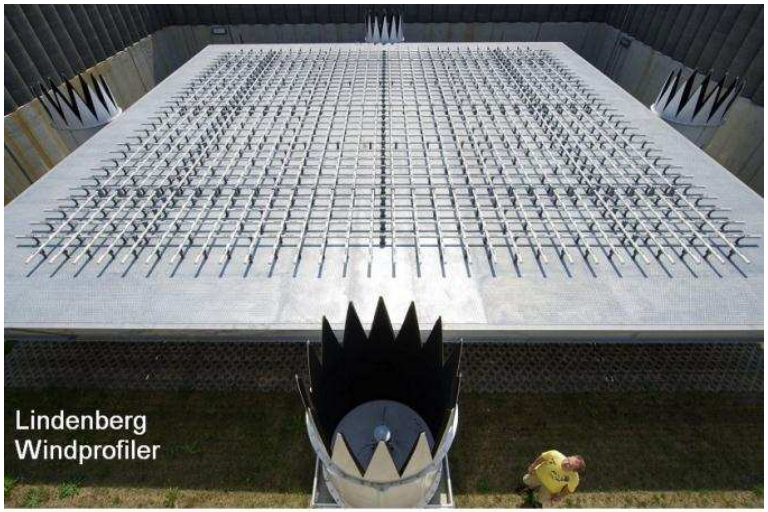

New generation compact pulsed infrared coherent Doppler Lidars validation against Wind Profiler Radar and Radiosonde measurements at the Lindenberg GRUAN site

B. Stiller (1), R. Leinweber (1), S. Emeis (2) , S. Lolli (3), M. Mauder (2), L. Sauvage (3), and L. Thobois (3)

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(2) KIT- Institute of Meteorology and Climate Research (IMK-IFU) Kreuzeckbahnstr. 19 82467 Garmisch-Partenkirchen, Germany

(3) Leosphere, 76 Rue Monceau, 75008 Paris, France

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Lidar Environmental Observations

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

DWD

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- Accurate knowledge of wind fields is crucial for the improvement of Numerical Weather Prediction (NWP) models.

- DWD (German National Meteorological Service) prepares Low Level Wind Shear Alert Systems (LLWAS) for the Frankfurt and Munich, Germany airports.

The systems will consist of a METEOR 50DX Dual Polarisation Weather Radar, and a WindTracer Doppler Lidar (Lockheed Martin Coherent Technologies).

Scientists of the Lindenberg GRUAN site are included in LLWAS-project as experts of remote sensing and prepare verification campaigns of LLWAS-sensors currently.

Three different Doppler Wind Lidar systems, developed by Leosphere and Halo Photonics, respectively, were deployed in two independent campaigns at Lindenberg Observatory during April/May 2011 and August-December 2011 within the framework of the European COST action ES 0702 (EG-CLIMET).

Lidar instruments were validated against the 482 MHz Wind Profiler, daily Radio Soundings, and NWP model output in order to be used operationally.

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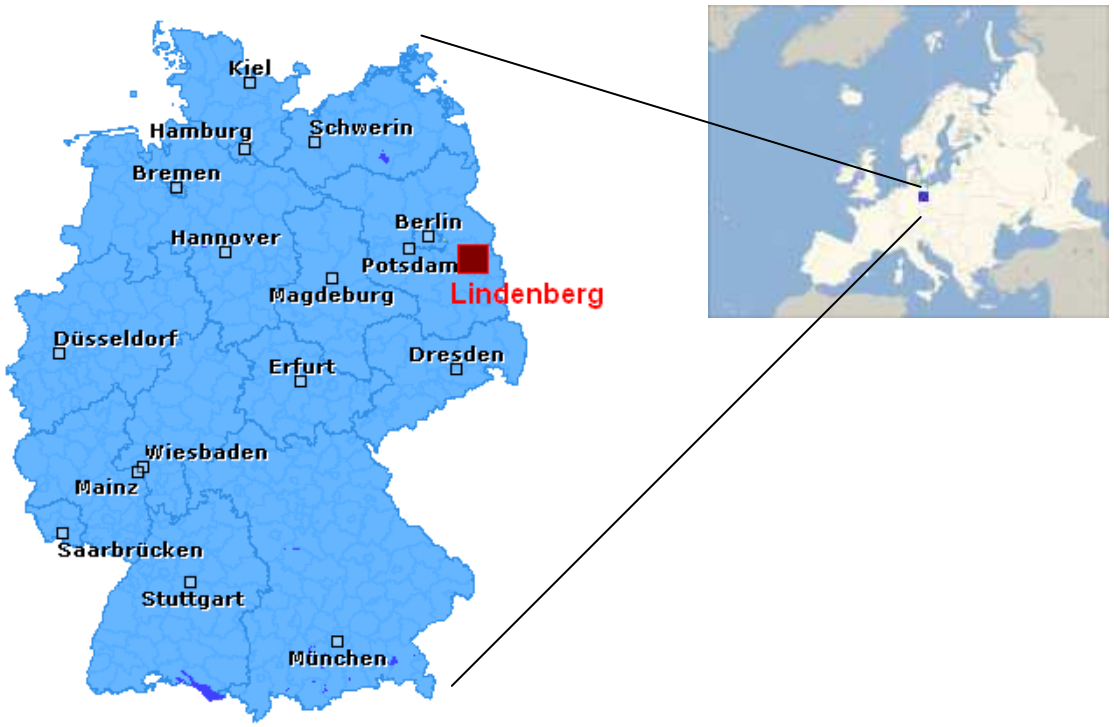
GRUAN = **G**COS **R**eference **U**pper **A**ir **N**etwork

The Richard Aßmann Observatory is located about 65 km south-east of Berlin.

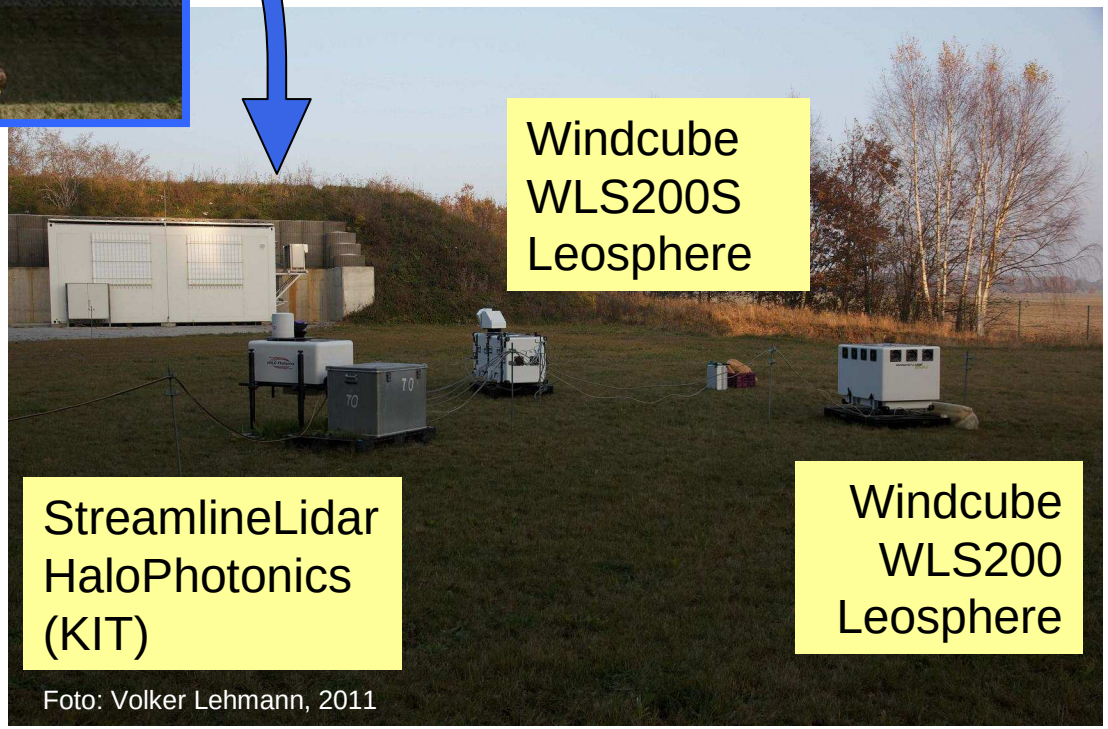
Latitude: 52.21 °N
Longitude: 14.12 °E
Altitude: 98 m



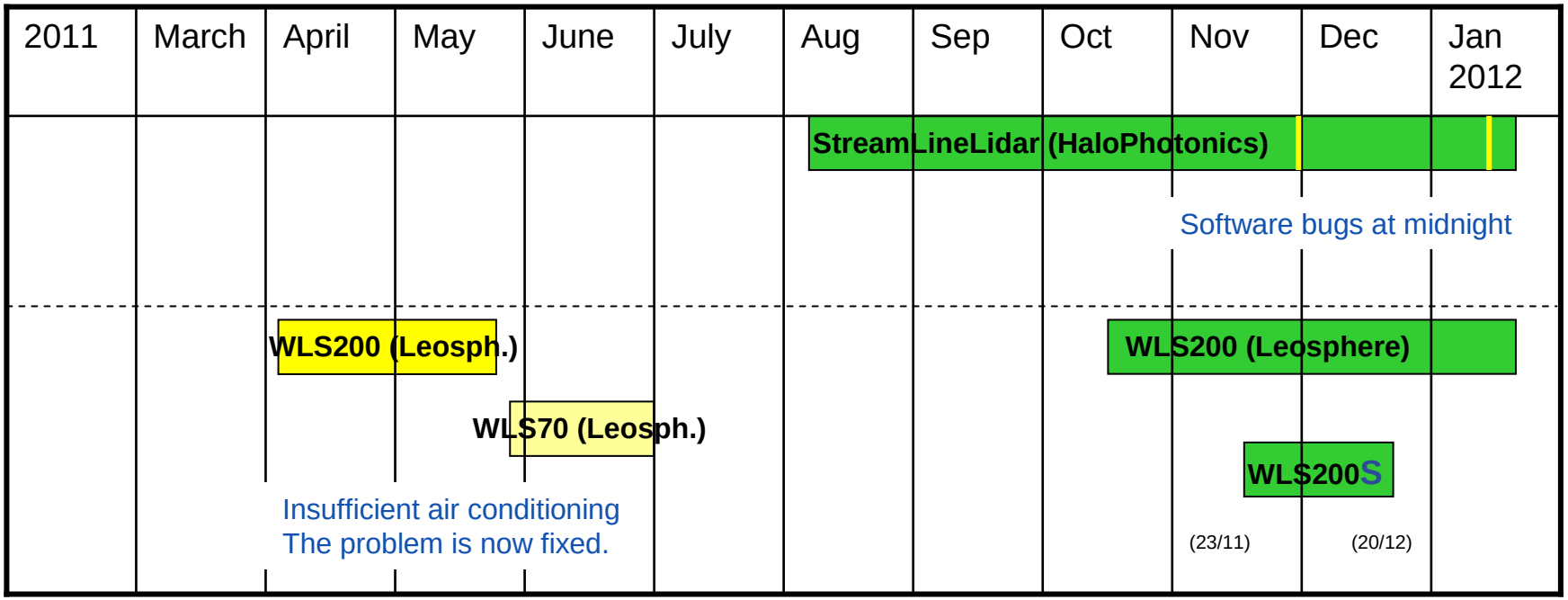
482 MHz Radar Wind Profiler (stationary)

behind the berm

Windlidar (temporary)



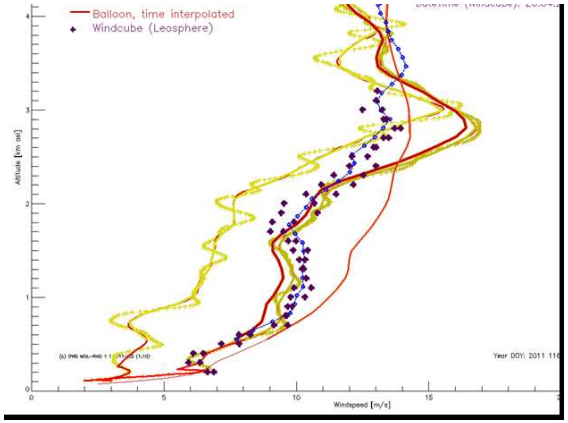
Windlidar Inter Comparison Campaign 2011
Performance (operational availability)



Campaign Intercomparison Methods

- compare / assess operational availability
- compare against the 482 Mhz Windprofiler, 4 times daily launched radiosoundings, and NWP models output
- … measurements as time series
- … profiles at a certain time
- … differences for longer periods
- … different elements

  (horizontal wind speed, direction, components u, v, w, root mean square differences)



- compare lidar ranges to meteorological conditions

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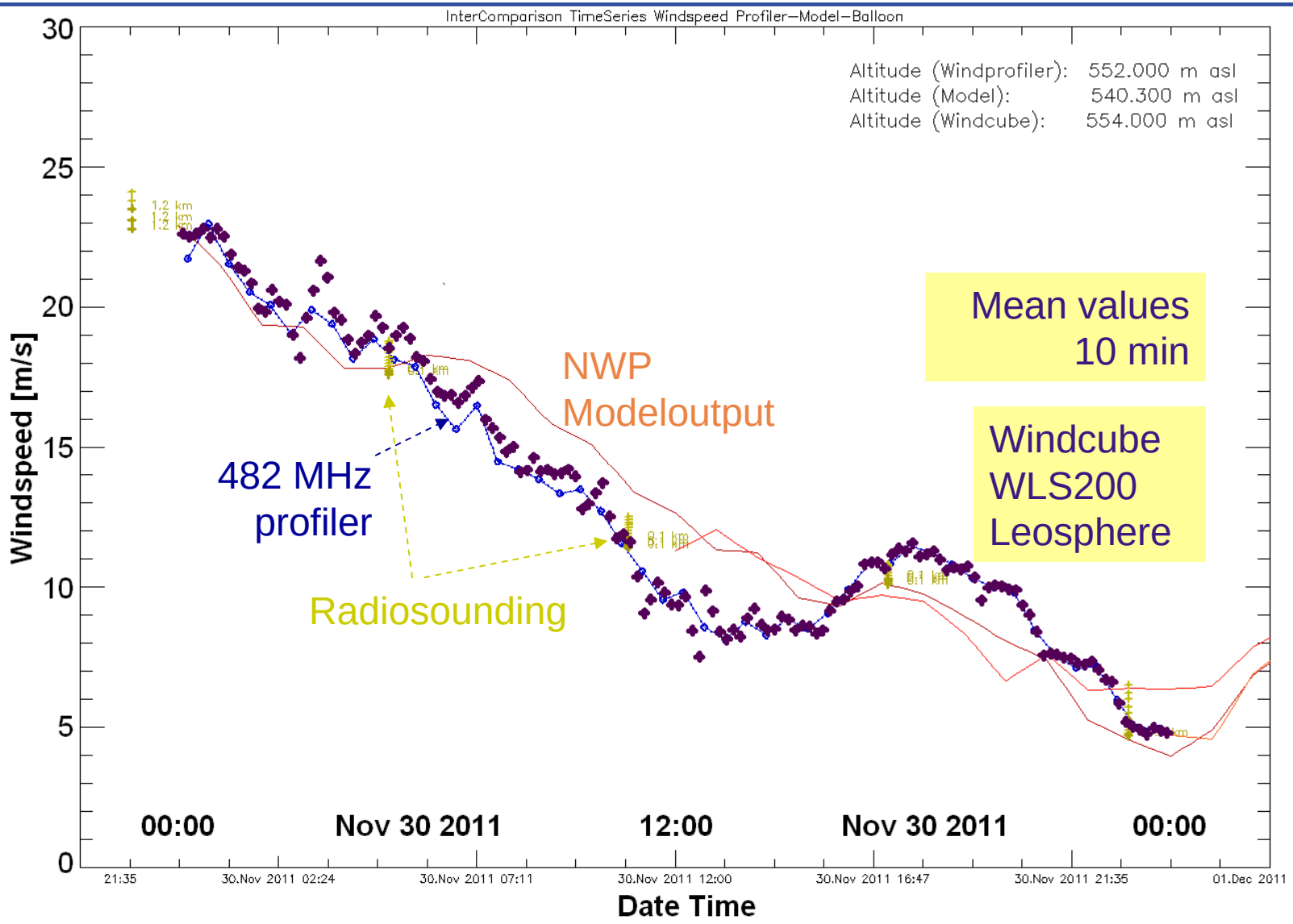
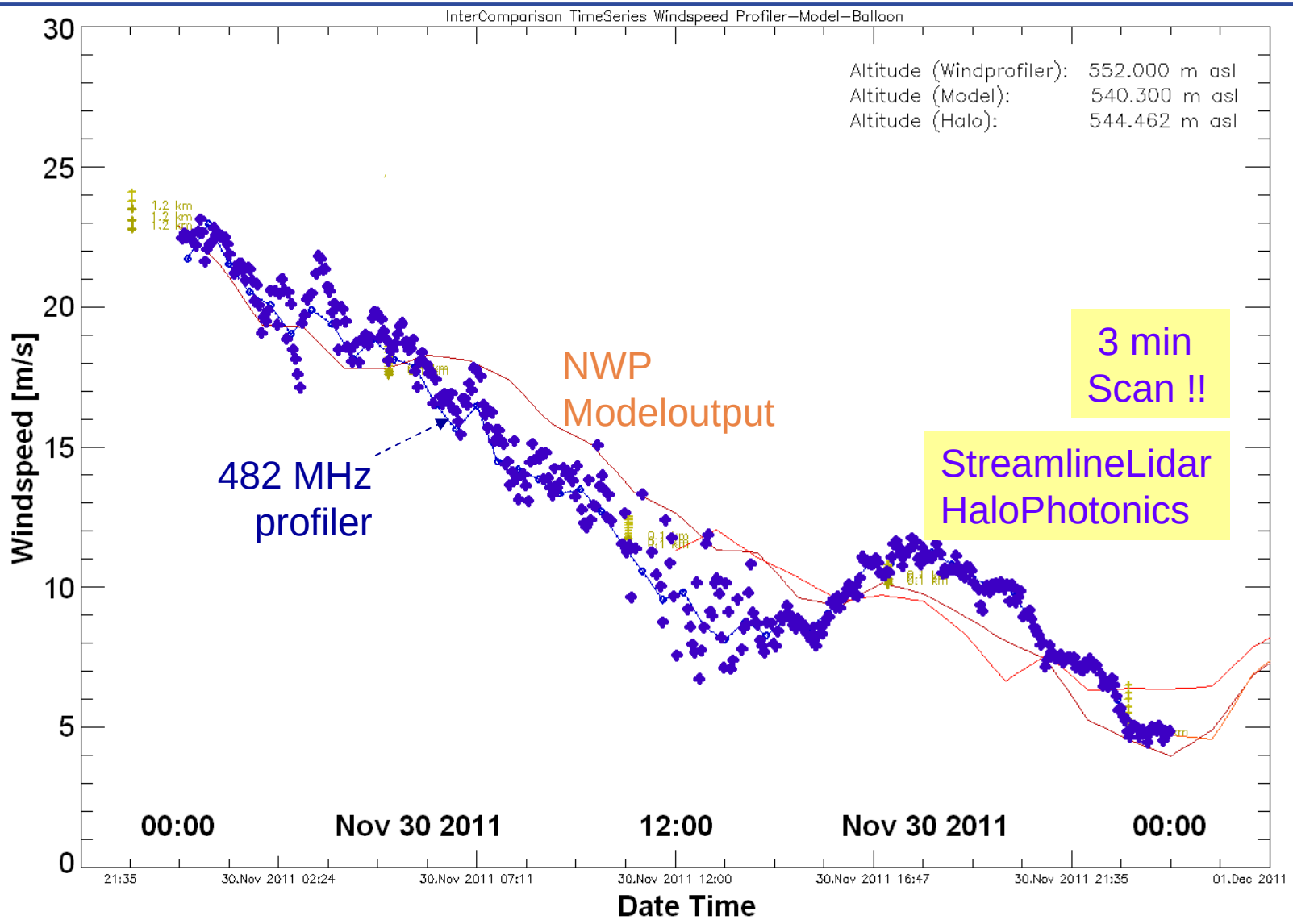
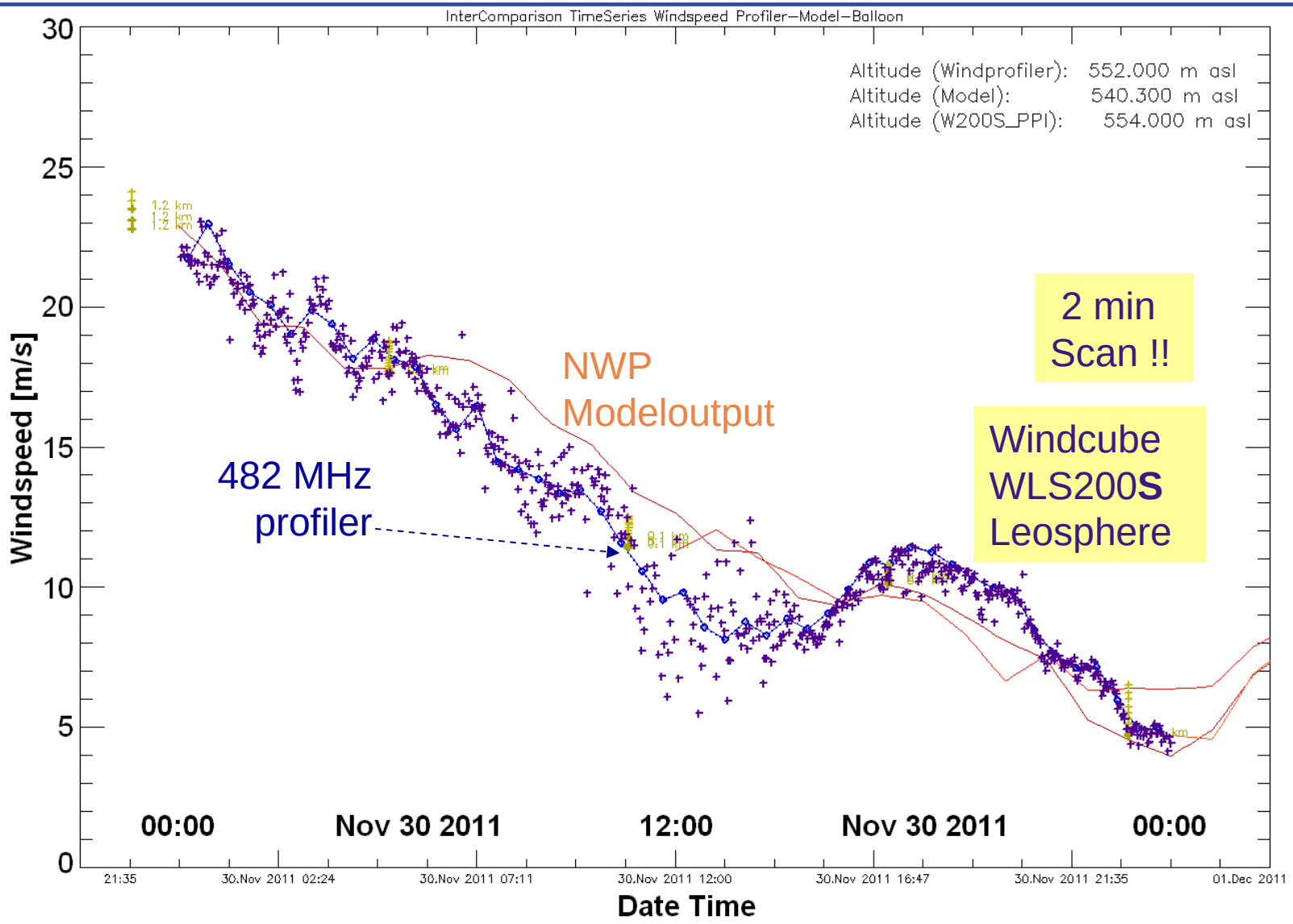
(Preliminary) Results

- All wind lidars are close to 482 Mhz Windprofiler and radiosoundings

Examples →


InterComparison TimeSeries Windspeed Profiler–Model–Balloon
Altitude (Windprofiler): 552.000 m asl
Altitude (Model): 540.300 m asl
Altitude (Windcube): 554.000 m asl
Windspeed [m/s]
0
5
10
15
20
25
30
00:00
Nov 30 2011
12:00
Nov 30 2011
00:00
21:35
30.Nov 2011 02:24
30.Nov 2011 07:11
30.Nov 2011 12:00
30.Nov 2011 16:47
30.Nov 2011 21:35
01.Dec 2011
Date Time
NWP
Modeloutput
482 MHz
profiler
Radiosounding
Mean values
10 min
Windcube
WLS200
Leosphere


InterComparison TimeSeries Windspeed Profiler–Model–Balloon
Altitude (Windprofiler): 552.000 m asl
Altitude (Model): 540.300 m asl
Altitude (Halo): 544.462 m asl
Windspeed [m/s]
30
25
20
15
10
5
0
482 MHz profiler
NWP Modeloutput
3 min Scan !!
StreamlineLidar HaloPhotonics
00:00
Nov 30 2011
12:00
Nov 30 2011
00:00
21:35
30.Nov 2011 02:24
30.Nov 2011 07:11
30.Nov 2011 12:00
30.Nov 2011 16:47
30.Nov 2011 21:35
01.Dec 2011
Date Time

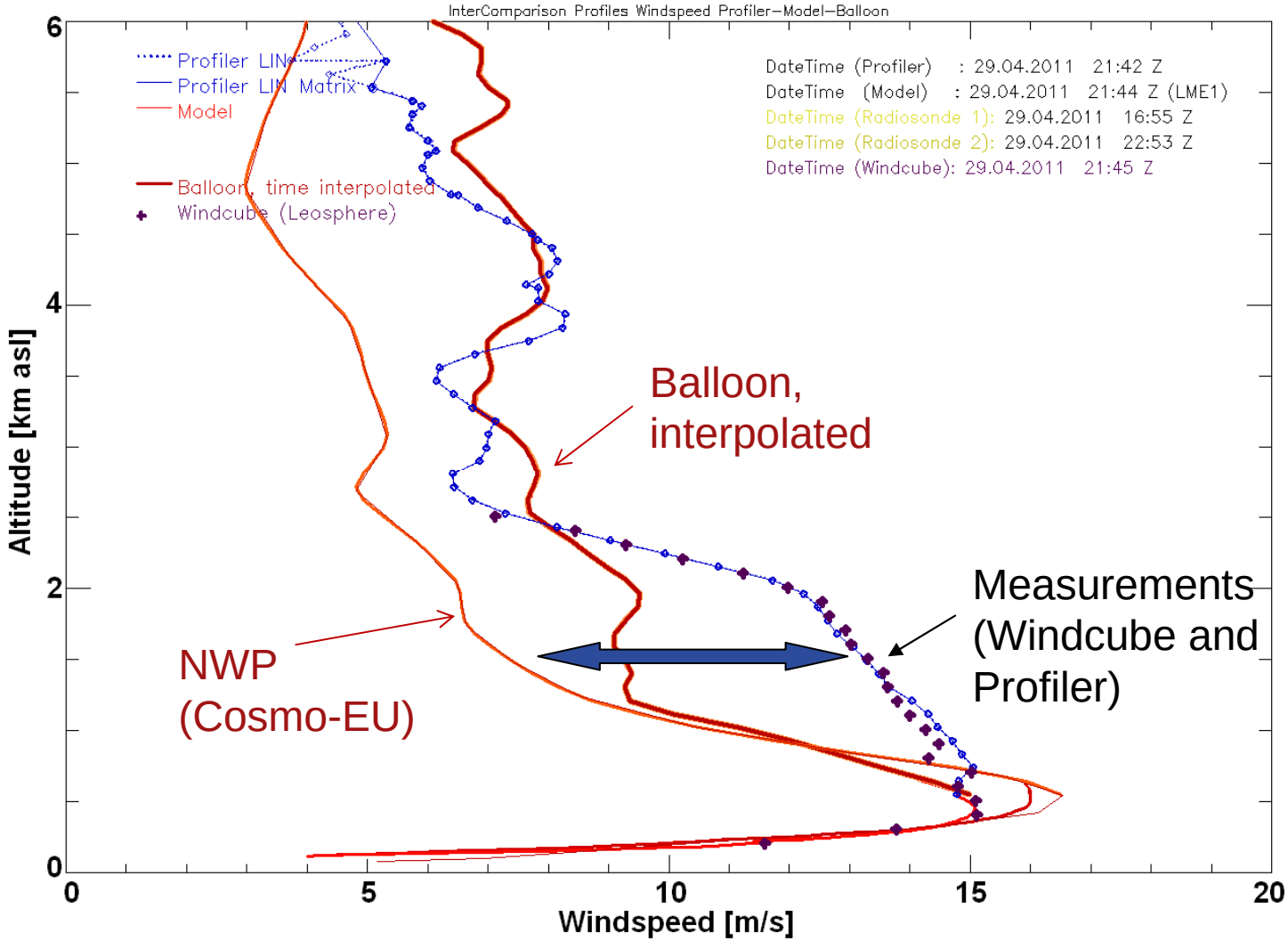

InterComparison TimeSeries Windspeed Profiler–Model–Balloon
Altitude (Windprofiler): 552.000 m asl
Altitude (Model): 540.300 m asl
Altitude (W200S_PPI): 554.000 m asl
Windspeed [m/s]
0
5
10
15
20
25
30
00:00
Nov 30 2011
12:00
Nov 30 2011
00:00
21:35
30.Nov 2011 02:24
30.Nov 2011 07:11
30.Nov 2011 12:00
30.Nov 2011 16:47
30.Nov 2011 21:35
01.Dec 2011
Date Time
NWP
Modeloutput
482 MHz
profiler
2 min
Scan !!
Windcube
WLS200S
Leosphere

(Preliminary) Results

- All wind lidars are close to 482 Mhz Windprofiler and radiosoundings
- There are sometimes differences to NWP model output

Examples →

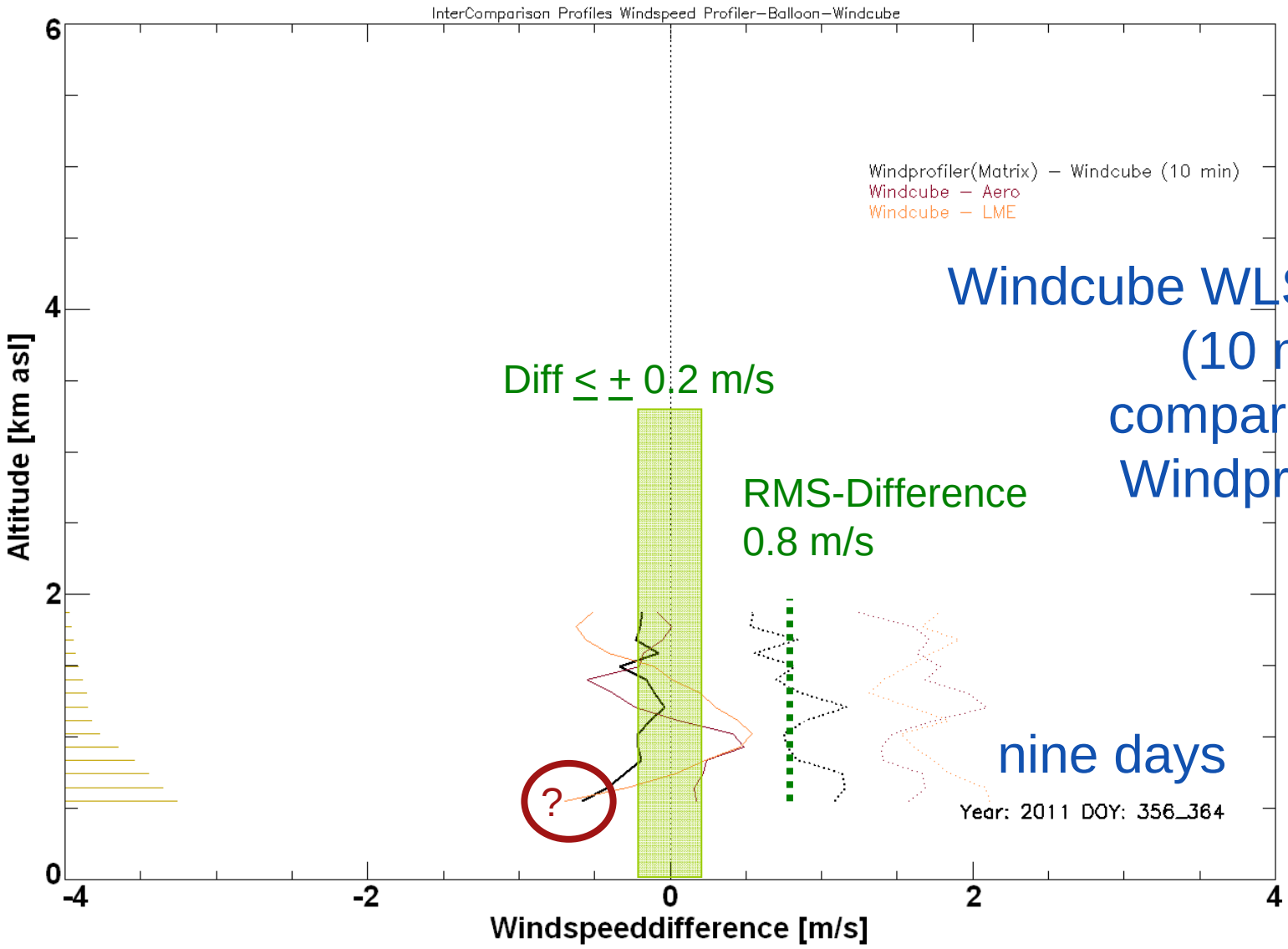
Advantages of two independent wind profiling systems:



(Preliminary) Results

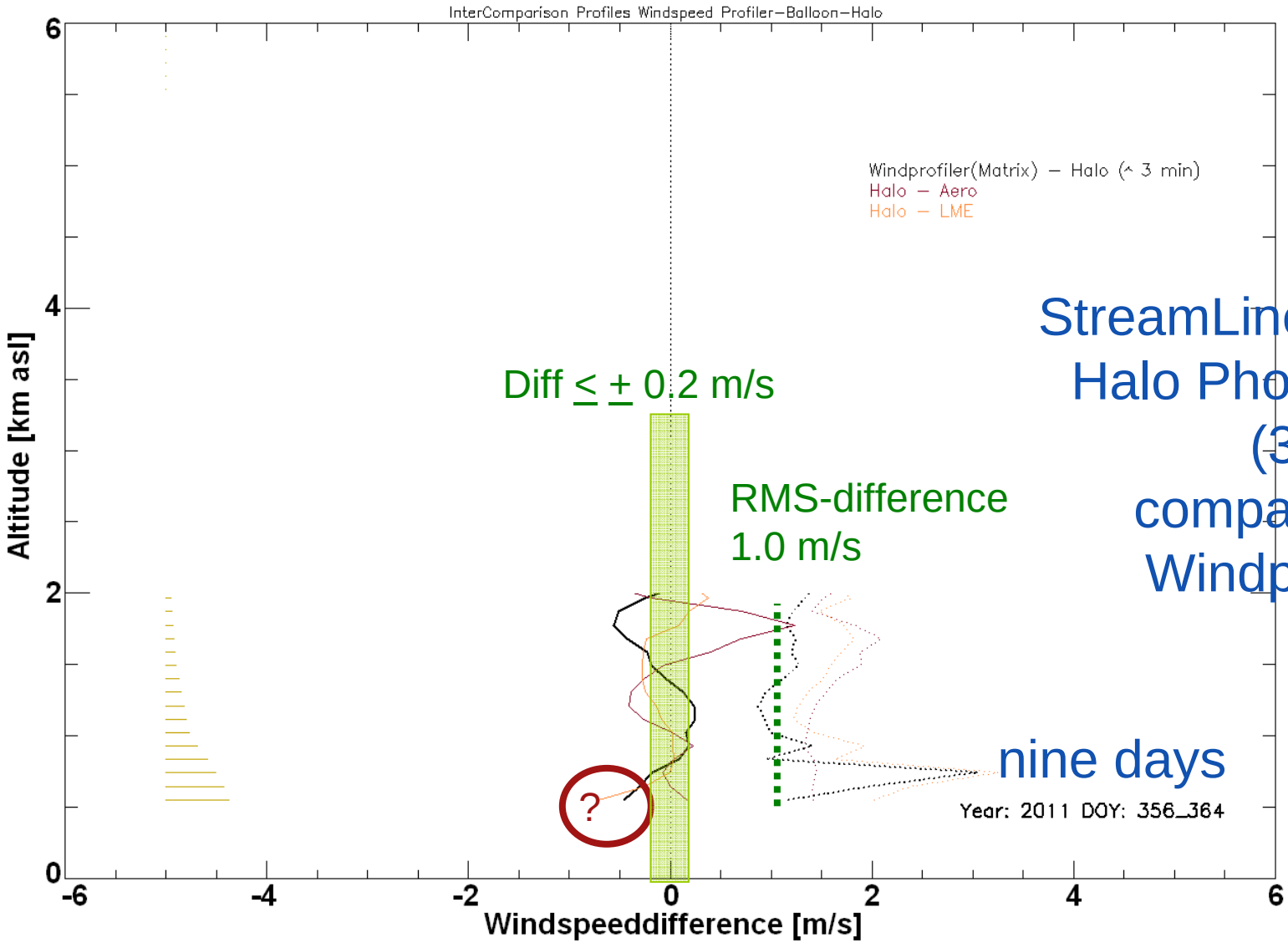
- All wind lidars are close to 482 Mhz Windprofiler and radiosoundings
- There are sometimes differences to NWP model output
- In April/May there was a bias in windcube WLS70 wind speed (0.4 .. 0.5 m/s) with Windprofiler as reference, in November/December no bias were found for wind lidars

Examples →



Windcube WLS200
(10 min !)
compared to
Windprofiler

nine days



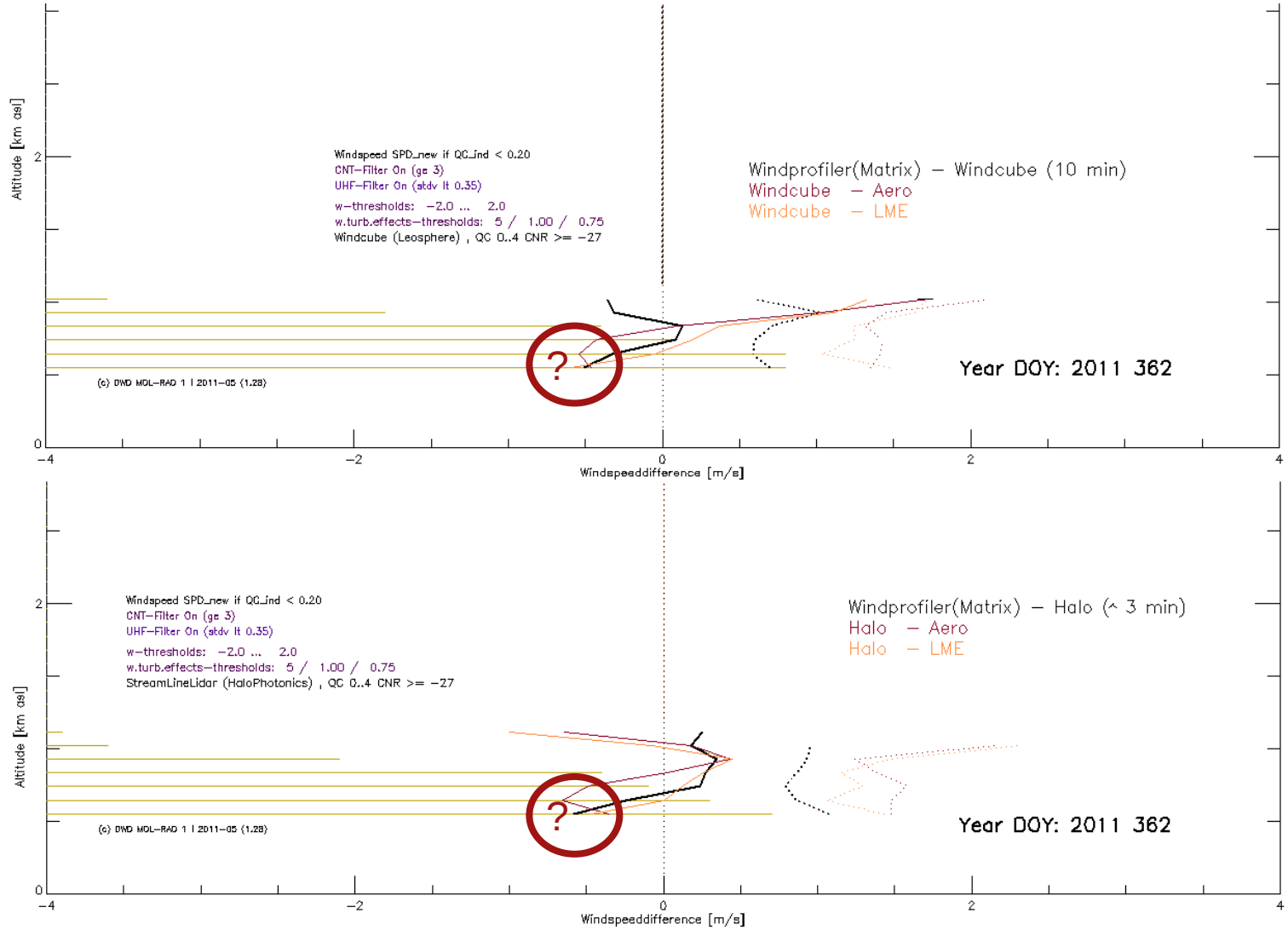
StreamLineLidar
Halo Photonics
(3 min!)
compared to
Windprofiler

nine days

(Preliminary) Results

- All wind lidars are close to 482 Mhz Windprofiler and radiosoundings
- There are some times differences to NWP model output
- In April/May there was a bias in windcube WLS70 wind speed (0.4 .. 0.5 m/s) with Windprofiler as reference, in November/December no bias were found for wind lidars
- Comparisons show ground clutter effects of Windprofiler?

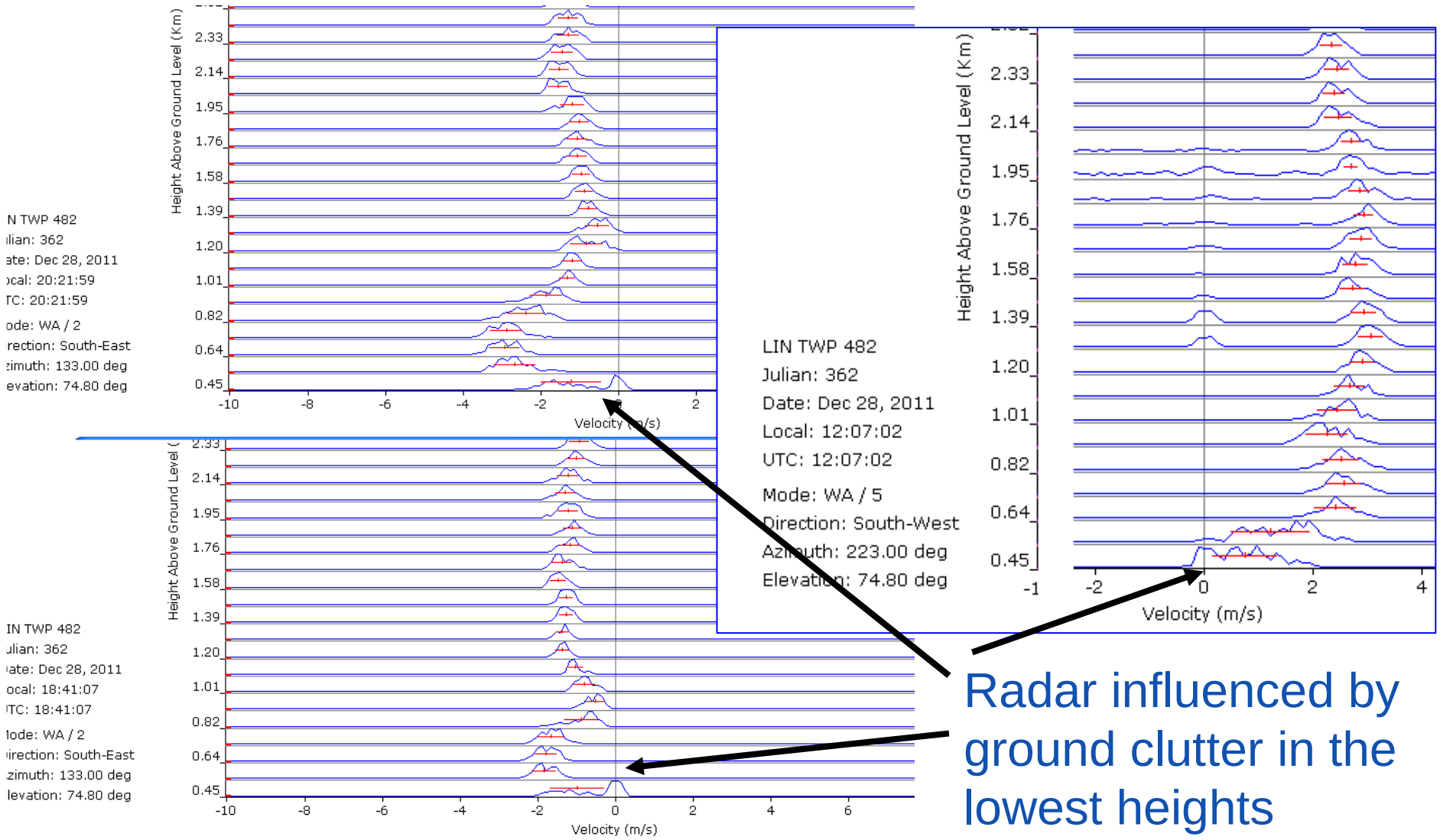
Examples →



Windcube
(24 hour)

Halo
(24 hour)

DOY 362

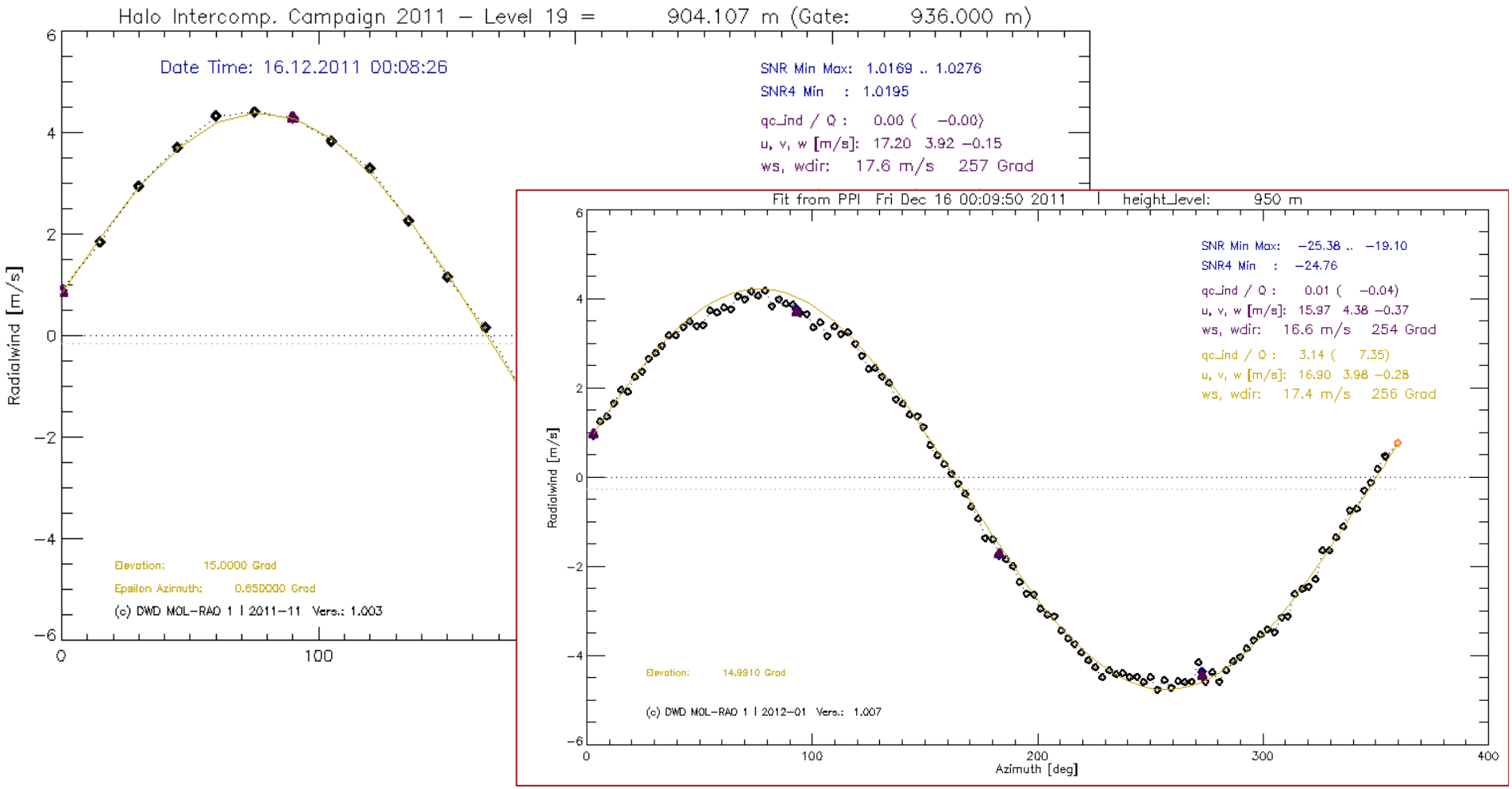


Radar influenced by ground clutter in the lowest heights

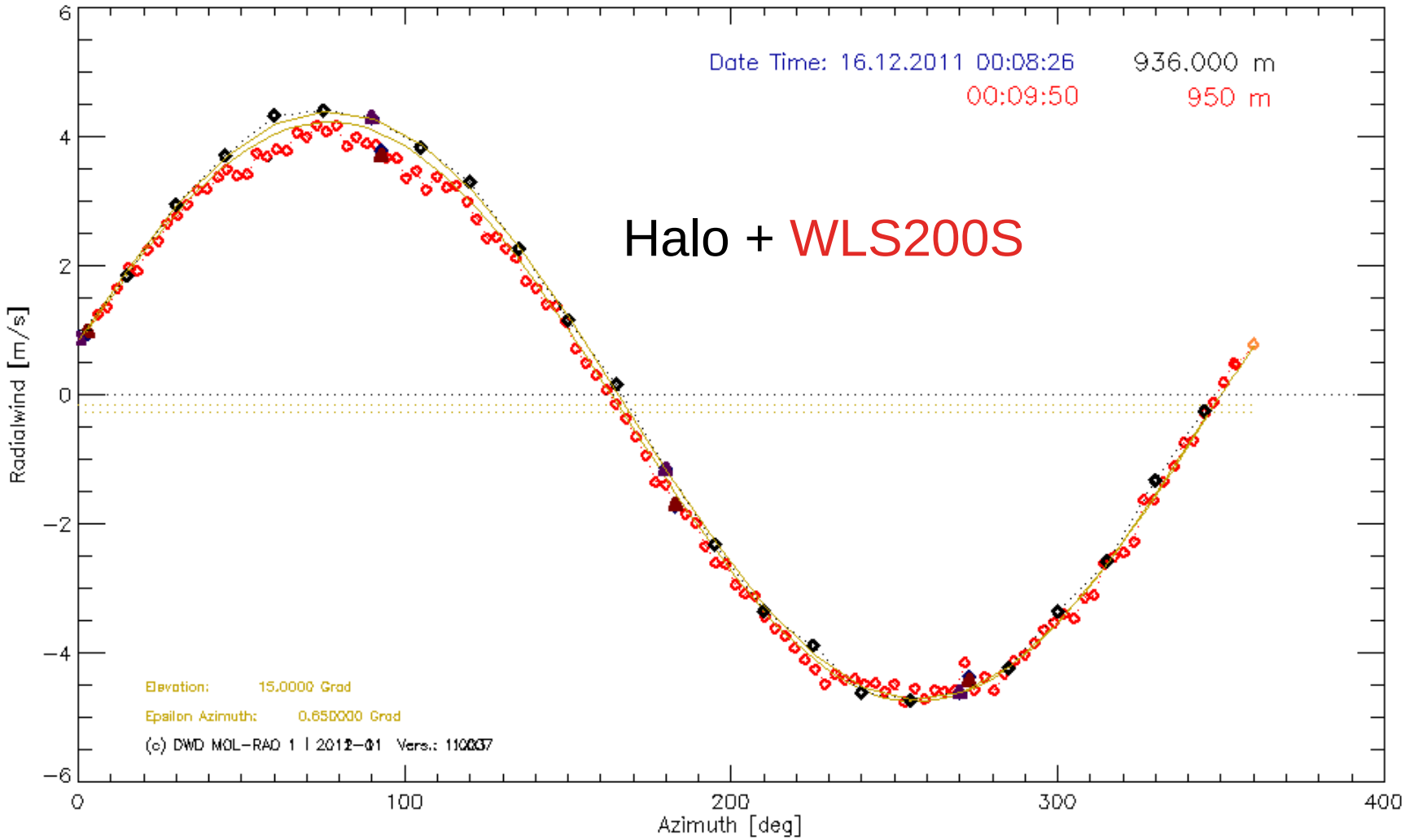
(Preliminary) Results

- All wind lidars are close to 482 Mhz Windprofiler and radiosoundings
- There are sometimes differences to NWP model output
- In April/May there was a bias in windcube WLS70 wind speed (0.4 .. 0.5 m/s) with Windprofiler as reference, in November/December no bias were found for wind lidars
- Comparisons show ground clutter effects of Windprofiler?
- The scanning lidars show similar performance ….

Examples →

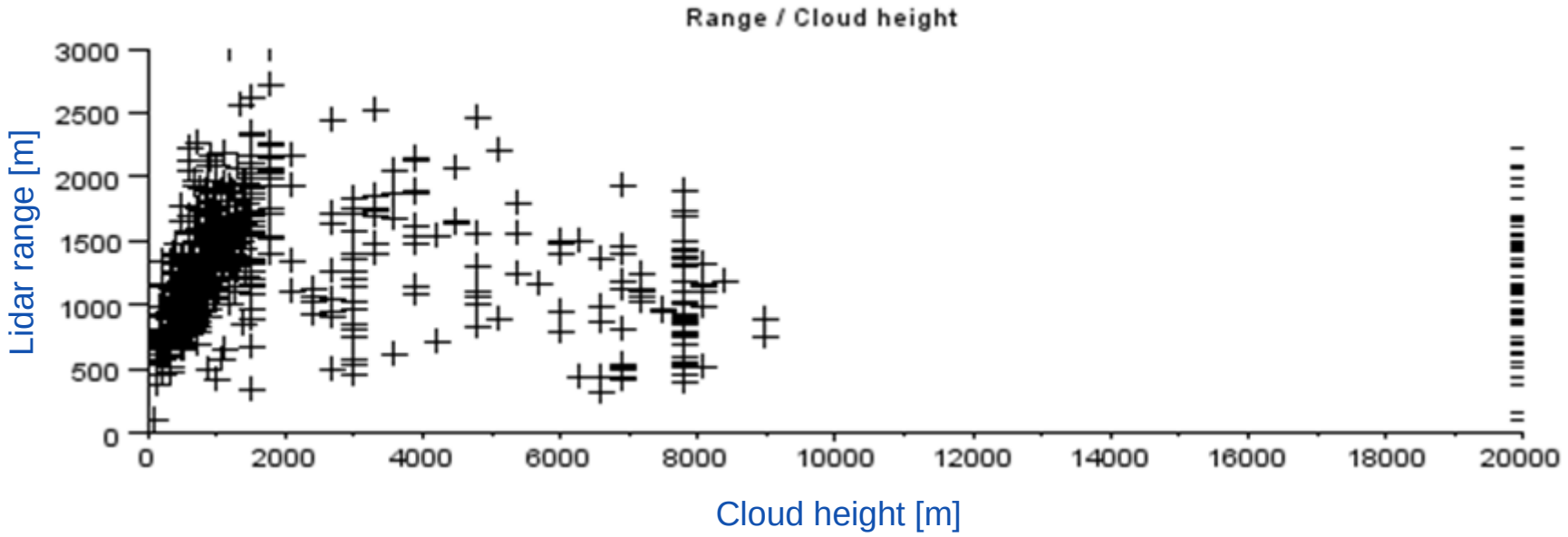


Halo (00:08 Z) 257°17.6 m/s WLS200S (00:09 Z) 256°17.4 m/s


Date Time: 16.12.2011 00:08:26
936.000 m
00:09:50
950 m
Halo + WLS200S
Radialwind [m/s]
Azimuth [deg]
Elevation: 15.0000 Grad
Epsilon Azimuth: 0.650000 Grad
(c) DWD MOL-RAO 1 | 2012-01 Vers.: 110237

Lidar ranges compare to meteorological conditions

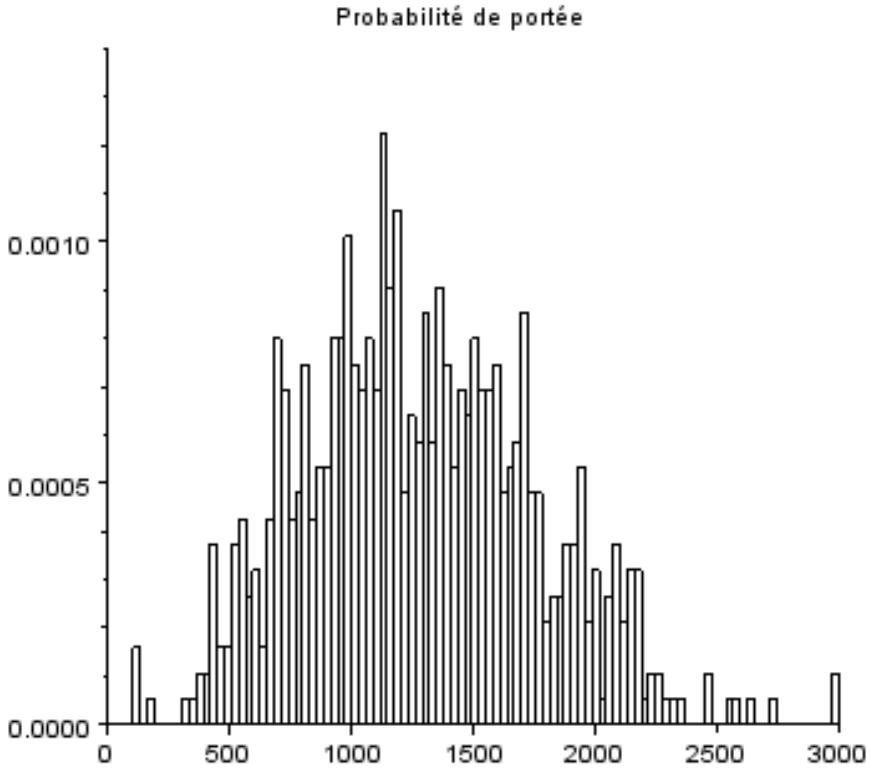
WLS200S: November 23 to December 20 2011



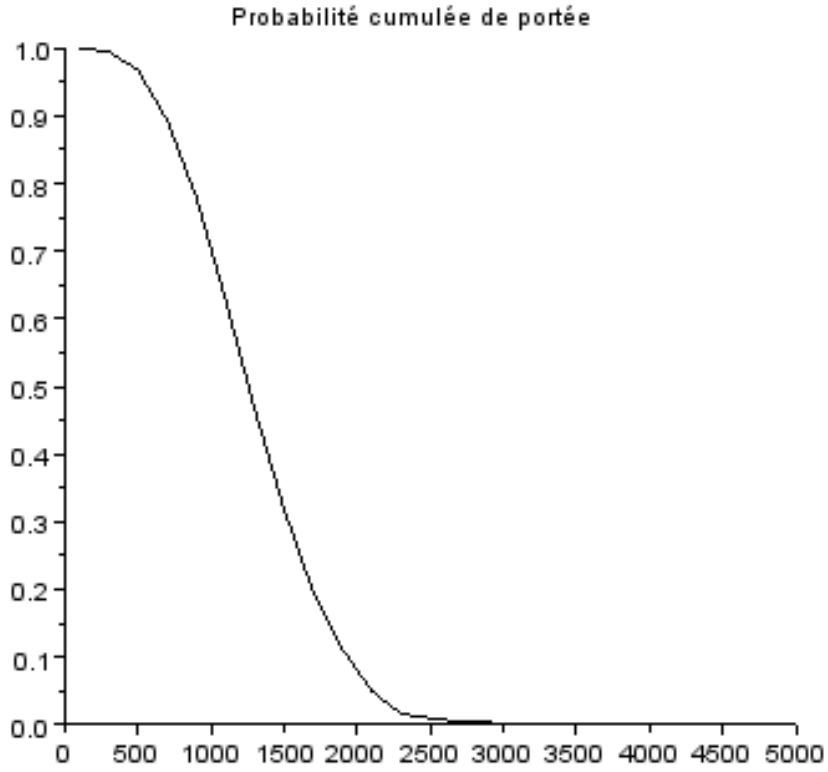
Frequency of maximal range

WLS200S

November 23 to December 20 2011



Height [m] above ground



Height [m] above ground

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- Intercomparison campaign provided a comprehensive data set over different seasons
- All wind lidars are close to 482 Mhz windprofiler and radiosoundings ($\leq \pm$ 0.2 m/s and < 0.8..1.0 m/s in RMS-diff)
- Comparison campaigns useful for new instrumentation, some bugs/problems could be identified and fixed
- Data coverage of wind lidars more than 90% up to 500 m height (even in fall) and complement the wind profile monitoring from ground to LS (lowest level 482 MHz RWP: 448 m)

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Thanks for attention

For discussion ….

	StreamlineLidar HaloPhotonics (KIT)	Windcube WLS200 Leosphere	Windcube WLS200S Leosphere
Manufactured by	Halo photonics	Leosphere	Leosphere
Provided by	Karlsruhe Institute of Technology (KIT)	GWU-Umwelt-technik GmbH	Leosphere
Wavelength	1,5 µm	1,5 µm	1,55 µm
Max. range (of the provided Lidar)	3 km	6 km	6 km
Beams configuration	LOS mapping	Four beams	LOS mapping
Scan modes	Stare, VAD, RHI, DBS		Stare, VAD, PPI

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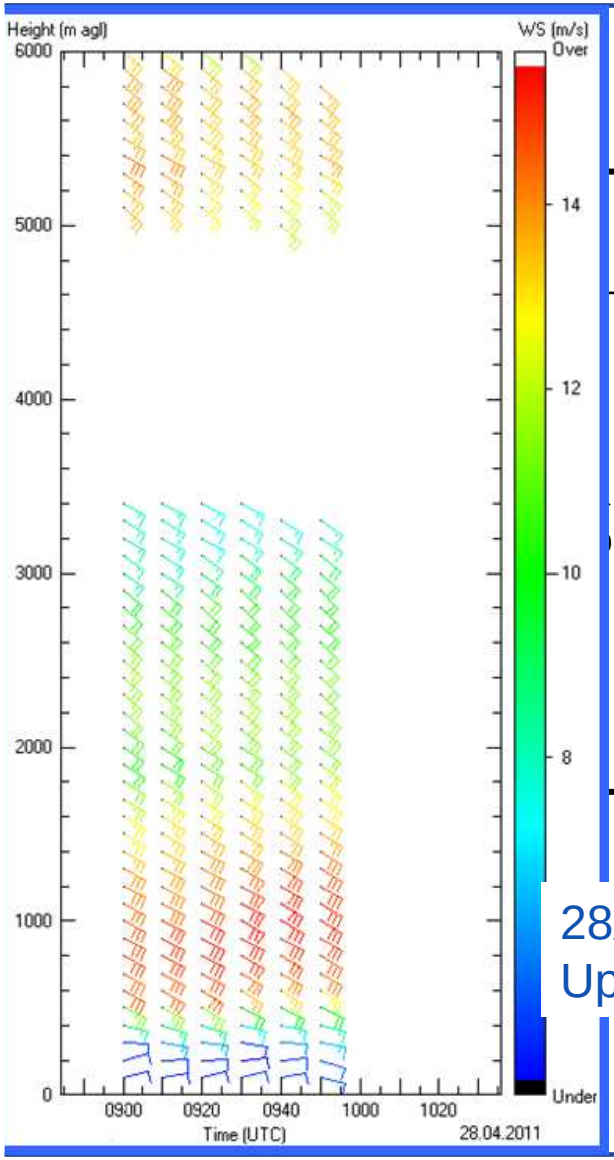
Windlidar Inter Comparison Campaign 2011
Performance (meteorological availability)



28/04/11
Up to 6 km

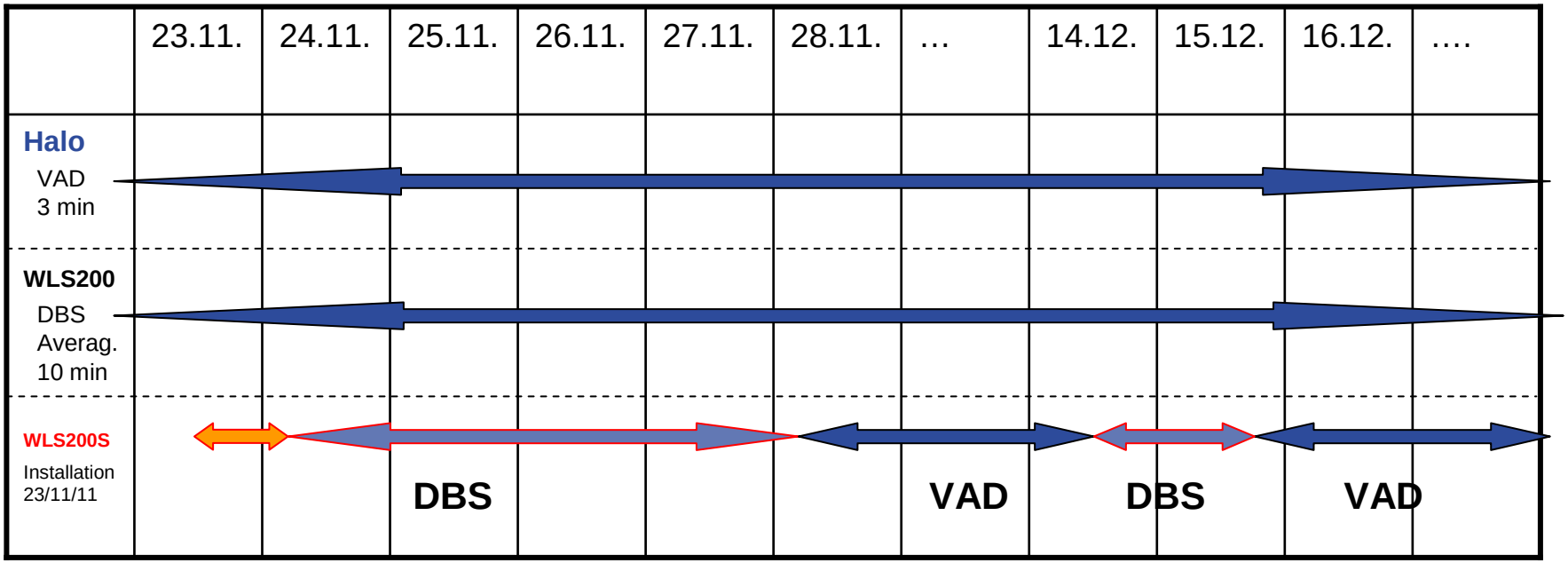
	June	July	Aug	Sep	Oct	Nov	Dec	Jan 2012
			Halo	**Halo**	**Halo**	**Halo**	**Halo**	**Halo**
	WLS70				**WLS200**	**WLS200** **WLS200S** (23/11)	**WLS200** **WLS200S**	

18/11/11
no windlidar measurements
due to low clouds/fog

Windlidar Inter Comparison Campaign 2011

2011	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan 2012
						Halo (8/8/11) VAD 7 min	**Halo** 13/9/11	**Halo** DBS 15 sec	**Halo** 3/11/11	**Halo** VAD 3 min	**Halo**
		WLS200 (20/4/11)	**WLS200** **WLS70**	**WLS70**				**WLS200** (20/10/11)	**WLS200** **WLS200S** (23/11/11)	**WLS200** **WLS200S**	

Windlidar Inter Comparison Campaign 2011

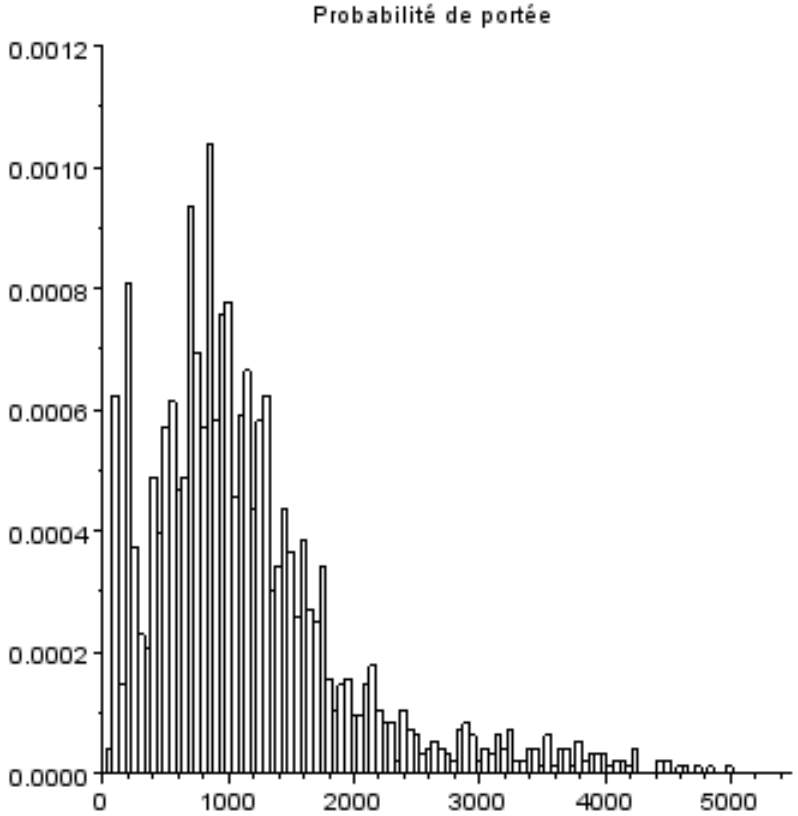


Leosphere

VAD - Velocity Azimuth Display (more than four directions) ≙ PPI

DBS - Doppler-Beam Swinging (four beams) ≙ VAD

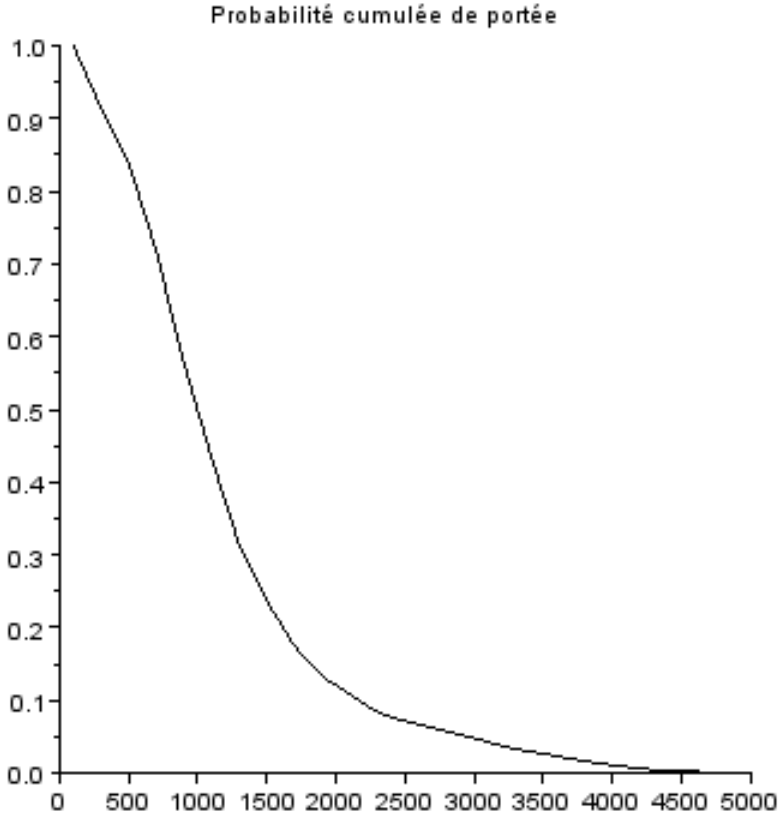
Frequency of maximal range



Height [m] above ground

WLS200

October 20 2011 to January 9 2012



Height [m] above ground