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Summary

Ground-based and airbourne observations of stratospheric and mesospheric gravity waves - Andreas Dörnbrack

During the last decades internal gravity waves (IGWs) have been studied intensely due to their importance for the circulation and structure of the middle atmosphere (Fritts and Alexander 2003). The most energetic part of the gravity wave spectrum is exited in the troposphere, with prominent source mechanisms being the flow over topography, convection, flow deformation and vertical shear at upper-level fronts. Momentum transport by IGWs and momentum deposition throughout the atmosphere have significant impacts on Earth's weather and climate. Momentum deposition causes drag on mean and larger-scale winds, e.g. resulting in the reversal of the mesospheric jet and in an induced residual circulation that impacts mean temperatures from the lower altitudes into the mesosphere and lower thermosphere. In this way, IGWs represent a prominent coupling mechanism between the troposphere and the middle atmosphere (e.g. Yigit and Medvedev, 2015).

The amount of gravity wave activity penetrating into the middle atmosphere is considerably affected by the background flow and thermal stability in the troposphere and stratosphere. Dissipation or reflection can hinder the propagation of IGWs into the mesosphere, i.e. the deep wave propagation. Vertical levels where the component of the background wind in the direction of wave propagation equals the horizontal phase speed are called critical levels. There, either total or partial critical level filtering impedes the vertical propagation of gravity waves. Often, the waves break and deposit their momentum at these levels.

In the lecture, selected results of two field campaigns are presented, the GW-LCYCLE 1 campaign which was conducted in northern Scandinavia in November/December 2013 and the DEEWPWAVE experiment in New Zealand with its intense observing period in June/July 2014. The experiments selected two of the world's gravity wave hotspots: the Scandinavian Alps and the Southern Alps on New Zealands South Island under boreal and austral winter conditions, respectively. At those locations, the climatological mean flow favors the deep vertical propagation of mountain waves. One of the hypotheses of both experiments was that mountain waves excited by the flow over the Scandinavian or Southern Alps act as a primary source of mesospheric GW activity. Therefore, both field campaigns aimed at quantifying the vertical propagation of mountain waves from their sources to the middle atmosphere. For this purpose, an impressive suite of airborne and ground-based sensors was combined to estimate the amount of gravity wave energy which was excited in the troposphere and penetrating into the middle atmosphere. Highlights of the preliminary results include the following: 1) strong orographic gravity wave forcing accompanying strong cross-mountain flows does not necessarily lead to enhanced mesospheric gravity wave activity, 2) strong high-altitude responses when orographic forcing was weak, 3) large-scale gravity waves at high altitudes arising from non-orgraphic sources, and 4) complex modification of IGWs signatures by the stratospheric wind minimum occurring above the tropopause and below the polar night jet.

References

Fritts, D. C. and M. J. Alexander, 2003: Gravity wave dynamics and effects in the middle atmosphere, Rev. Geophys., 41, 1003, http://dx.doi.org/10.1029/2001RG000106.

Fritts, D. C, R. B. Smith, M. J. Taylor, J. Doyle, S. Eckermann, A. Dörnbrack, M. Rapp, B. P. Williams, P.-D. Pautet, K. Bossert, N. Criddle, C. Reynolds, A. Reinecke, M. Uddstrom, M. Revell, R. Turner, B. Kaifler, J. Wagner; T. Mixa, C. Kruse, A. Nugent, C. Watson, S. Gisinger, S. Smith. J. Moore, W. Brown, J. Haggerty, A. Rockwell, G.Stossmeister, S. Williams, G. Hernandez, D. J. Murphy, A. Klekociuk, I. M. Reid, Jun Ma, R. S. Lieberman, B. Laughman, 2015: The Deep Propagating Gravity Wave Experiment (DEEPWAVE): An Airborne and Ground-Based Exploration of Gravity Wave Propagation and Effects from their Sources throughout the Lower and Middle Atmosphere, Bull. Am. Meteorol. Soc., April 2015, accepted; doi:http://dx.doi.org/10.1175/BAMS-D-14-00269.1