SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2016
Project Title:	Atmospheric waves in the middle atmosphere measured by the ALIMA lidar onboard the research aircraft HALO
Computer Project Account:	SPDEKAIF
Principal Investigator(s):	Bernd Kaifler Natalie Kaifler
Affiliation:	Institute of Atmospheric Physics German Aerospace Center (DLR) DLR Oberpfaffenhofen Münchner Straße 20 82234 Weßling
Name of ECMWF scientist(s) collaborating to the project (if applicable)	
Start date of the project:	2014
Expected end date:	2016

Computer resources allocated/used for the current year and the previous one

(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	100000	0	100000	0
Data storage capacity	(Gbytes)	40	0	40	0

Summary of project objectives
(10 lines max)

The objective of the project is to study atmospheric waves using the ALIMA instrument (short for Airborne LIDAR for the Middle Atmosphere). The lidar will measure atmospheric density, temperature and disturbances caused by atmospheric waves between 10 and 120 km using different scattering mechanisms. A prototype for the new instrument is built and tested on ground before ALIMA is certified for operations on the research aircraft HALO. Atmospheric gravity waves are excited near ground level, e.g. by flow over mountains and propagate throughout the atmosphere up to thermospheric altitudes (> 100 km). Gravity waves interact with the background flow by convective or dynamic instabilities and are subject to selective filtering. They contribute significantly to the energy budget of the atmosphere and play a major role in the vertical coupling of the atmosphere.

Summary of problems encountered (if any)
(20 lines max)

No problems encountered.

Summary of results of the current year (from July of previous year to June of current year)
This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

The Temperature Lidar for research of the Middle Atmosphere (TELMA), developed as prototype for the ALIMA lidar, was part of the international Deep Propagating Wave Experiment (DEEPWAVE, Fritts et al., 2015). Between June and November 2014, a large dataset was acquired at Lauder, New Zealand. From temperature measurements in the stratosphere and mesosphere (22 to 85 km), temperature perturbations caused by gravity waves are extracted using different filter techniques. The highest resolution is 10 min x 900 m.

For comparison with the DEEPWAVE lidar and radiosonde datasets, temperature data from hourly predictions of the ECMWF integrated forecast system were retrieved for the location of Lauder as well as at the coast upstream of Lauder. During events of strong orographic forcing, high-amplitude quasi-stationary waves (mountain waves) were observed by the lidar instrument in the lower stratosphere. We used ECMWF data to characterize the forcing of mountain waves and investigate gravity wave propagation conditions. It was found that propagation of mountain waves to mesospheric altitudes occurs under conditions of (a) weak to moderate forcing and (b) sufficiently strong winds in the stratosphere (Kaifler et al., 2016). During strong tropospheric forcing, mountain waves obtain already very large amplitudes at low altitudes and are therefore likely to break in the lower stratosphere. As a result, these large-amplitude waves do not penetrate into the mesosphere.

ECMWF data were used as background fields for raytracing experiments. The experiments show that, under certain atmospheric conditions, mountain waves generated above the Southern Alps are refracted and propagate into regions of large horizontal wind speeds caused by the polar jet. A manuscript discussing the mountain wave event on 1 August 2014 is currently in preparation.

We also compared observed mean temperature profiles to ECMWF forecast data. Figure 1 shows mean profiles for the period July to September 2014 for the location Lauder, New Zealand. The observed stratopause is significantly lower and warmer compared to the model data. Moreover, ECMWF data show a cold bias above 65 km altitude.

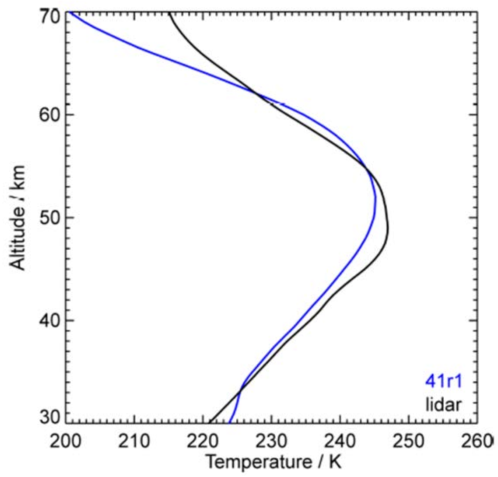

Figure 1 Mean temperature profiles above Lauder between July and September 2014 as simulated by the ECMWF IFS (blue) and observed by the TELMA instrument. Only ECMWF profiles with coinciding lidar observations were used.

A detailed comparison between gravity waves resolved in ECMWF data and gravity wave-induced temperature perturbation observed by lidar is work in progress. Preliminary results suggest that the ECMWF model forecasts mountain waves above Lauder (vertical wavelength, phase, amplitude, and temporal evolution) surprisingly well up to approximately 45 km altitude.

A second lidar data set similar to TELMA observations during DEEPWAVE was recently acquired at Sodankylä, Finland. This data set comprises lidar measurements between September 2015 and April 2016. ECMWF data are used to characterize the propagation conditions of gravity waves in the troposphere and stratosphere.

List of publications/reports from the project with complete references

(1) Fritts, D. C., R. B. Smith, M. J. Taylor, J. D. Doyle, S. D. Eckermann, A. Drnbrack, M. Rapp, B. P. Williams, P.-D. Pautet, K. Bossert, N. R. Criddle, C. A. Reynolds, P. A. Reinecke, M. Uddstrom, M. J. Revell, R. Turner, B. Kaifler, J. S. Wagner, T. Mixa, C. G. Kruse, A. D. Nugent, C. D. Watson, S. Gisinger, S. M. Smith, R. S. Lieberman, B. Laughman, J. J. Moore, W. O. Brown, J. A. Haggerty, A. Rockwell, G. J. Stossmeister, S. F. Williams, G. Hernandez, D. J. Murphy, A. R. Klekociuk, and I. M. Reid, 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, Bulletin of the American Meteorological Society, 2016.

(2) Kaifler, B., N. Kaifler, B. Ehard, A. Dörnbrack, M. Rapp, and D. C. Fritts (2015), Influences of source conditions on mountain wave penetration into the stratosphere and mesosphere, Geophys. Res. Lett., 42, 9488–9494, doi:10.1002/2015GL066465

Summary of plans for the continuation of the project

(10 lines max)