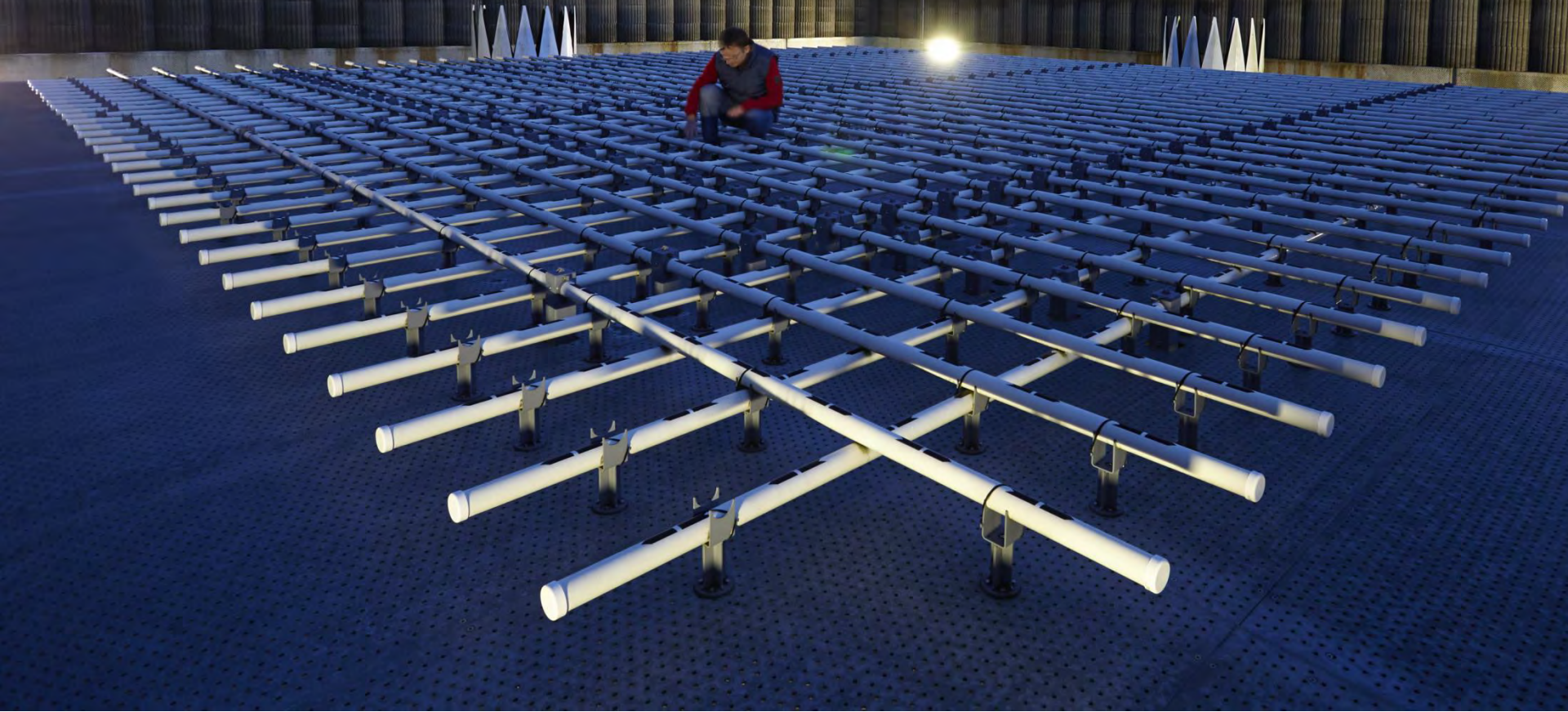


Meteorologisches Observatorium Lindenberg Remote Sensing Group



Background, Motivation

- ➔ Measurements of atmospheric data are one of the key objectives in meteorology

The problem of weather prediction, considered from the viewpoints of mechanics and physics

VILHELM BJERKNES

translated from German and edited by ESTHER VOLKEN¹ and STEFAN BRÖNNIMANN^{2*}

If it is true, as any scientist believes^{E1}, that subsequent states of the atmosphere develop from preceding ones according to physical laws, one will agree that the necessary and sufficient conditions for a rational solution of the problem of meteorological prediction are the following:

- 1. One has to know with sufficient accuracy the state of the atmosphere at a given time.*
- 2. One has to know with sufficient accuracy the laws according to which one state of the atmosphere develops from another.*



Operational Networks:
Initial data for NWP assimilation



Observatories and research networks:
Process-oriented observations for research and model development

Background, Motivation

- ➔ Measurements of atmospheric data are one of the key objectives in meteorology
- ➔ Until the 1960s in-situ measurements were the main data source (like radiosondings).

Background, Motivation

- ➔ Measurements of atmospheric data are one of the key objectives in meteorology
- ➔ Until the 1960s in-situ measurements were the main data source (like radiosondings).
- ➔ Due to the rapid technical developments (new) remote sensing methods became a reality and paved the way for a quasi-continuous monitoring of atmospheric variables, in order to provide data...
 - as initial values for the NWP (assimilation)
 - for process studies (research and model development)
 - for operational weather service (Aviation Weather)

Tasks

- Test of new remote sensing systems
- Providing data for process studies, model evaluation
- Development/improvements of measurement methods and procedure
- Providing data for NWP

Sites of remote sensing systems

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Remote sensing systems (aktive, passive)

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Laser-Ceilometer



UHF Radar Wind Profiler /RASS



K_a-band Radar MIRA36



Doppler Lidar



Microrainradar



Sodar/RASS



Raman Lidar RAMSES



Microwave Radiometer



UHF Radar Wind Profiler / RASS LAP-16000

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$f = 482.0078 \text{ MHz}$ ($\lambda \sim 62 \text{ cm}$)

Manufacturer: Vaisala, Rohde&Schwarz

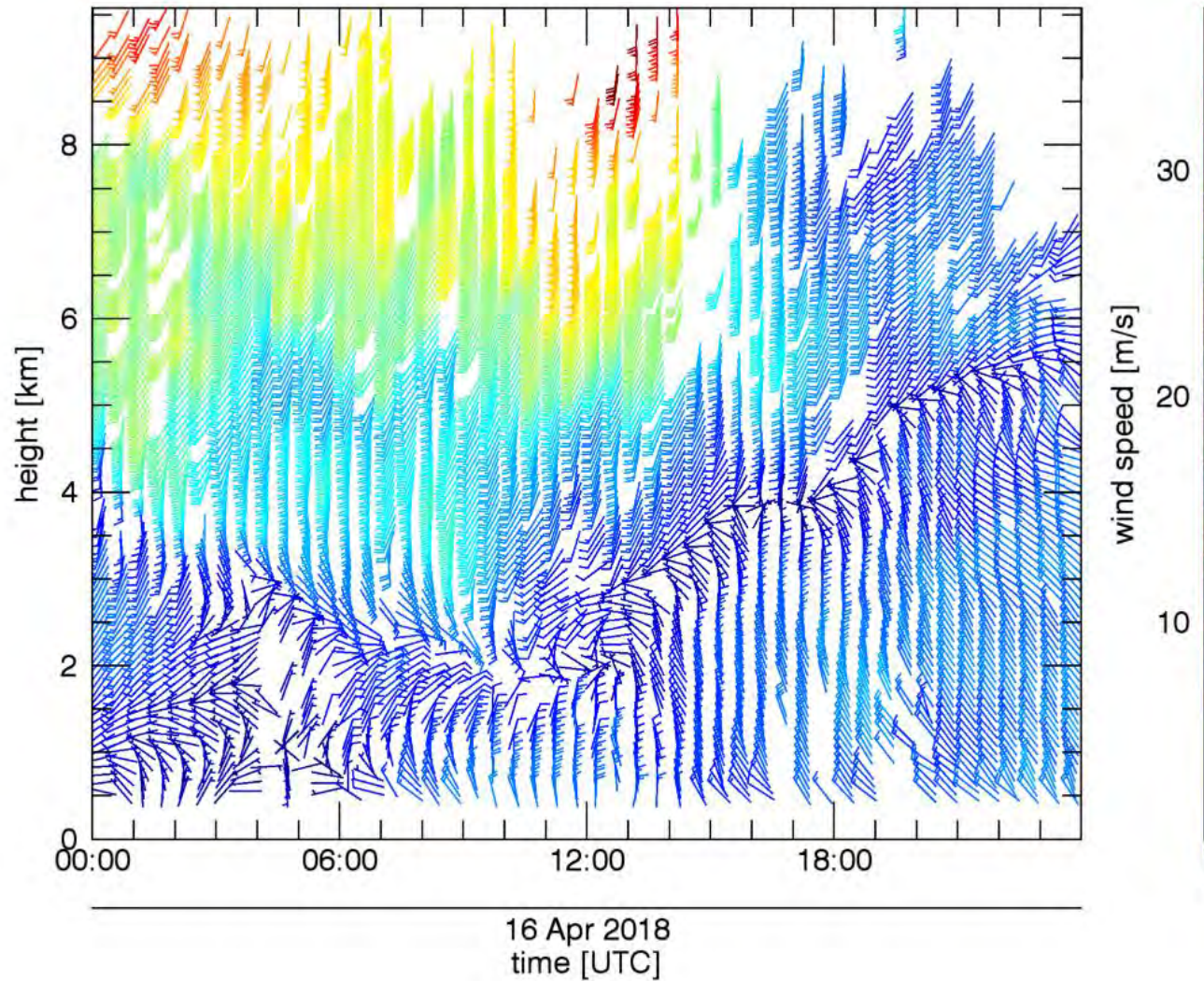
→ 3D wind vector
precipitation: 2D wind vector

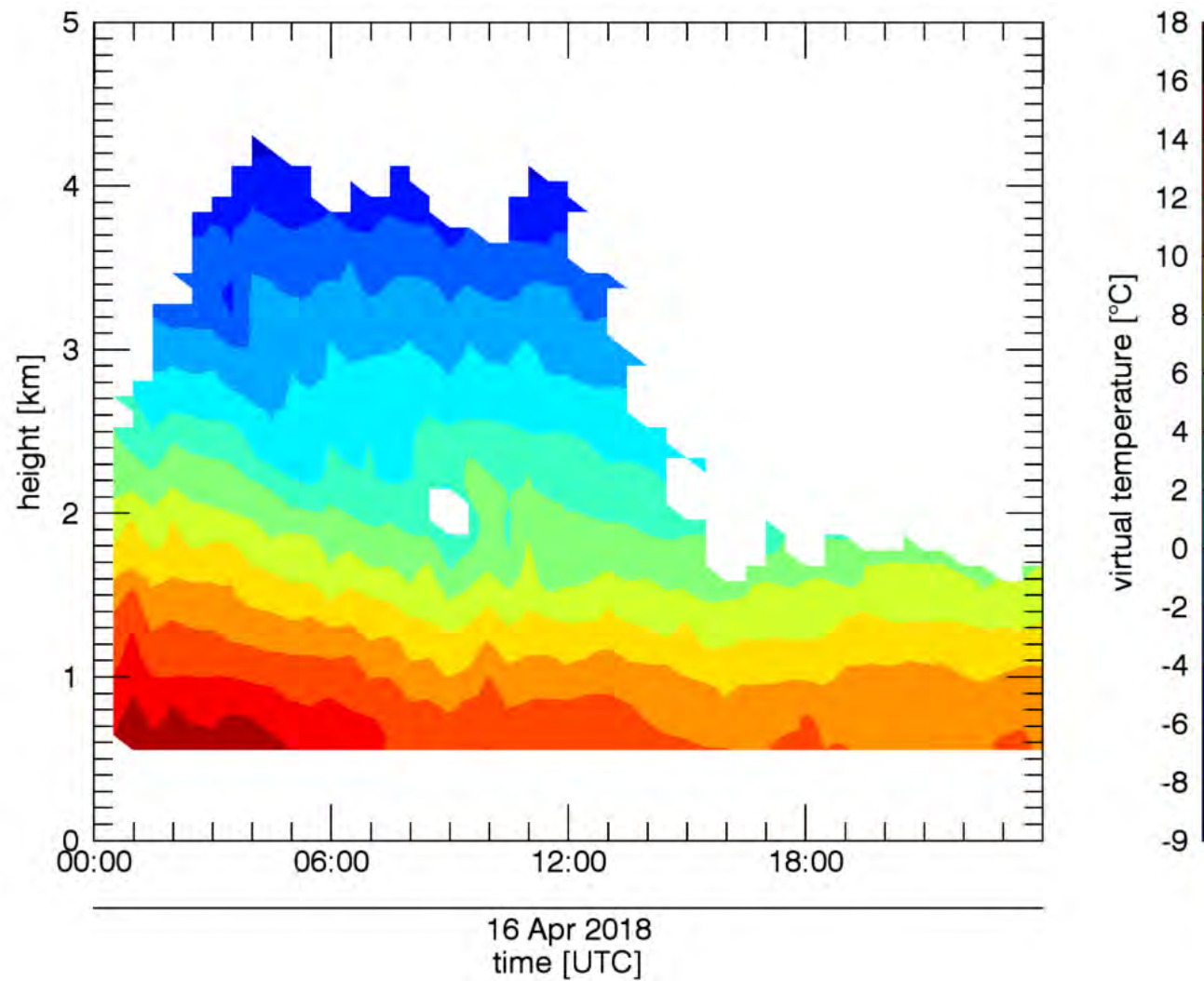
Vertical range: 0,5 – 16 km
Vertical resolution: 150 / 330 m
Averaging time: ~10 – 30 min

→ virtual temperature (RASS)

Vertical range: 0,5 – 4 km
Vertical resolution: 150 m
Averaging time: 5 min









Testsystems

- ➔ 1993: Lindenberg (1290 MHz)
- ➔ 1996: Lindenberg (482 MHz)

New systems for the network

- ➔ 2003: Ziegendorf
- ➔ 2004: Nordholz
- ➔ 2005: Bayreuth
- ➔ 2009: Lindenberg

Part of European Network
E-PROFILE (26 stations)

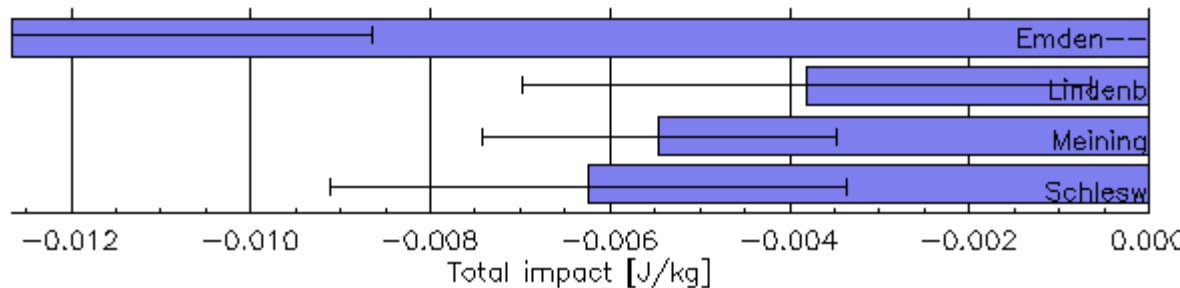
Transition phase from first testing of a commercial system to a fully operational network: **10 years !**

UK MetOffice estimate of RWP impact

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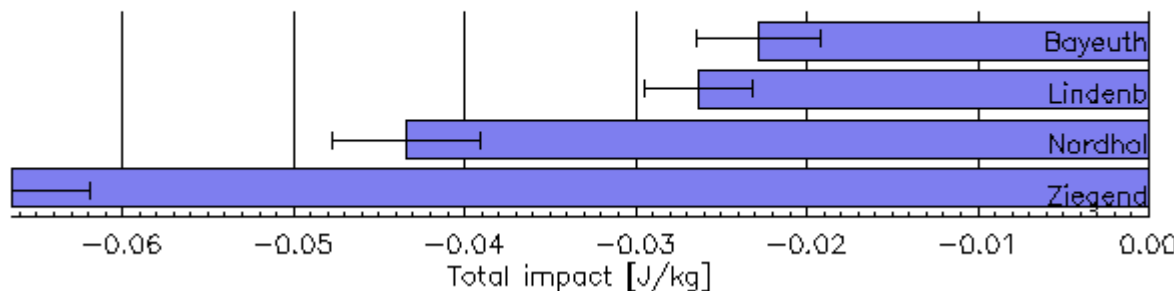
TEMP Europe / 100822_qu18-100929_qu12



Reduction of forecast error
measured by global total
energy norm (u,v,T,p,q)

4 German TEMP stations vs.
4 German RWP (482 MHz)

WINPRO Germany / 100822_qu18-100929_qu12



First results from UK MetO
FSO-tool for the period
Aug 22 – Sep 29, 2010

**Lindenberg RWP impact is 5 times bigger than the
impact of a co-located Radiosonde !**

Courtesy:

Richard Marriott

Catherine Gaffard

Ronny Leinweber



Ka-Band cloud radar MIRA 36

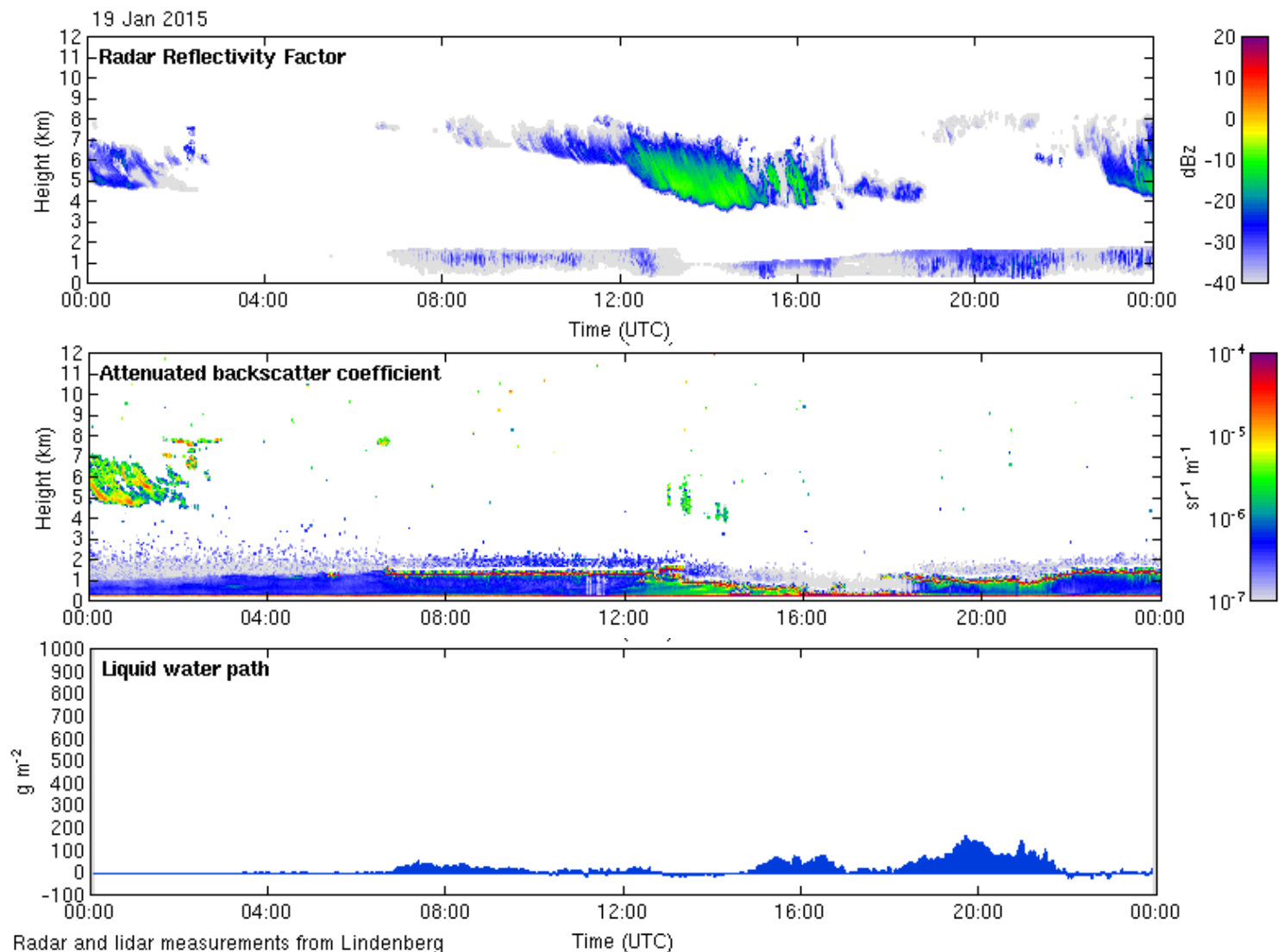
Wavelength	35.5 GHz ($\lambda=8$ mm)
Manufacturer	Metek GmbH
Transmitter	Magnetron, PEP 30 kW
Antenna	Cassegrain antenna with polarization filter
Receiver	<ul style="list-style-type: none">-Coherent on receive-Dual linear polarization-Doppler moments in two RX channels
Vertical range	0.25 – 15 km
Vertical resolution	30 m
Averaging time	10 s (2 s spectra)
Sensitivity	- 55 dBZ (5km, 10s)

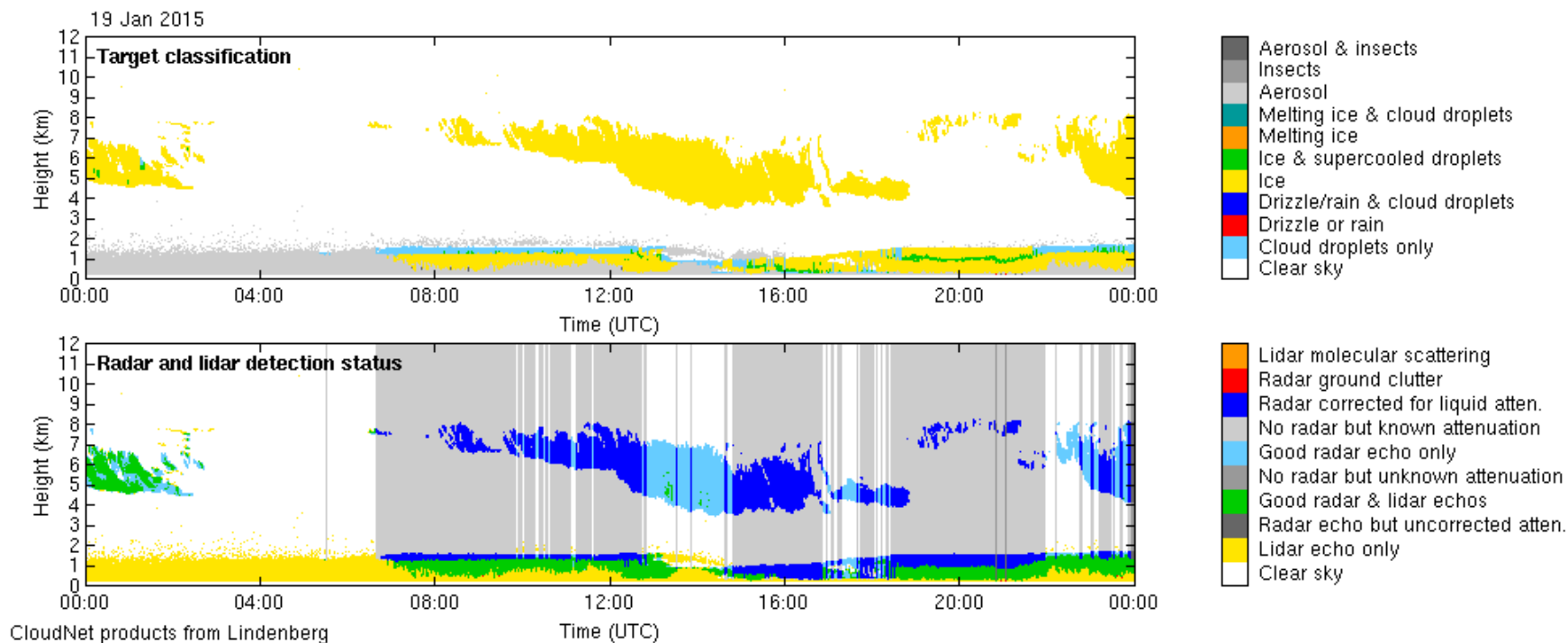
→ Reflectivity, Doppler velocity, spectral width, LDR

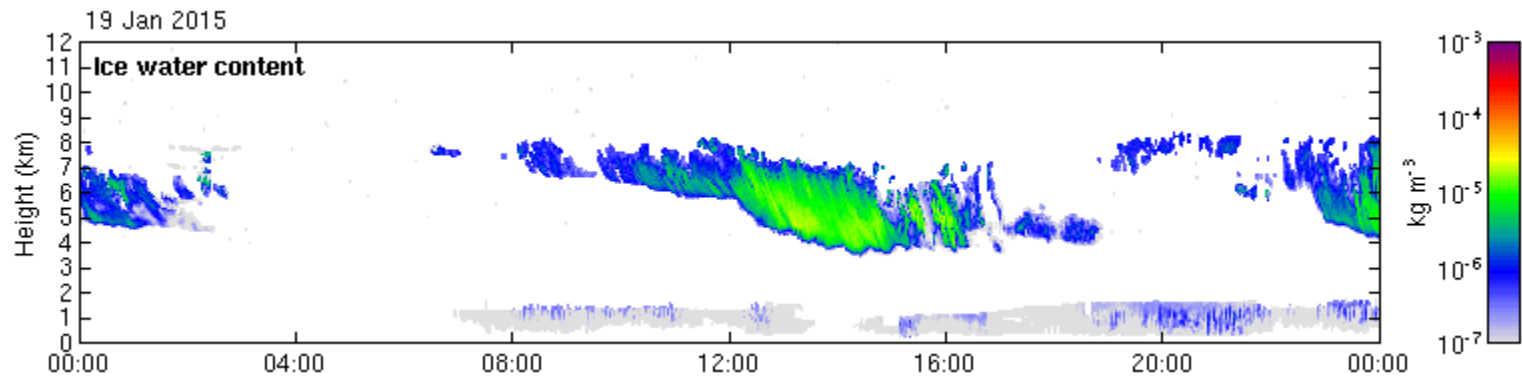
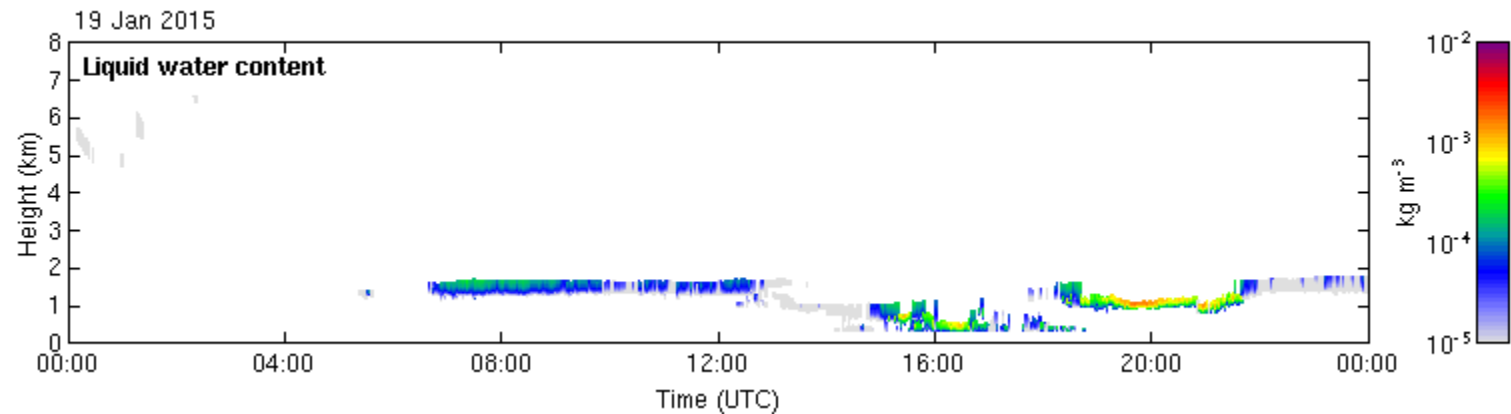
Continuously operating since April 2004



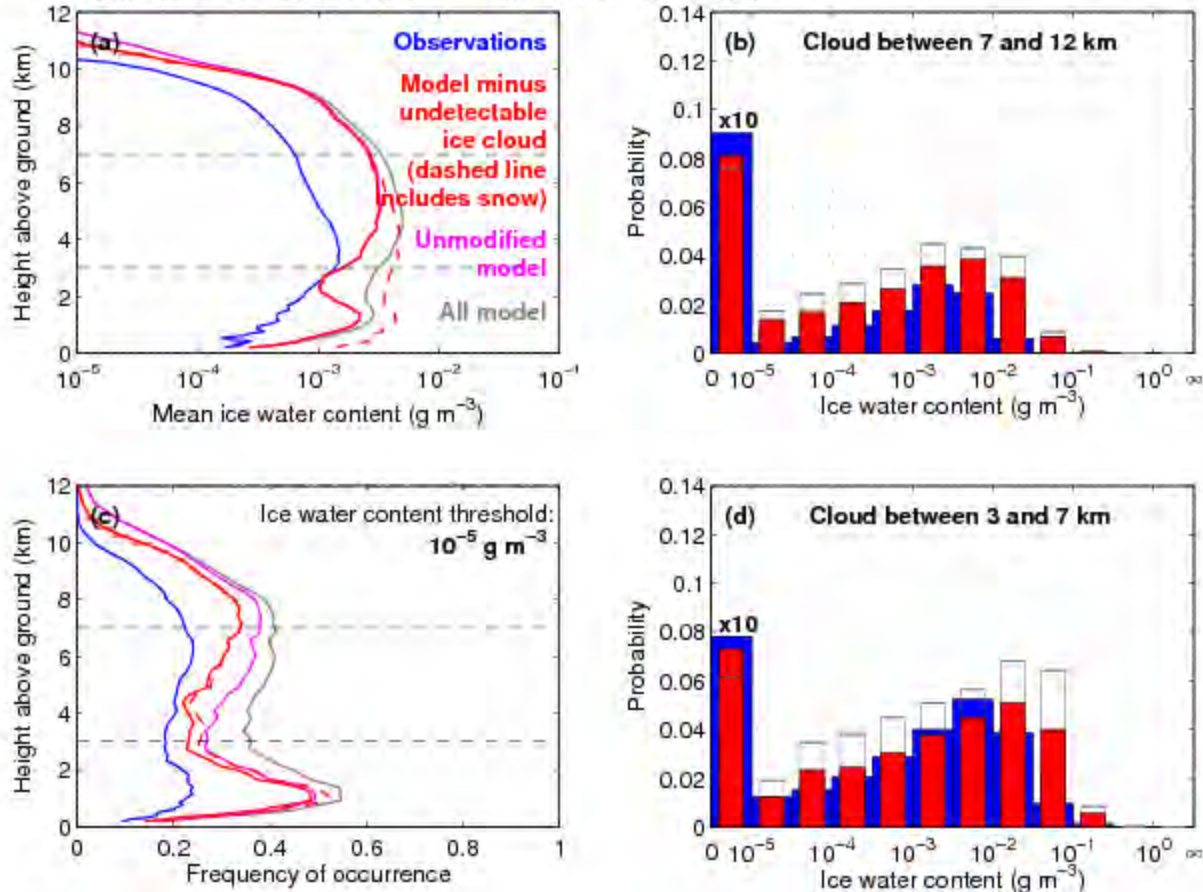








Evaluation of ECMWF ice water content at Lindenberg between 1 Jan 2016 and 14 Apr 2016
Equivalent of 69.2 days of data (12–35 hour forecasts)



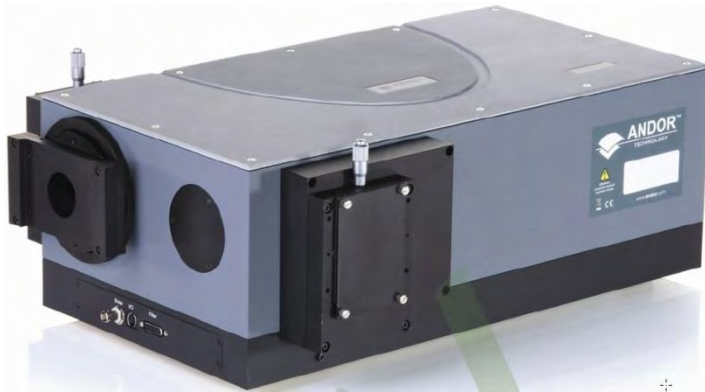
“Raman lidar for Atmospheric Moisture SEnSing”

- Autonomous 24/7 operation
- 355-nm primary wavelength, 15 W, 30 Hz
- Near-range receiver
 - + 20-cm telescope, fiber-coupled
 - + 3 detection channels
 - + optical particle properties (α , β , S)
 - + water-vapor mixing ratio
- Far-range receiver
 - + 80-cm telescope, nonfiber-coupled
 - + 9 detection channels
 - + optical particle properties (α , β , S , δ)
 - + temperature
 - + water-vapor mixing ratio

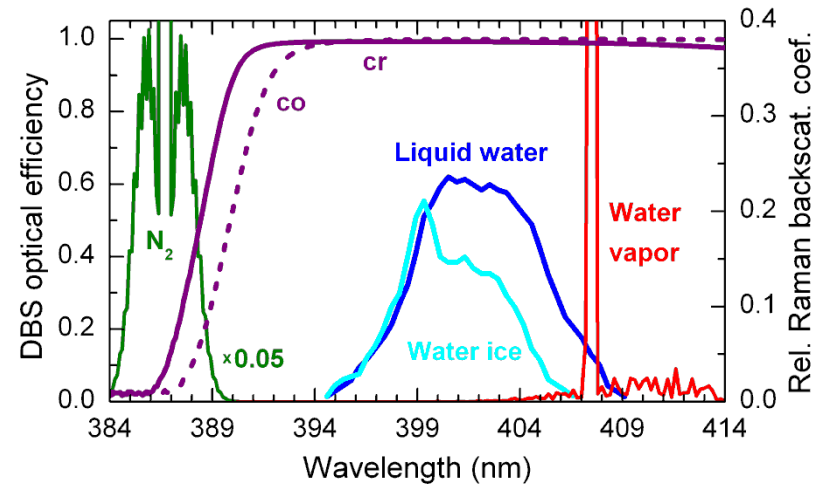


RAMSES (Jens Reichardt): New, unique features

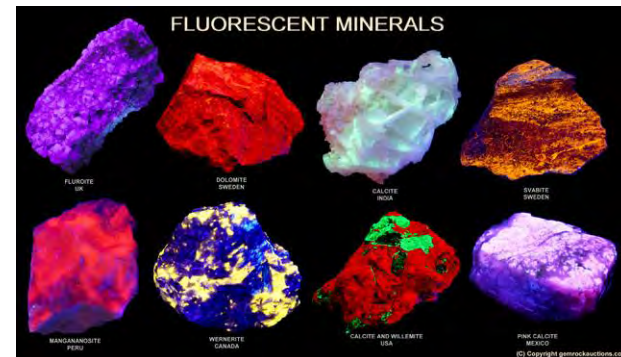
Water **spectrometer**: Measurement of all 3 water phases!!!



J. Reichardt, J. Atmos. Ocean. Technol., 39, 1946-1963, 2014



Fluorescence **spectrometer**: Measurement of (aerosol) fluorescence!!!



June – September 2015, 6 Ceilometer types vs. Raman lidar Polly XT



CS135
2xCampbell



Vaisala
CL51
1xMOL
1xCG



Vaisala
CL31
1xMOL
1xRUB



Vaisala
LD40, WHX
2xMOL/RAO



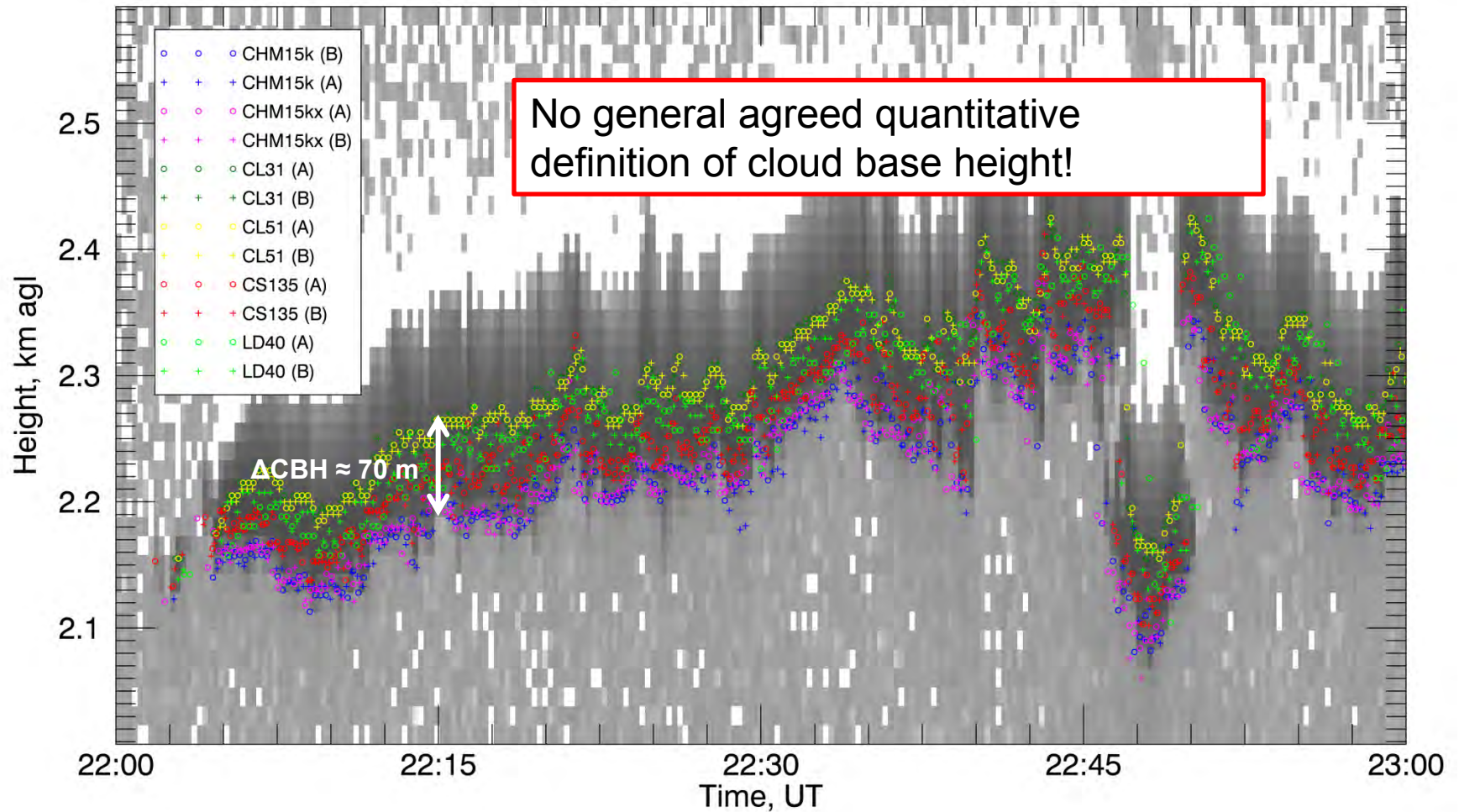
LUFFT
CHM15k
2xMOL



LUFFT
CHM15kx
1xLMU
1xMOL

Time series of CBH for Stratocumulus

chm140101 20150715



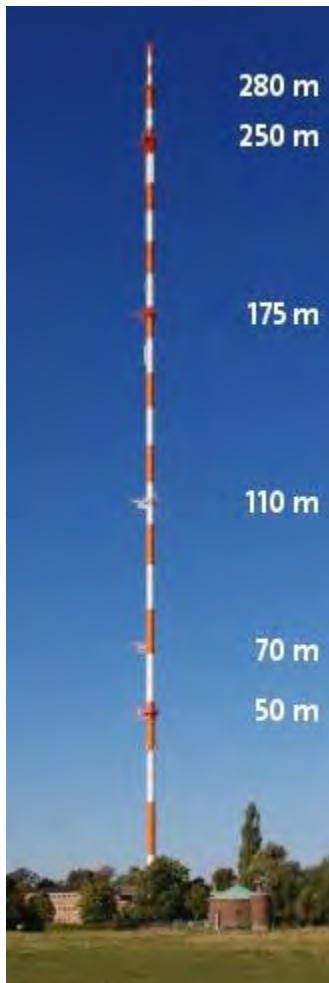
„Cloud Foot Ruler (Wolkenzollstock)“

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Used by University of Hamburg for meteorological measurements: (<http://wettermast-hamburg.zmaw.de>)

Measuring campaign September 2016 – April 2017

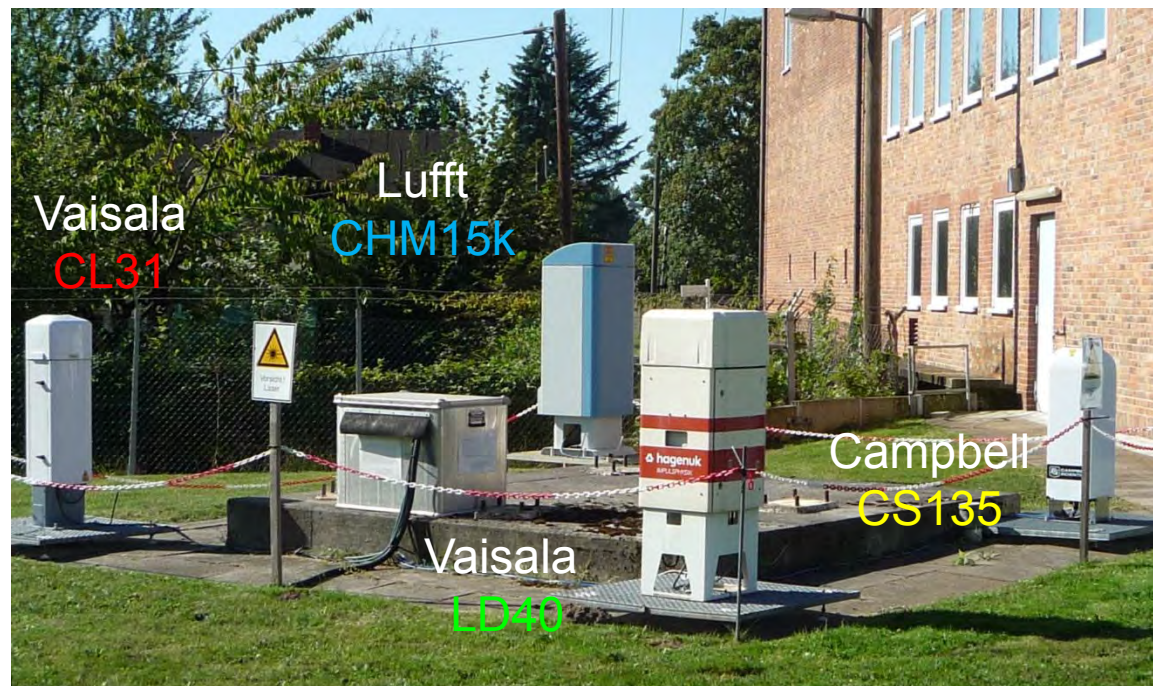


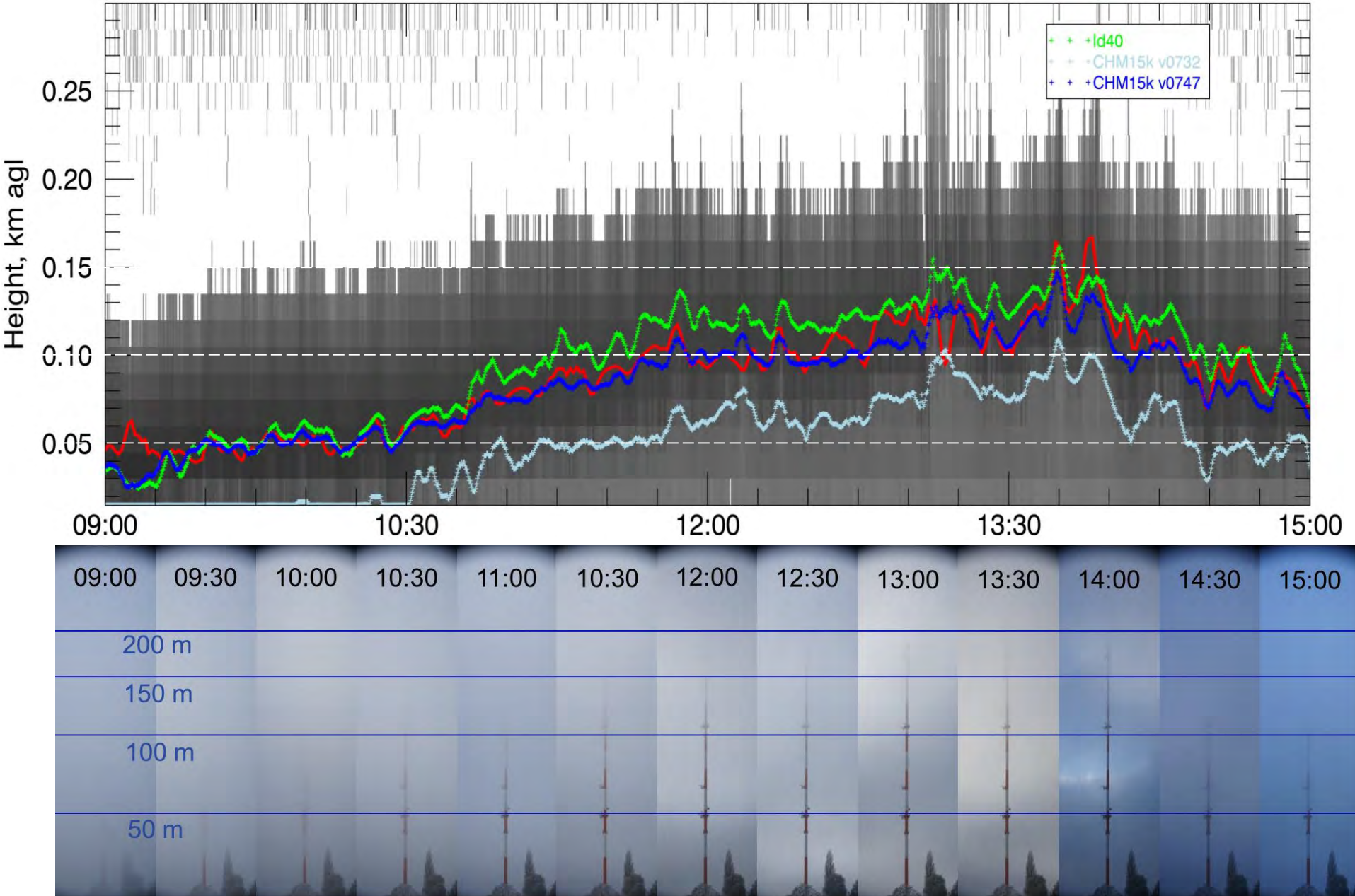
Broadcasting
tower

Sony α7



4 Ceilometer





Thank you for your attention!

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

