Contributions to DEEPWAVE-NZ from the DLR

Andreas Dörnbrack
Hans Schlager, Markus Rapp, Bernd Kaifler, et al.

DLR Oberpfaffenhofen
Institut für Physik der Atmosphäre

DLR contribution integrated in the BMBF Research Initiative:

Role of the Middle atmosphere In Climate (ROMIC)

by the project „Investigation of the life cycle of gravity waves (GW-LCYCLE)“
ROMIC - Field Campaigns

(1) GW-LCYCLE I
- 2 – 14 December 2013, Kiruna, Sweden
- DLR Falcon
- simultaneous 3 hourly radiosonde launches along a West-East section from Andøya (N), Esrange (S) to Sodankylä (FIN) during 3 IOPs
- ground-based observations at ALOMAR (radars, lidars) and at Esrange (Lidar)

(2) DEEPWAVE-NZ (DLR contribution)
- total period: 6 June – 22 July 2014, New Zealand
- DLR Falcon participation: 22 June – 14 July 2014
- ground-based observations (Na-Lidar, radiosondes)

(3) POLSTRACC/GW-LCYCLE II
- winter 2015/2016, Kiruna, Sweden
- coordinated flights of HALO and Falcon
- simultaneous 3 hourly radiosonde launches along a West-East section from Andøya (N), Esrange (S) to Sodankylä (FIN)
- ground-based observations at ALOMAR (radars, lidars) and at Esrange (Lidar, radar)
(1) Scientific Interest in DEEPWAVE-NZ

- gravity excitation by the flow over the New Zealand mountain range
- gravity wave propagation from the troposphere to the mesosphere
- gravity wave modification across the tropopause
- dynamical and chemical processes in the upper troposphere
  lower stratosphere (StratTrop exchange)
(2) Specific DLR contributions

(a) Falcon observations
- deployment from June 22 until July 14 2014
- about 60 h for research flights
- combined remote-sensing and in-situ payload of wind, temperature and various trace gases (H₂O, O₃, CH₄, CO, CO₂, N₂O, SO₂)

(b) Ground-based observations
- Sodium-Rayleigh-Brillouin-Raman Lidar (Na-RBR Lidar) at Lauder
- radiosonde launches in the lee of the southern Alps at Lauder

(c) Forecast support (ECMWF-IFS, WRF driven by ECMWF-IFS)
Rack 1: Doppler Wind Lidar (Backscatter, Wind)
Rack 2: Doppler Wind Lidar
Rack 3: CIMS (SO\textsubscript{2}) + Waran/CR2 (H\textsubscript{2}O)
Rack 4: CIMS
Rack 5: QCL (CO, N\textsubscript{2}O)
Rack 7: Picarro (CH\textsubscript{4}, CO\textsubscript{2}) + O\textsubscript{3}
Falcon observations - Contributions

Flight level measurement of vertical momentum and energy flux and of various trace gases (H₂O, O₃, CH₄, CO, CO₂, N₂O, SO₂)

- at altitudes from 4 to 11 km, below the NG V,
- on parallel tracks to the NG V tracks, and
- on shorter tracks than the long 400 km NG V tracks.

Disturbed wind field and gravity waves over the S. Alps terrain using the 2 μm Doppler wind lidar system underneath the Falcon

Mapping out the cloud field over the S. Alps using the backscatter intensity of the down-looking lidar. Cloud mapping is important as clouds may alter the generation of vertically propagating gravity waves. Expected cloud types include

- Lenticular (liquid or ice) clouds
- Undulating alto-stratus
- Shallow convective clouds
The Box-Pattern can be flown two times – assuming the Falcon is based in Christchurch.
Falcon observations - Contributions

The leg can be flown 5 to 6 times – assuming the Falcon is based in Christchurch.
2µ Wind Lidar data 03.12.13
Flight 1
2µ Wind Lidar data 03.12.13
Spectral analysis of vertical wind

A spectral analysis of the measured LOS wind speed is exemplarily performed in an altitude of 6500 km.
Amplitudes – Flight 1

$N_2O$ – amplitude low
$CO$ – amplitude high
→ Tropopause region

$N_2O$ – amplitude high
$CO$ – amplitude low
→ „Deep“ stratosphere

S. Müller and P. Hoor
Oberpfaffenhofen, 12th - 13th Februar 2014
Radiosonde Launches from Lauder
DLR, LMU Munich, Innsbruck University

(1) Väisälä radiosonde station of the LMU Munich
   60 .. 80 sondes with 600 g balloons

(2) GRAW radiosonde station of the University of Innsbruck
   20 sondes with 600 g balloons

Purposes:
- the determination of wind, temperature and humidity
  from the surface up to about 30 km altitude
- the determination of the tropopause height
- the characterization of gravity waves in the troposphere and stratosphere

Different launch techniques can be applied in coordination with the other Radiosonde stations deployed during DEEPWAVE-NZ

- simultaneous launches of two balloons with different gas fillings
- series of balloon launches every 90 min or 180 min during IOPs
Andøya, N

Esrange, S

Sodankylä, FIN

Horizontal Wind (m/s)
IOP 1 Simultaneous Radiosonde Launches every 3 h
3 December 2013 06 UTC - 4 December 2013 06 UTC
Sodium-Rayleigh-Brillouin-Raman Lidar (Na-RBR)

**Transmitter**
- 0.5 W at 589 nm (Sodium resonance)
- 10 W at 532 nm
- 100 Hz rep rate
- Bandwidth <100 MHz

**Receiver**
- 1 Channel at 589 nm
- 1 Raman channel at 608 nm
- 2 Channels at 532 nm
- 1 Rayleigh-Brillouin channel
# Na-RBR Lidar

| Operation                        | Ground based system; remote/autonomous operation  
|                                 | Real-time data analysis, quicklook plots on webpage  
| Metal                            | Sodium (589 nm wavelength)  
| Measurements                     | Temperature (5-105 km)  
|                                 | Sodium density (80-105 km)  
|                                 | One horizontal wind component (80-105 km)  
|                                 | Aerosol (5-35 km)  
| Resolution                       | 2 km, 15-60 min depending on altitude; 1-2 km, 20 min within metal layer  
| Observations in daylight         | Currently not planned, degraded performance in daylight conditions  
| Output power                     | 0.5 W at 589 nm, 10 W at 532 nm  
| Telescope aperture               | 63 cm  
| Field of view                    | 365 microrad (sodium), 200 microrad (Rayleigh/Raman)  

Modelling/Forecast Capabilities

(1) ECMWF IFS (provided by DLR)
- two runs 00 UTC and 12 UTC available, 1 hourly forecasts until lead time +72 h, 3 hourly fcs afterwards until +240 h
- 137 layers up to 0.01 hPa, ~16 km horizontal resolution
- various fields (U, V, W, T, RH, PRECIP, DIV, VOR, PV maps,...) on pressure levels and on selected vertical cross-sections visualized on: www.pa.op.dlr.de/missionsupport/classic/forecasts

(2) WRF driven by ECMWF IFS (Innsbruck University)
- two runs driven by 00 UTC and 12 UTC IFS forecasts
- nested simulations with 6 km resolution and $z_{\text{TOP}} \sim 50$ km
- similar fields as ECMWF IFS plus TKE and non-hydrostatic vertical wind visualized on: www.pa.op.dlr.de/missionsupport/classic/forecasts

(3) COSMO (Bundeswehr Geoinformation Service, Rene Heise)
- 2.8 km runs to provide vertical wind, eddy dissipation rate and TKE
IOP5 Flight 1: in-situ $\leftrightarrow$ WRF
Stratospheric "Wave Soup" only occasionally excited by flow over topography
(Examples from GW-LCYCLE 2013)