Contributions of DLR to DEEPWAVE-NZ

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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 (Gulfstream V) 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 (H$_2$O, O$_3$, CH$_4$, CO, CO$_2$, N$_2$O, SO$_2$, HNO$_3$)

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

(c) Forecast support (see talk by Jim Doyle)
Falcon measurements - Logistics

Royal New Zealand Air Force Base
Ohakea (or Christchurch Airport?)

Airports on New Zealand
Falcon - Instrumentation

Rack 1: Doppler Wind Lidar (Backscatter, Wind)
Rack 2: Doppler Wind Lidar
Rack 3: CIMS + Waran / CR2 (H₂O)
Rack 4: CIMS (SO₂, HNO₃)
Rack 5: QCL (CO, N₂O)
Rack 7: Picarro (CH₄, CO₂) + O₃

**Falcon observations - Contributions**

Flight level measurement of vertical momentum and energy flux and of various trace gases (H\(_2\)O, O\(_3\), CH\(_4\), CO, CO\(_2\), N\(_2\)O, SO\(_2\))

- 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 \(\mu\)m 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
Falcon observations - Contributions

One-way ferry from Ohakea to Christchurch region ~ 40 min

The Box-Pattern can be flown two times – assuming the Falcon is based in Christchurch
Falcon observations - Contributions

One-way ferry from Ohakea to Christchurch region ~ 40 min

The leg can be flown 5 to 6 times – assuming the Falcon is based in Christchurch.
Selected examples of IOP 1

- Doppler Wind Lidar observations
- in-situ wind and temperature from basic sensoric
- trace gases
GW-LCYCLE Campaign, 2-14 Dec. 2013, Kiruna, Sweden
GW-LCYCLE I
Kiruna, Sweden, 2 – 14 December 2013

- 24 flight hours of the DLR Falcon in 4 IOPs

- ground-based lidar and radar observations of the stratospheric and mesospheric flow and temperature at Alomar (N) and at Esrange (S)

- simultaneous 3 hourly radiosonde launches from Andøya (N), Esrange (S) and Sodankylä (FIN) during 3 IOPs

- simultaneous radiosonde launches from Arena Arctica at Kiruna airport with two systems (Väisälä and GRAW) and different balloon fillings to obtain different ascent rates (altogether 22 soundings)

- Focus of IOPs: deep mountain wave propagation for strong cross-mountain flow events above northern Scandinavia
Favorite meteorological conditions:
- strong cross mountain flow in the lower troposphere
- alignment of tropospheric and stratospheric jet streams
- different regimes wrt tropopause height
Falcon observations
Examples from GW-LCYCLE I
Kiruna, Sweden, 2 – 14 December 2013

Föhn gap

IOP 1: 3 Dec 2013
Infrared satellite image: 13 UTC
2 μm Doppler Wind Lidar Quicklooks
IOP 1 03.12. 2013

First flight – first lag – East to West

- The instrument was working without any problems
- The coverage was much larger than expected
- Entire flight was performed with fixed LOS (Nadir)
- The shown flight lag was performed in FL 260 (7.9 km asl)
2 μm Doppler Wind Lidar Quicklooks
IOP 1 03.12. 2013

Vertical wind speed (entire lag) FL 260
flight direction from East to West

vertical wind velocity/(m/s)

horizontal distance/(km)
altitude/(m)
vertical wind velocity/(m/s)
orography

IOP 1 03.12. 2013
Vertical wind speed (region over the mountains) FL 260 flight direction from East to West
Wind ~ 30 m/s

λ ~ 17 km

W W W
13122013 Flight 6 GW-LCYCLE

CO and N$_2$O measurements by Uni Mainz (Hoor and Müller)

N$_2$O gives clear indication for stratospheric air:

- N$_2$O > 327 ppbv: Troposphere
- N$_2$O < 327 ppbv: Stratosphere
Box 1

Waves with various wavelengths both to see in N₂O and CO!

13122013 Flight 6 GW-LCYCLE

CO and N₂O measurements by Uni Mainz (Hoor and Müller)
Box 2

Waves with various wavelengths close to tropopause: stronger signal in CO than in N$_2$O!

13122013 Flight 6 GW-LCYCLE

CO and N$_2$O measurements by Uni Mainz (Hoor and Müller)
Selected examples of IOP 1

- simultaneous 3 hourly radiosonde launches from Andøya, Esrange, Sodankylä
IOP 1 Simultaneous Radiosonde Launches every 3 h
3 December 2013 06 UTC - 4 December 2013 06 UTC
IOP 1 Simultaneous Radiosonde Launches every 3 h
3 December 2013 06 UTC - 4 December 2013 06 UTC
Andøya, N

Esrange, S

Sodankylä, F

Wind direction (deg)
# Na-RBR Lidar

| Operation | Ground based system; remote/autonomous operation  
Real-time data analysis, quicklook plots on webpage |
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<tr>
<td>Metal</td>
<td>Sodium (589 nm wavelength)</td>
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| 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) |
Lidar Messungen über Davis
15./16. August 2011

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
Thank you for your attention