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A ten-year satellite record of gravity wave activity in the lower stratosphere to study polar stratospheric cloud formation

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Polar stratospheric clouds (PSCs) play a key role in ozone chemistry in the polar stratosphere. Atmospheric gravity waves yield small-scale temperature fluctuations that can trigger PSC formation if synoptic-scale temperatures exceed typical formation thresholds. Here we introduce a new satellite record of gravity wave observations in the polar lower stratosphere that can be used to investigate this process in more detail.

The record is based on observations of the Atmospheric InfraRed Sounder (AIRS) aboard NASA's Aqua satellite during the years 2003 to 2012. Gravity wave activity is measured in terms of detrended and noise-corrected 15 micron brightness temperature variances on a daily basis. The AIRS channels selected for the data product are most sensitive to atmospheric temperature fluctuations at about 17-32 km altitude. Observations respond to the short horizontal and long vertical wavelength part of the gravity wave spectrum due to the nadir geometry.

The analysis of temporal patterns in the AIRS data set revealed a strong seasonal cycle in gravity wave activity at mid and high latitudes. The analysis of spatial patterns showed that orography as well as geostrophic imbalances related to the polar jet are the most prominent sources of the observed waves. Wave activity was found to be closely correlated with 30 hPa zonal winds, which is attributed to the 'observational filter' effect of the AIRS observations.

We show the benefits of the new satellite record in two applications. First, it can be used to validate explicitly resolved temperature fluctuations in high-resolution model simulations. We demonstrate that the European Centre for Medium-Range Weather Forecast (ECMWF) operational analysis and the ERA-Interim reanalysis reproduce observed wave patterns pretty well, but that wave amplitudes are significantly underestimated (by factors of 2-3 and 5-8, respectively).

Second, we present a survey of gravity wave-induced PSC formation events based on joint AIRS and Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) observations. In the 2003-2012 time span we identified nearly 50 individual events that highlight that gravity wave-induced PSC formation is an important process in polar ozone chemistry. The new AIRS long-term record will become a valuable resource in future studies of this process.