waves. We also find that the distribution of AIRS net momentum fluxes is dominated by gravity waves of relatively large amplitude, and of relatively long horizontal scale. Particularly for convective gravity wave sources in the summertime subtropics, this finding is in contradiction with traditional thoughts. However, the observational filter effect needs to be kept in mind when interpreting the results.