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_2O, O_3, CH_4, CO, CO_2, N_2O, 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

- Full International
- Regional International
- Domestic Scheduled
- Local Aerodromes
- Military Aerodromes

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

Airports on New Zealand

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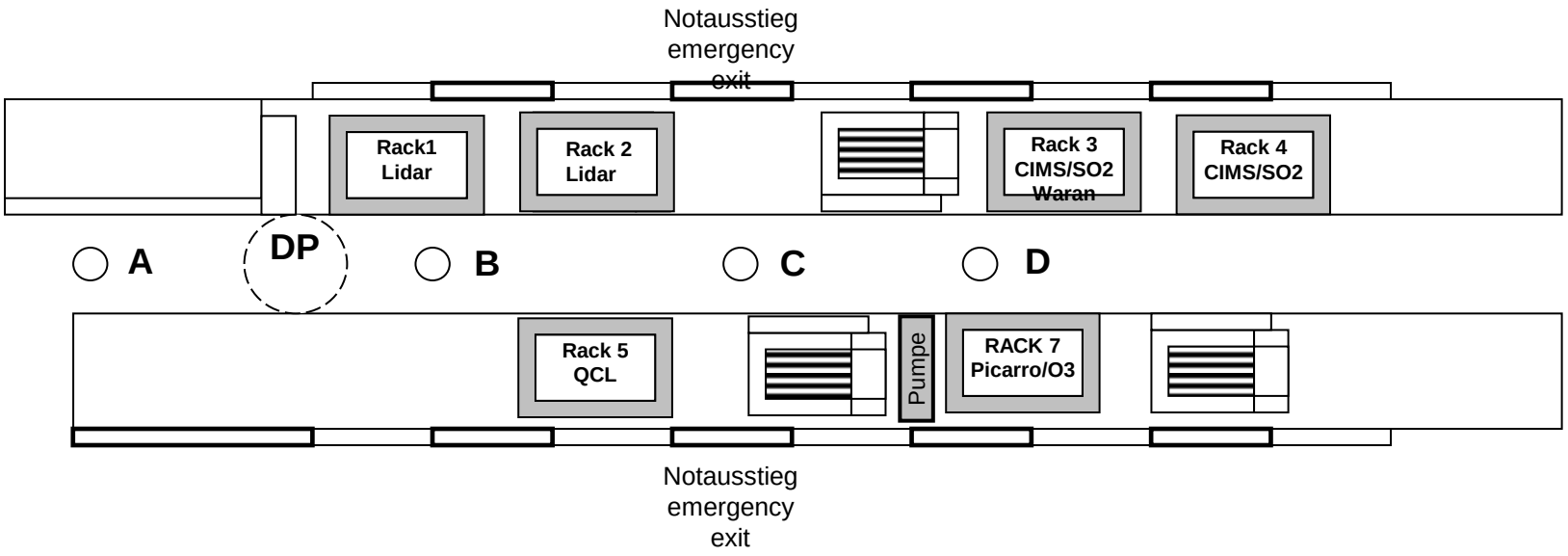
Falcon - Instrumentation



Rack 1	**Doppler Wind Lidar (Backscatter, Wind)**
Rack 2	**Doppler Wind Lidar**
Rack 3	**CIMS + Waran / CR2 (H_2O)**
Rack 4	**CIMS (SO_2, HNO_3)**
Rack 5	**QCL (CO, N_2O)**
Rack 7	**Picarro (CH_4, CO_2) + O_3**

Met. Probes: Temp, rel. Humidity, horizontal / vertical Wind

Flugrichtung
flight direction

Falcon 20

D-CMET

Falcon observations - Contributions

Flight level measurement of vertical momentum and energy flux and of various trace gases (H_2O, O_3, CH_4, CO, CO_2, N_2O, 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 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

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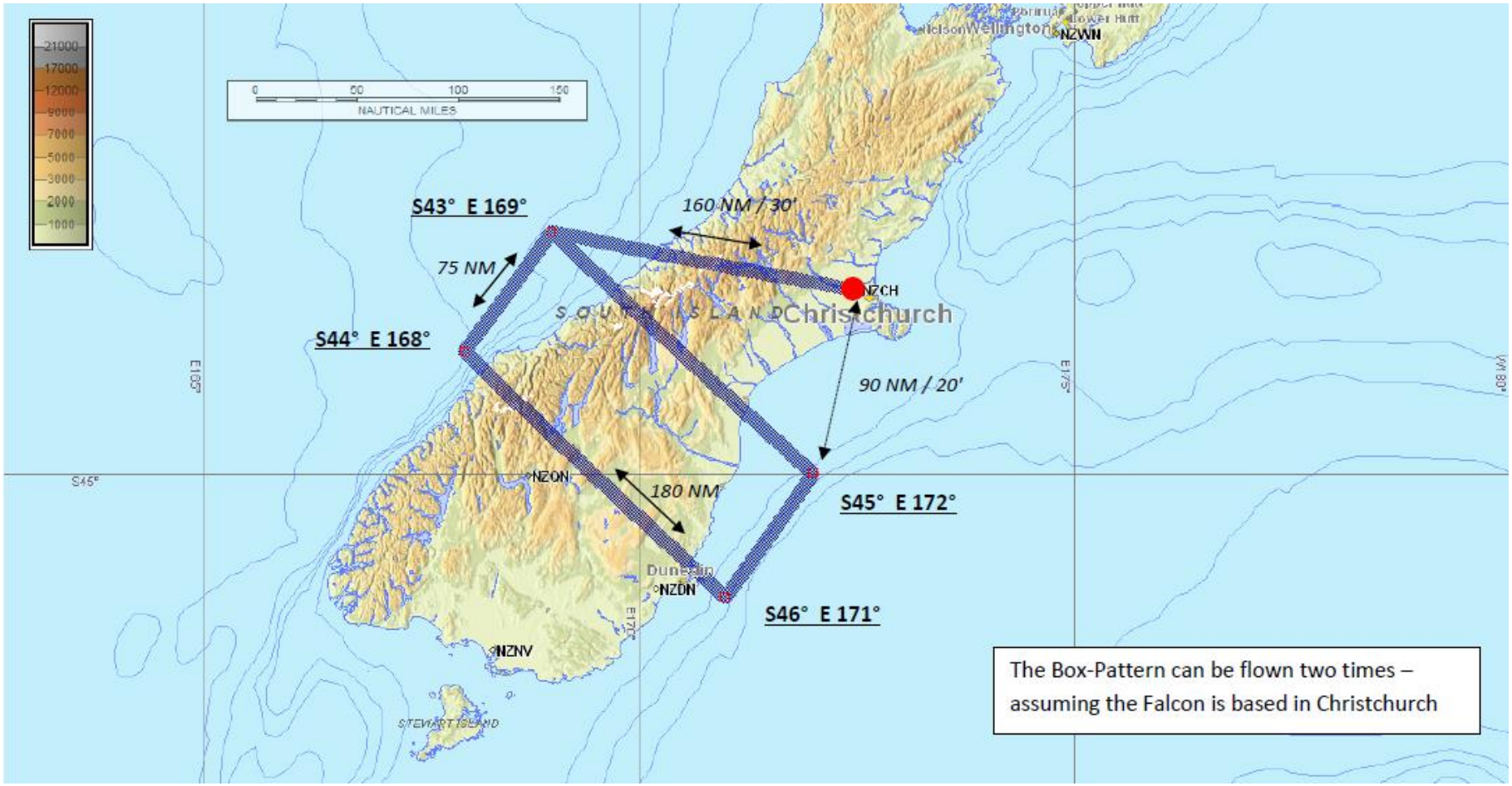
Falcon observations - Contributions

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



Falcon observations - Contributions

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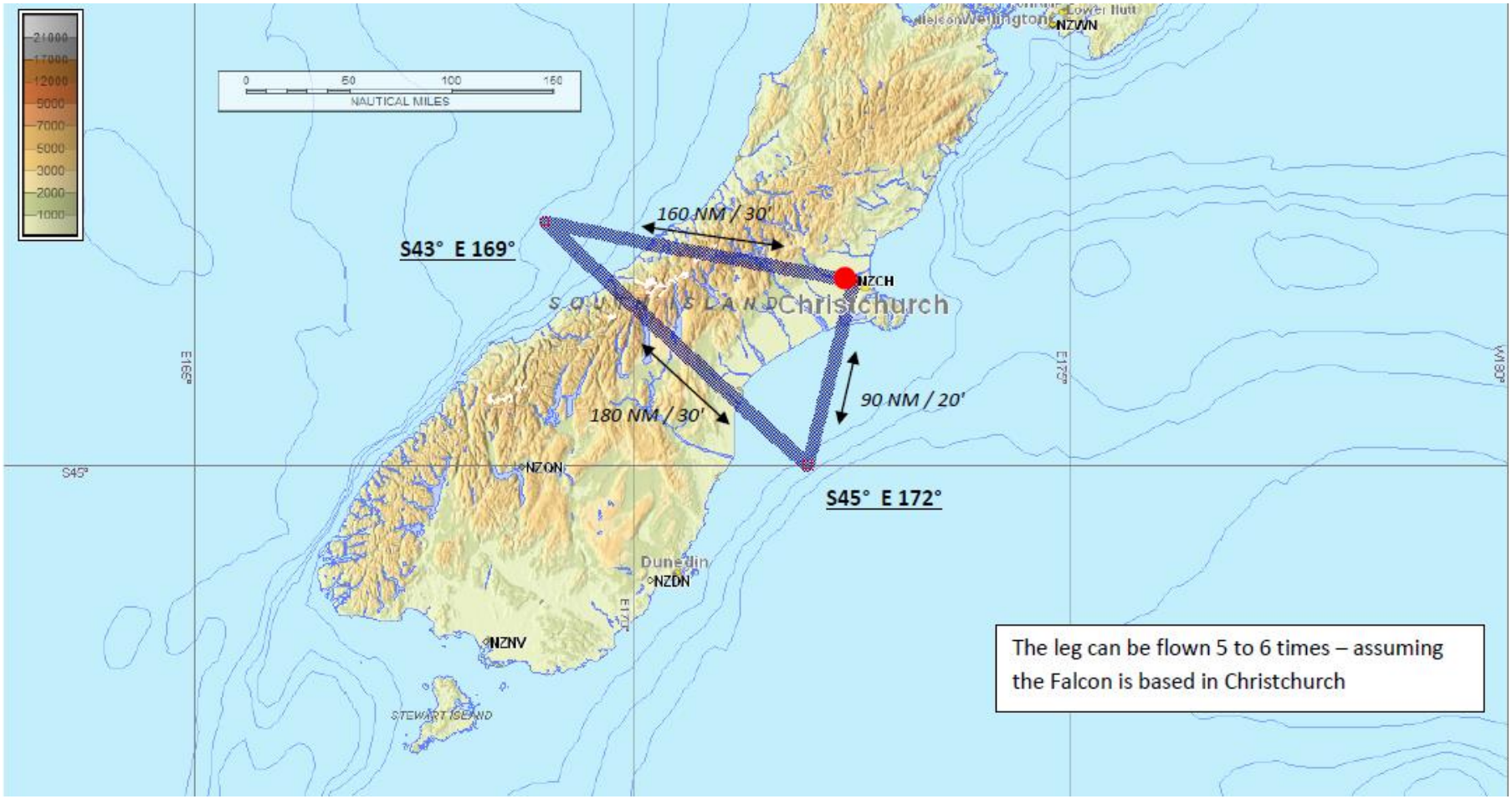

Falcon observations

Examples from GW-LCYCLE I

Kiruna, Sweden, 2 – 14 December 2013

Selected examples of IOP 1

- Doppler Wind Lidar observations
- in-situ wind and temperature from basic sensoric
- trace gases

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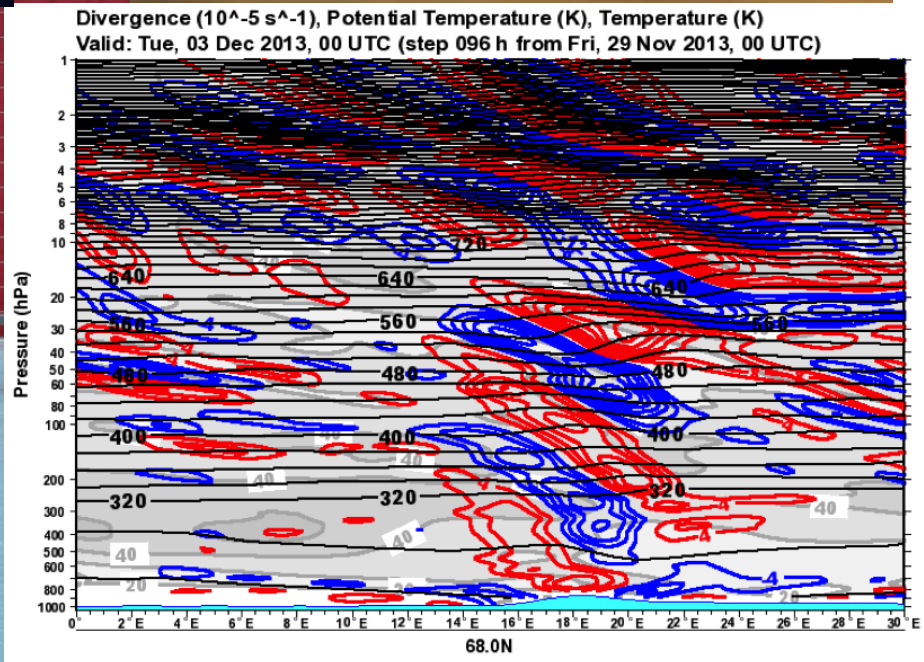
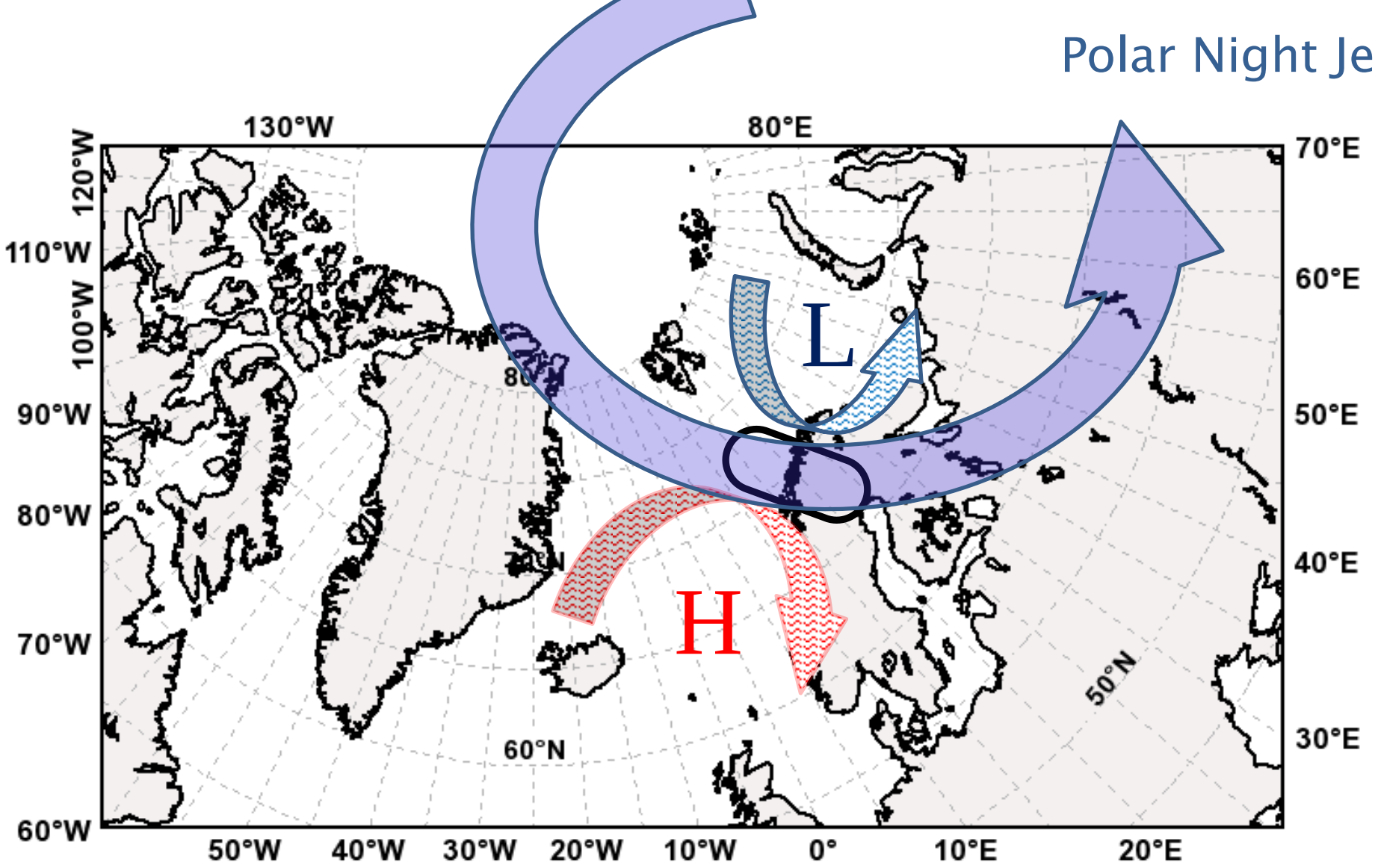
GW-LCYCLE Campaign, 2-14 Dec. 2013, Kiruna, Sweden



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



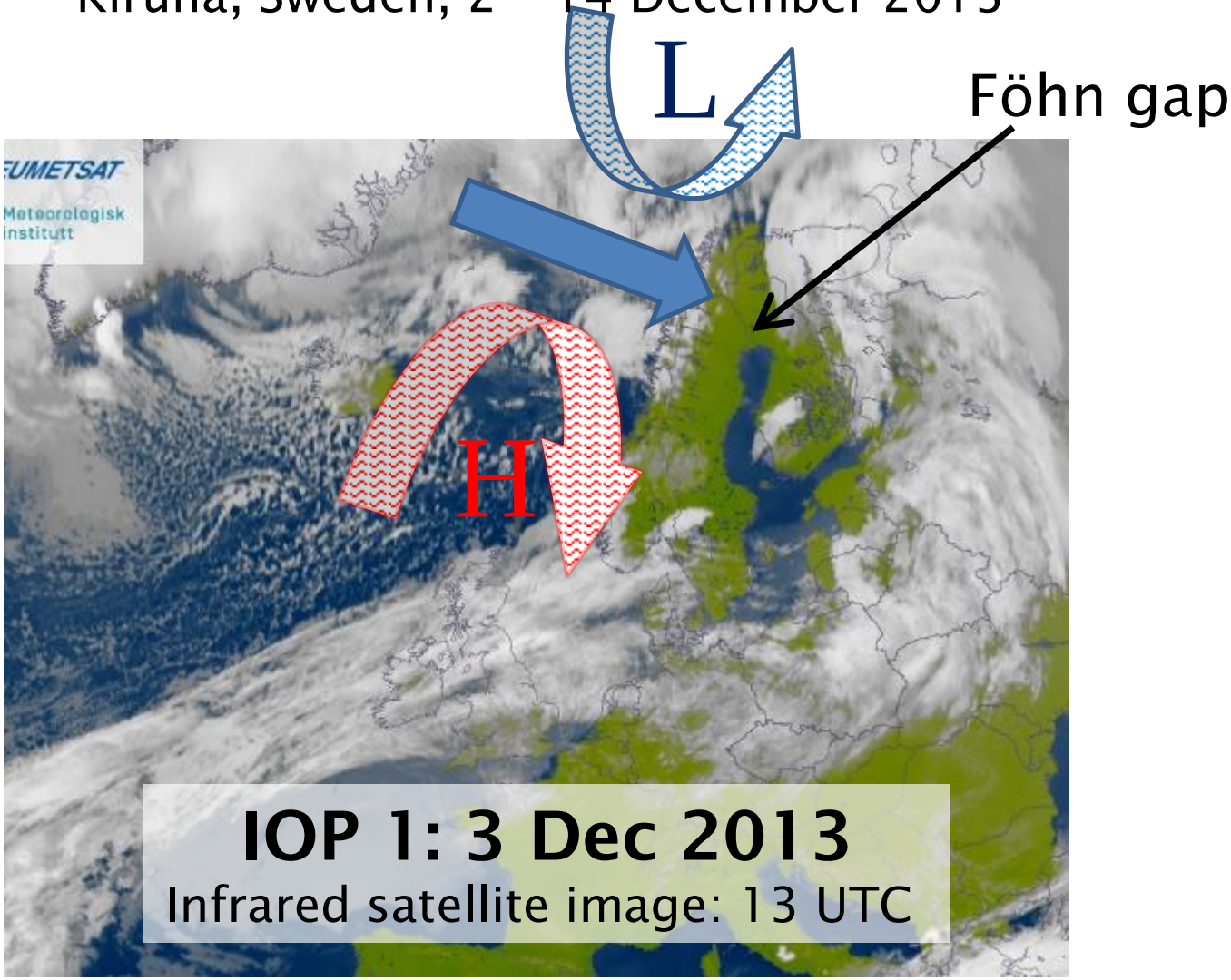
Favorite meteorological conditions:

- 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

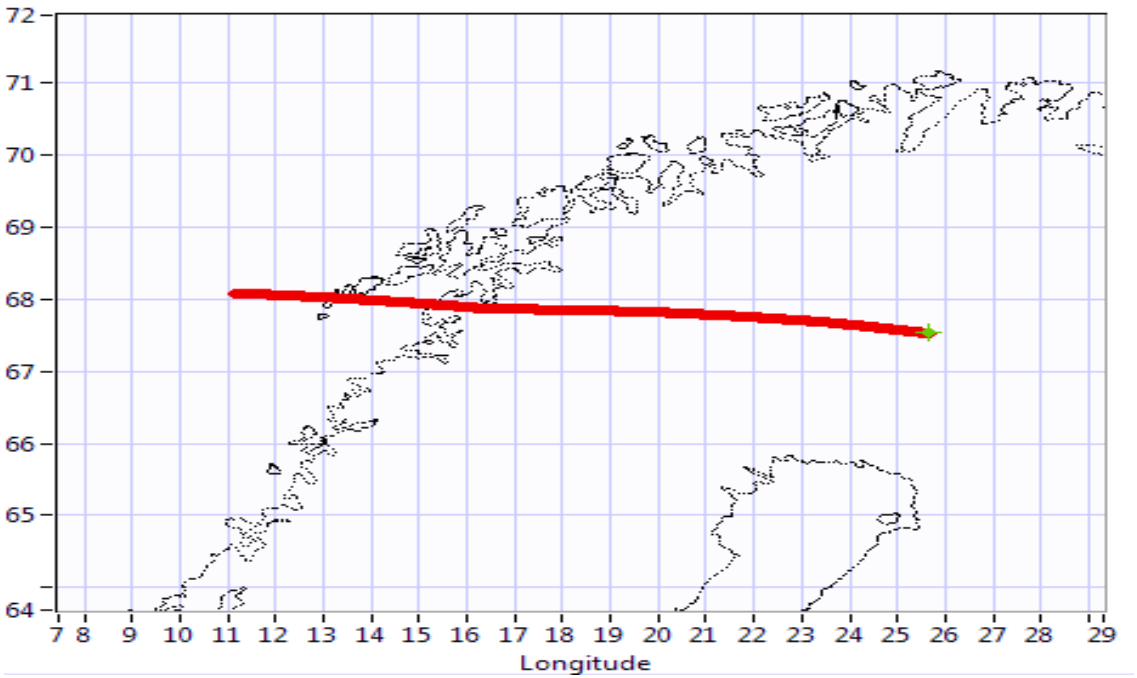
Kiruna, Sweden, 2 – 14 December 2013



2 μm Doppler Wind Lidar Quicklooks IOP 1 03.12. 2013

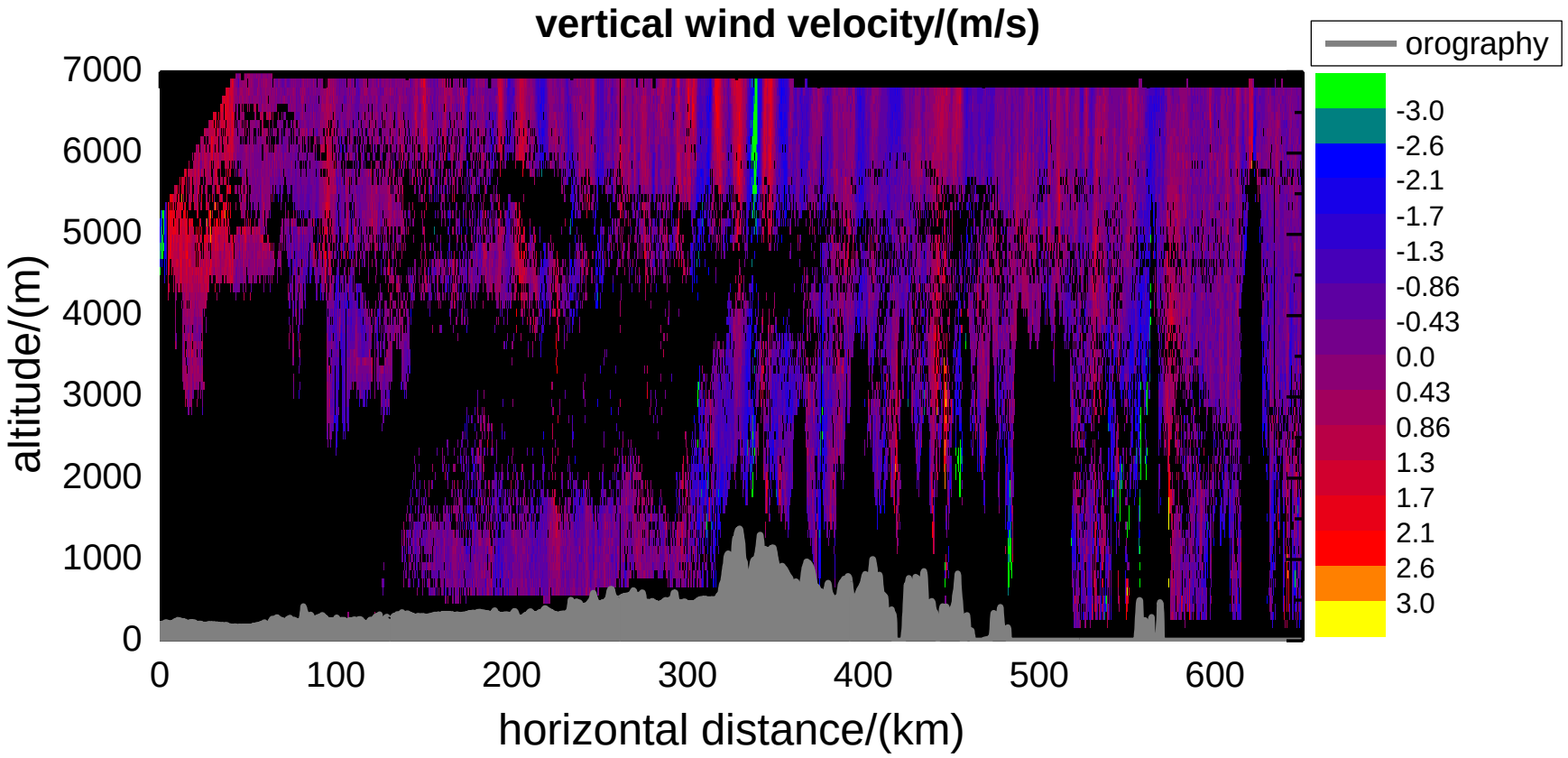
First flight – first lag – East to West

- The instrument was working without any problems
- The coverage was much lager than expected
- Entire flight was performed with fixed LOS (Nadir)
- The shown flight lag was performed in FL 260 (7.9 km asl)



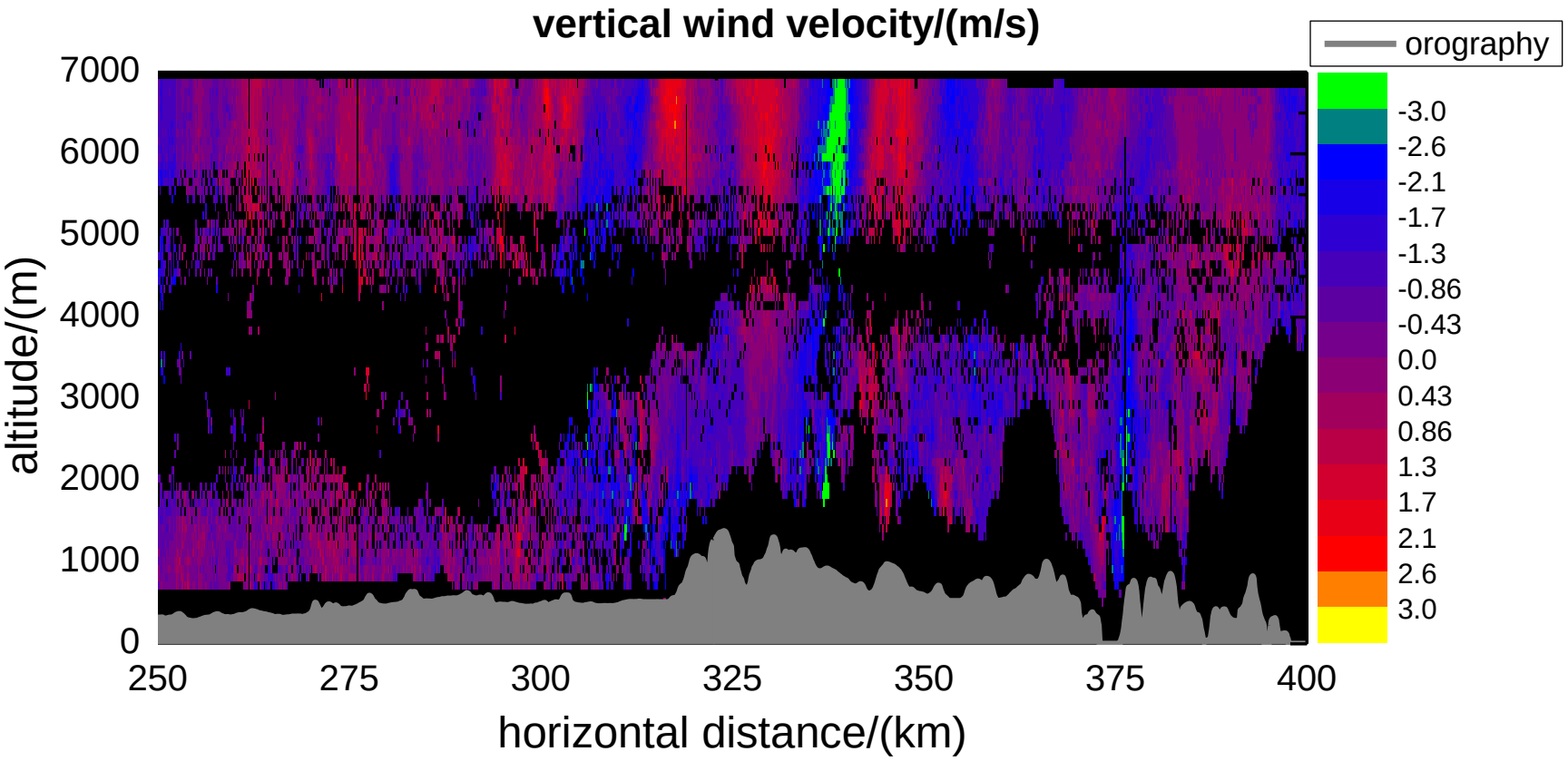
2 μm Doppler Wind Lidar Quicklooks
IOP 1 03.12. 2013

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

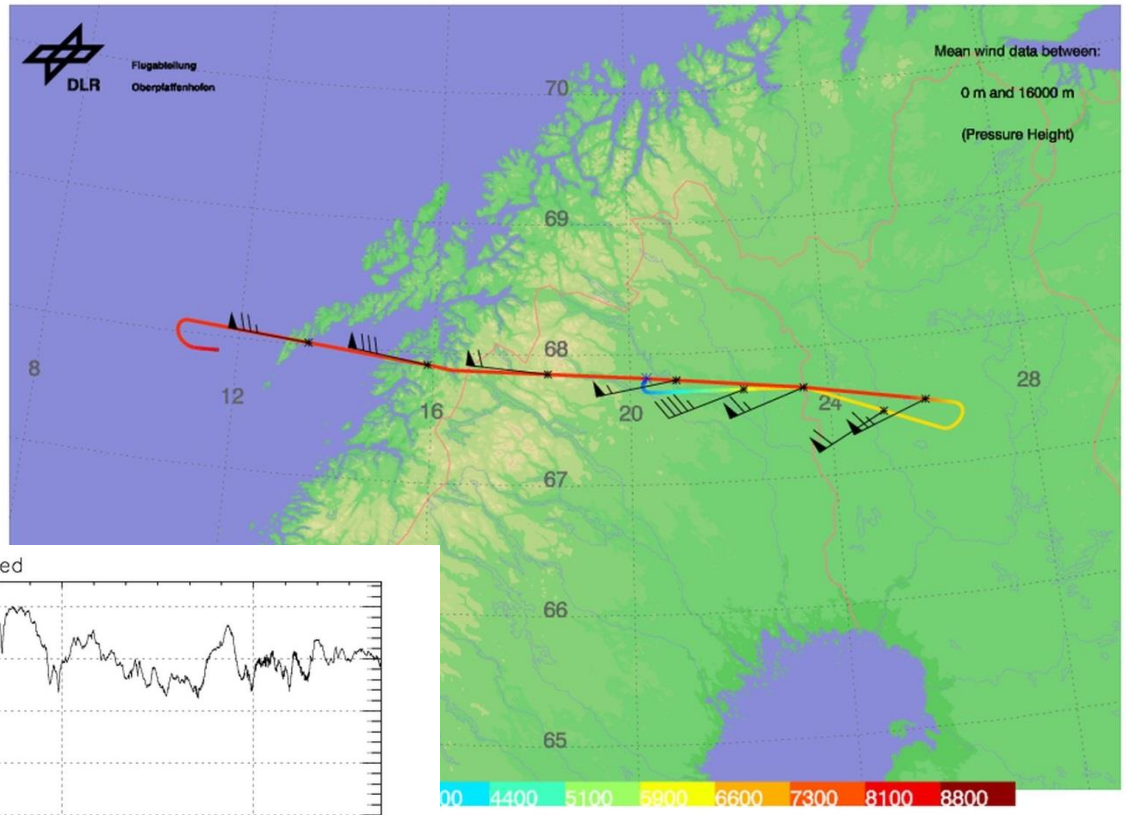


2 μm Doppler Wind Lidar Quicklooks
IOP 1 03.12. 2013

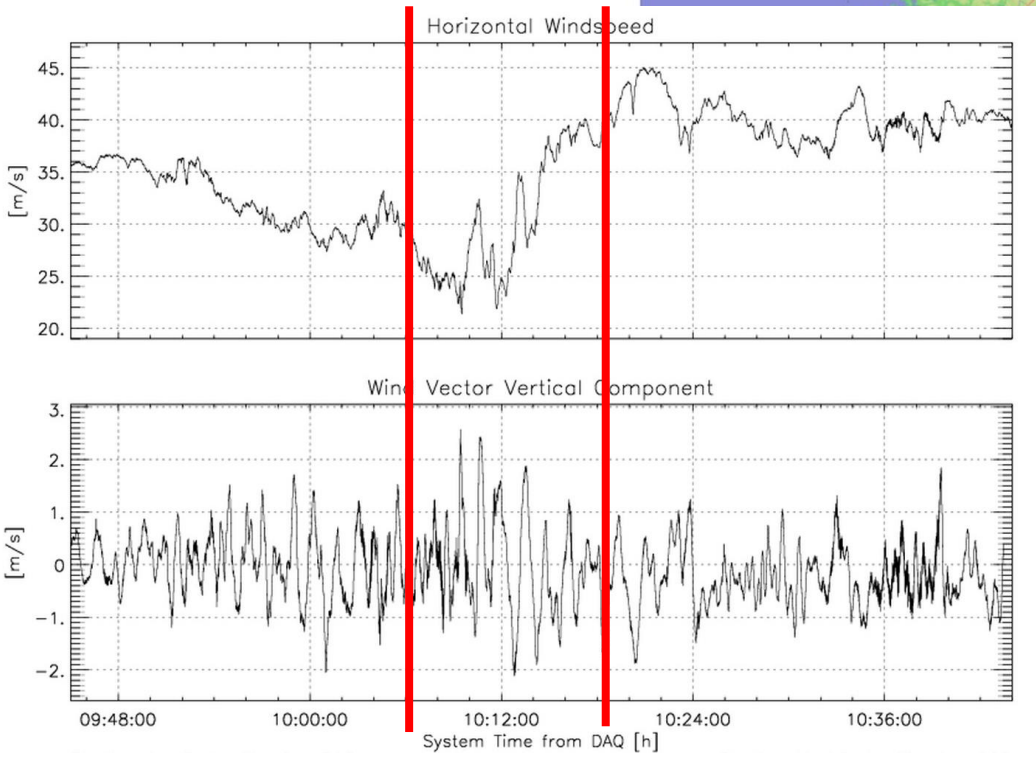
Vertical wind speed (region over the mountains) FL 260
flight direction from East to West



GW-LCYCLE Flug #1 03/12/2013



:47:35 System Time from DAQ SCALE=1:4.00000e+006



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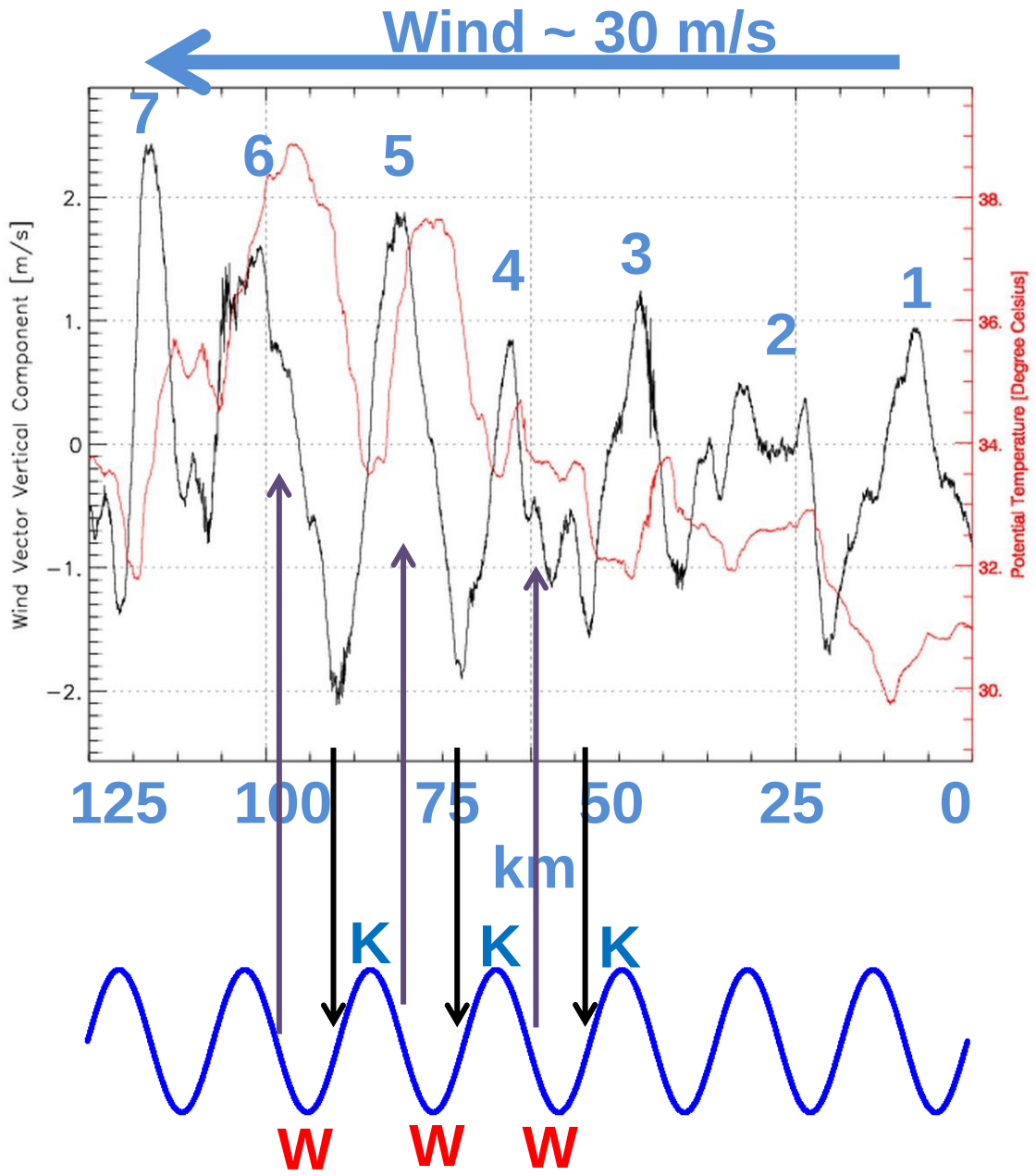
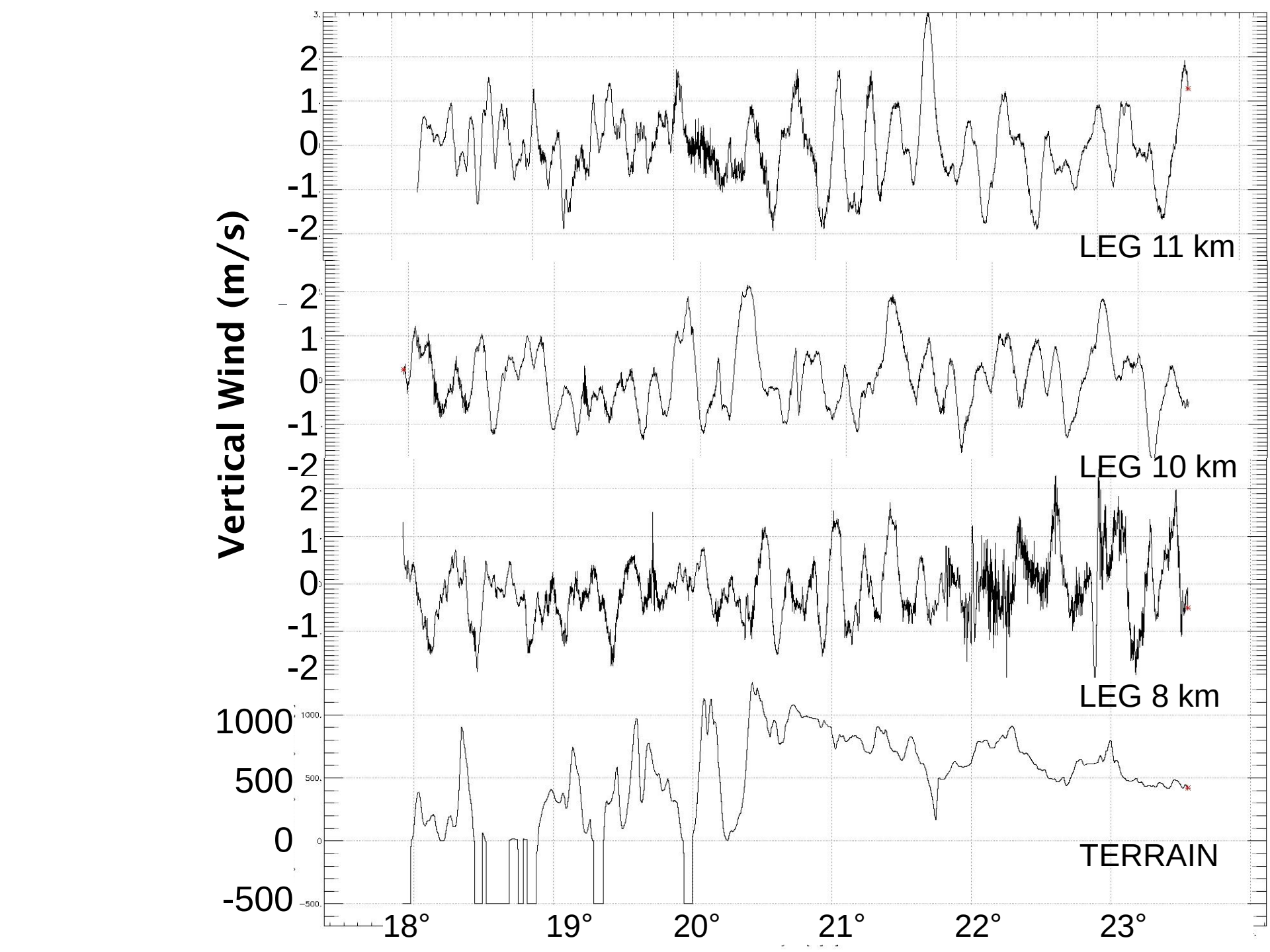
D-CMET
GW-LCYCLE Flug #1 03/12/2013



λ ~ 17 km

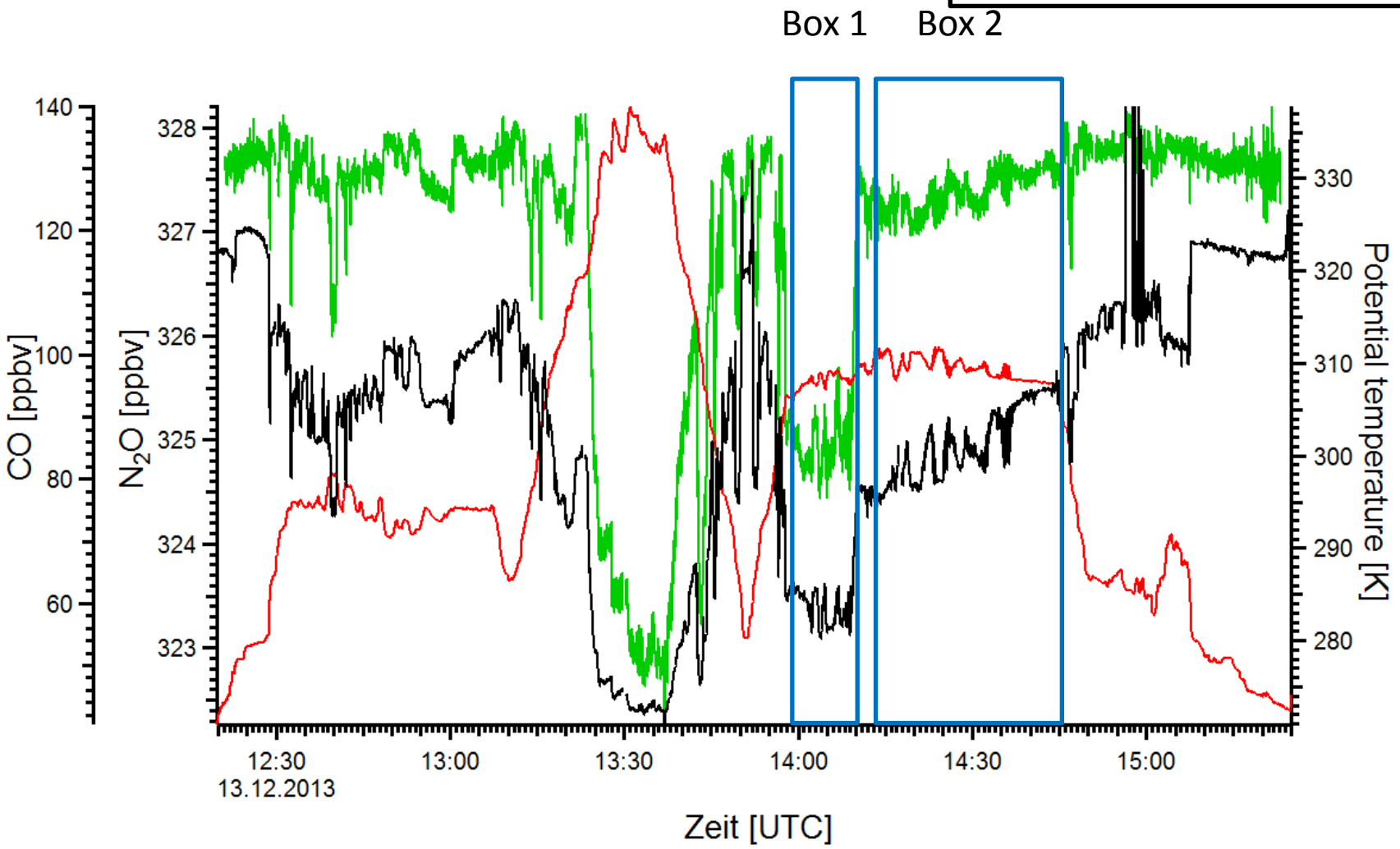

Vertical Wind (m/s)
2
1
0
-1
-2
LEG 11 km
LEG 10 km
LEG 8 km
1000
500
0
-500
TERRAIN
18°
19°
20°
21°
22°
23°

13122013 Flight 6 GW-LCYCLE

CO and N_2O measurements by Uni Mainz (Hoor and Müller)

N_2O gives clear indication for stratospheric air:

N_2O > 327 ppbv : Troposphere
N_2O < 327 ppbv: Stratosphere

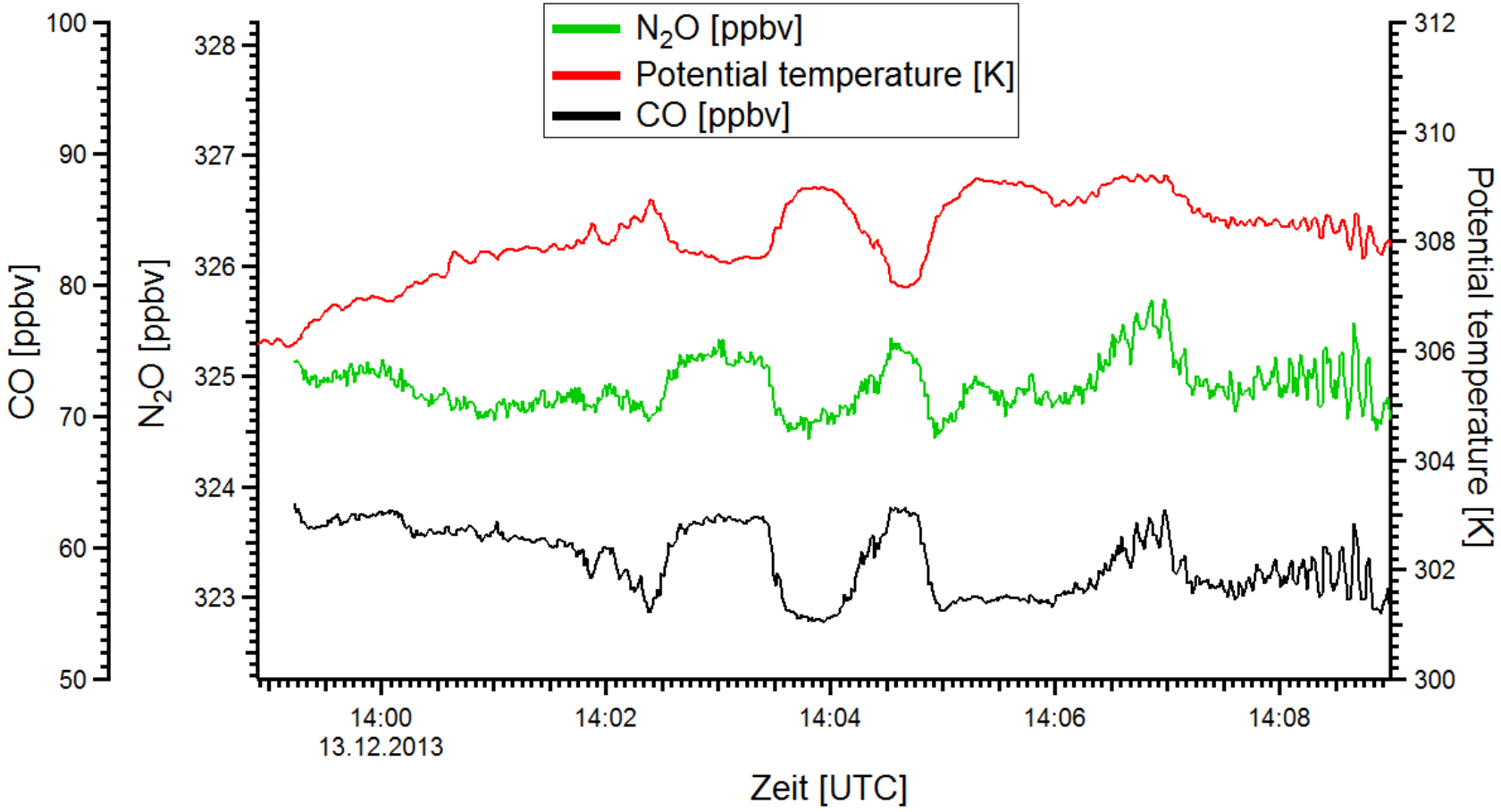


13122013 Flight 6 GW-LCYCLE

CO and N_2O measurements by Uni Mainz (Hoor and Müller)

Box 1

Waves with various wavelengths both to see in N_2O and CO!

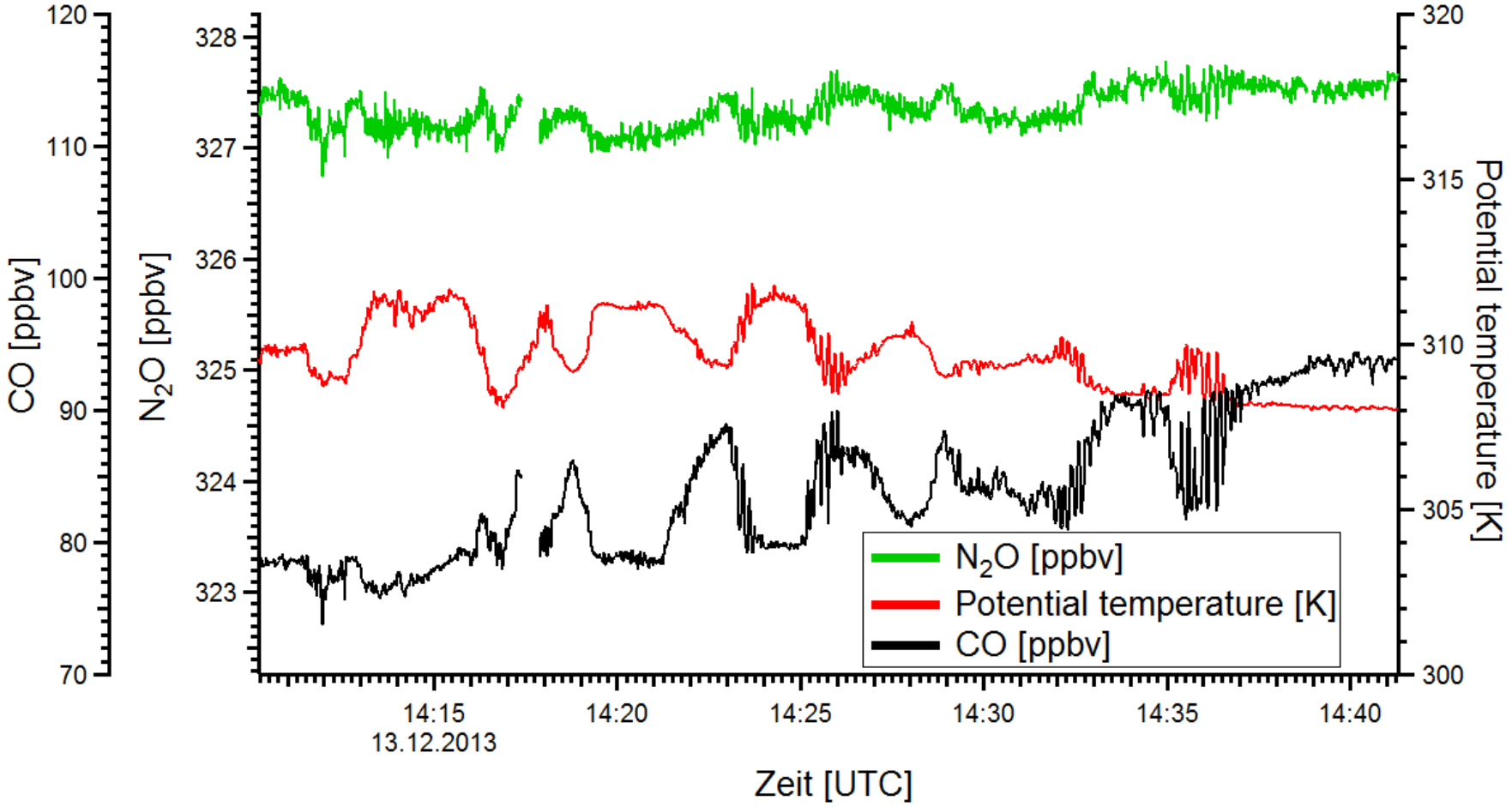


13122013 Flight 6 GW-LCYCLE

CO and N_2O measurements by Uni Mainz (Hoor and Müller)

Box 2

Waves with various wavelengths close to tropopause: stronger signal in CO than in N_2O!



Ground-based observations

Examples from GW-LCYCLE I

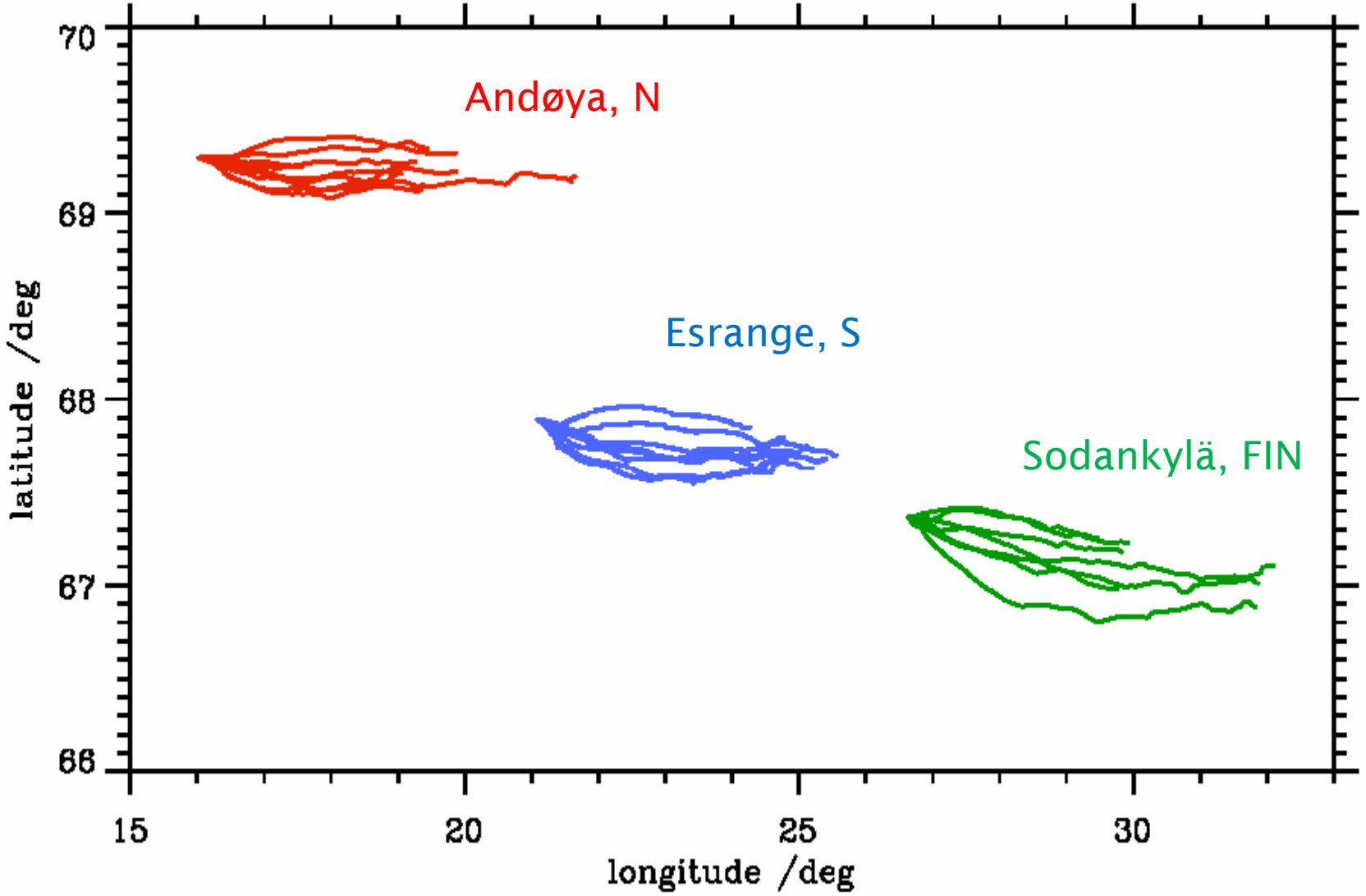
Kiruna, Sweden, 2 – 14 December 2013

Selected examples of IOP 1

- simultaneous 3 hourly radiosonde launches from Andøya, Esrange, Sodankylä

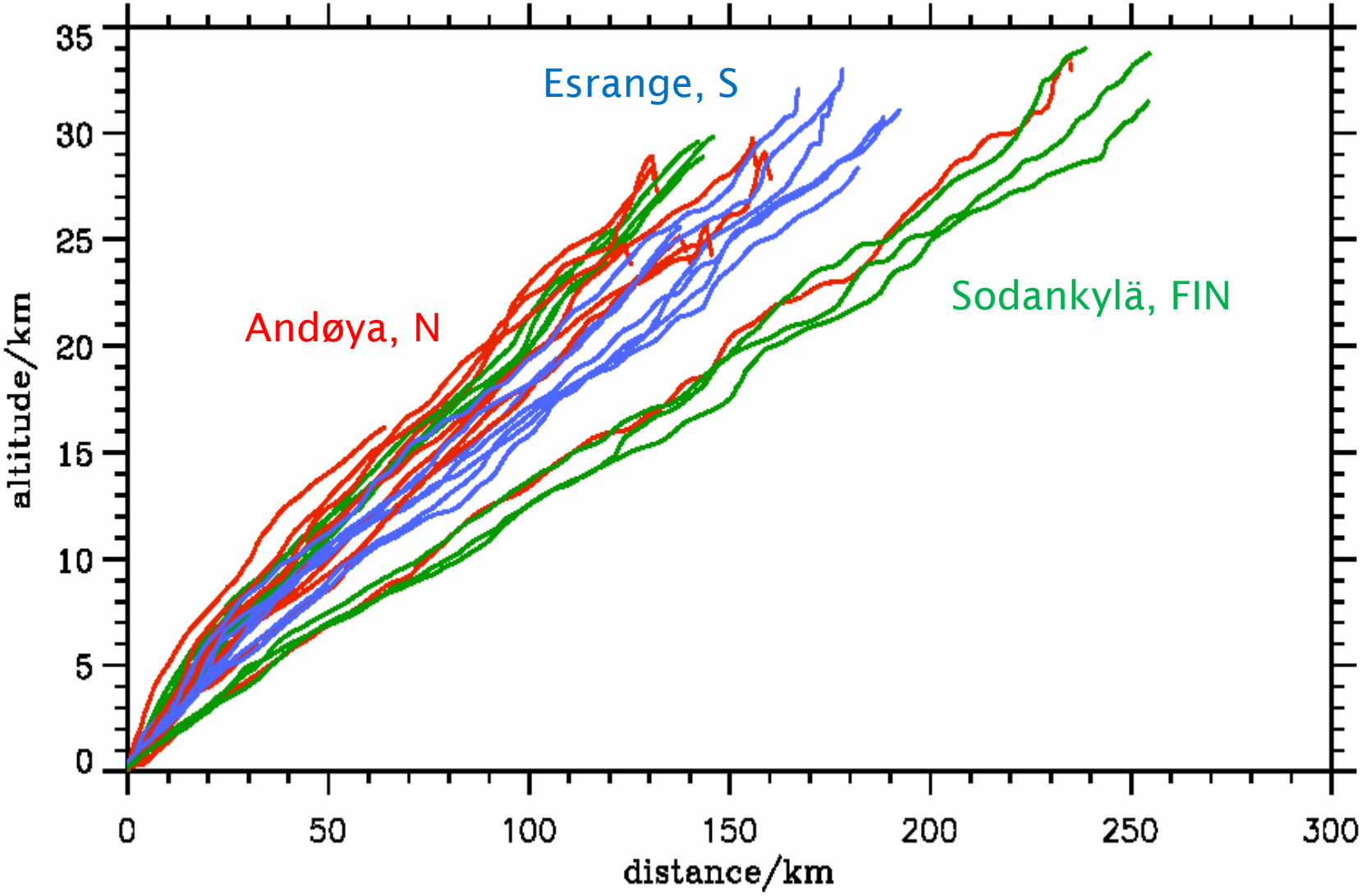
IOP 1 Simultaneous Radiosonde Launches every 3 h

3 December 2013 06 UTC - 4 December 2013 06 UTC



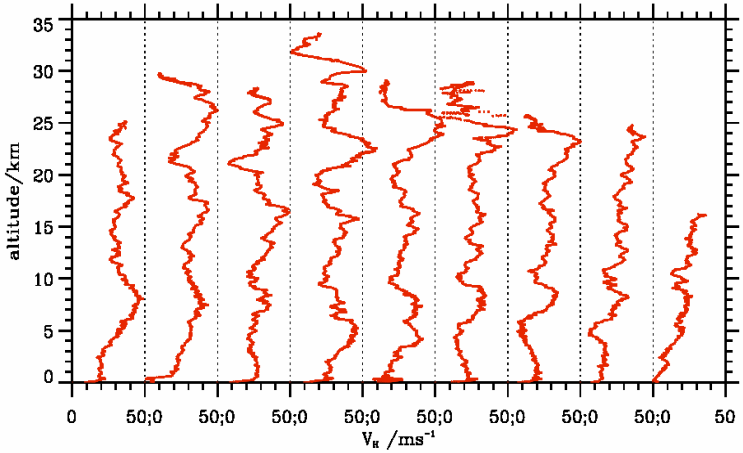
IOP 1 Simultaneous Radiosonde Launches every 3 h

3 December 2013 06 UTC - 4 December 2013 06 UTC

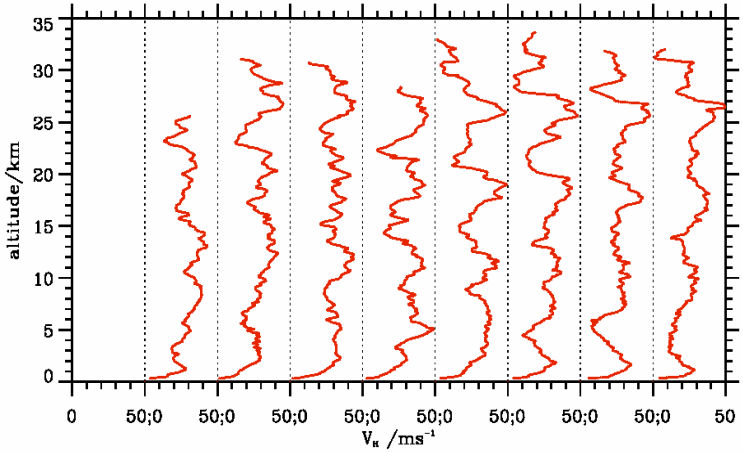


3 Dec 2013 06 09 12 15 18 21 00 03 06 UTC 4 Dec 2013

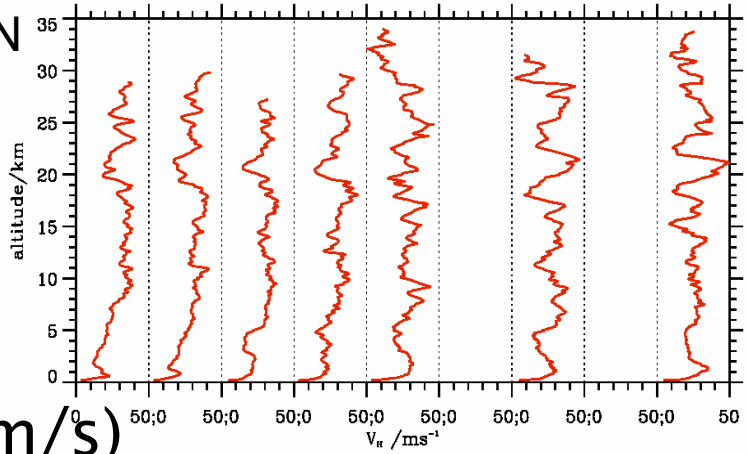
Andøya, N



Esrange, S



Sodankylä, FIN



Horizontal Wind (m/s)

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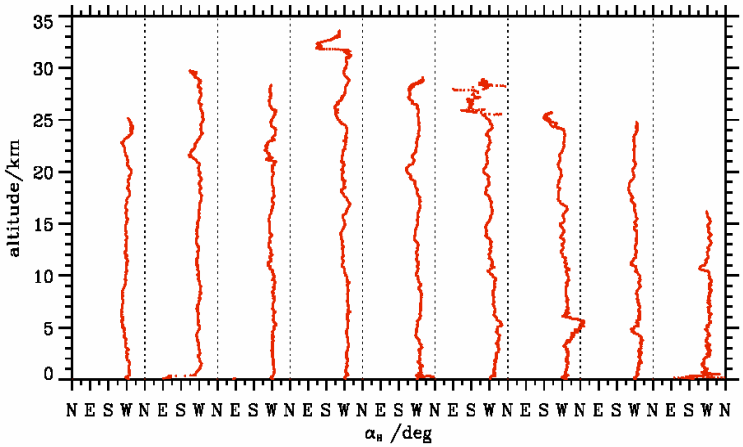
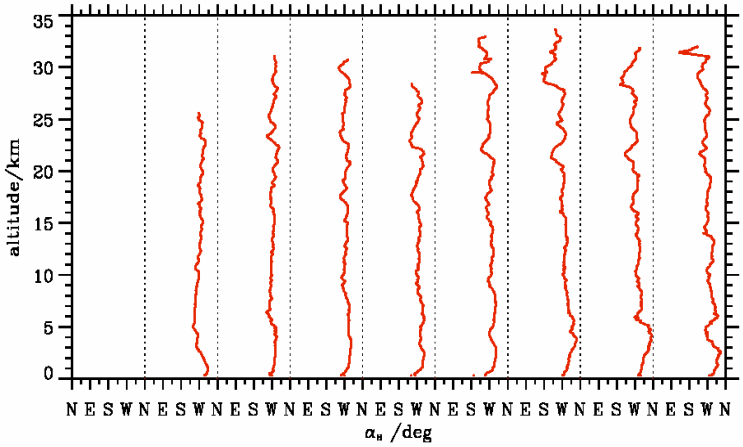
3 Dec 2013 06 09 12 15 18 21 00 03 06 UTC 4 Dec 2013

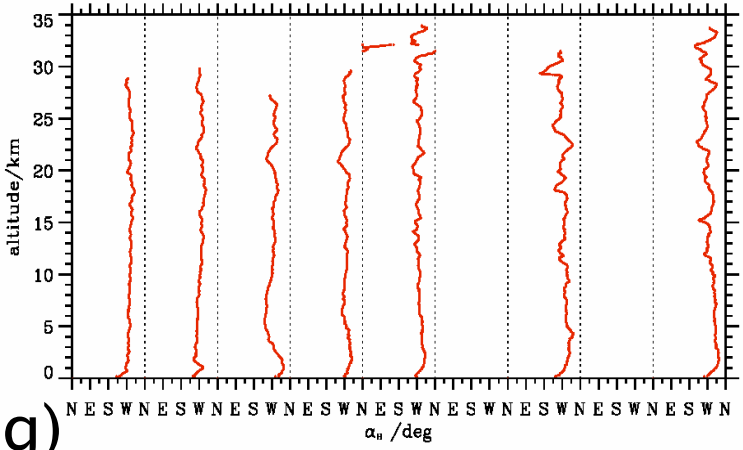
Andøya, N



Esrange, S



Sodankylä, F



Wind direction (deg)

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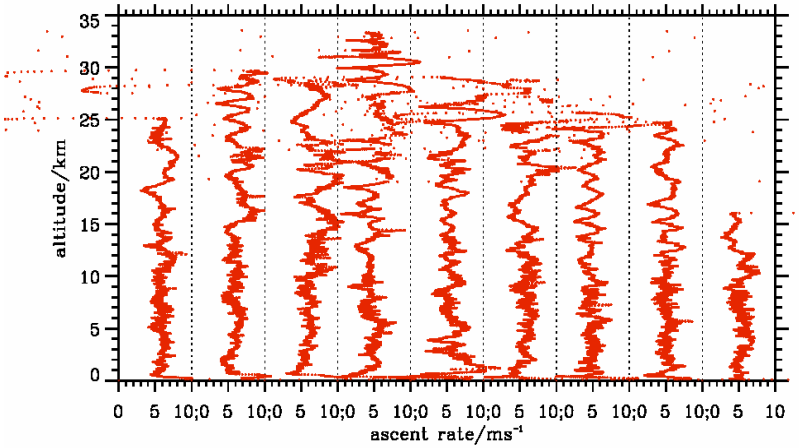
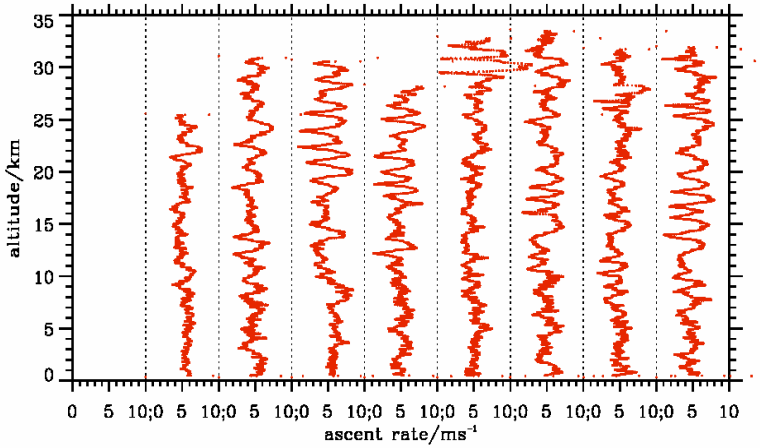
3 Dec 2013 06 09 12 15 18 21 00 03 06 UTC 4 Dec 2013

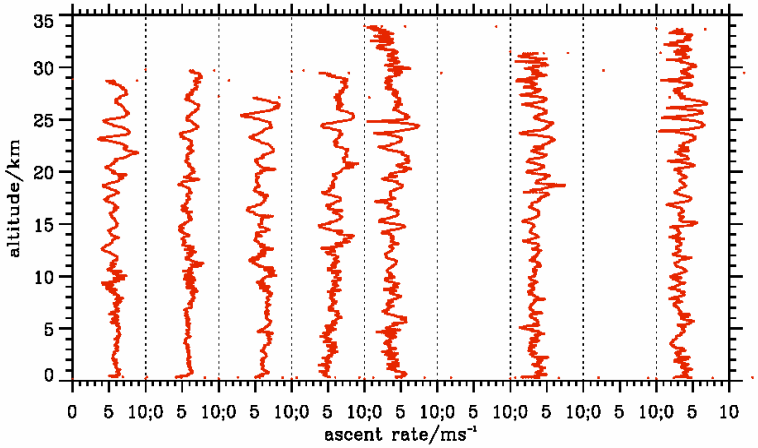
Andøya, N



Esrange, S



Sodankylä, FI



Ascent Rate (m/s)

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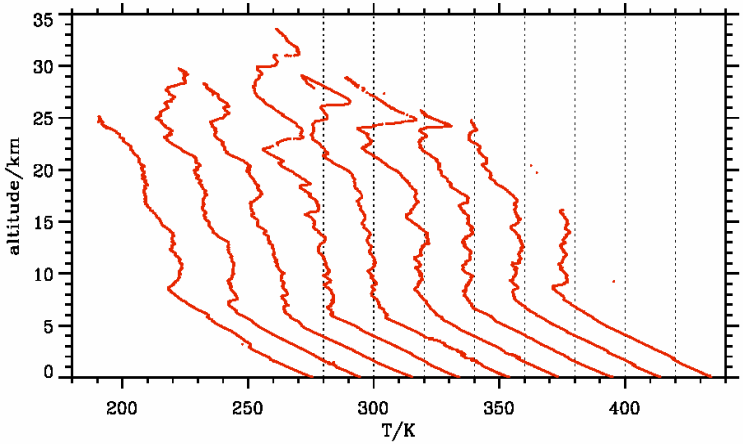
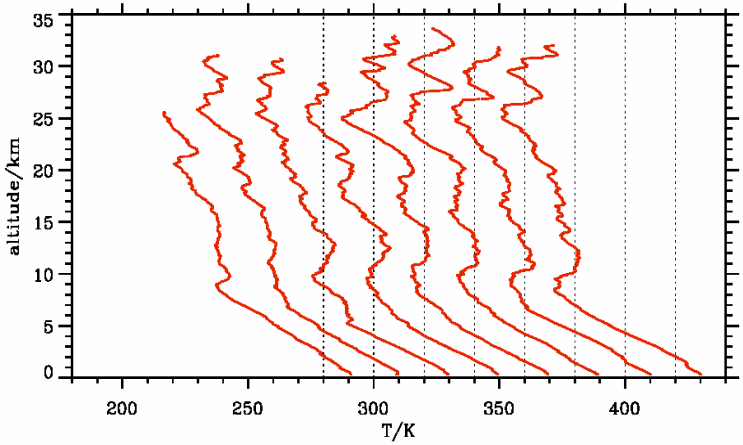
3 Dec 2013 06 09 12 15 18 21 00 03 06 UTC 4 Dec 2013

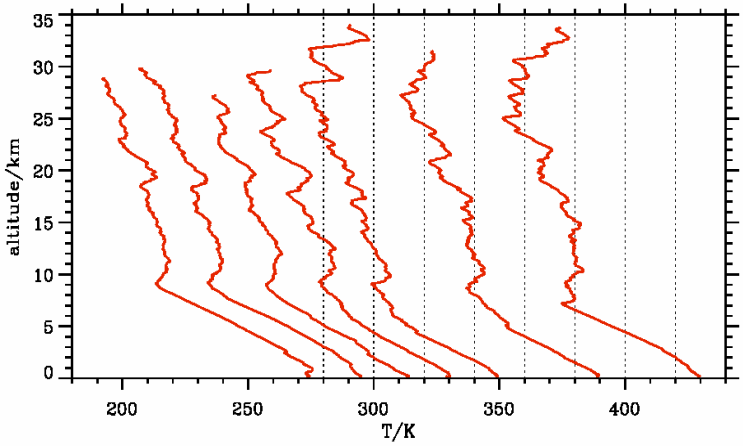
Andøya, N



Esrange, S



Sodankylä, FIN



Temperature (K)

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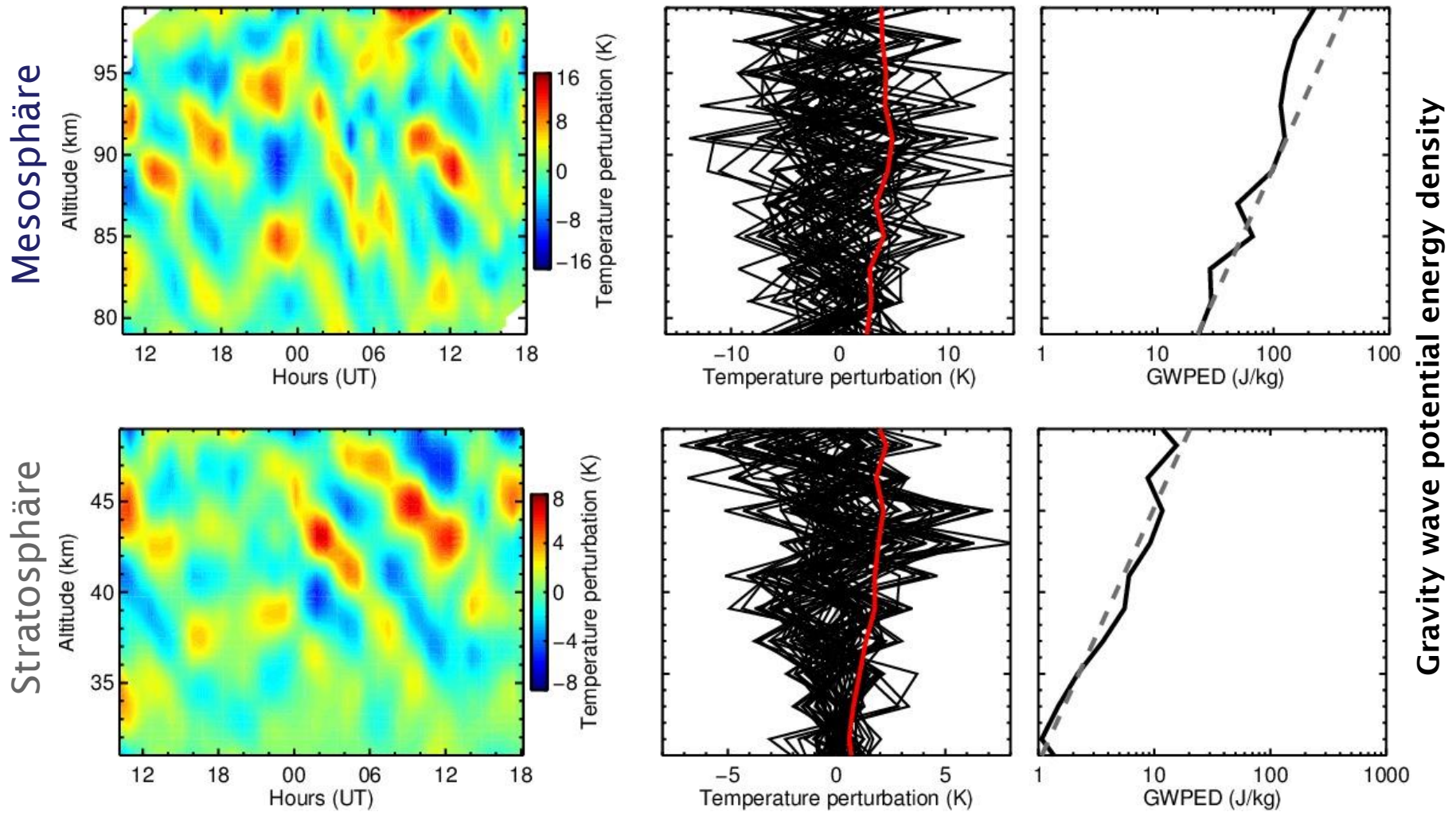
Na-RBR Lidar

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)

Lidar Messungen über Davis
15./16. August 2011



Bernd Kaifler, *Thermal Structure and Gravity Waves in the Antarctic Middle Atmosphere Observed by Lidar*, PhD Thesis, 2013

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_{TOP} ~ 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

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