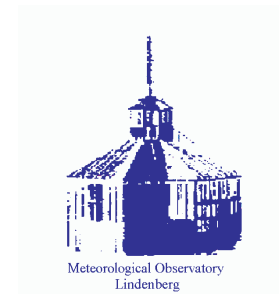


Wind profiler radar in the aerological network of the DWD

Dirk A.M. Engelbart, Volker Lehmann and Ulrich Görsdorf
Deutscher Wetterdienst
Meteorolog. Observatory Lindenberg
D-15848 Lindenberg, GERMANY

March 3, 2005



Wind profiler radar (WPR) in the DWD

- October 1993: Installation of the 1290 MHz boundary layer wind profiler/RASS at the Meteorological Observatory Lindenberg (MOL)
- July 1996: Installation of the 482 MHz tropospheric wind profiler/RASS at the MOL
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- May 2004: Begin of operation of the second system in Nordholz
- Summer 2005: (planned) Begin of operation of the third system in Bayreuth

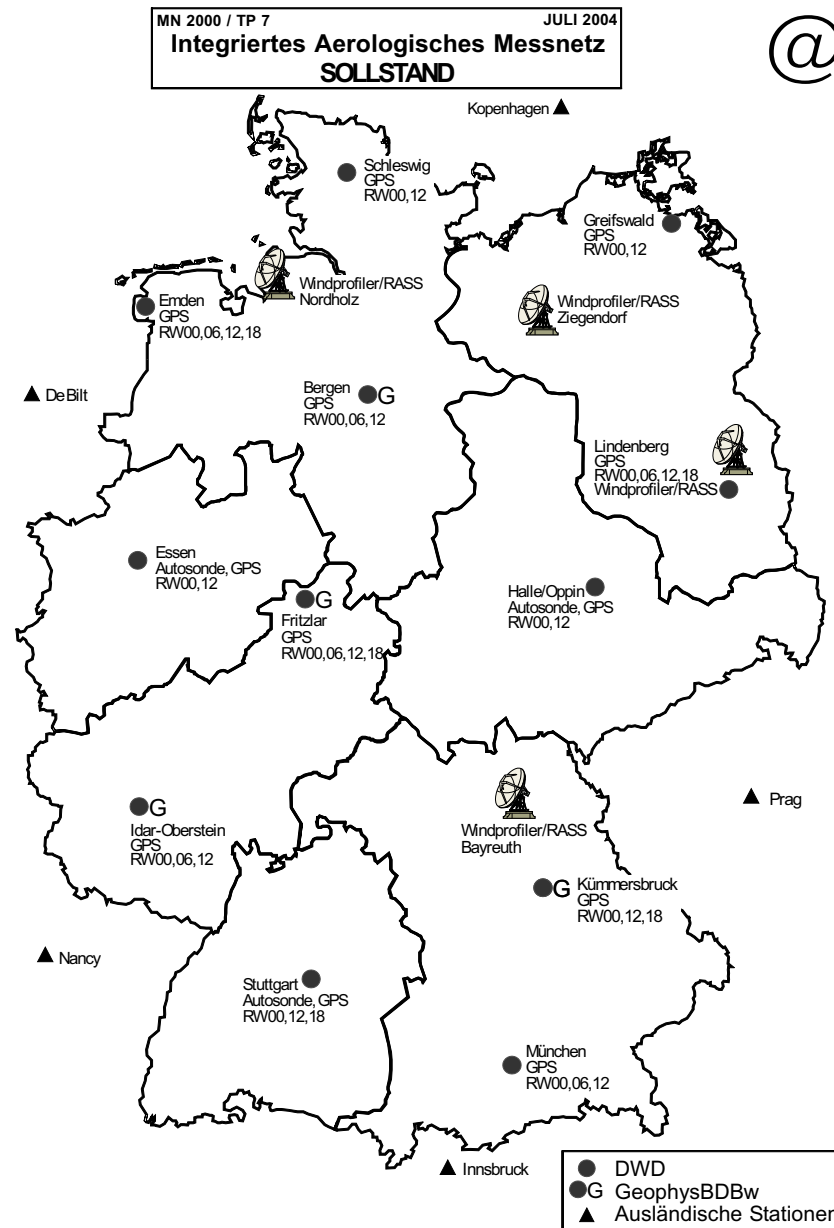
Remote-sensing field site at MOL, June 2003



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The aerological network of the DWD



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482 MHz Wind profiler radar system (WPR), Ziegenderdorf

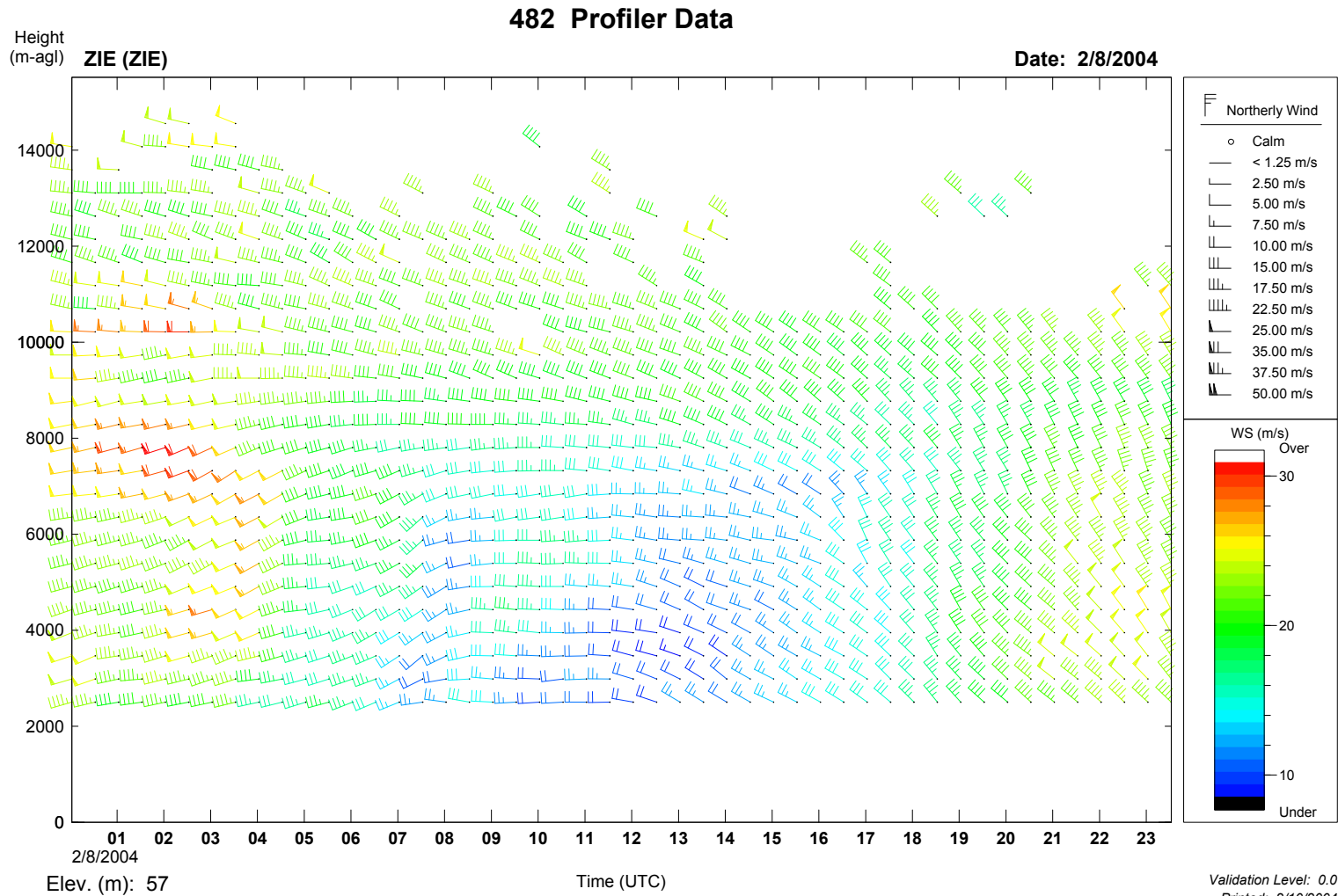
System parameters of the network WPR systems

Frequency	482,0078 MHz
Peak power (averaged)	16 (2,4) kW
Pulse modulation	Amplitude, Phase (Pulse compression)
Pulse width (vert. resolution)	1,7 μ s (250 m) 2,2 μ s (330 m) 3,3 μ s (500 m) 4,4 μ s (660 m)
Antenna type	Array of 180 CoCo elements
Antenna aperture	142 m ² (12,5 × 11,5 m)
Antenna gain	\geq 34 dBi
3 dB - Beam width	\leq 3°
Beam tilt	15,2°
Receiver type	Heterodyn, Digital. der ZF
A/D Converter	14 bit
System sensitivity	\leq -154 dBm

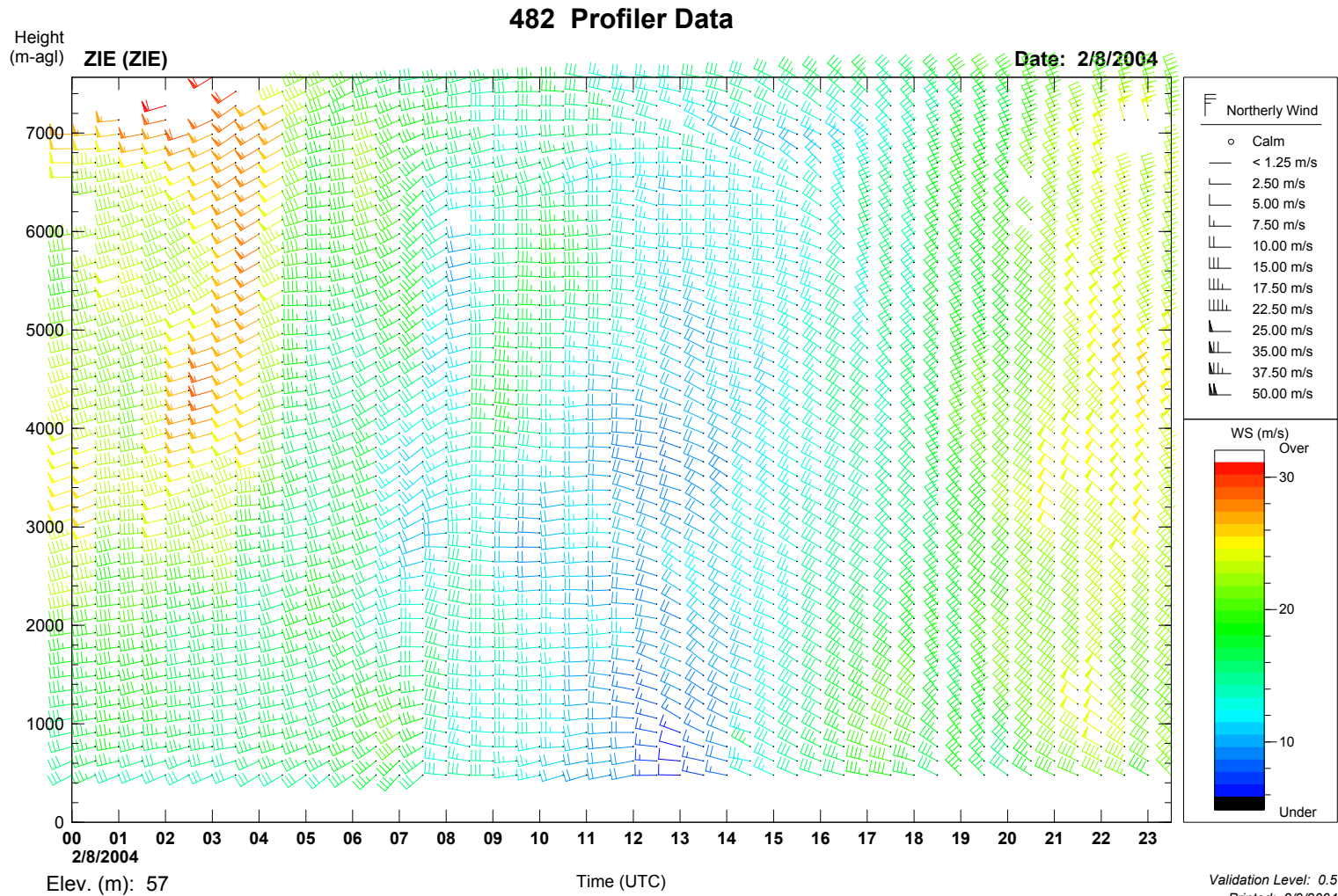
Measuring characteristics

Mode	Wind		Virt. Temperature
	High Mode	Low Mode	
Pulse length	3333 ns	1666 ns	1666 ns
Vertical resolution	500 m	250 m	250 m
Spacing	500 m	150 m	135 m
Min. measuring height (agl)	2502 m	479 m	496 m
Max. measuring height (agl)	16484 m	7566 m	4203 m
Averaging time	26 min		4 min

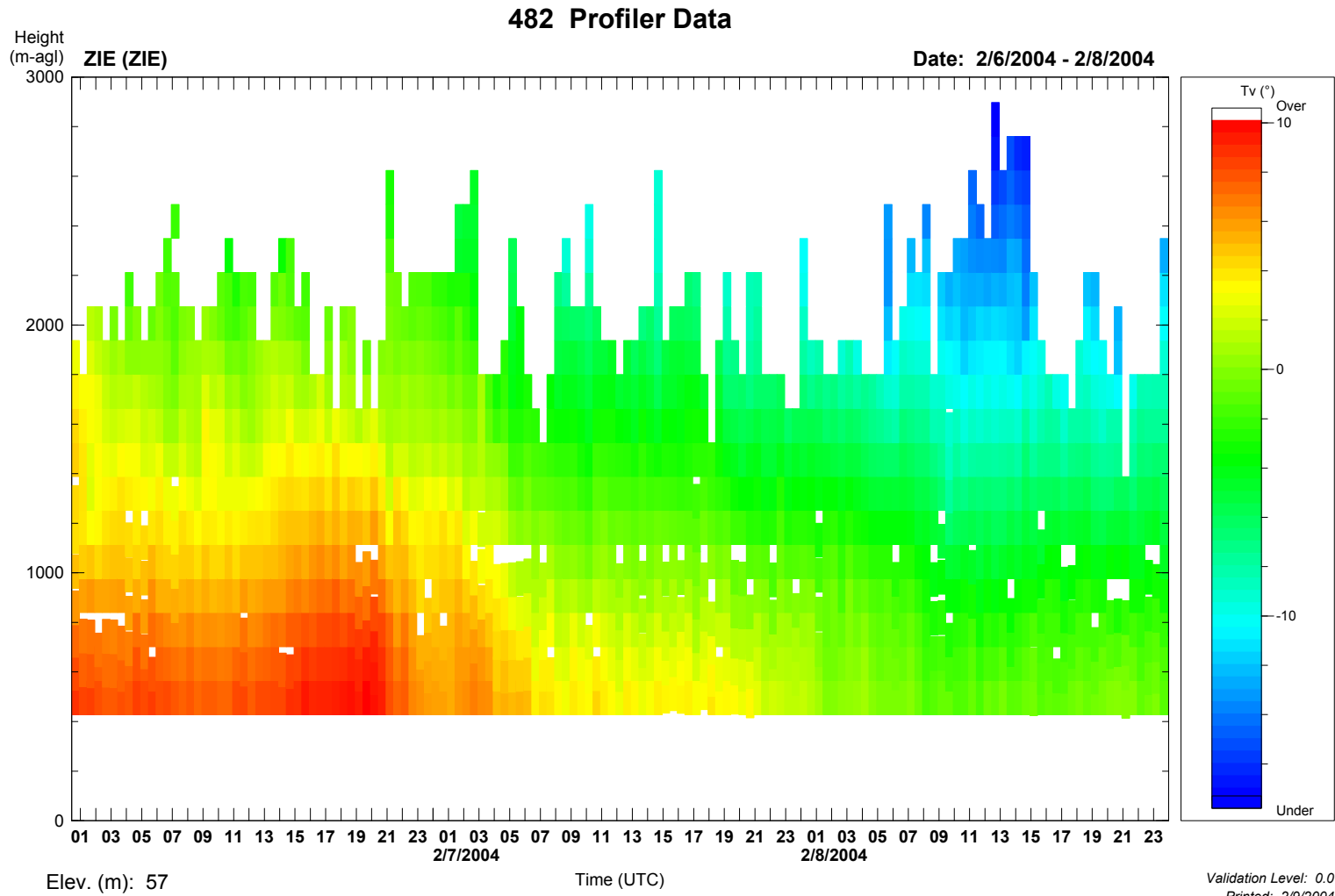
Example Feb 8th, 2004: Wind measurement - High Mode



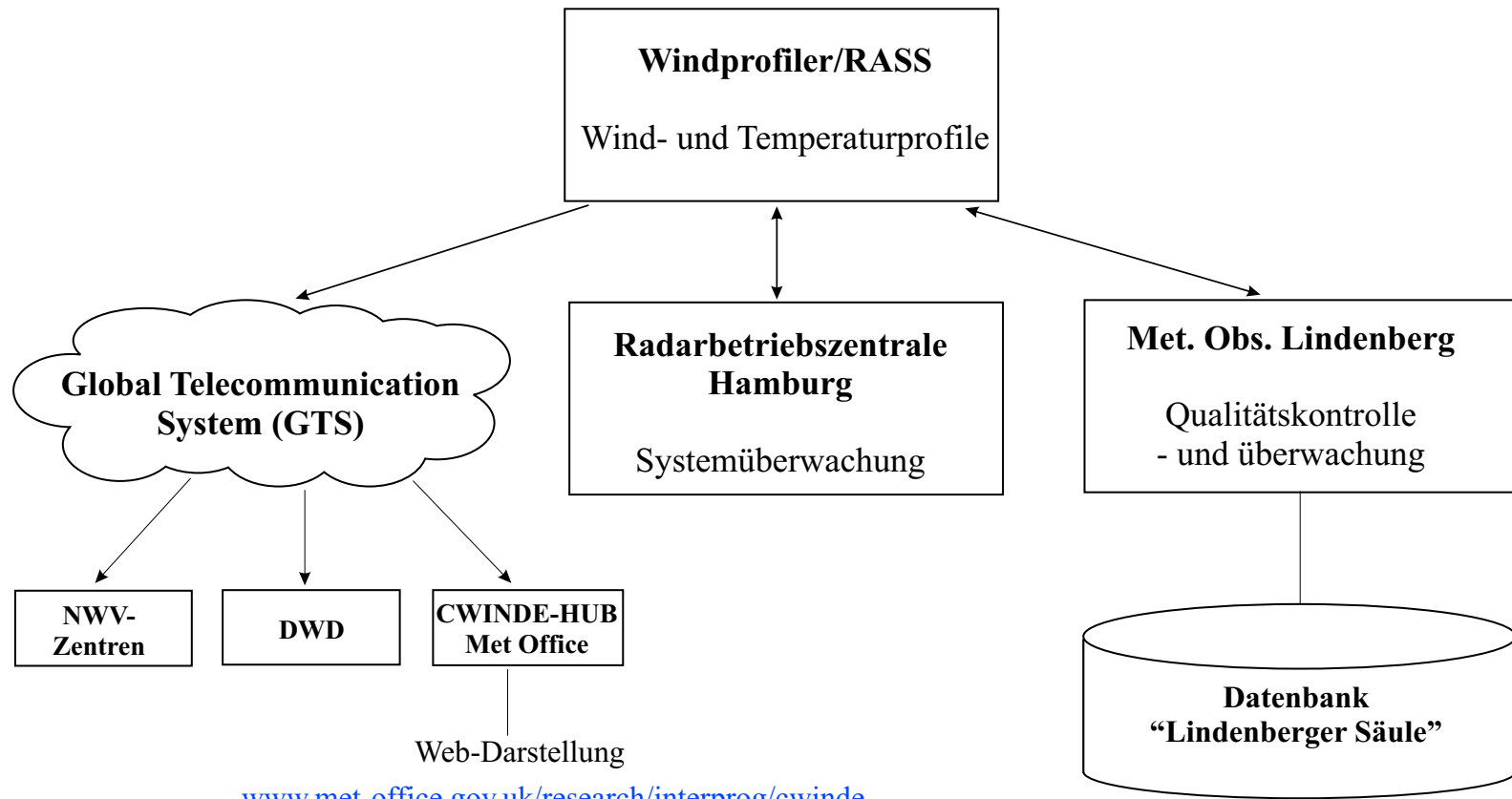
Example Feb 8th, 2004: Wind measurement - Low Mode



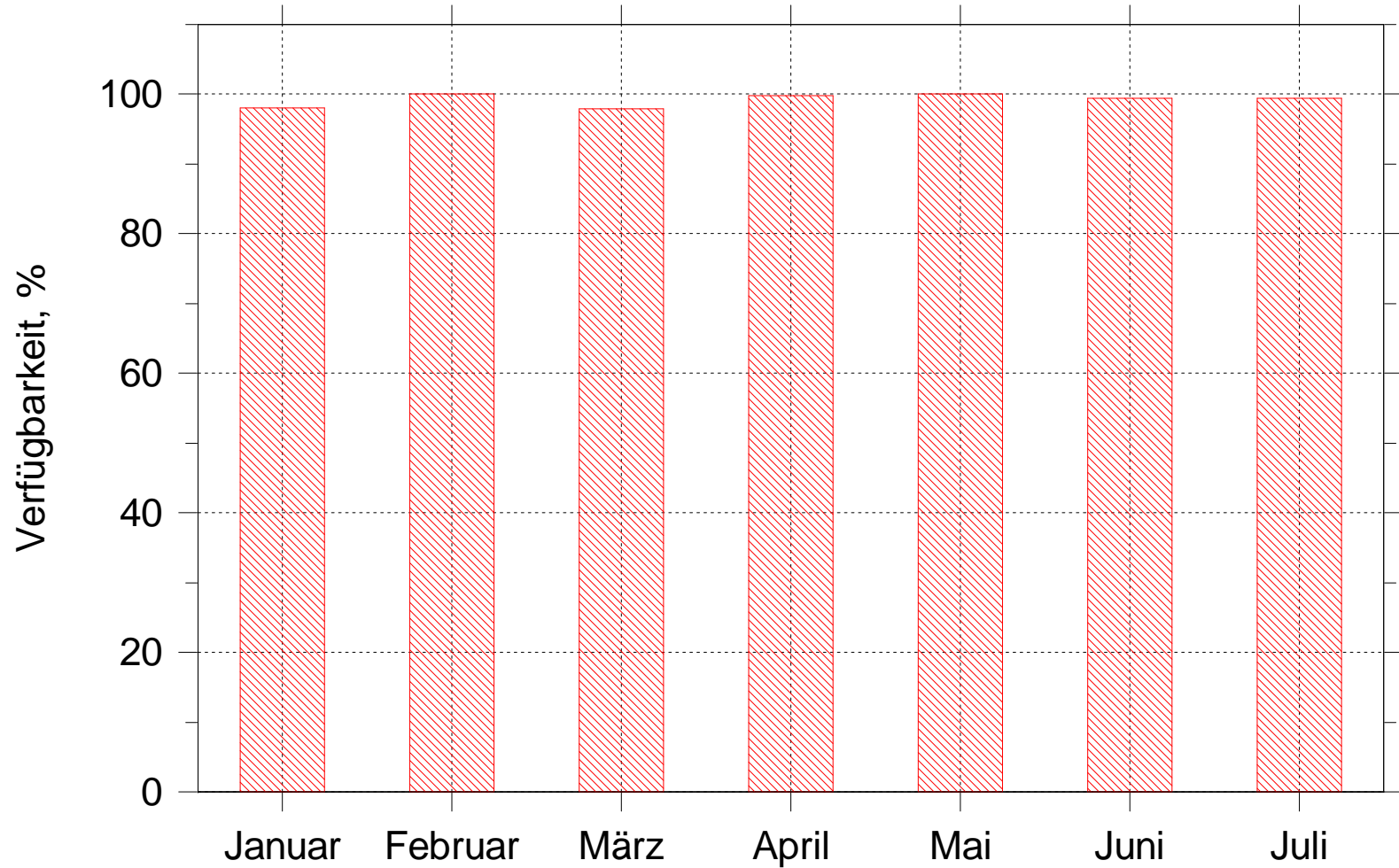
Example Feb 6 - 8, 2004: Measurement of virt. temperature



WPR as part of the aerological network

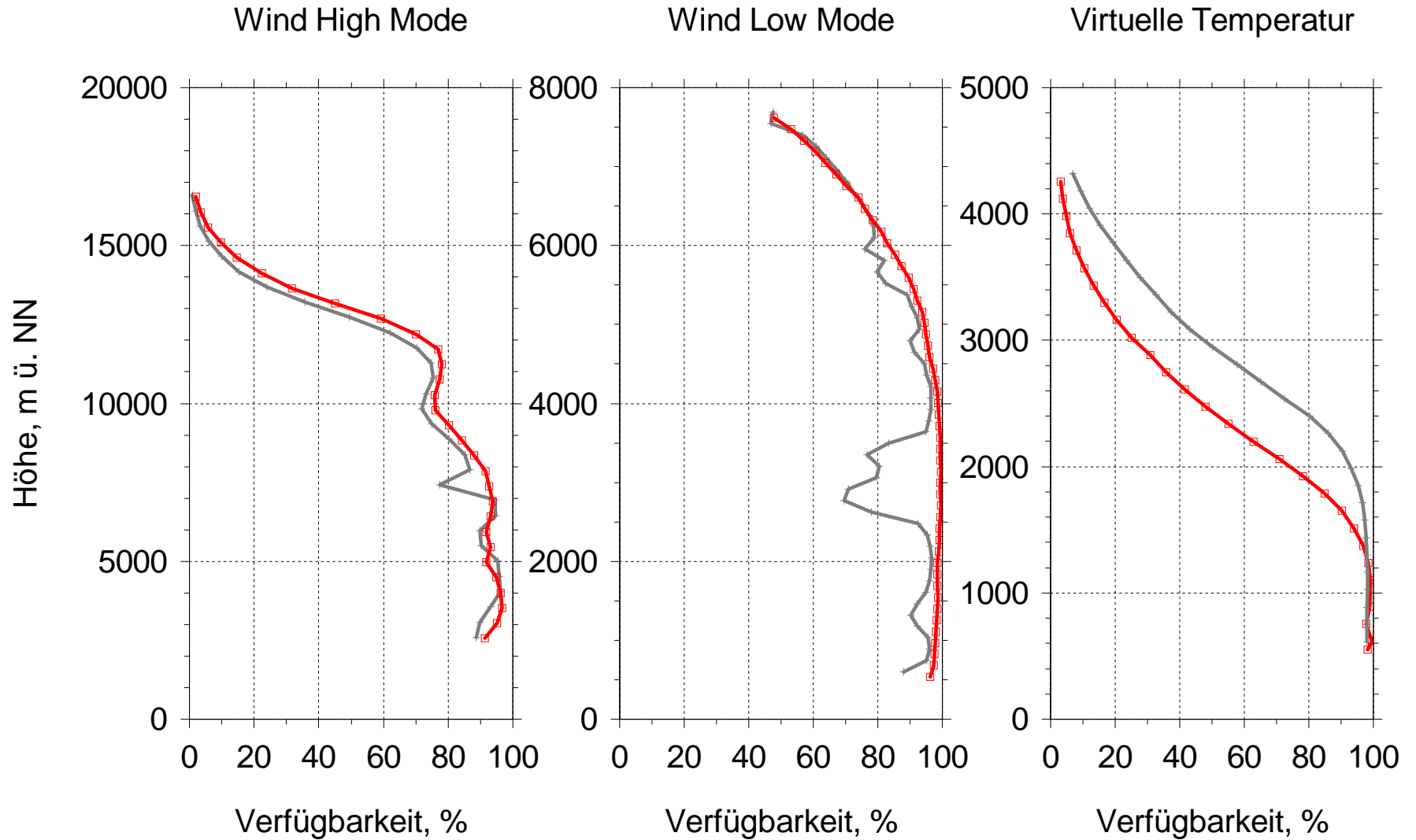


Availability of the Ziegenderf wind profiler radar



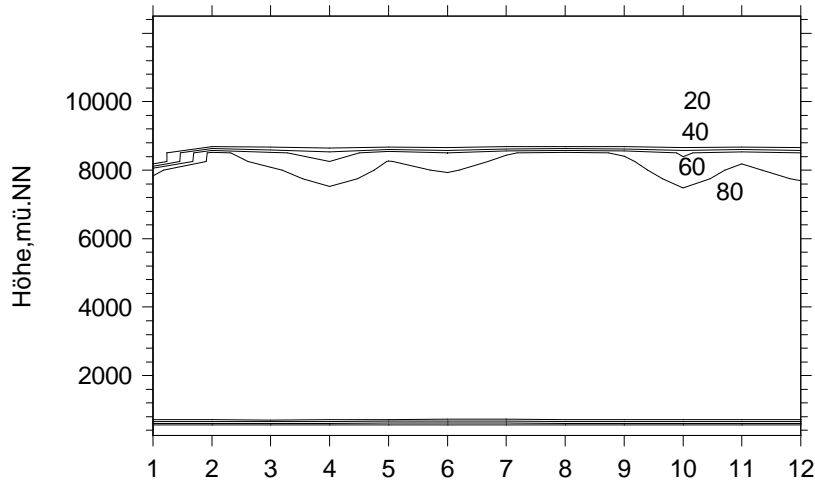
Height coverage

6 month, red: Ziegendorf / grey: Lindenberg

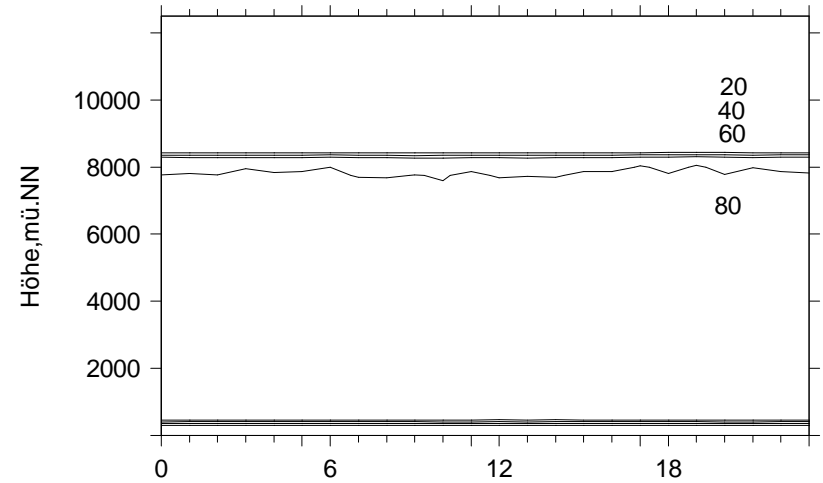


Annual- and diurnal cycle: Wind

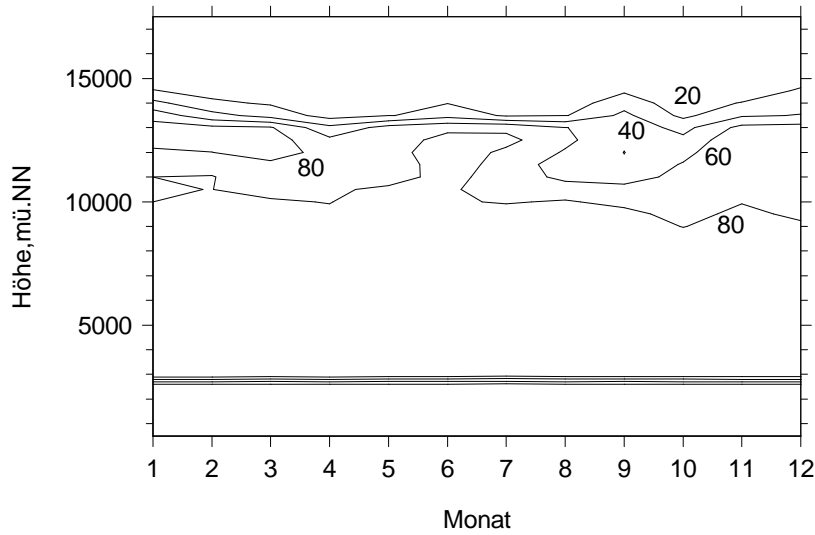
TWPLowMode,1997



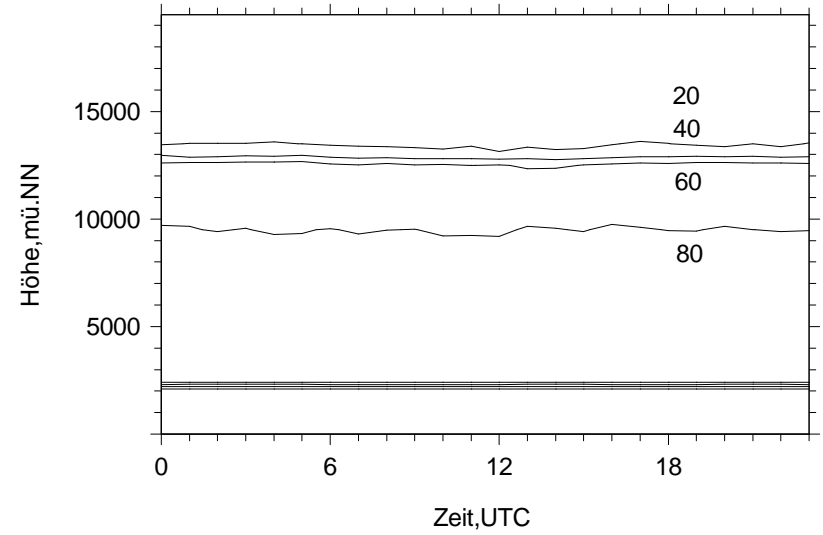
TWPLowMode,1997



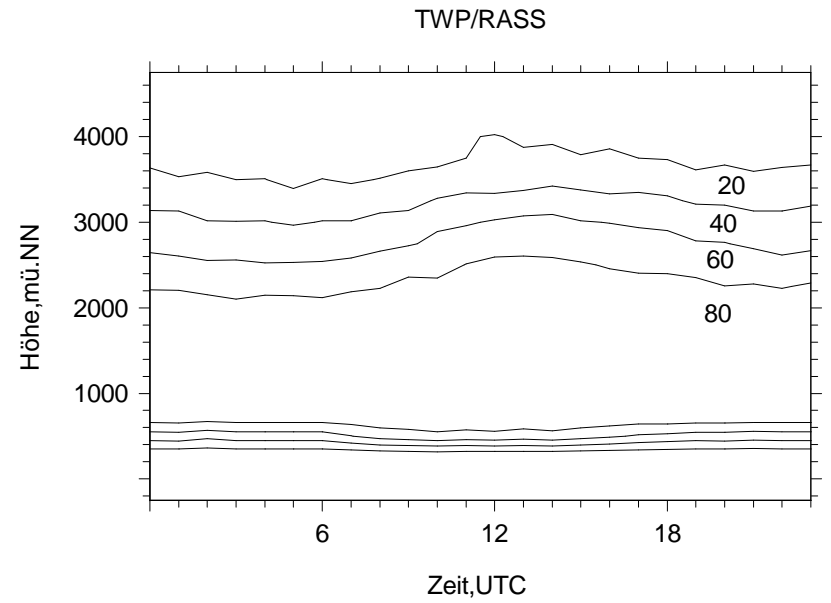
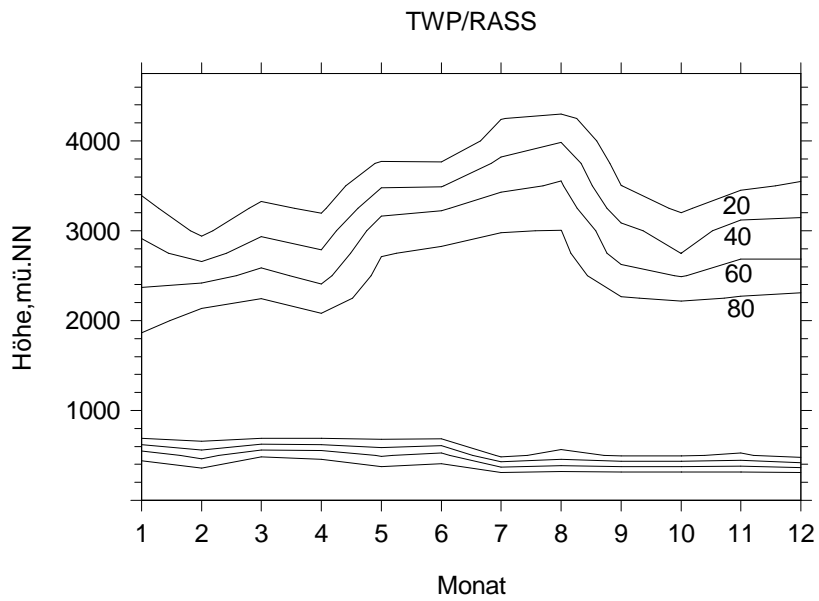
Monat
TWPHighMode,1997



Zeit,UTC
TWPHighMode



Annual- and diurnal cycle: Temperature



Accuracy

Methods for estimation of measurement accuracy:

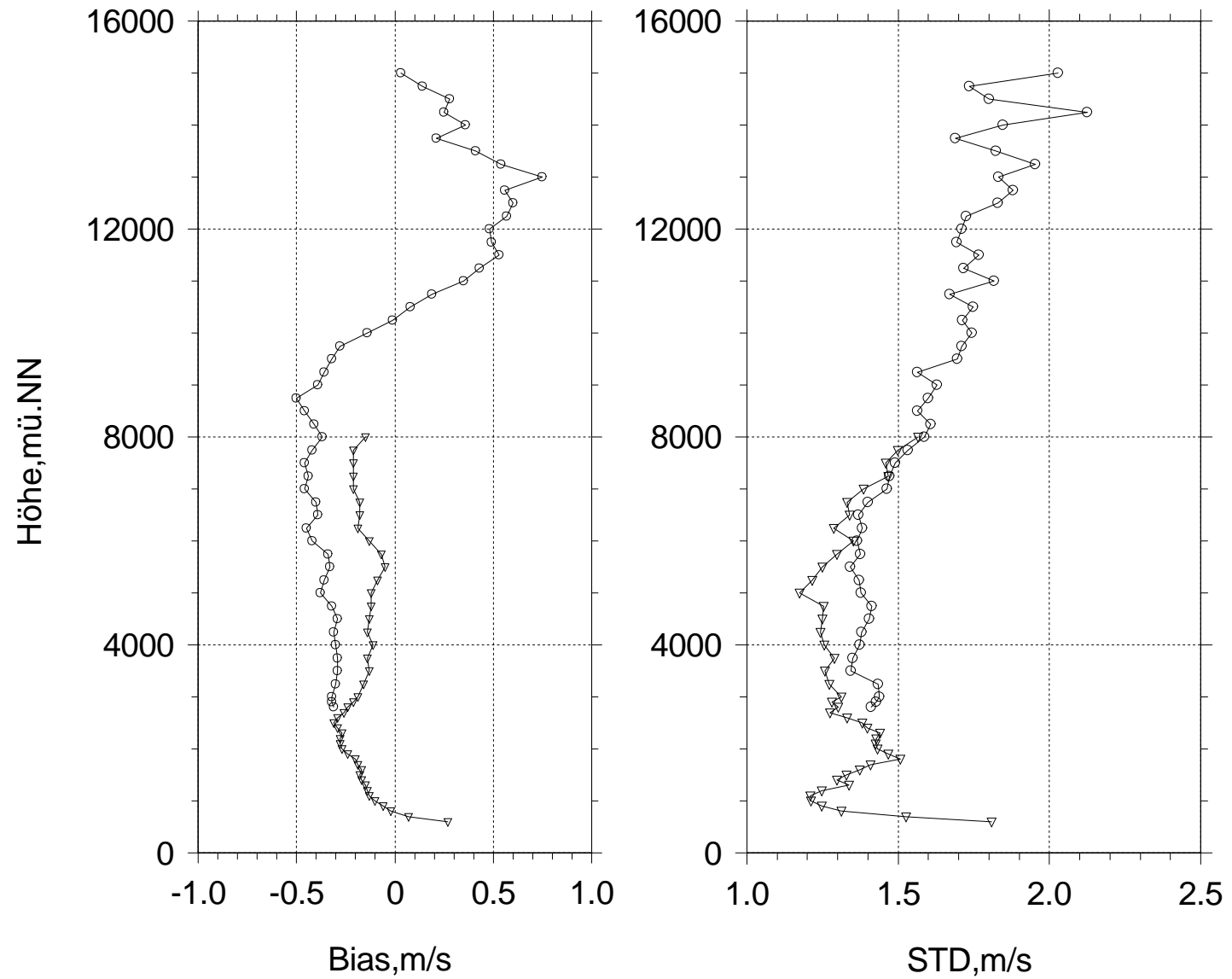
- Error propagation
- Using redundant measuring information (z.B. Strauch et al., 1987)
- Evaluation of consistency of measurements (Nash und Lyth, 1997)
- **Comparison with reference to (Radiosonde or Modell output; $\Delta X = \Delta X_{WRR/RASS} - \Delta X_{Reference}$)**
advantage: Information about systematic and random errors

Problem:

$$\Delta X = \Delta X_{error(WPR/RASS)} + \Delta X_{error(Referenz)} + \Delta X_{atm.var.}$$

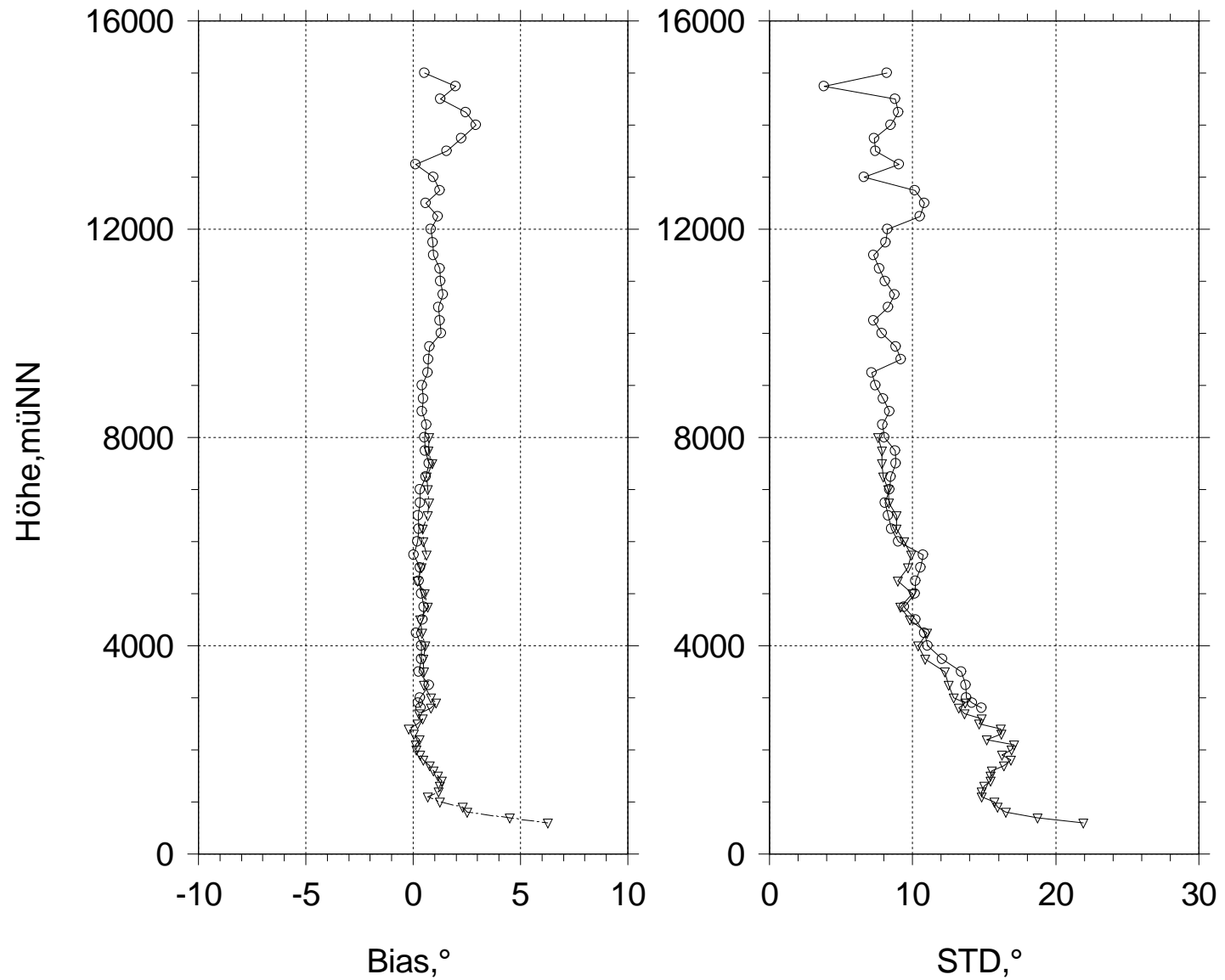
Comparison of WPR measurements vs. radiosonde: wind speed

Cycles: High Mode; triangles: Low Mode



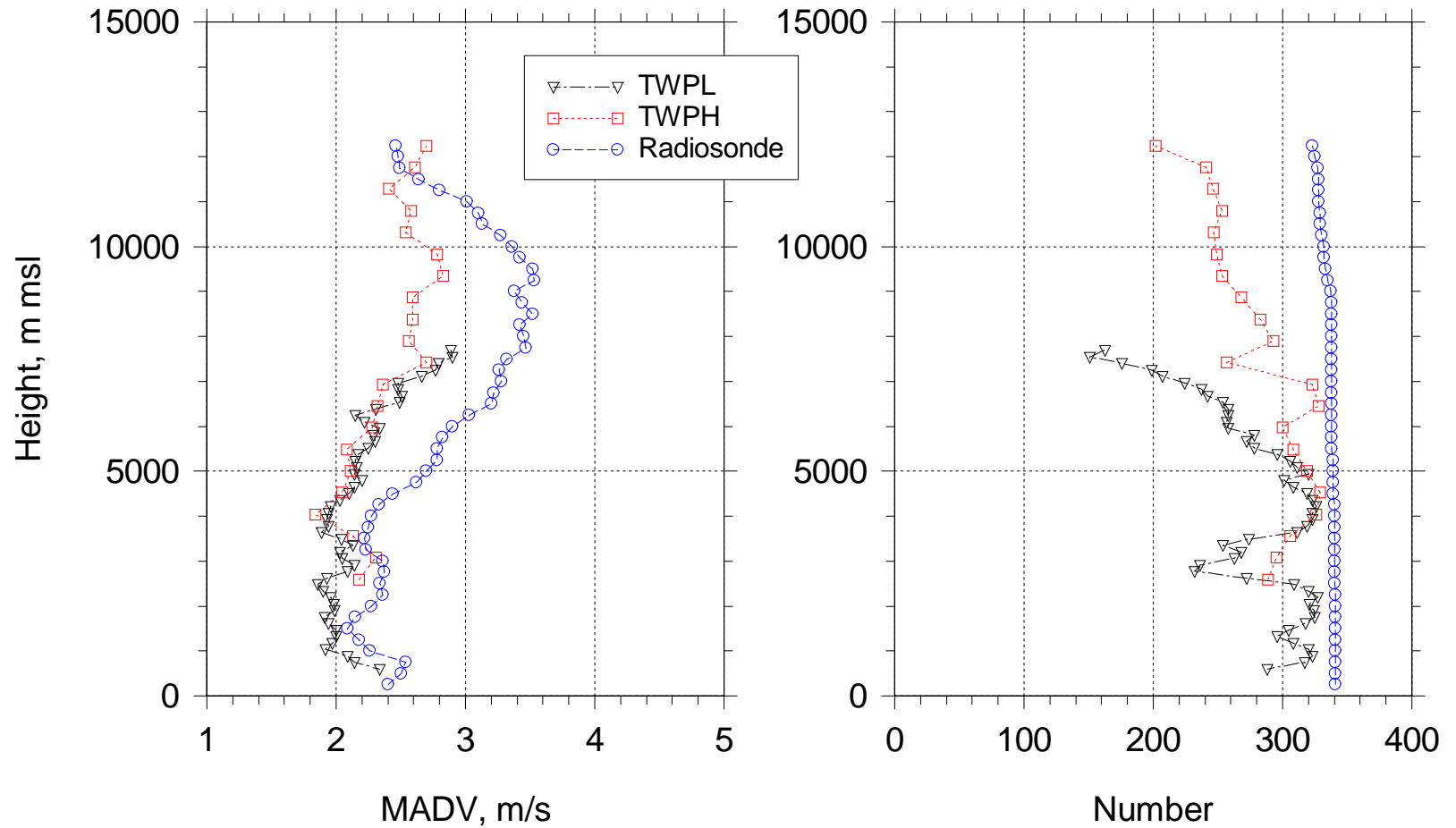
Comparison of WPR measurements vs. radiosonde: wind direction

Cycles: High Mode; triangles: Low Mode



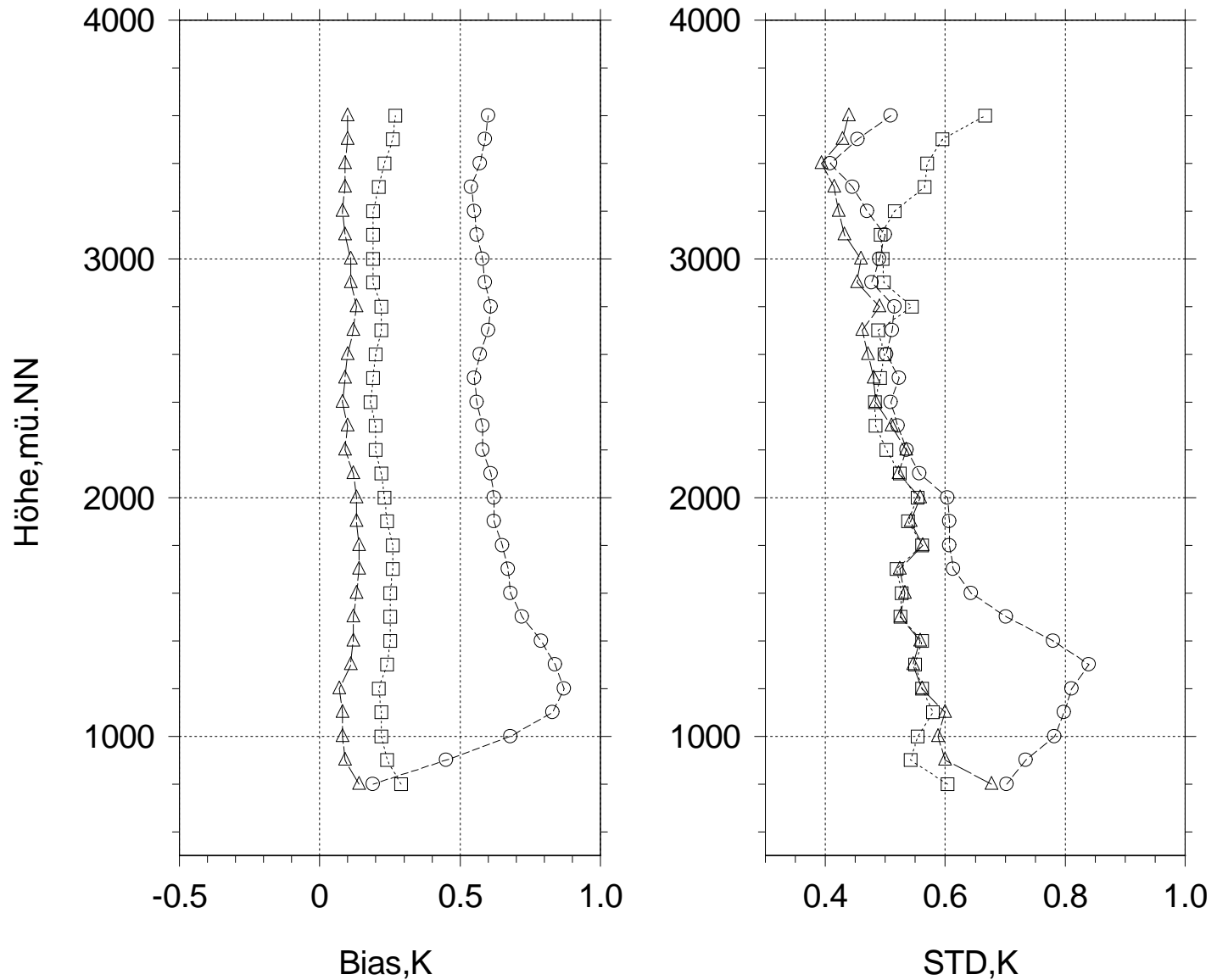
Comparison of WPR measurements vs. NWP model: amount of difference vector

Dec. 2003 - May 2004



Comparison of WPR data vs. radiosonde: virt. temperature

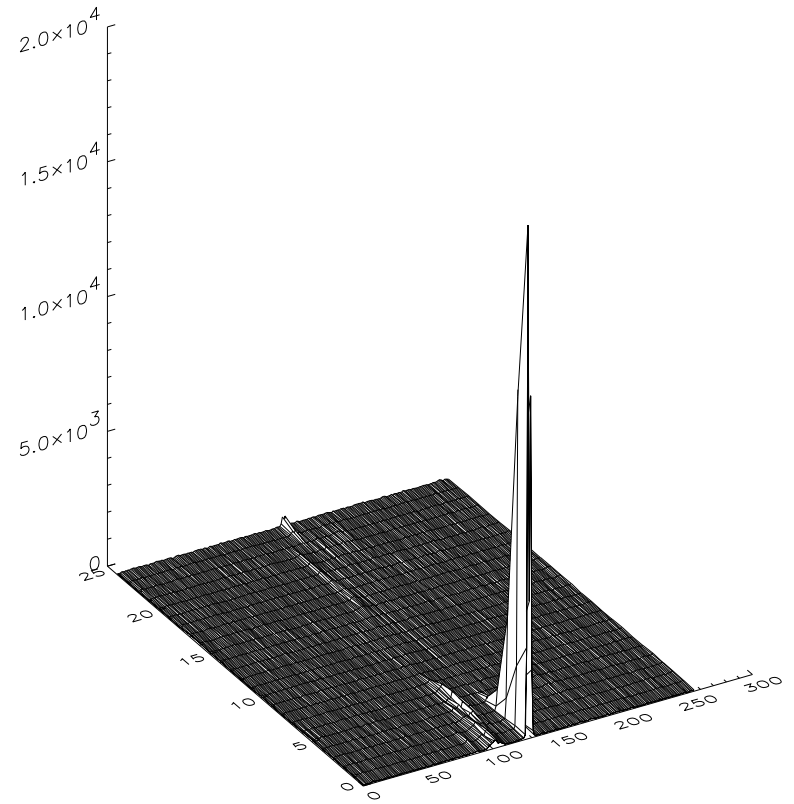
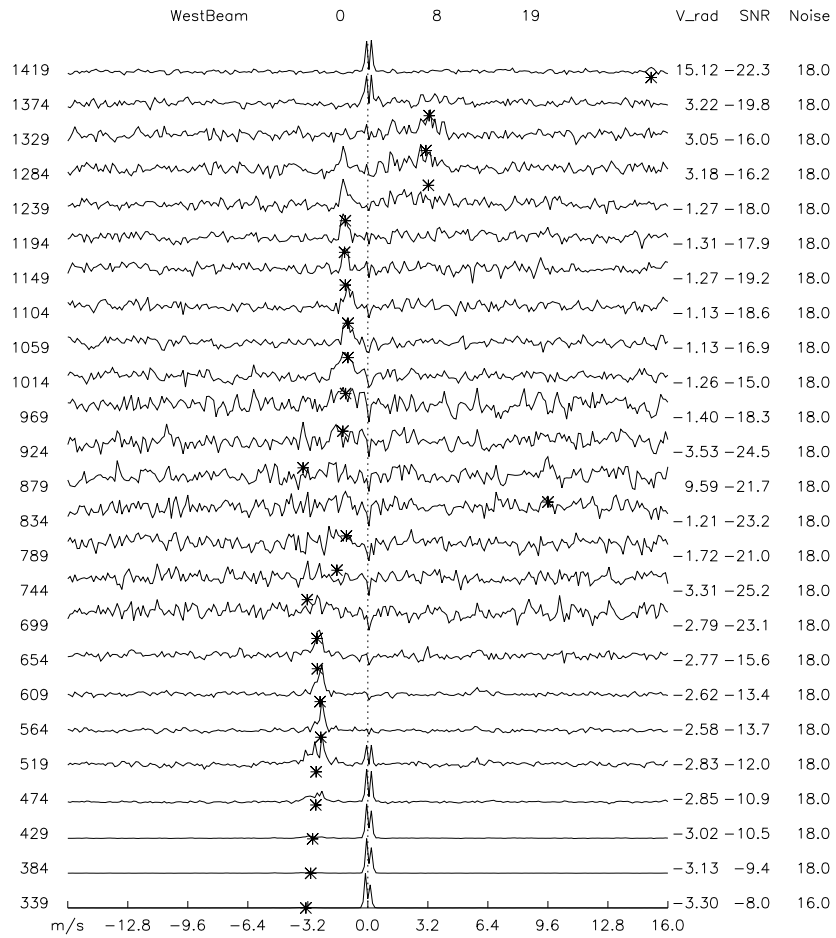
Cycles: without correction; squares: with constant-, range- and vertical wind correction;
triangles: with constant-, range correction



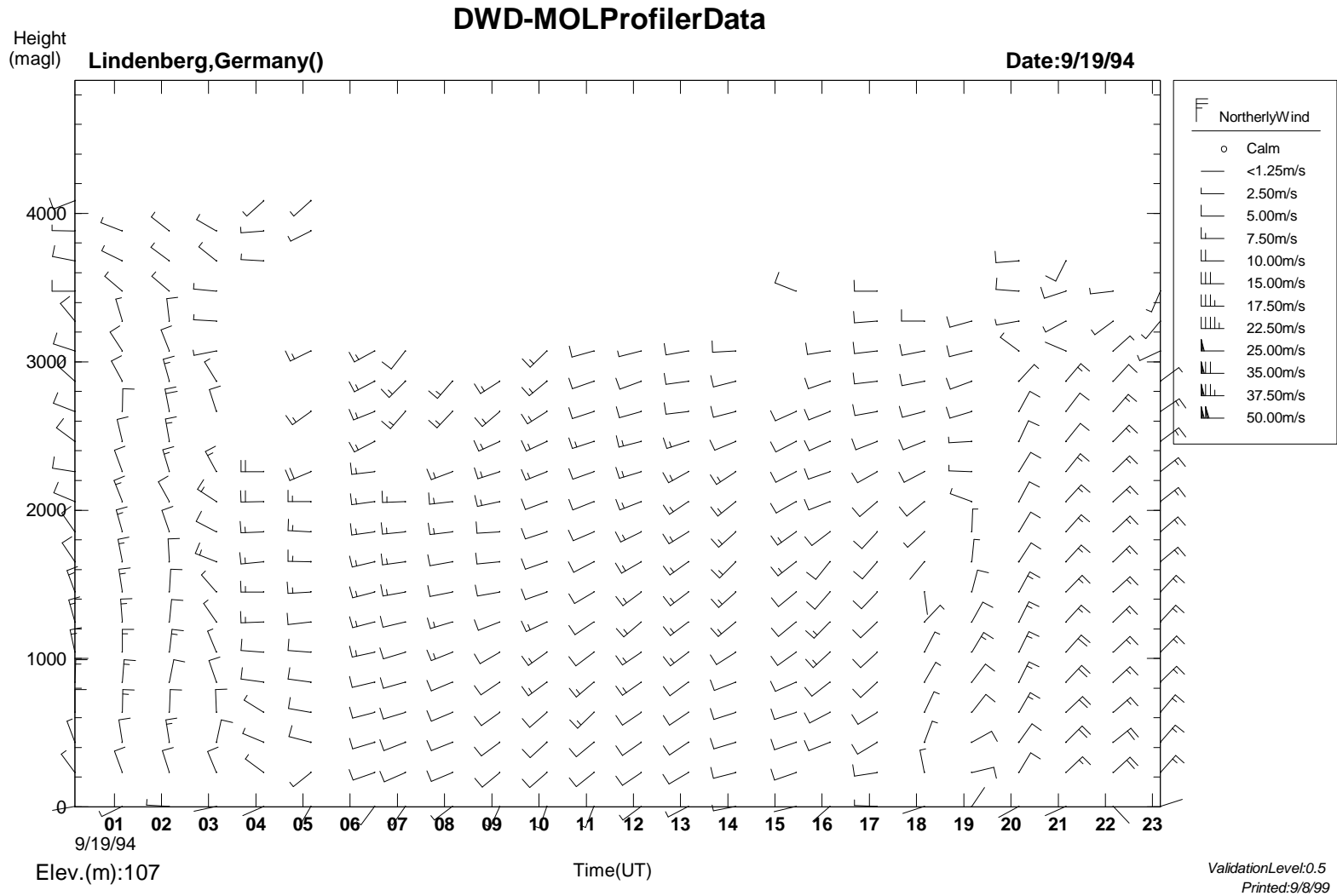
Error sources for wind measurements

- **Undesirable backscattering processes**
 - Ground clutter (trees, towers, wind power plants)
 - Hard targets (airplanes, birds)
 - Precipitation
- Radio frequency interference (RFI)
- Inhomogeneity of the 3D windfield
 - Gravity waves or Lee waves
 - Convection, convective or horizontal inhomogeneous precipitation
- Interpretation errors
 - Range errors
 - Range-aliasing, velocity-aliasing
 - Imperfection of the pulse-compression algorithm
- Hardware-errors

Groundclutter



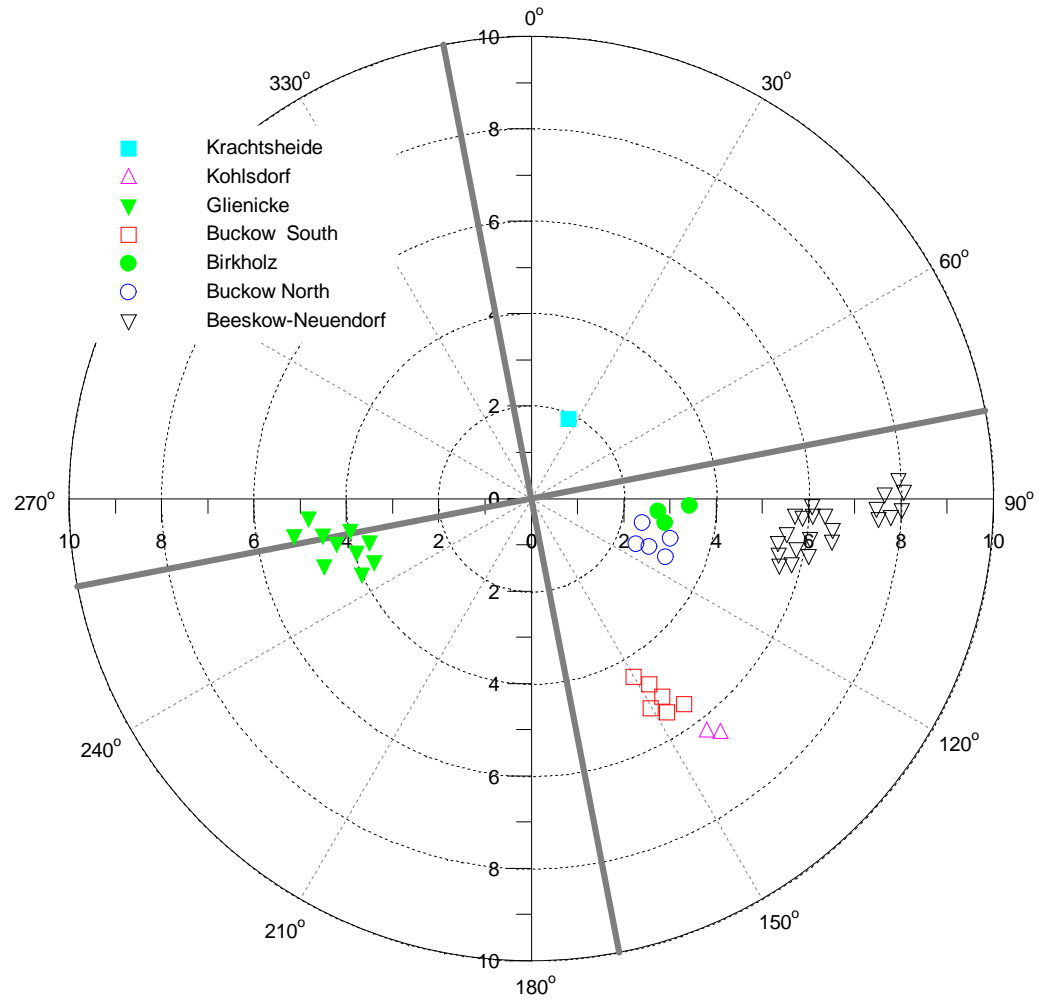
Bird migration



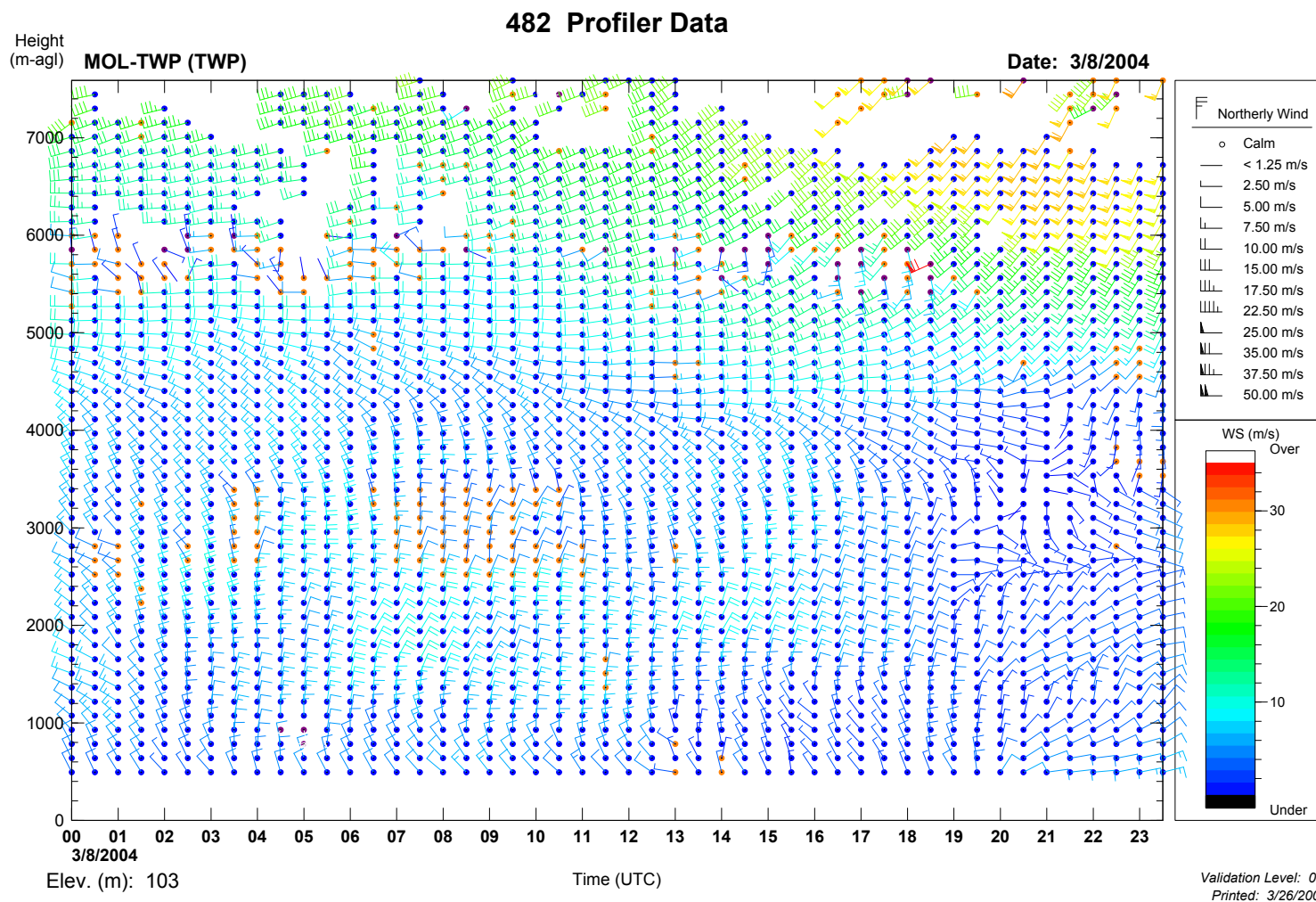


Wind turbine REpower MD 70

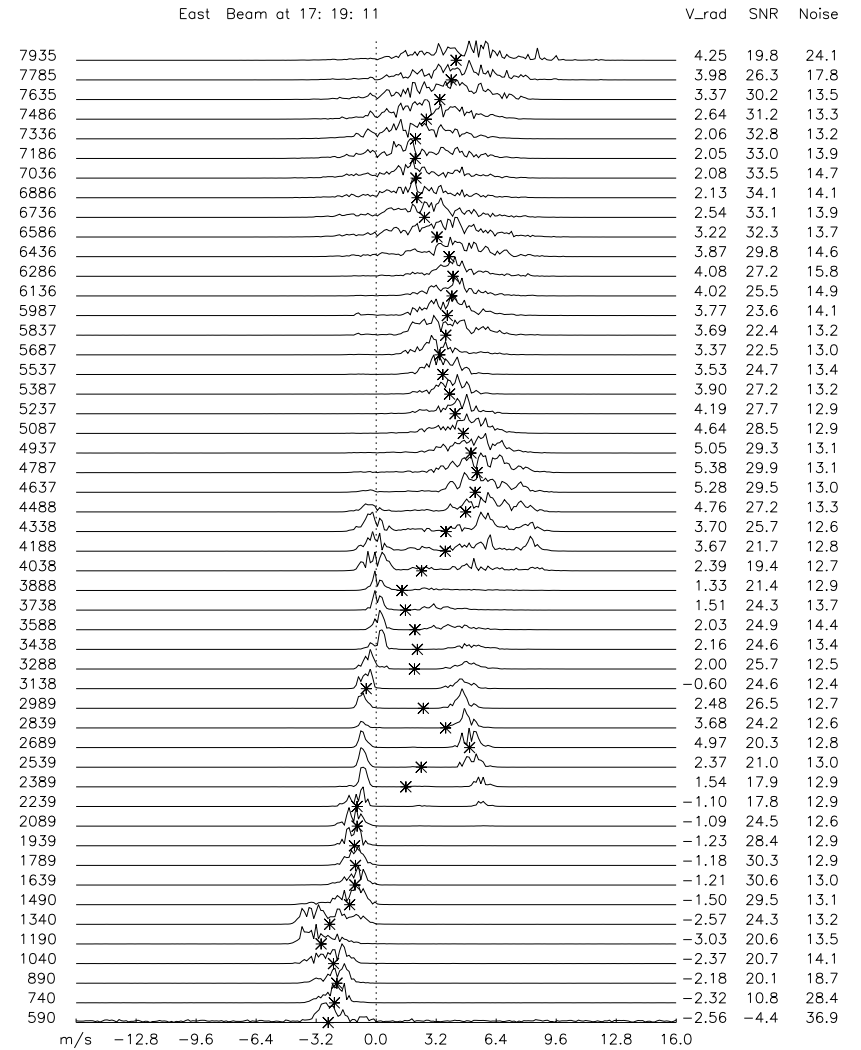
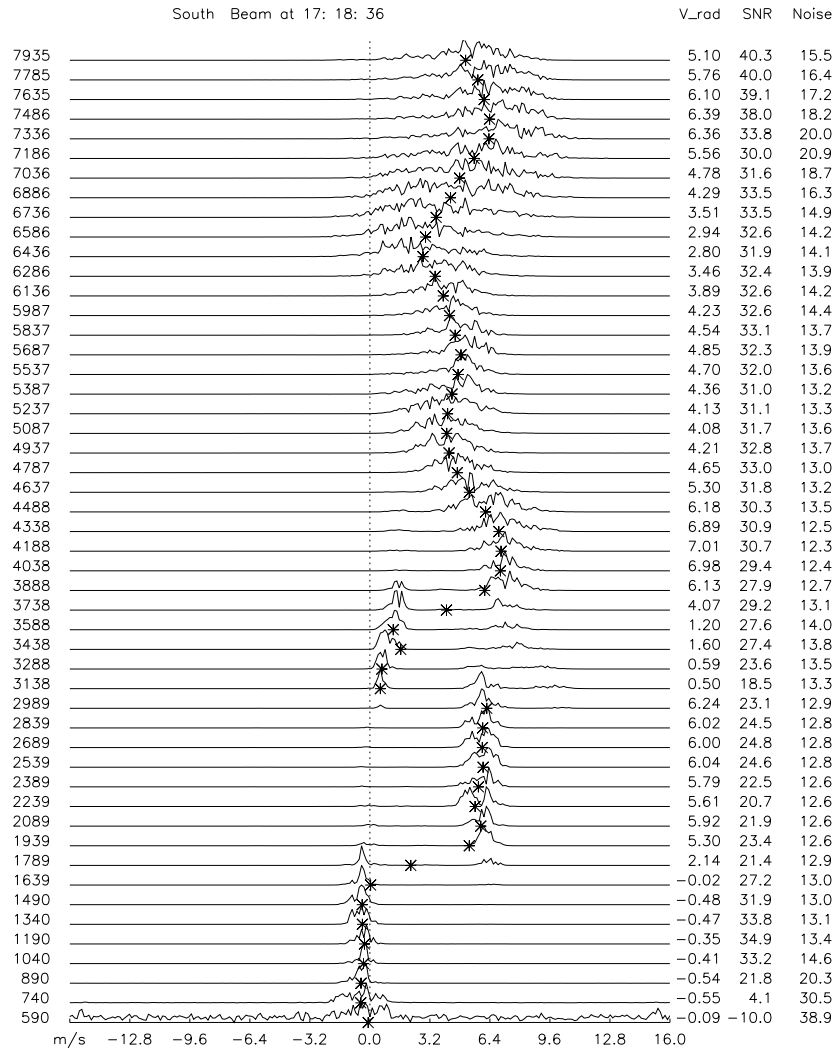
Locations of wind power plants



Interferences by wind power plants



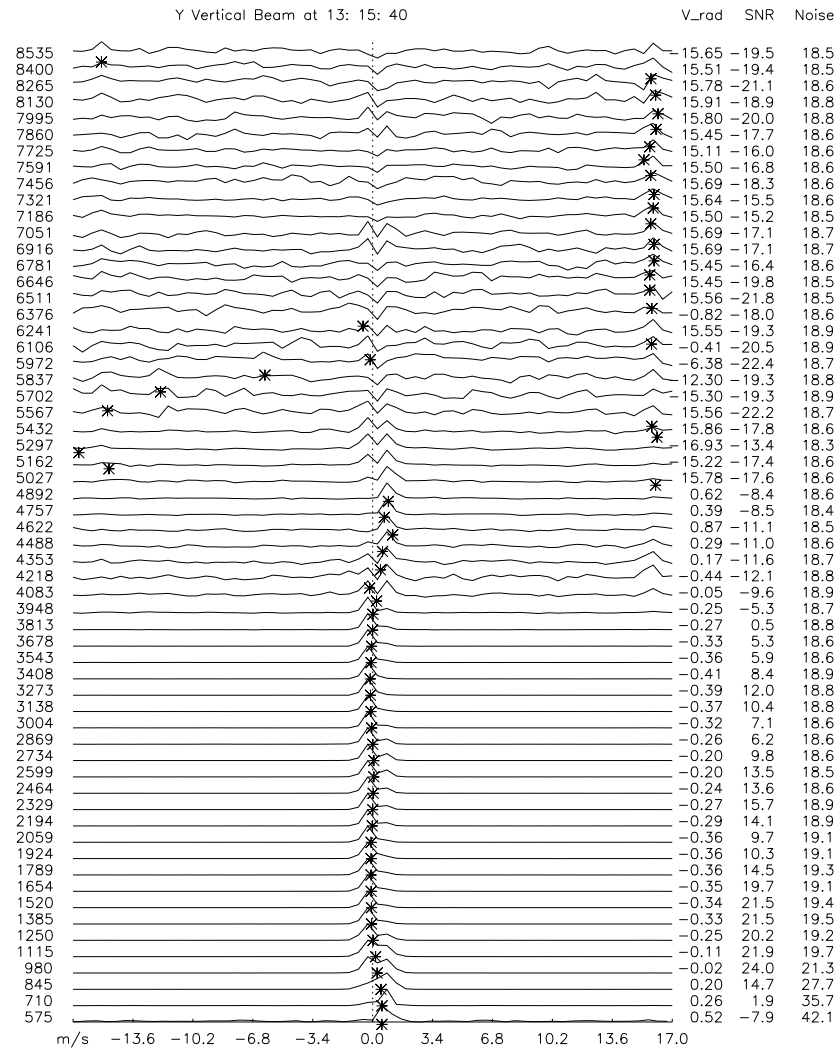
Interferences due to convective precipitation



Error sources for wind measurements

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 - Range errors
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- **Hardware-errors**

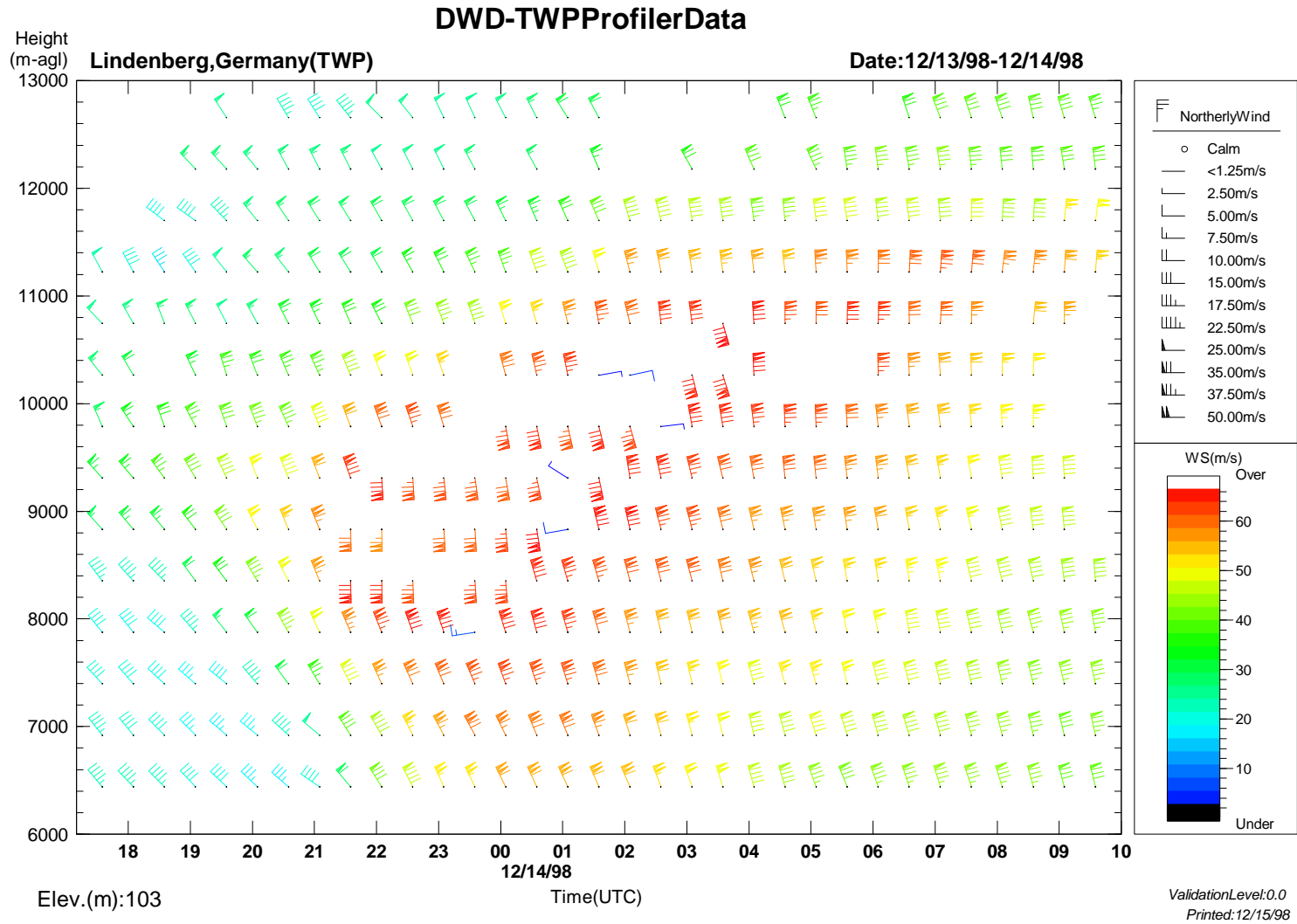
Internal radio frequency interference (50 Hz)



Error sources for wind measurements

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- Radio frequency interference (RFI)
- **Inhomogeneity of the 3D wind field**
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 - Range errors
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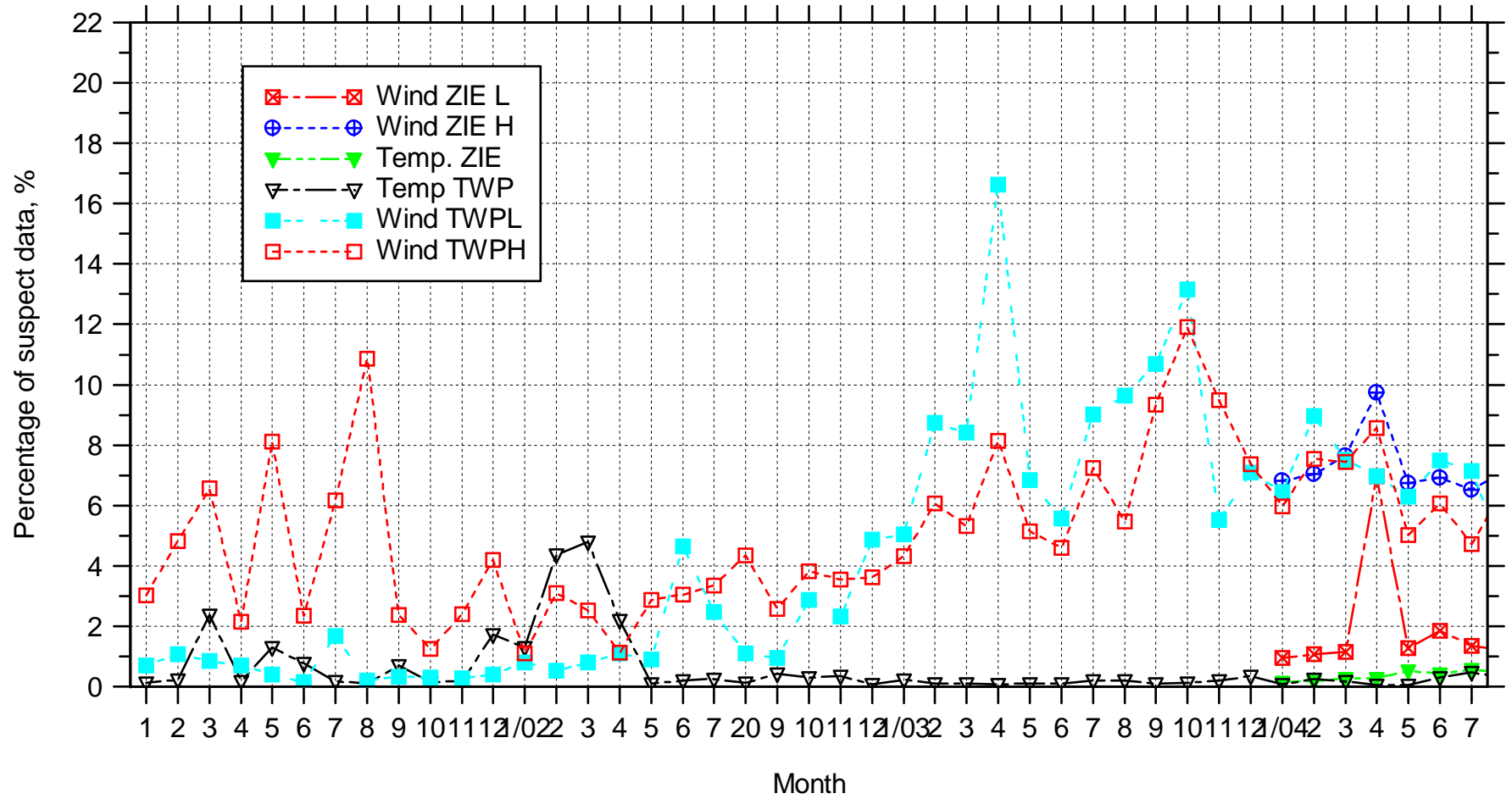
Velocity - aliasing



Error sources for wind measurements

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Relative amount of suspect data



Quality control and quality assurance

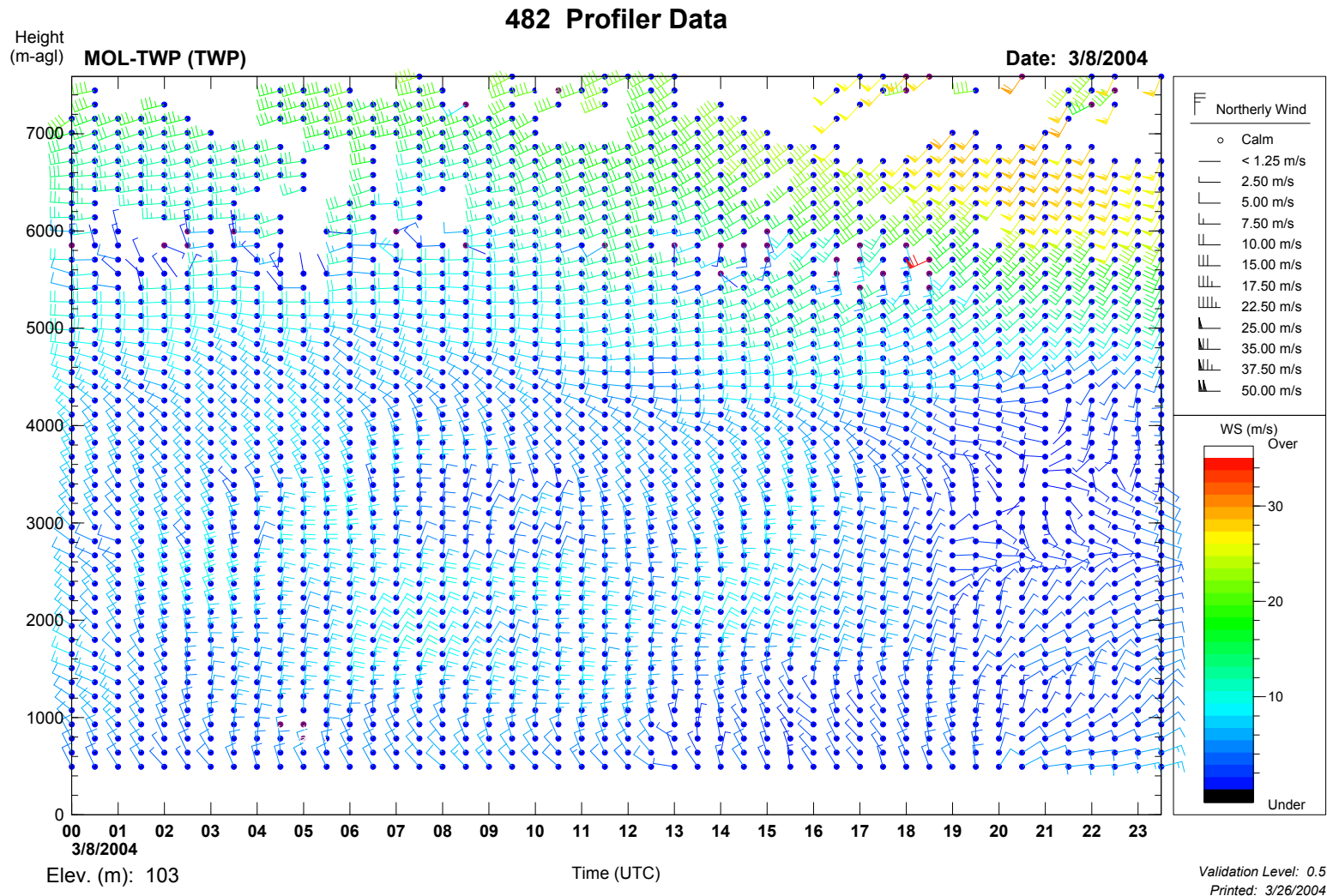
- **Quality control**

- Elimination of gross errors by automatic (real time) and manual check

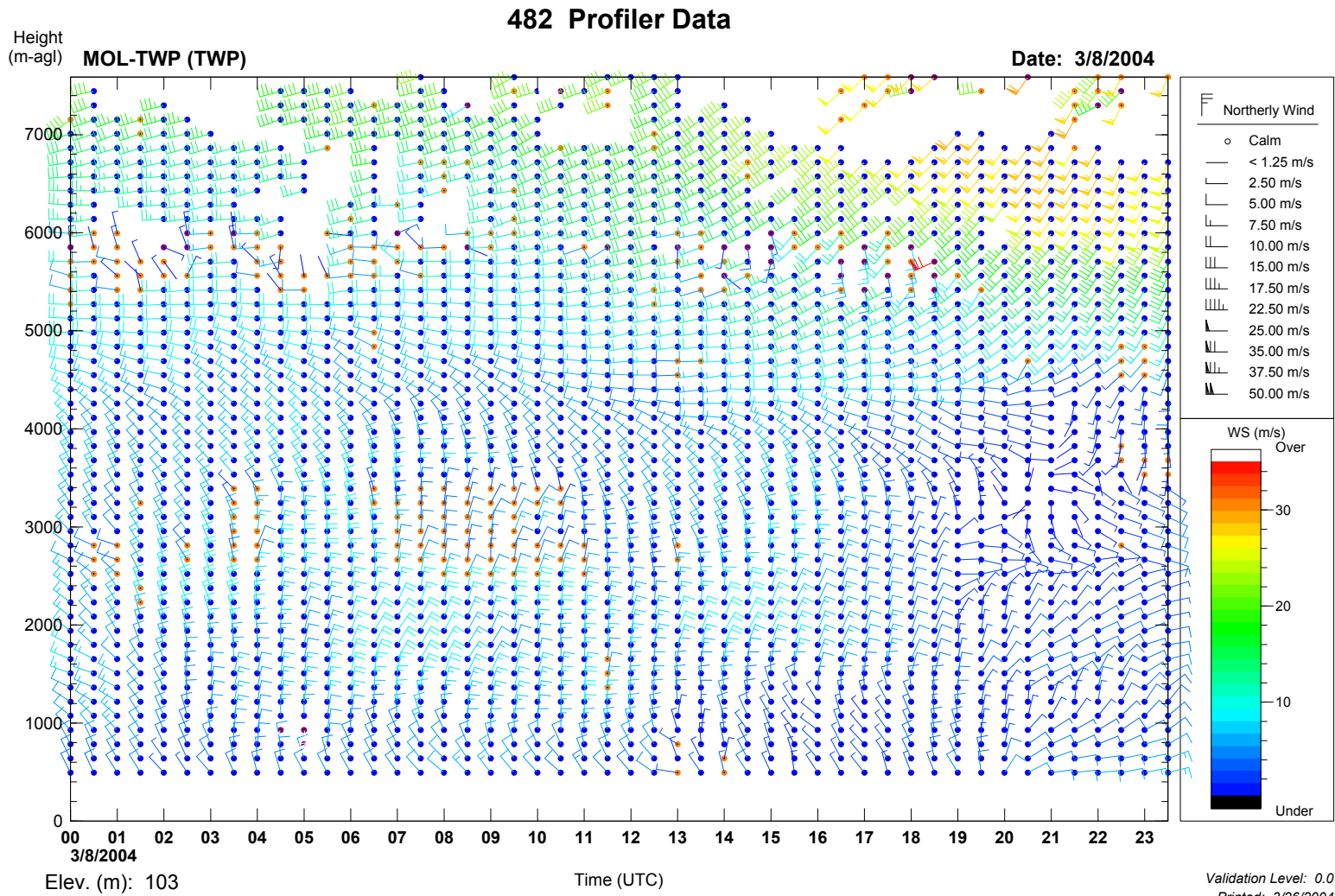
- **Quality assurance**

- Monitoring of system parameters
- Monitoring of height coverage and accuracy

QC-I: Automatic quality control - Weber und Wuertz



QC-II: Manual quality control



Quality control and quality assurance

- **Quality control**

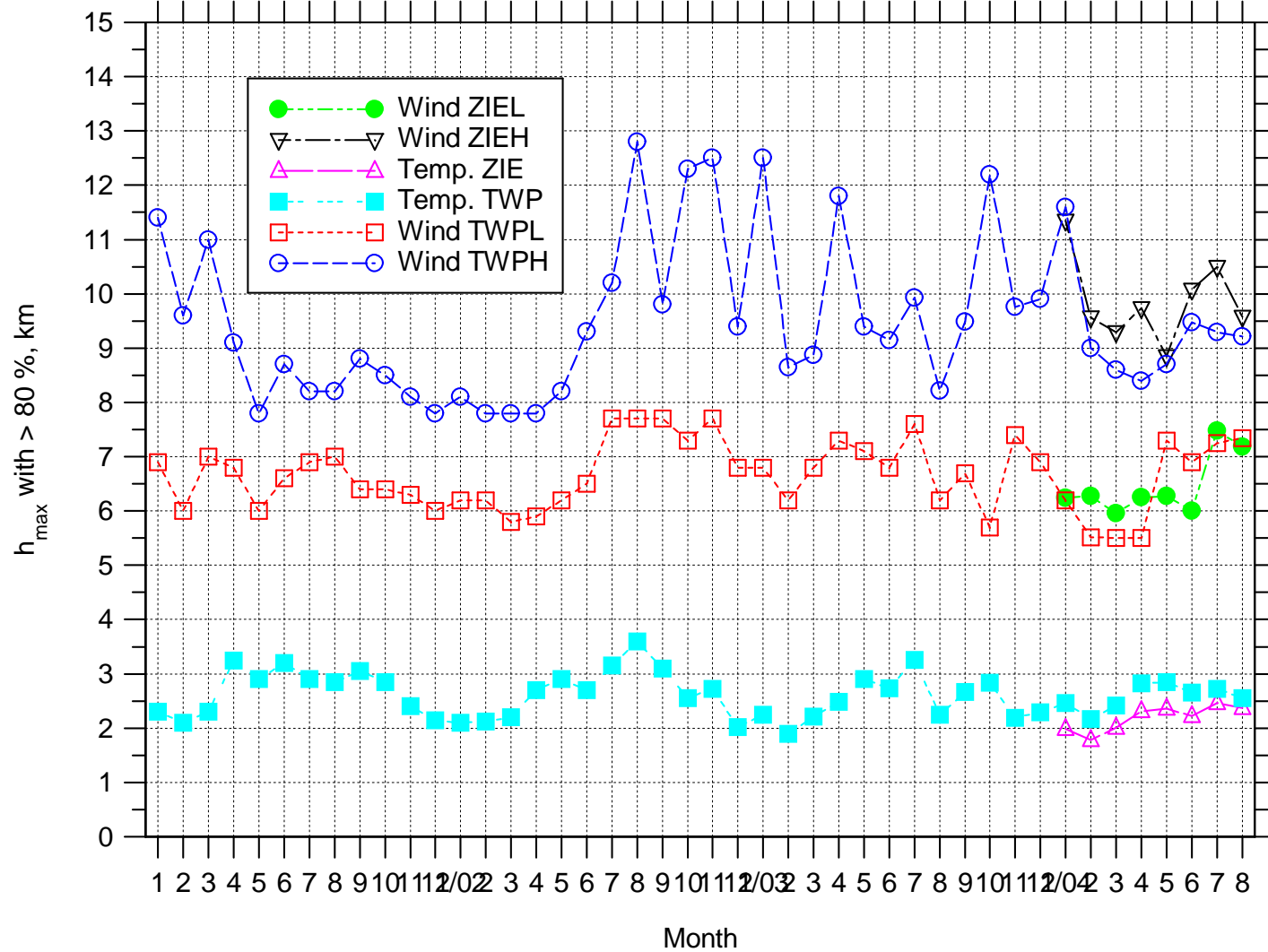
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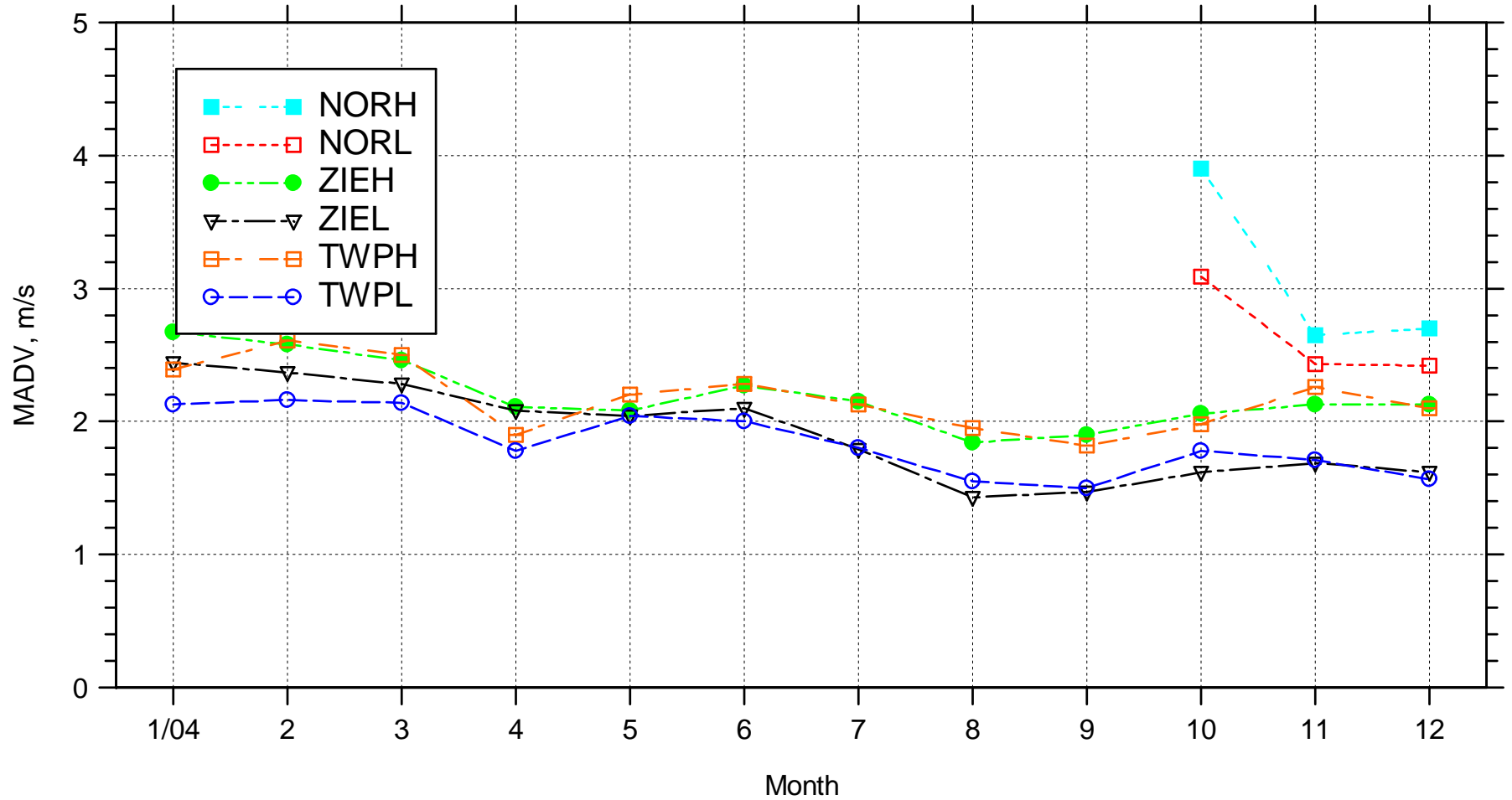
Monitoring

Average maximum height for an availability threshold of 80%.

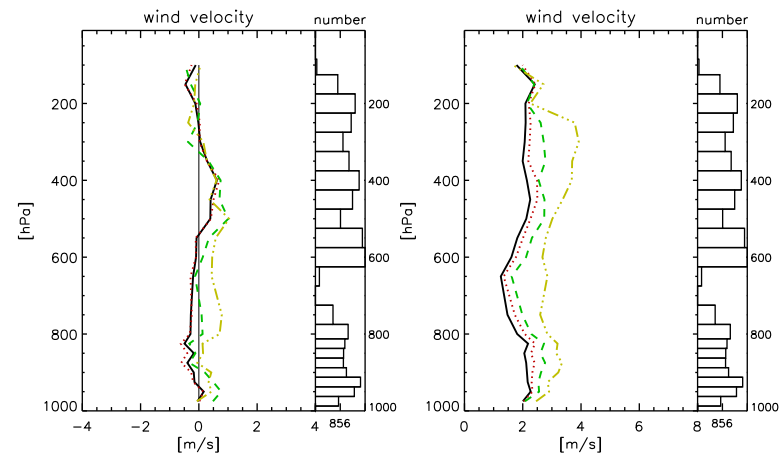
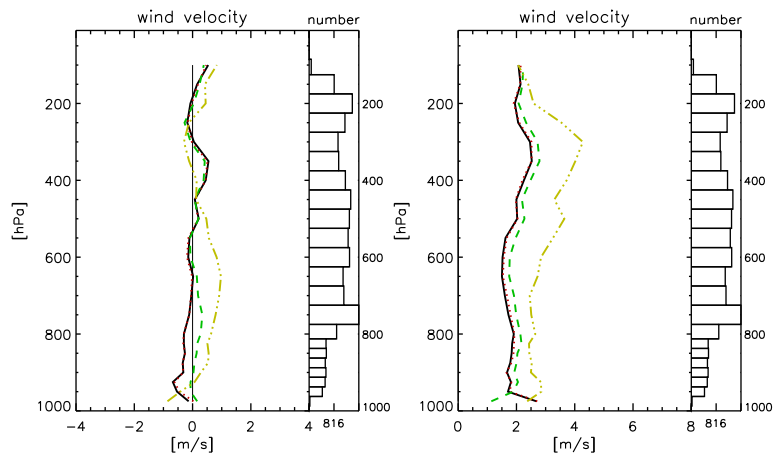
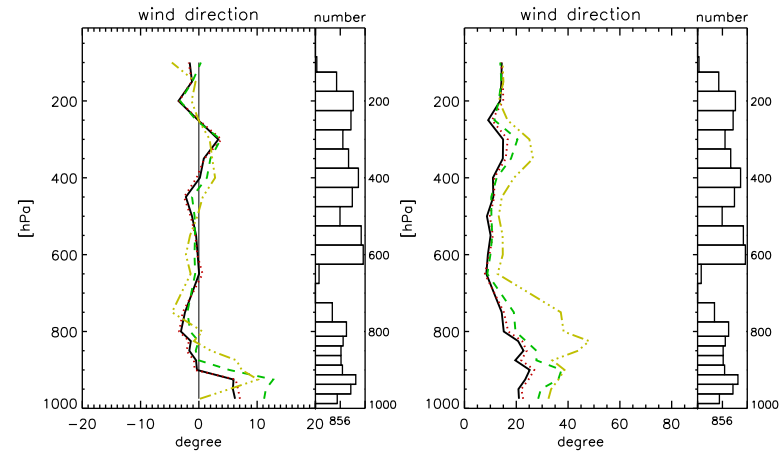
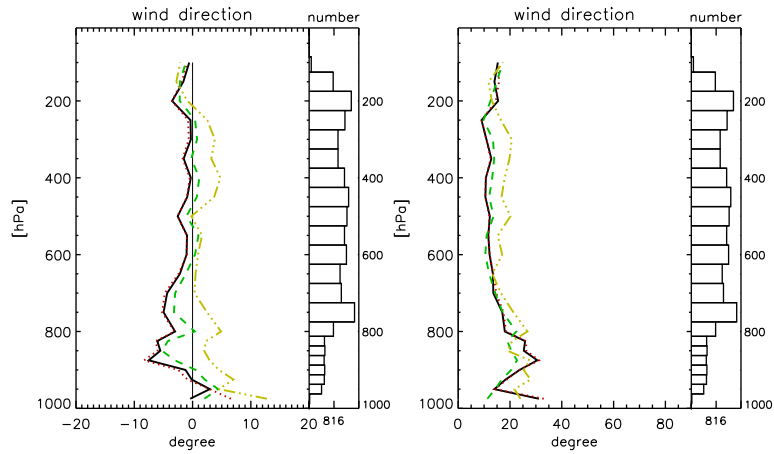


Monitoring

Monthly average for the amount of the vector difference: WPR vs DWD-LM



LM Verification (DWD)



Ziegendorf

Lindenberg

Summary

- The WPR/RASS of the DWD are remote-sensing systems for operational measurements of wind- and temperature profiles up to 16 and 4 km height, respectively.
- Successful deployment of systems in Ziegendorf and Nordholz (data transmission into the GTS since January 2004 (ZIE) and 2005 (NOR), respectively)
 - Reliable operation with availability of $> 98\%$
 - Height coverage and accuracy in accordance with expectations (accuracy comparable to radiosondes)
- Preparations for installation in Bayreuth are in time
- DWD WPR data are used in data assimilation by several European Weather Services (a significant positive impact on forecast results have been evidenced)

Online presentation

www.met-office.gov.uk/research/interprog/cwinde