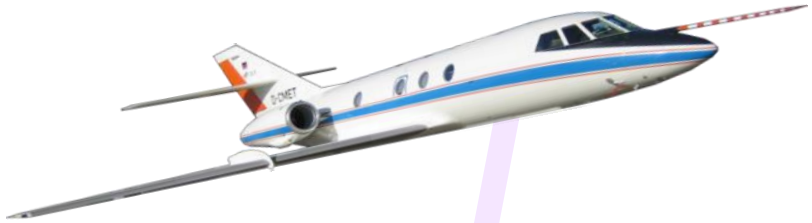
Overview of 2µ wind lidar data acquired during DEEPWAVE

Benjamin Witschas
Stephan Rahm, Fernando Chouza Keil, Rudolf Simmet, Johannes Wagner, et al.



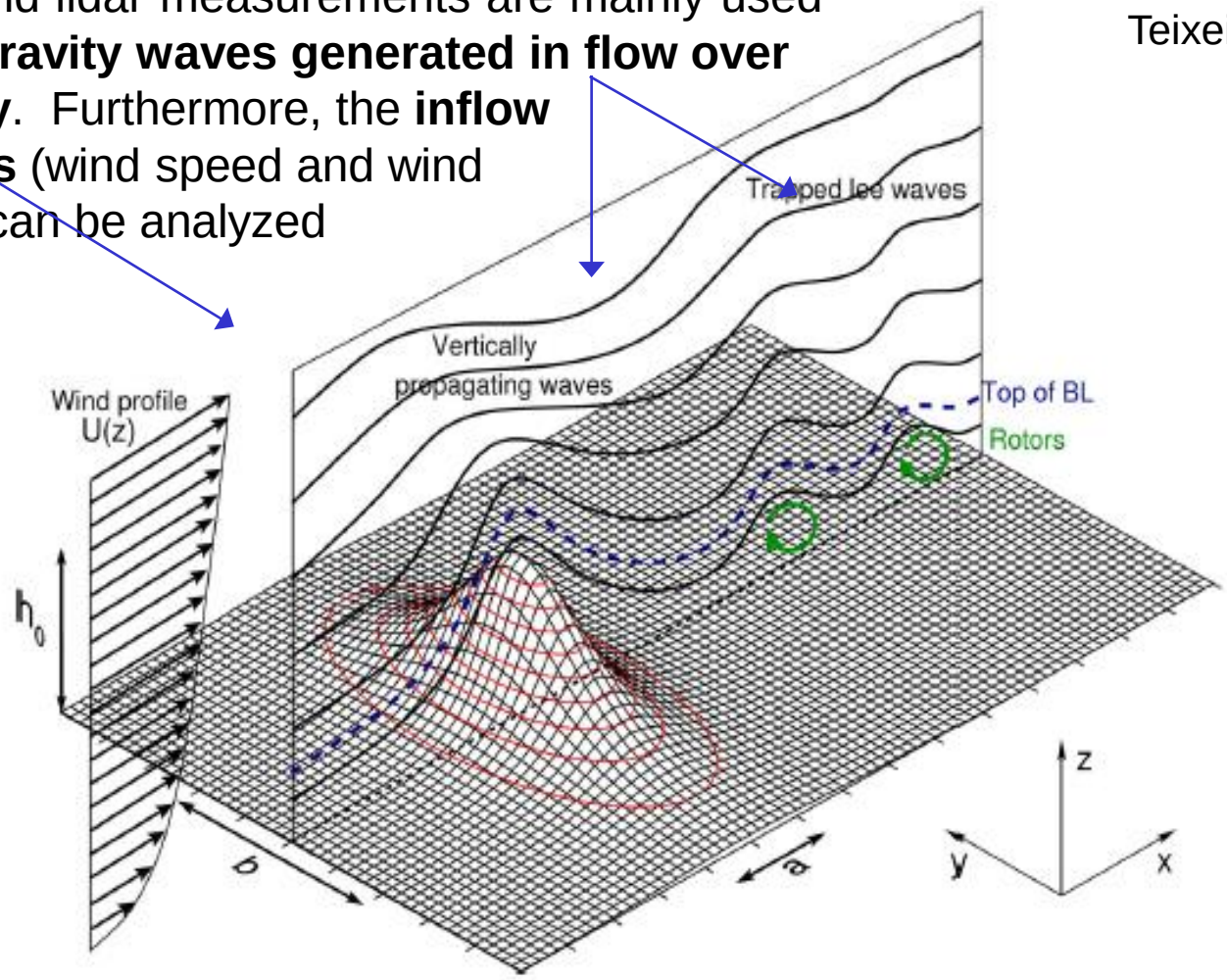
DLR

Introduction

The 2µ wind lidar within the Deepwave campaign

The 2µ wind lidar measurements are mainly used to **study gravity waves generated in flow over orography**. Furthermore, the **inflow conditions** (wind speed and wind direction) can be analyzed (scanning mode).

Teixeira, 2014



Introduction

Instrument description

Transceiver specifications

- Wavelength 2.022 µm
- repetition rate 500 Hz
- pulse energy 1.5 mJ
- pulse length 0.5 µs (150 m)

Resolution:

- Vertical **100 m**
- Horizontal (scan) ~**6.7 km** (32 s)
- Horizontal (Nadir) ~**0.2 km** (1 s)

Accuracy

- Better than **1 m/s**

Off-axis telescope:

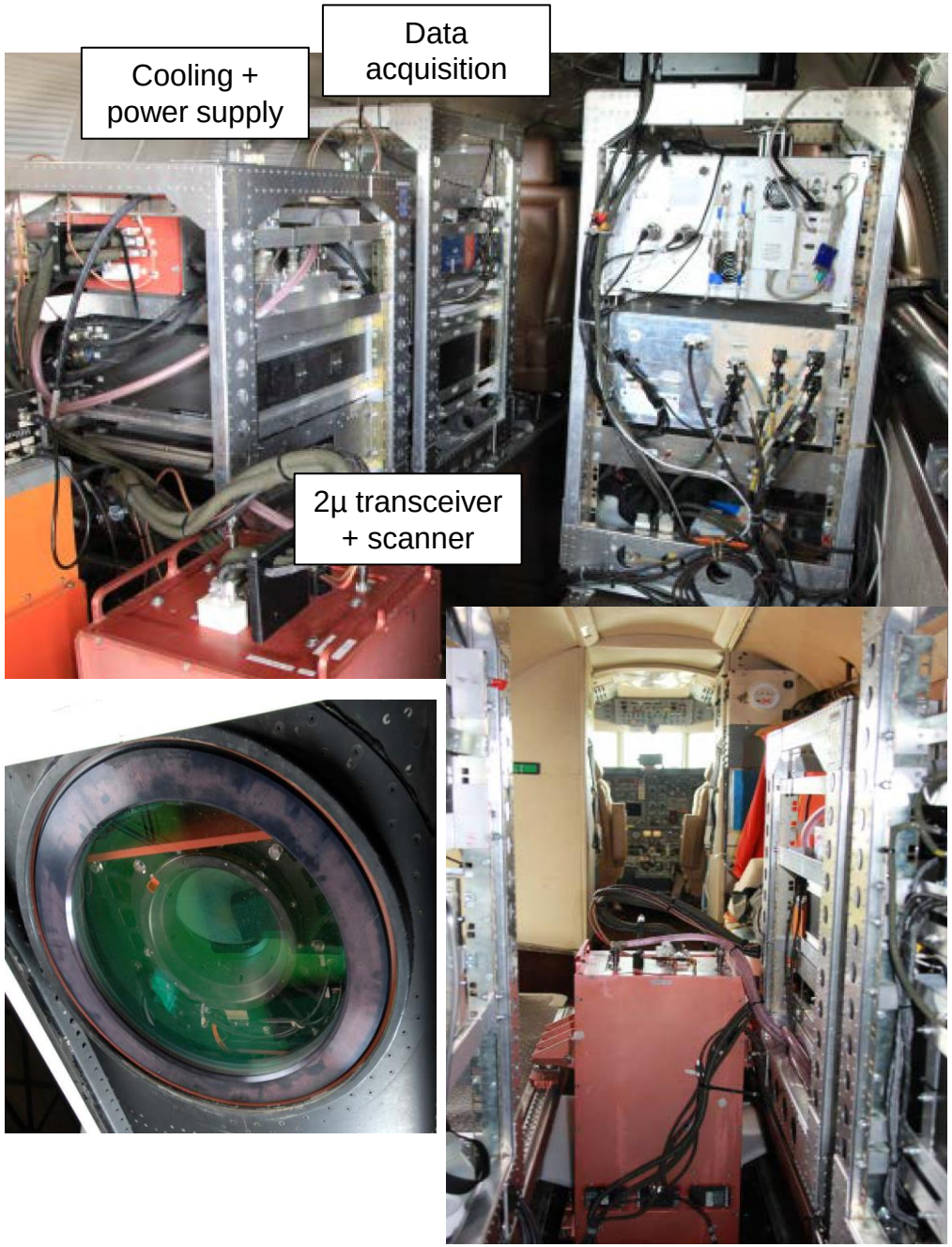
- Aperture 10 cm

Double Wedge Scanner:

- Elevation sector +/- 30 °
- Scan speed variable

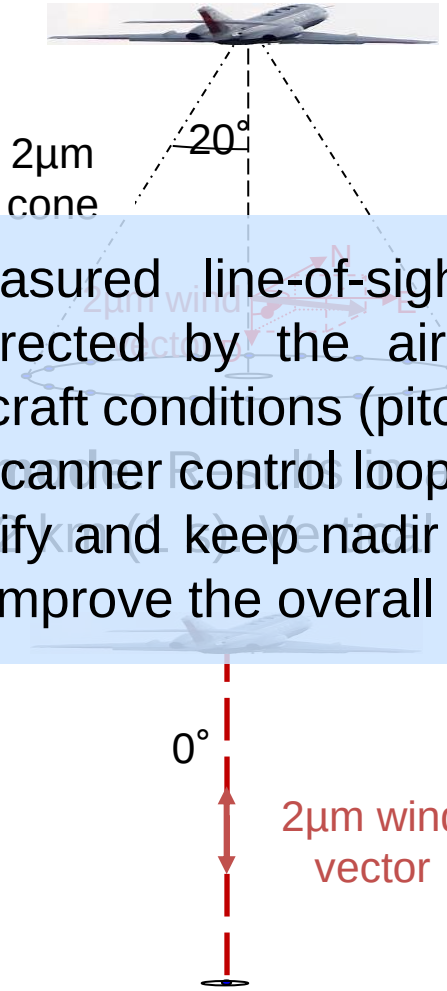
Sign convention

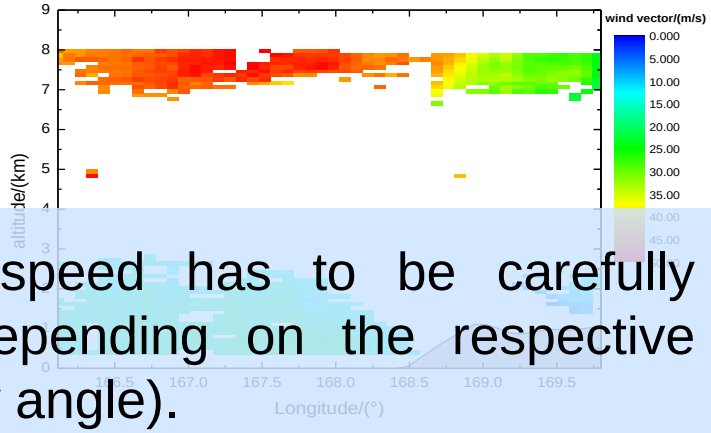
- "+" = towards the Lidar
- "-" = away from the Lidar



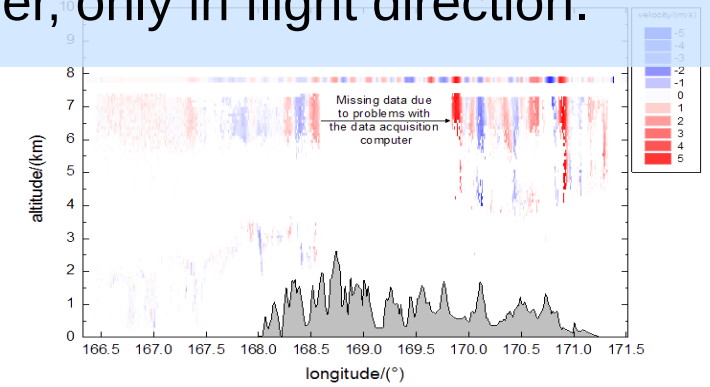
Operation principle – scanning / fix LOS mode

Scanning model: Results in a 3D wind vector with a horizontal resolution of ~**6.7 km** (32 s). Vertical resolution ~**100 m**.



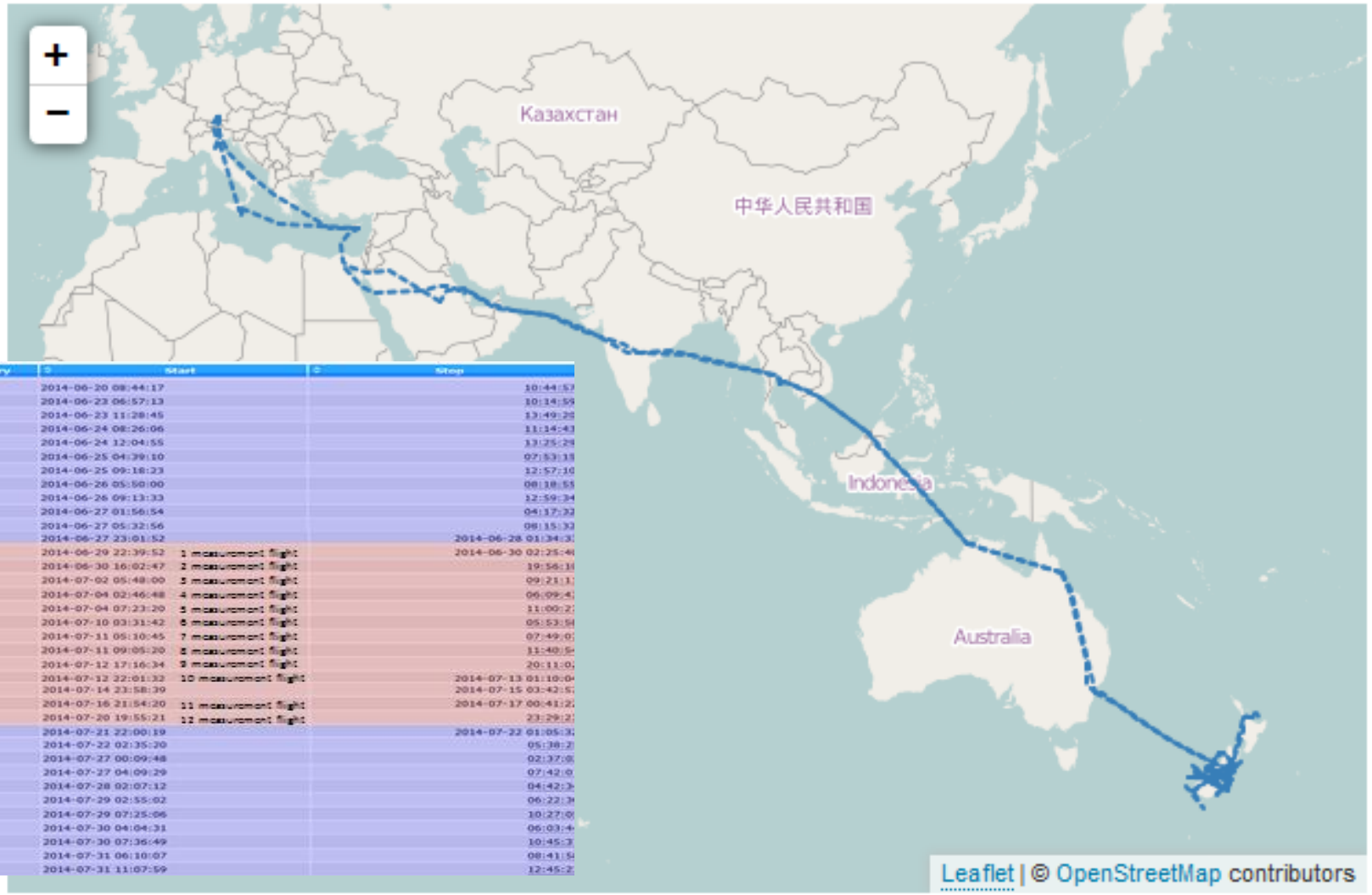


- Measured line-of-sight (LOS) wind speed has to be carefully corrected by the aircraft velocity, depending on the respective aircraft conditions (pitch-, roll-, and yaw angle).
- A scanner control loop based on ARINC-data was applied in order to verify and keep nadir pointing. Ground reference (zero wind) helps to improve the overall accuracy, however, only in flight direction.



Overview of conducted flights

MAP OF THE MEASURING AREA



Flights	Category	Start		Stop
40620a	Falcon	2014-06-20 08:44:17		10:44:57
40623a	Falcon	2014-06-23 06:57:13		10:14:59
40623b	Falcon	2014-06-23 11:28:45		13:49:28
40624a	Falcon	2014-06-24 08:26:06		11:14:43
40624b	Falcon	2014-06-24 12:04:55		13:25:29
40625a	Falcon	2014-06-25 04:39:10		07:53:13
40625b	Falcon	2014-06-25 09:18:23		12:57:10
40626a	Falcon	2014-06-26 05:50:00		08:18:55
40626b	Falcon	2014-06-26 09:13:33		12:59:34
40627a	Falcon	2014-06-27 01:56:54		04:17:32
40627b	Falcon	2014-06-27 05:32:56		08:15:33
40627c	Falcon	2014-06-27 23:01:52		2014-06-28 01:34:3
40629a	Falcon	2014-06-29 22:39:52	1 measurment flight	2014-06-30 02:25:4
40630a	Falcon	2014-06-30 16:02:47	2 measurment flight	19:56:1
40702a	Falcon	2014-07-02 05:48:00	3 measurment flight	09:21:1
40704a	Falcon	2014-07-04 02:46:48	4 measurment flight	06:09:4
40704b	Falcon	2014-07-04 07:23:20	5 measurment flight	11:00:2
40710a	Falcon	2014-07-10 03:31:42	6 measurment flight	05:53:5
40711a	Falcon	2014-07-11 05:10:45	7 measurment flight	07:49:0
40711b	Falcon	2014-07-11 09:05:20	8 measurment flight	11:40:5
40712a	Falcon	2014-07-12 17:16:34	9 measurment flight	20:11:0
40712b	Falcon	2014-07-12 22:01:32	10 measurment flight	2014-07-13 01:10:0
40714a	Falcon	2014-07-14 23:58:39		2014-07-15 03:42:5
40716a	Falcon	2014-07-16 21:54:20	11 measurment flight	2014-07-17 00:41:2
40720a	Falcon	2014-07-20 19:55:21	12 measurment flight	23:29:2
40721a	Falcon	2014-07-21 22:00:19		2014-07-22 01:05:3
40722a	Falcon	2014-07-22 02:35:20		05:38:2
40727a	Falcon	2014-07-27 00:09:48		02:37:0
40727b	Falcon	2014-07-27 04:09:29		07:42:0
40728a	Falcon	2014-07-28 02:07:12		04:42:3
40729a	Falcon	2014-07-29 02:55:02		06:22:3
40729b	Falcon	2014-07-29 07:25:06		10:27:0
40730a	Falcon	2014-07-30 04:04:31		06:03:4
40730b	Falcon	2014-07-30 07:36:49		10:45:3
40731a	Falcon	2014-07-31 06:10:07		08:41:5
40731b	Falcon	2014-07-31 11:07:59		12:45:2

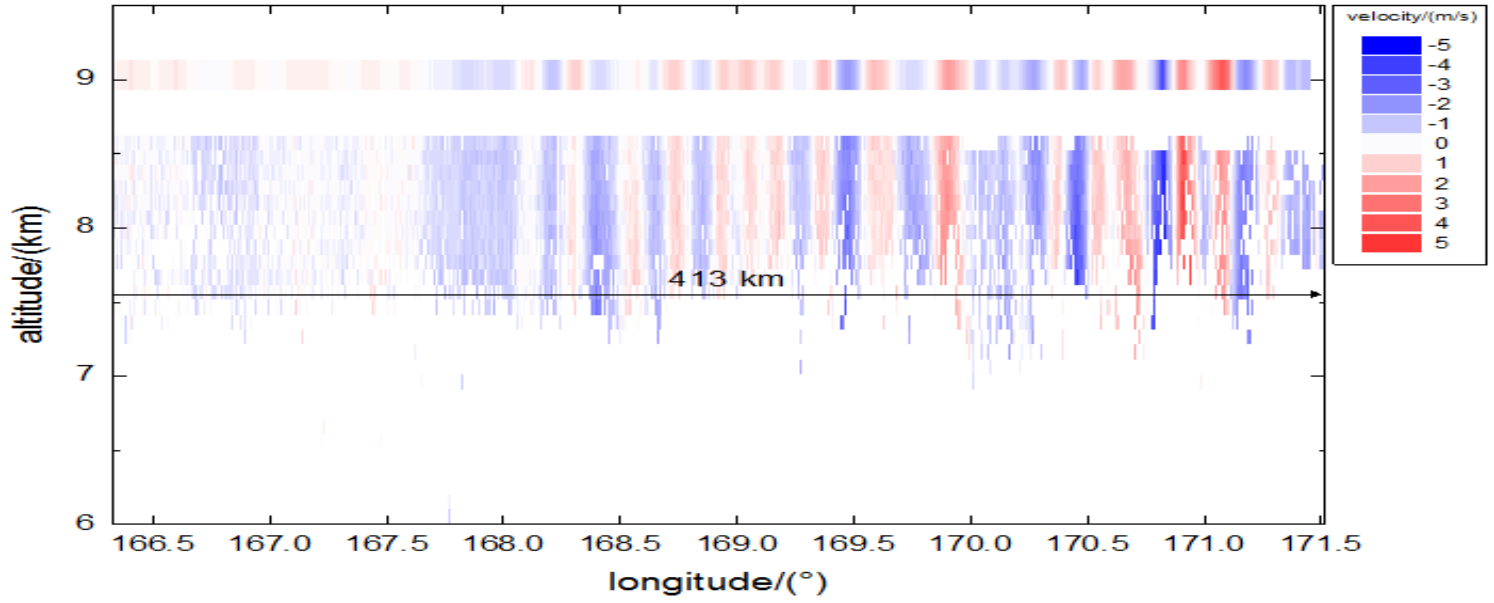
Overview of conducted flights

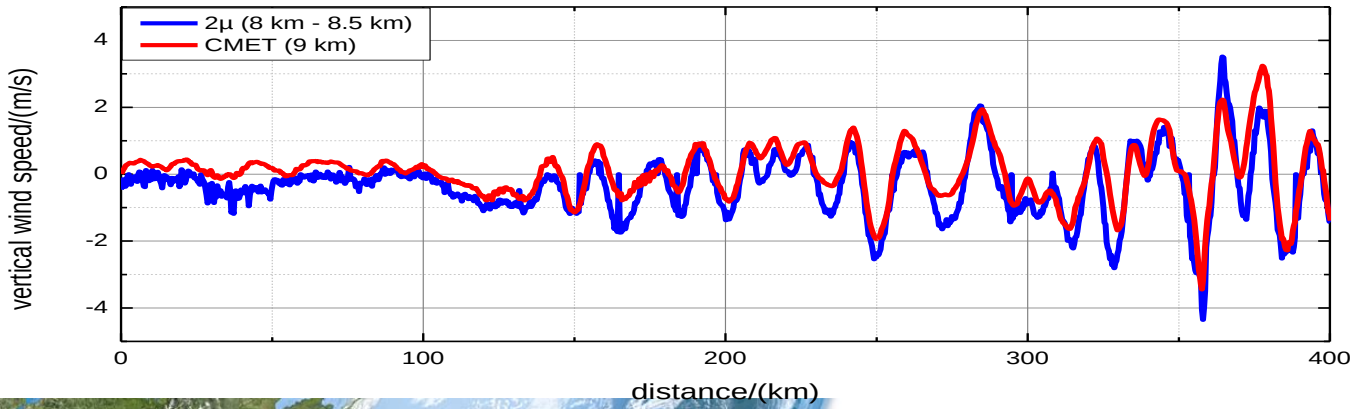
Flight No	IOP	Date	Objective
RF-F01, RF-F02	9	30 June-1 July	GW event under transient forcing
RF-F03		2 July	tropopause fold
RF-F04, RF-F05	10	4 July	GW event under WSW flow
RF-F06	10	10 July	intercomparison
RF-F07, RF-F08	12	11 July	GW event under strong NW winds
RF-F09, RF-F10	13	13 July	GW event with strongly varying responses
RF-F11		14 July	volcanoe
RF-F12	15	17 July	critical level flow
RF-F13	16	20 July	GWs in SW flow

- The 2µ wind lidar was working well during the entire campaign period.
  - Missing SBAS information and a corrupt GPS-module software caused a few data gaps at the beginning of the campaign.
  - The low aerosol/ice/water content in New Zealand caused low coverage.
- All measurements are processed, converted to .netcdf, and will be uploaded to the HALO-database

2014-07-04b – comparison to Falcon in-situ wind

- The same longitudinal grid size is used to interpolate the Falcon in-situ data (mainly vertical wind)

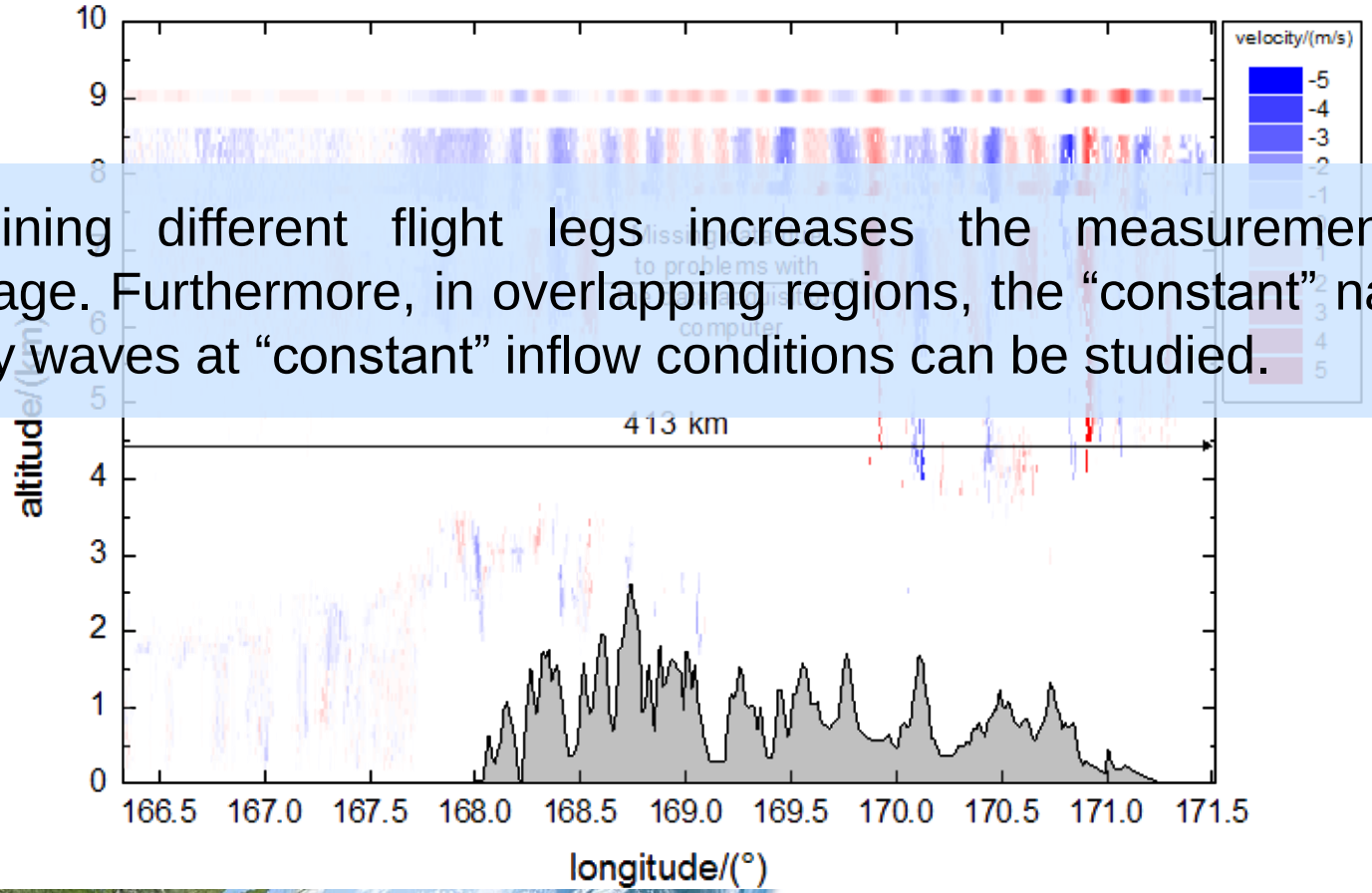




2014-07-04b – combining different flight legs

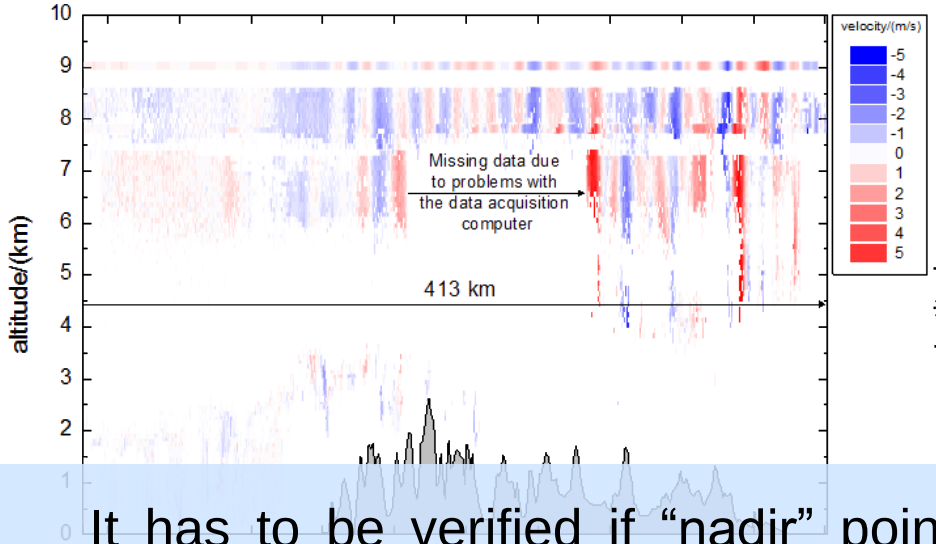
"Clear" air over New Zealand decreases the coverage of 2µ wind lidar measurements

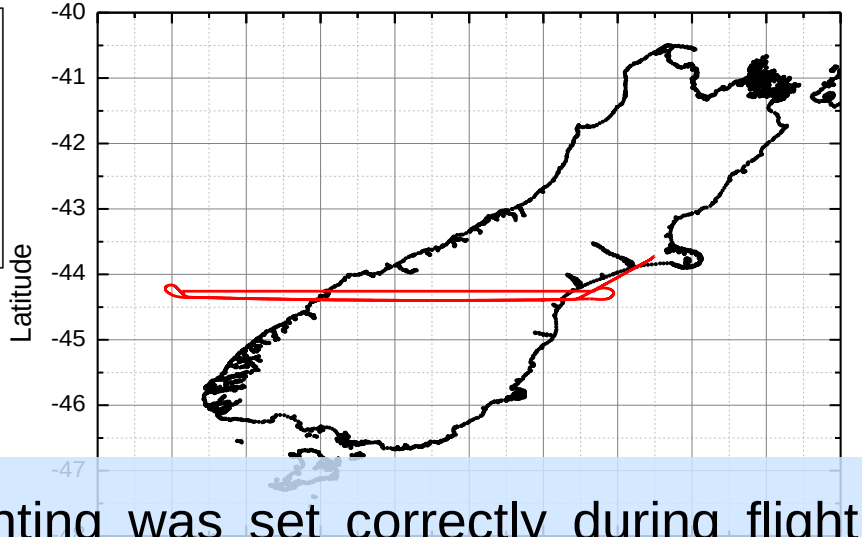
→ Flight legs in different altitudes (but same geographical location) were flown (also because of in-situ measurements) and can be combined.



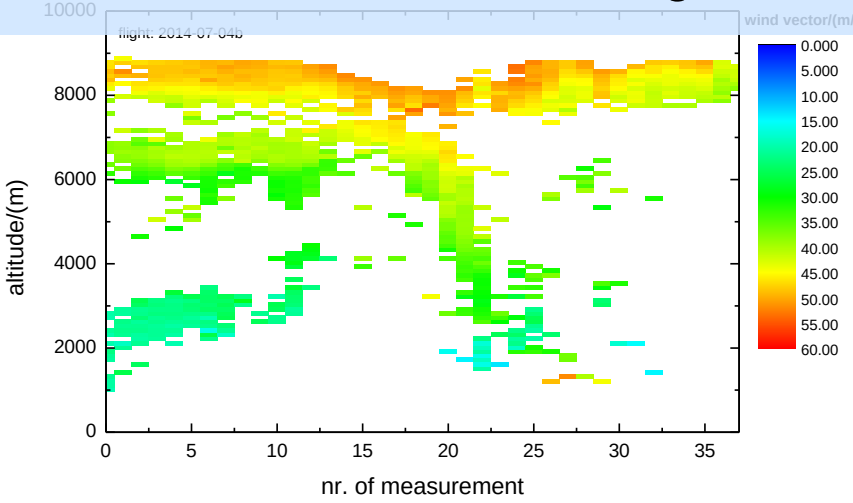
Combining different flight legs increases the measurement data coverage. Furthermore, in overlapping regions, the "constant" nature of gravity waves at "constant" inflow conditions can be studied.

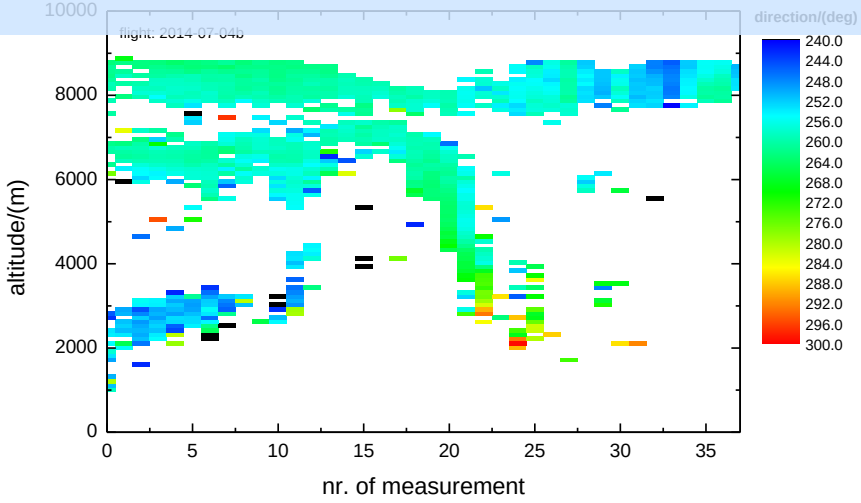
2014-07-04b – optional correction for vertical wind



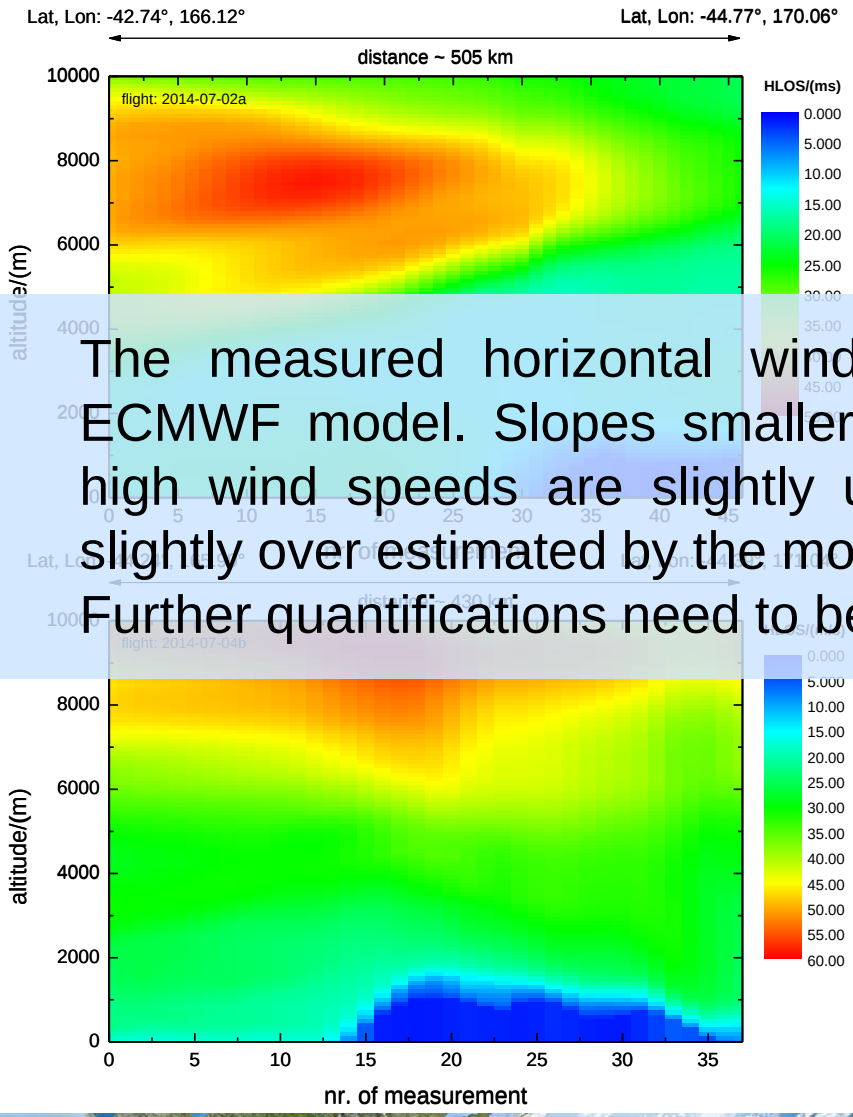


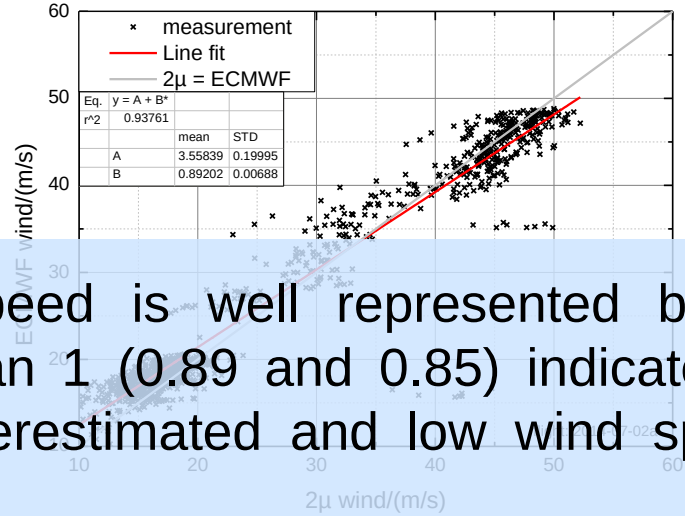
It has to be verified if “nadir” pointing was set correctly during flight (especially perpendicular to flight direction). Different legs and wind vector measurement might be used for correction.



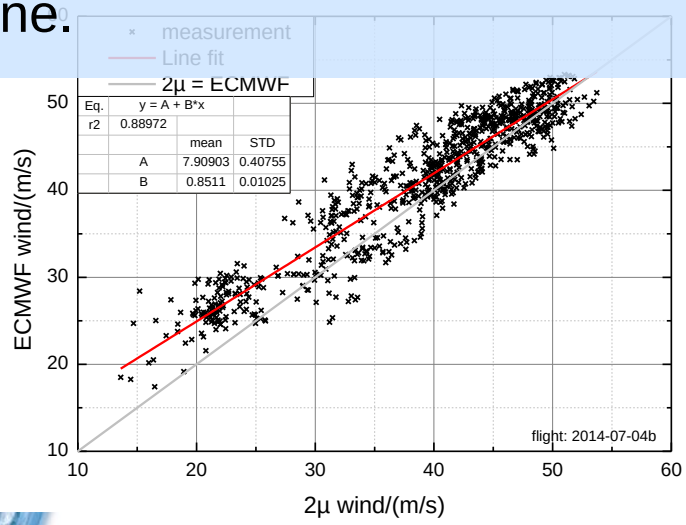


Comparison to ECMWF data – Wind vector

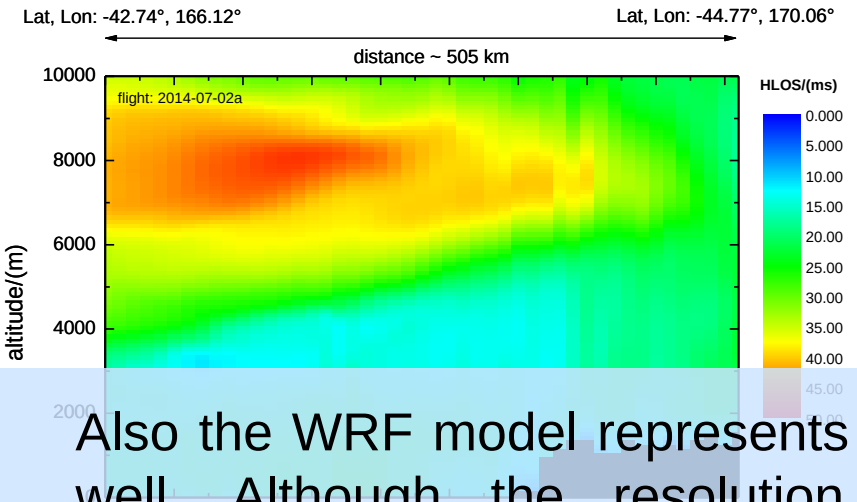


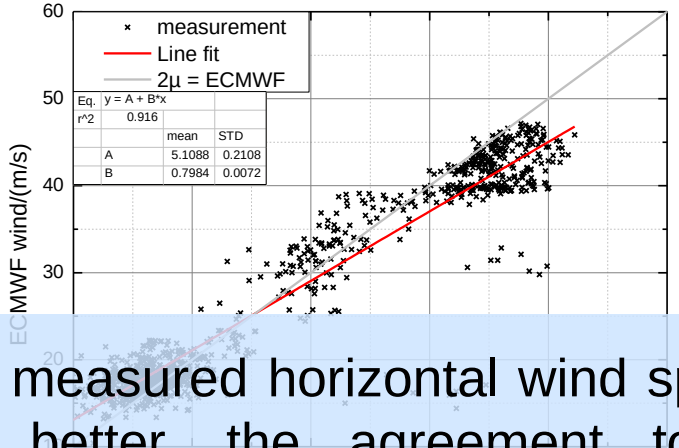


The measured horizontal wind speed is well represented by the ECMWF model. Slopes smaller than 1 (0.89 and 0.85) indicate that high wind speeds are slightly underestimated and low wind speeds slightly over estimated by the model.
Further quantifications need to be done.

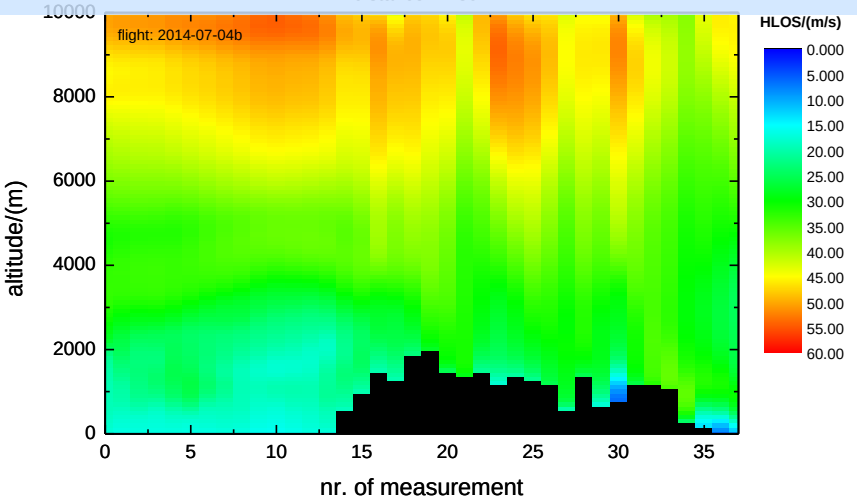


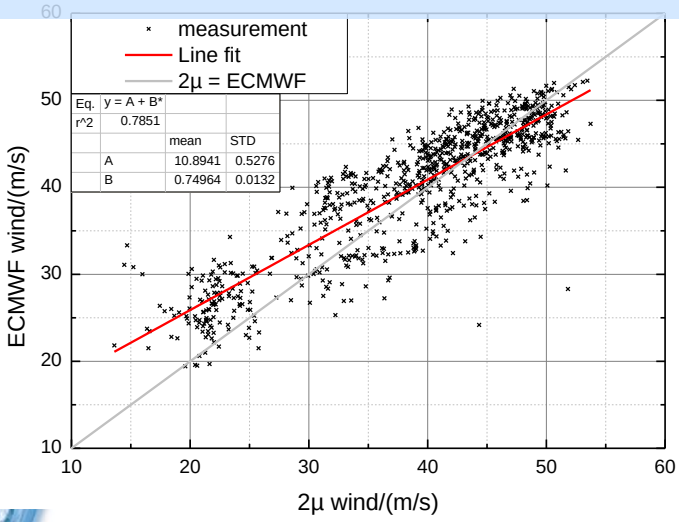
Comparison to WRF data – Wind vector





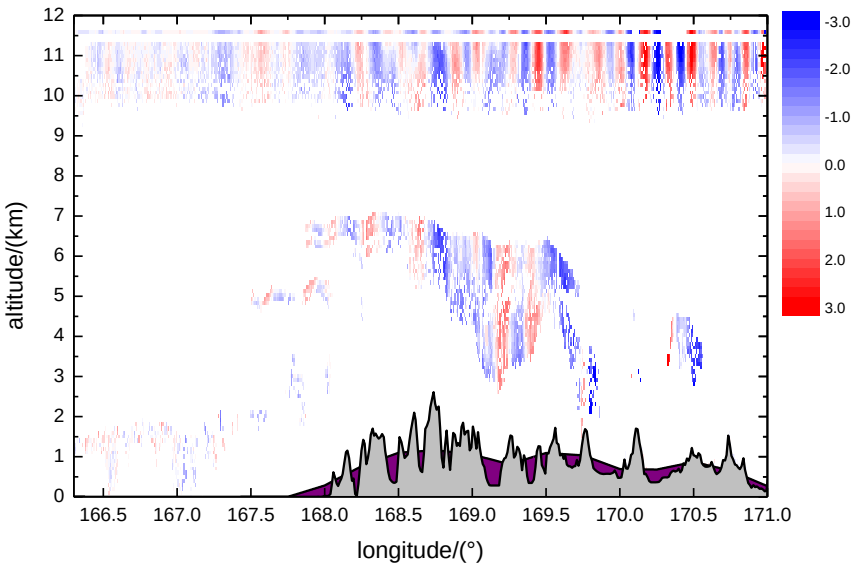
Also the WRF model represents the measured horizontal wind speeds well. Although the resolution is better, the agreement to the measurement is worse. Quantification still has to be done.

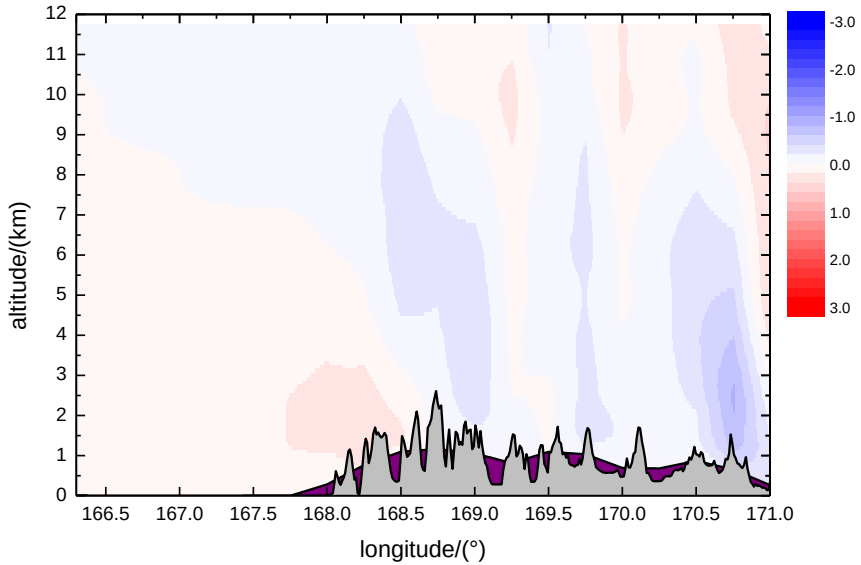




2014-07-04b – comparison to ECMWF – vertical wind

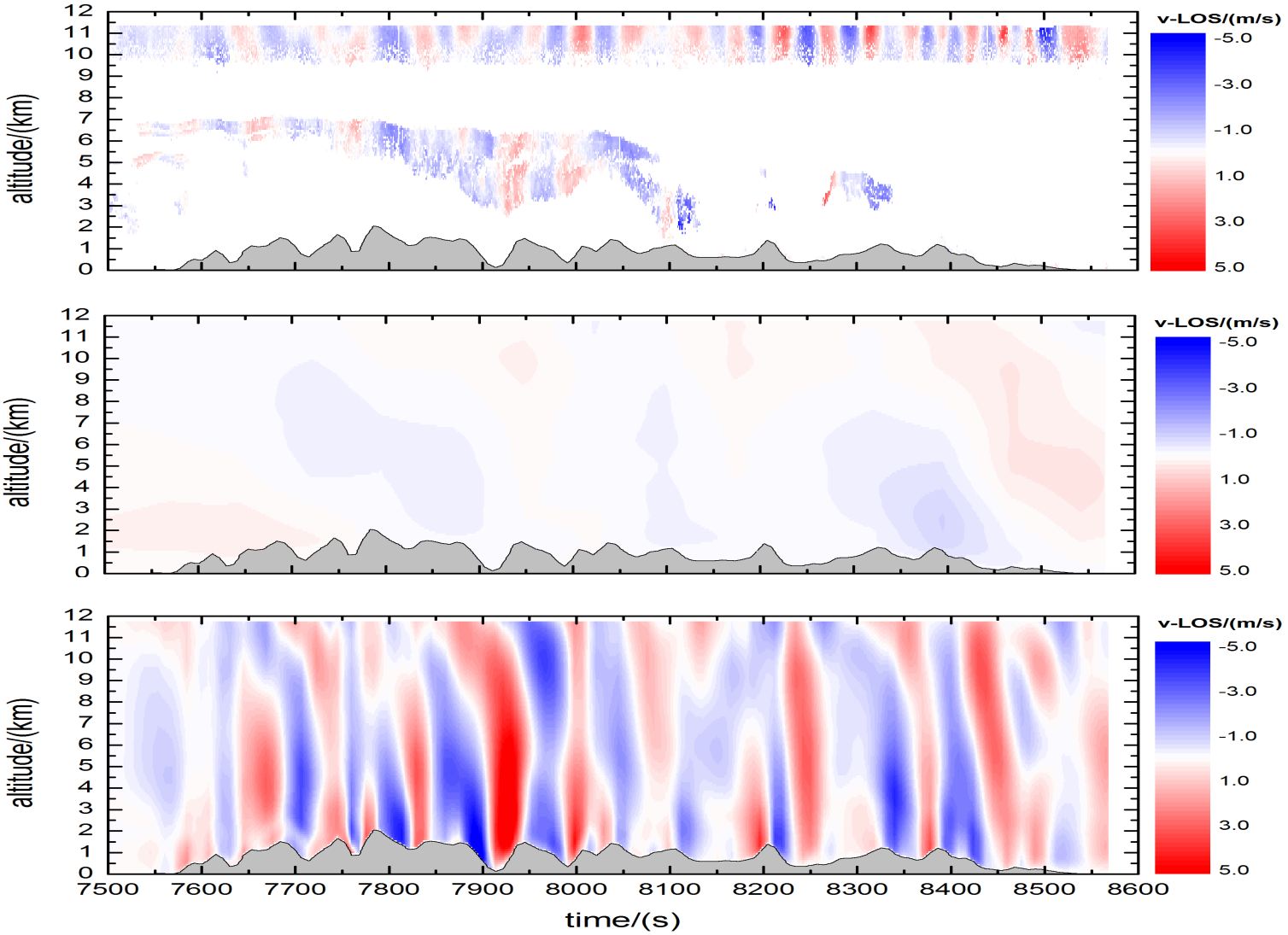
Although the inflow conditions are well described by ECMWF data, vertical wind speeds are dramatically underestimated. Additionally, the fine structure of appearing waves is not resolved at all (figures: left: 2µ w-wind incl. Falcon, right: ECMWF w-wind).



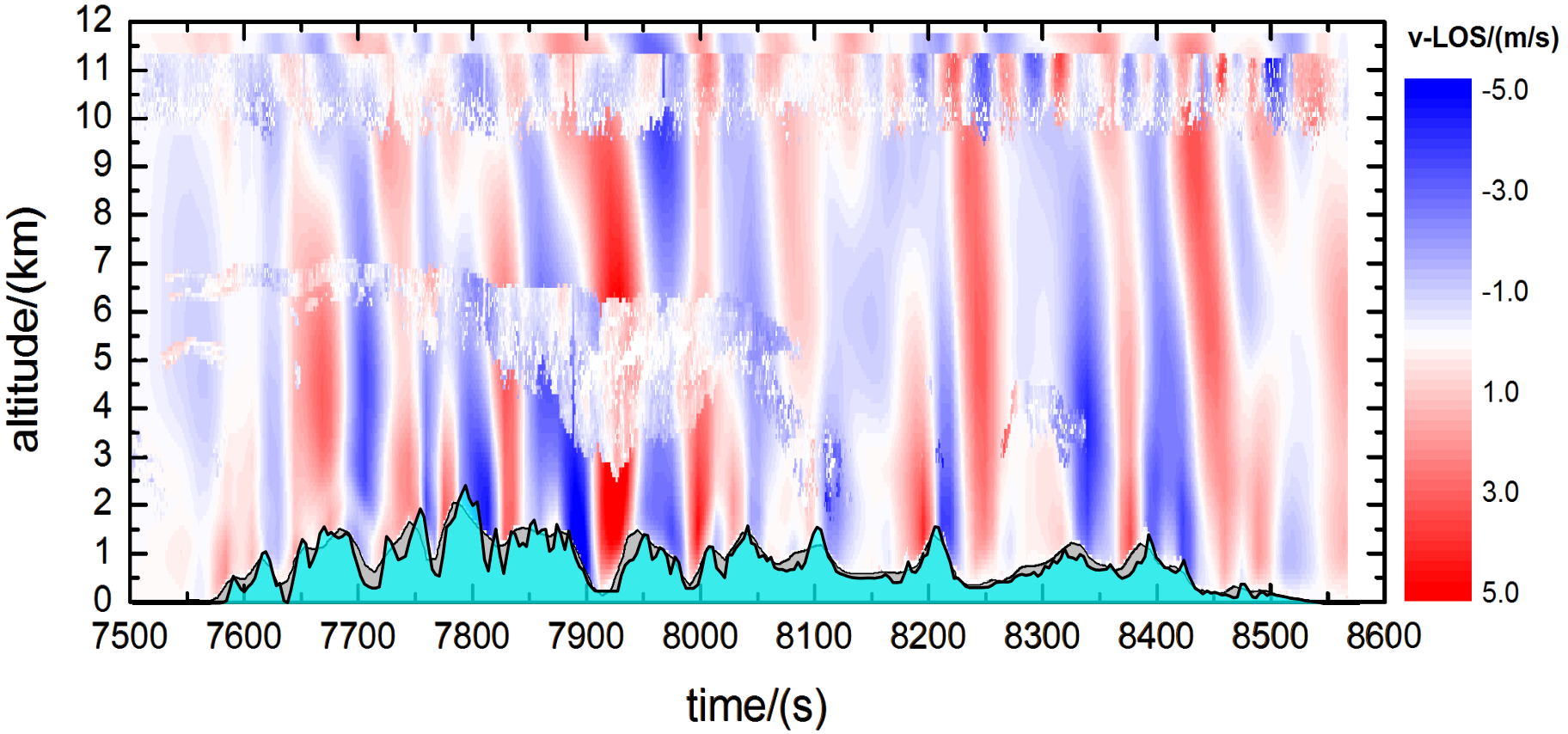


This is (among others) due to the coarse resolution of the orography (violet = ECMWF, gray = DEM model). The WRF model, which uses higher resolution for the investigated area, leads to a better description as known from the GW-LCYCLE campaign.

2014-07-04b – Comparison to ECMWF and WRF data

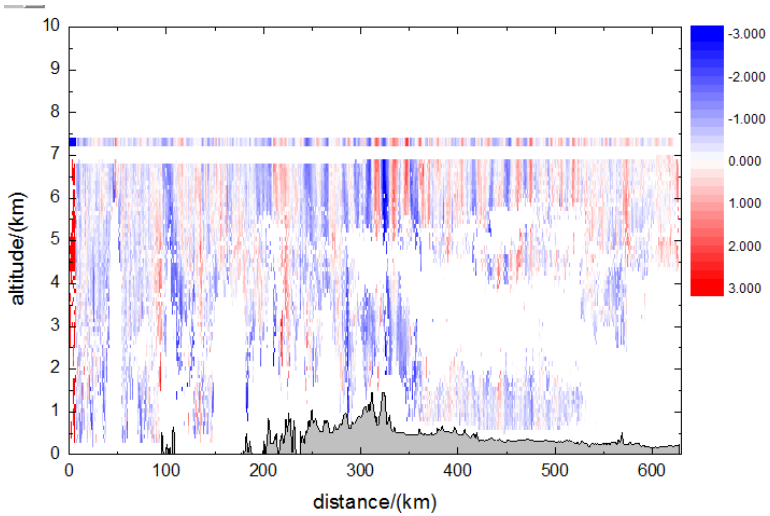


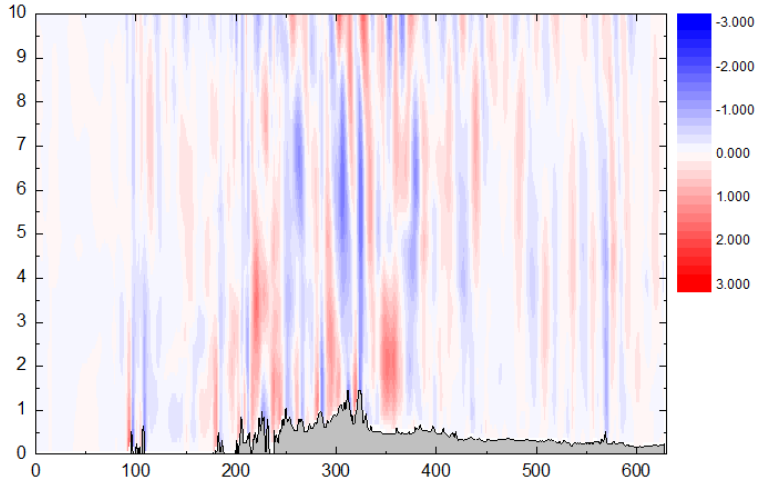
Comparison to ECMWF and WRF data – vertical wind

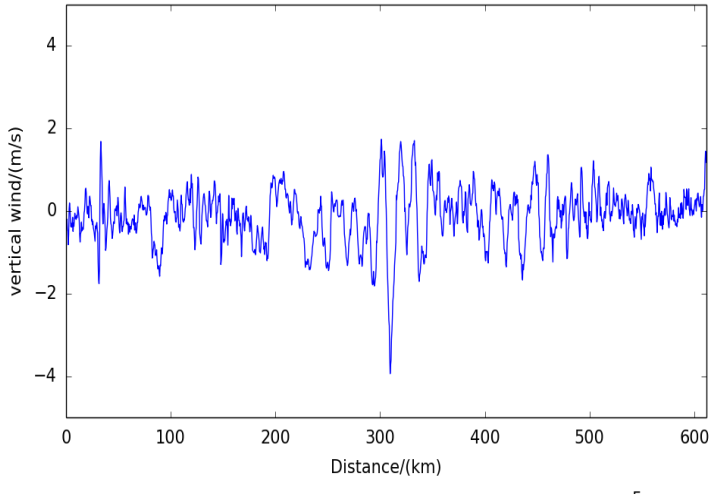


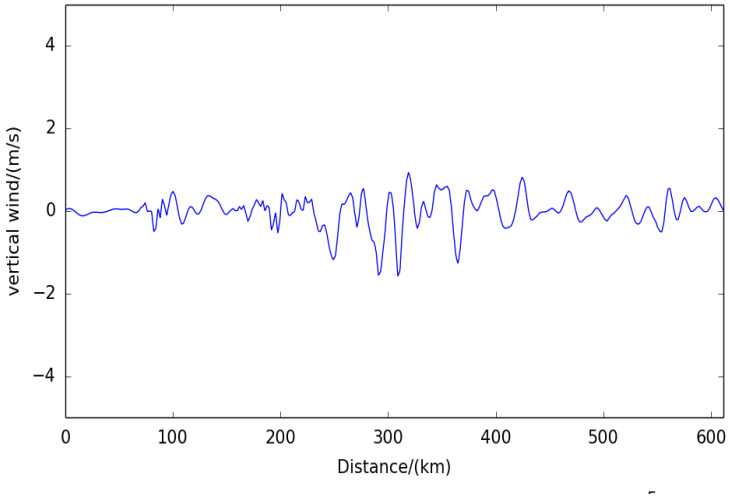
WRF model calculations with a nesting of **600 m** are envisaged to investigate if the wave parameters can be better descript by using even higher resolution.

Wavelet analysis – Comparison to WRF (2013-12-03a -1)



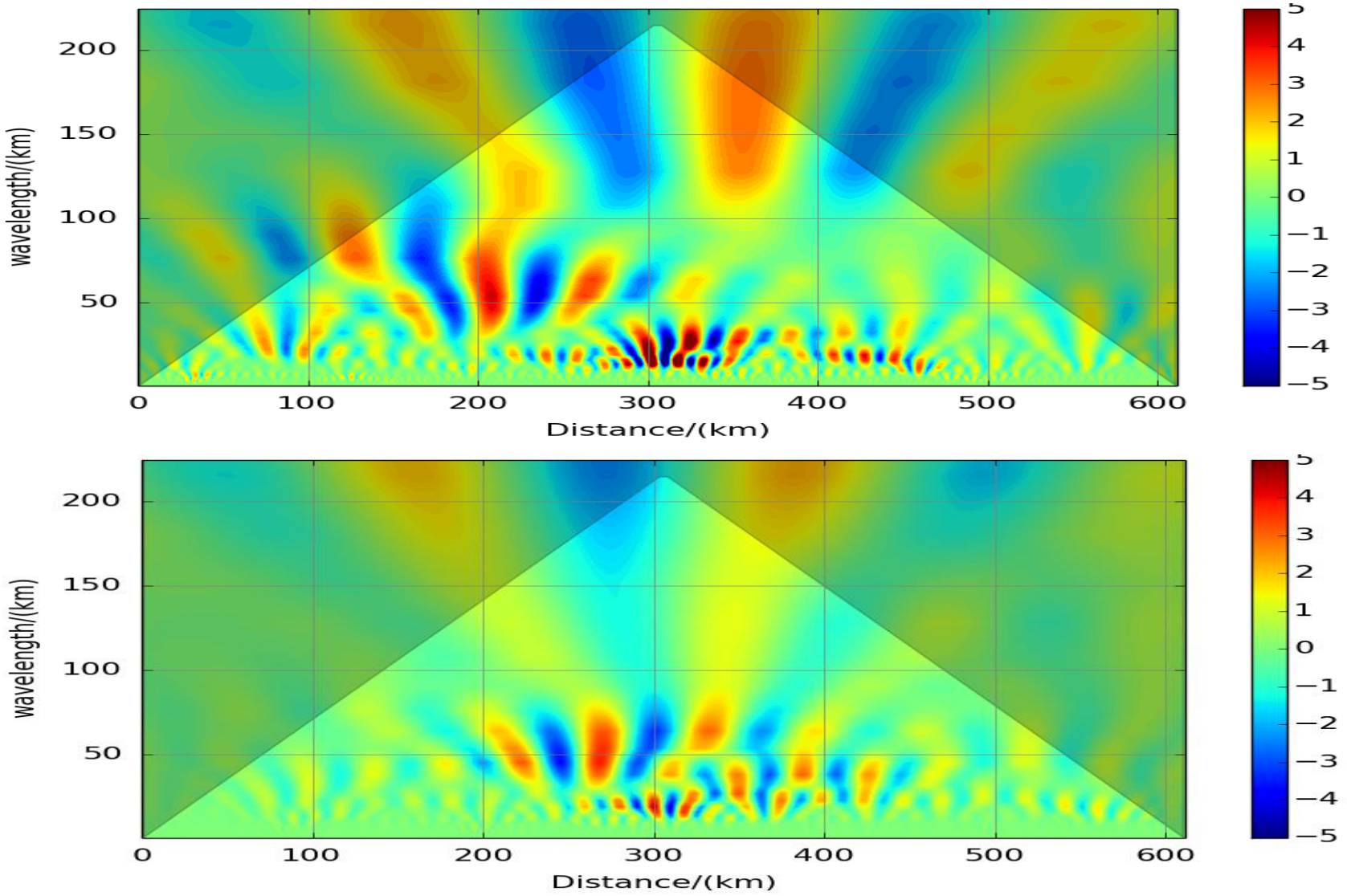






6.0 km – 6.5 km

Wavelength analysis – Comparison to WRF (2013-12-03a -1)



Summary

- All 2µ wind lidar measurements preformed during the Deepwave campaign are processed, are converted to .netcdf format, and are ready for being uploaded to the database.
- The comparison to aircraft in-situ measurements demonstrates the performance of the lidar measurements and the retrieval algorithms.
- First comparisons to ECMWF and WRF model calculations have been performed.
  - horizontal wind measurements: both models shown **reasonably good** agreement.
  - vertical wind measurements: ECMWF completely underestimates the small scale variations of the measured **vertical wind**, whereas the **WRF model** calculations partly represent them (quantitative analysis foreseen).
- A wavelet analysis tool is available and will be used for wave characterization.

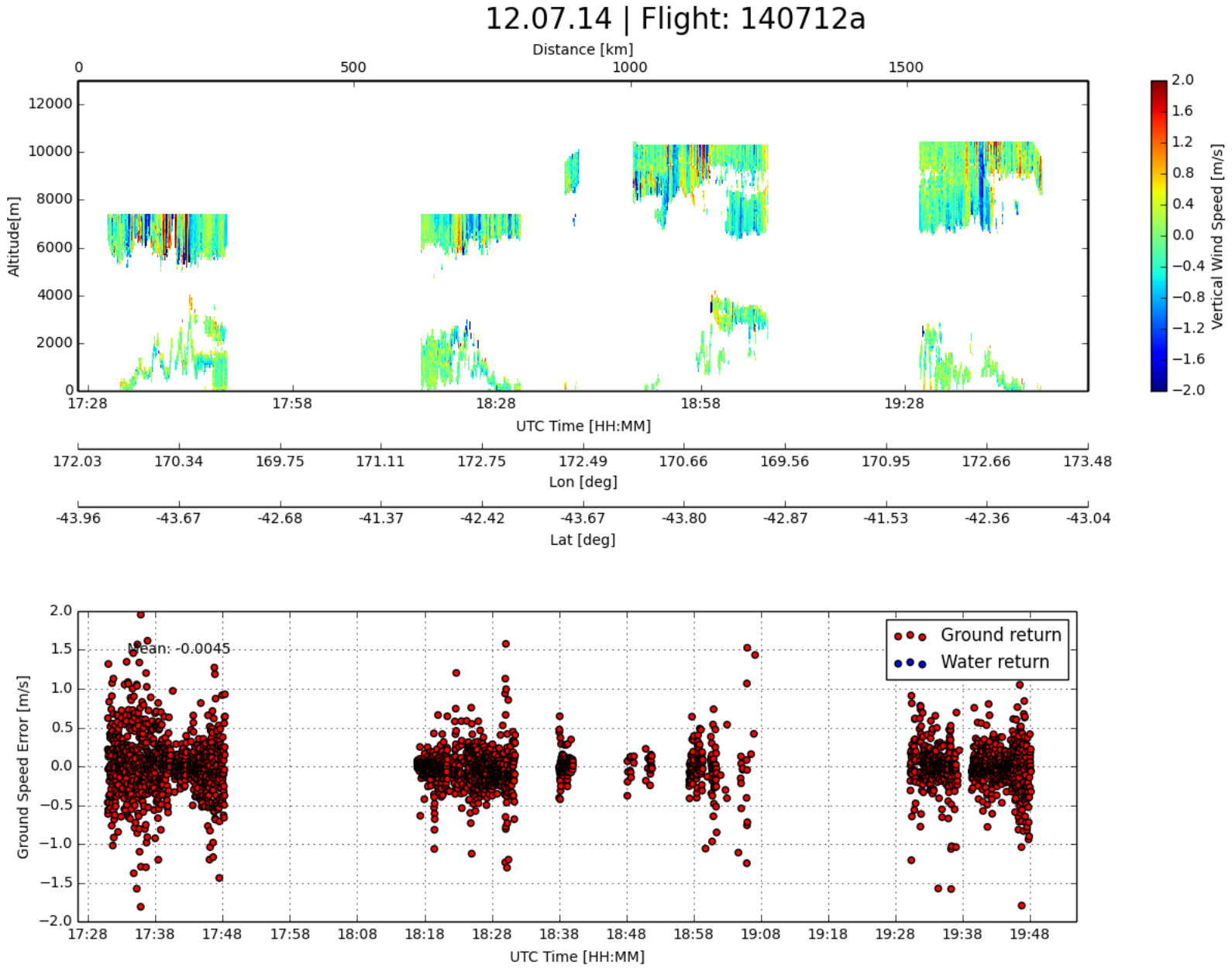
Outlook

- A further pointing correction for vertical wind measurements needs to further improve the wind retrieval and to thus, to avoid systematic errors in the retrieved vertical wind speeds.
- Further WRF model calculations with 600 m nesting are envisaged.
- A quantitative comparison to ECMWF and WRF model calculations is planned.
- From end of May until mid August, the entire 2µ dataset obtained during Deepwave will be extensively analyzed and merged with the data from the instruments on the GV (**sabbatical at GATS**).

Discussion with the community:

- What can we learn from 2µ wind measurements?
- Which quantities (fluxes) can be derived from the measurements.
- Any comments, suggestions, and discussions are highly appreciated.


Thank you


12.07.14 | Flight: 140712a
Distance [km]
0
500
1000
1500
Altitude[m]
12000
10000
8000
6000
4000
2000
0
17:28
17:58
18:28
18:58
19:28
UTC Time [HH:MM]
Vertical Wind Speed [m/s]
2.0
1.6
1.2
0.8
0.4
0.0
−0.4
−0.8
−1.2
−1.6
−2.0
172.03
170.34
169.75
171.11
172.75
172.49
170.66
169.56
170.95
172.66
173.48
Lon [deg]
-43.96
-43.67
-42.68
-41.37
-42.42
-43.67
-43.80
-42.87
-41.53
-42.36
-43.04
Lat [deg]
Mean: -0.0045
Ground return
Water return
Ground Speed Error [m/s]
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
17:28
17:38
17:48
17:58
18:08
18:18
18:28
18:38
18:48
18:58
19:08
19:18
19:28
19:38
19:48
UTC Time [HH:MM]