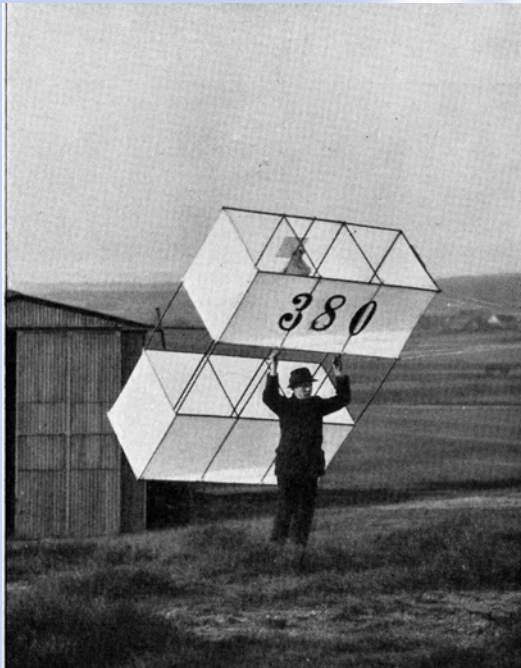


From Weather Kites to Windprofilers: A Century of Atmospheric Profiling at *Lindenberg Observatory*

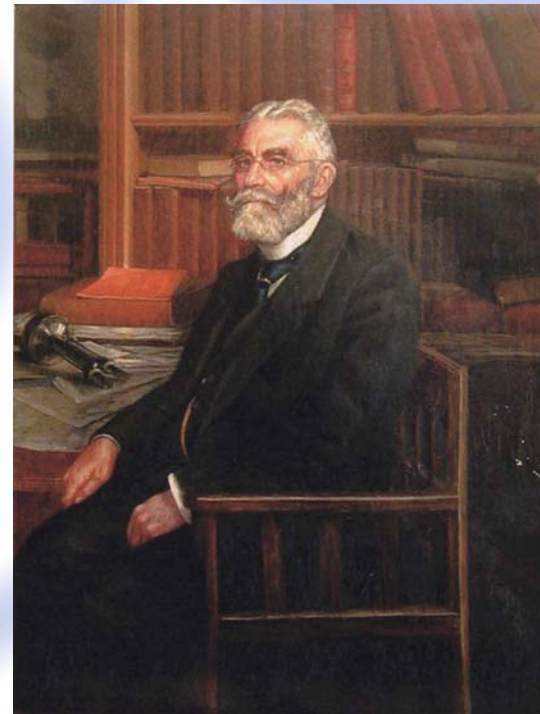


16.10.1905: Official Inauguration of the Royal Prussian Aeronautical Observatory



The German Emperor Wilhelm II. at the Observatory

1st director Prof. Dr. R. Assmann



Historical Milestones (I)

- 31.07.1901** **BERSON / SÜRING: Balloon flight:**
„Preußen“ (V : 8400 m³)
h_{max} = 10.800
- 01.05.1902** **ASSMANN: Report on the**
„Existence of warm layers at 10 -
15 km altitude“ at the Session of
the Royal Prussian Academy of
Sciences at Berlin → **discovery of**
the stratosphere (in parallel with
Teisserenc de Bort)
- 05.-07.04.1906** **A. and K. WEGENER: Manned**
free-flying balloon flight over
52,5 hrs

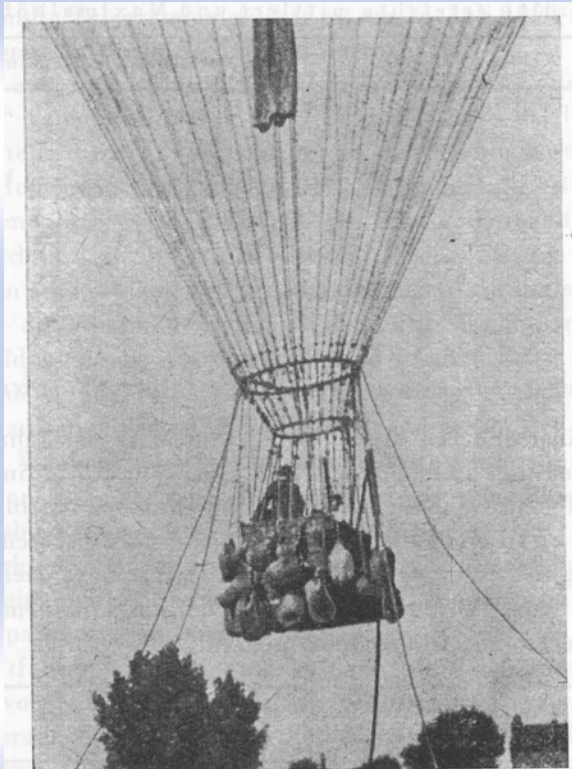


Abb. 6. Ballon „Preußen“ vor der Hochfahrt am
24. 6. 1903 nach einer fotografischen Aufnahme von
A. Lawrence Rotch

Historical Milestones (II)

1900-1913	68 scientific cruises with free-flying balloons
since 1903	daily tethered balloon soundings
1910	Aeronautic weather service at Lindenberg (center of a network of 15 sites in Germany performing regular pilot balloon soundings)
1911	Thunderstorm / gust warning service at Lindenberg (participation of 600 post offices in Germany)
1913	„Radio station“ Lindenberg
26.09.1916	Tethered balloon sounding record: 9.200 m
01.08.1919	Kite sounding world record: (8 combined kites): 9.750 m



Vertical soundings at the beginning of the 20th century



Am Aeronautischen Observatorium Lindenberg (1914—1931)
mit Fesselaufstiegen erreichte Höhen in m

Jahr	mit Drachen			mit Fesselballonen		
	Anzahl	max. Höhe	mittl. tägl. Höhe	Anzahl	max. Höhe	mittl. tägl. Höhe
1914	778	6200	3340	454	8000	3668
1915	701	5610	3517	439	5500	3089
1916	755	7500	3998	400	9200**	4332
1917	720	8240	4025	360	8500	4160
1918	703	7305	3661	312	3990	2869
1919	601	9750*	3811	182	5334	2484
1920	697	6700	3306	91	3950	2427
1921	711	5710	2968	39	2560	1867
1922	697	5860	2880	—	—	—
1923	630	4720	2560	55	4080	1677
1924	410	4660	2800	203	3260	2089
1925	456	4470	2488	166	4270	2462
1926	431	5403	2551	203	4788	2384
1927	461	4708	1535	222	4219	2182
1928	508	4260	2321	320	4070	2309
1929	703	5705	2308	220	4175	2567
1930	640	5865	2553	233	4421	2594
1931	609	5772	3030	142	4131	2385
1914—1931	11211			4032		

*) 1. 8. 1919 9750 m Abreißer

**) 26. 9. 1916 9200 m!

Number and max. heights (absol. and daily mean) of soundings at Lindenberg for kites („Drachen“) and tethered balloons („Fesselballone“) between 1914 - 1931

Vertical soundings at the beginning of the 20th century

sounding system	number of ascents	maximum height (date)
kite	15.553	9.750 (01.08.1919)
tethered balloon	5.930	9.200 (26.09.1916)
registr. balloon	687	32.000 (14.04.1925)
pilot balloon	4.837	36.100 (08.12.1925)

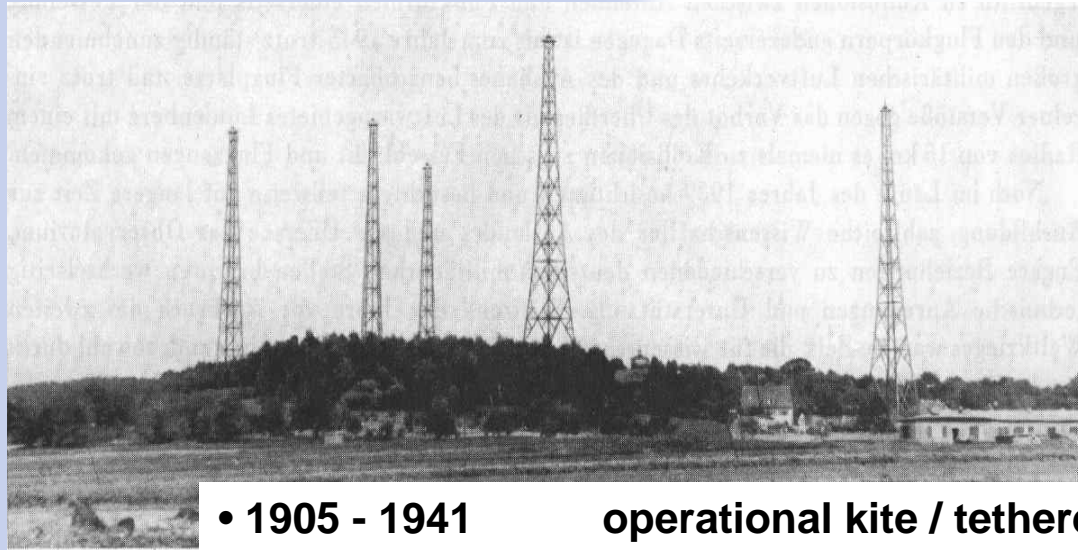
27.007
(2.6/day)

tethered ascents: ~ 2.1 / day

28 %: wind speed $< 5 \text{ ms}^{-1}$: balloon

72 %: wind speed $> 5 \text{ ms}^{-1}$: kite

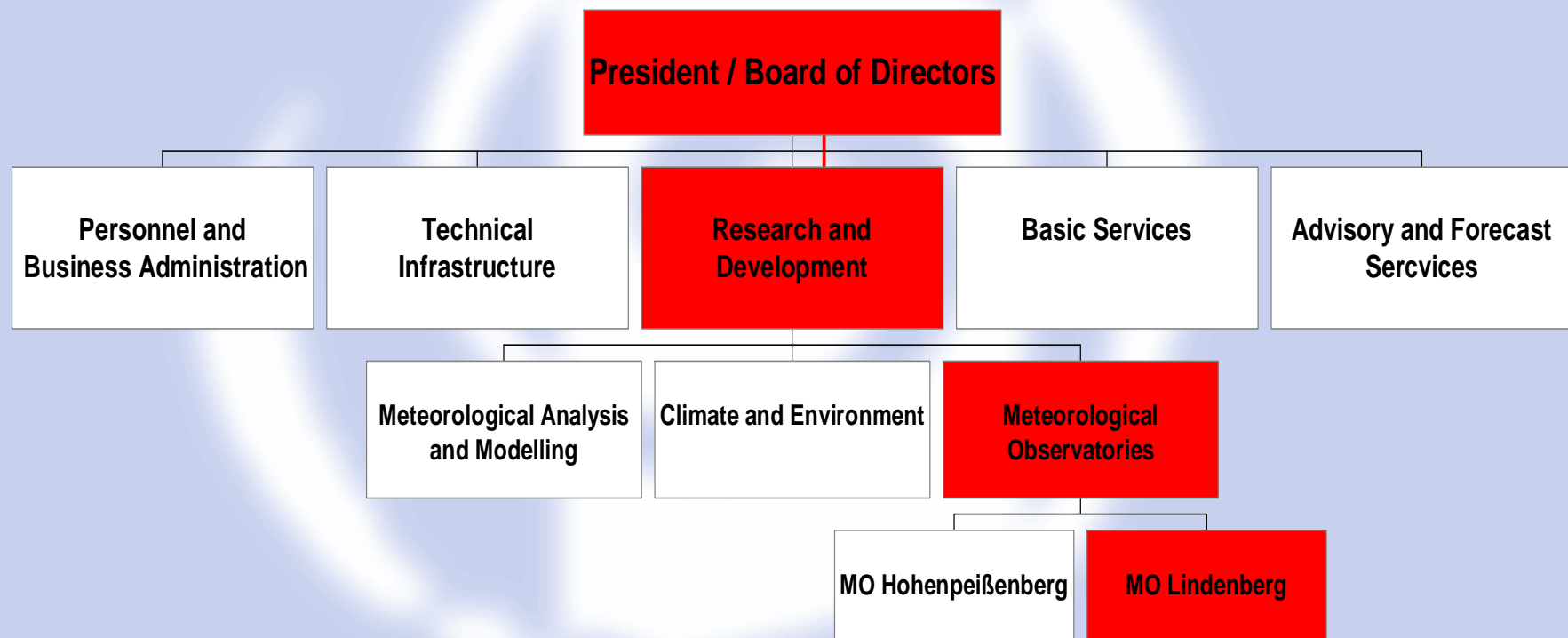




MOL History: Milestones

- 1905 - 1941 operational kite / tethered balloon soundings
- 1910 - 1944 aeronautical weather service
- 1929 - today radiosoundings
- 1950 - 1990 **MHD /MD of the (former) GDR**
 - 1975 - today ozone soundings (Antarctica 1985 - 1990)
 - 1970 - 1989 upper atmosphere soundings (weather rockets 1989)
- since 1990 **DWD**
 - 1993 - today ground-based remote sensing
 - 1998 - today operational ABL measurements
 - 2003 migration of MO Potsdam to Lindenberg (BSRN since 1996)

The Meteorological Observatory Lindenberg (MOL) within the German Meteorological Service (DWD)



Meteorological Observatory Lindenberg (MOL)

MOL 1

Ground-Based Remote Sensing

- Dr. D. Engelbart -

- derivation of atmospheric parameters
- 2 Wind profiler / RASS
- Sodar / RASS
- Microwave Profiler
- FTIR
- 36 GHz cloud-radar / 1,29 GHz Micro-rain-radar
- Lidar (in operat. 2005)

MOL 2

Boundary Layer and Land Surface Processes

- Dr. F. Beyrich -

- experimental investigations
- network of micrometeorological / energy budget stations
- turbulence sensors
- scintillometers

MOL 3

„Lindenberg Column“

- Dr. U. Leiterer -

- operational standard
- weather- / radiosonde station
- GM Falkenberg
- Ceilometers

MOL 4

Radiation Processes

- Dr. M. Weller -

- regional radiation center
- BSRN - station
- spectrometers
- photometers
- whole -sky imager
- Reference for WMO-RA VI

Observatory

Measurements / Scientific Interpretation

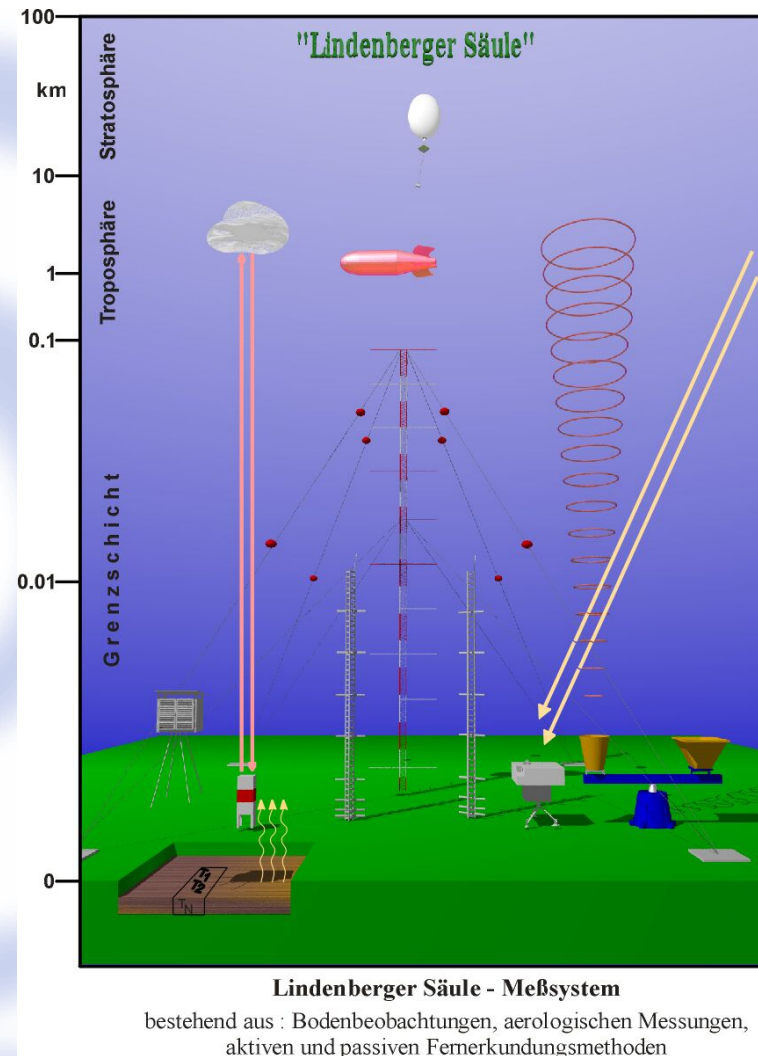
Measuring Methods:
Development / Tests /
Assessment

Analysis and Data
Evaluation
Methods

Operational Monitoring

- representative site
- physical structure of the atmosphere

Database „Lindenberg Column“



Monitoring Programme (long-term measurements)

- **vertical structure** of the atmosphere (wind, temperature, humidity, clouds)
- land surface - atmosphere interaction
- high-precision humidity profiles for **satellite validation** (CM-SAF)
- water-vapour monitoring for **GVaP** (WMO)
- solar and terrestrial radiation (**WMO RA-VI regional center**)
- **BSRN** station

Remote-Sensing Systems

- **SODAR/RASS** (0.02...0.6km)
- **2 Windprofiler/RASS** (0.3...2km , 0.5....16km)
- **12-channel microwave profiler** (0.1....10km)
- **FTIR**
- **GPS** receiver (co-operat. with **BKG**)
- **35 GHz cloud radar**
- **Water-vapour Lidar** (Raman system in **2005**)

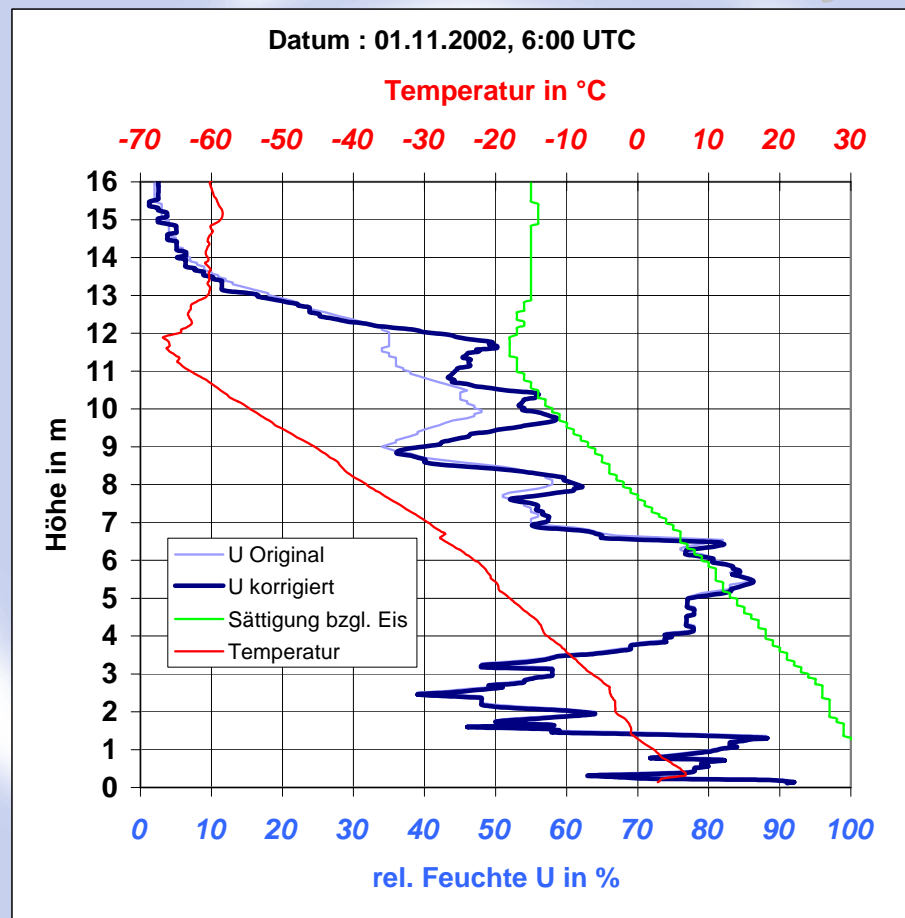
Other systems for vertic. profiling (+validation)

- **4 - rawinsondes** / day (Rawin + high-precision humidity sondes; **1 ozone sonde** / week)
- **100 m meteorol. tower**
- **2 x 6-sonde** tethered-balloon systems (**ff,dd,T,q, p, z**)
- **sun- and starphotometer**

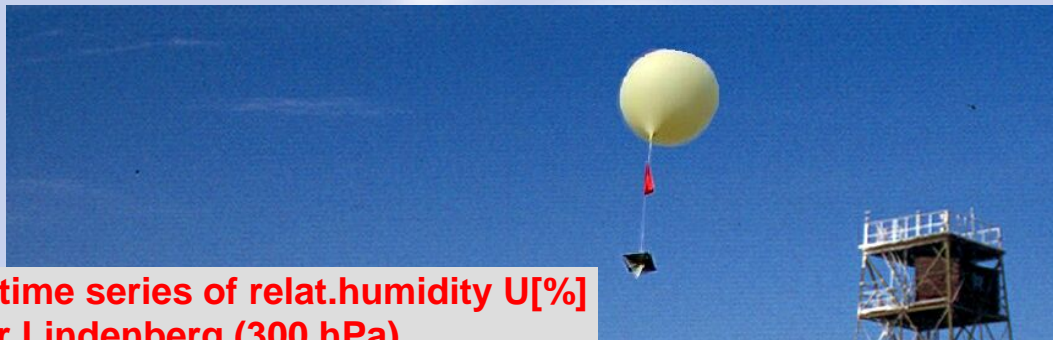


The **winch house** at **Lindenberg Observatory**:
Technical monument for the operational monitoring of
atmospheric parameters using **kites** in the last century

Improvement of Radiosonde Humidity Measurements



Synoptic and aerological station

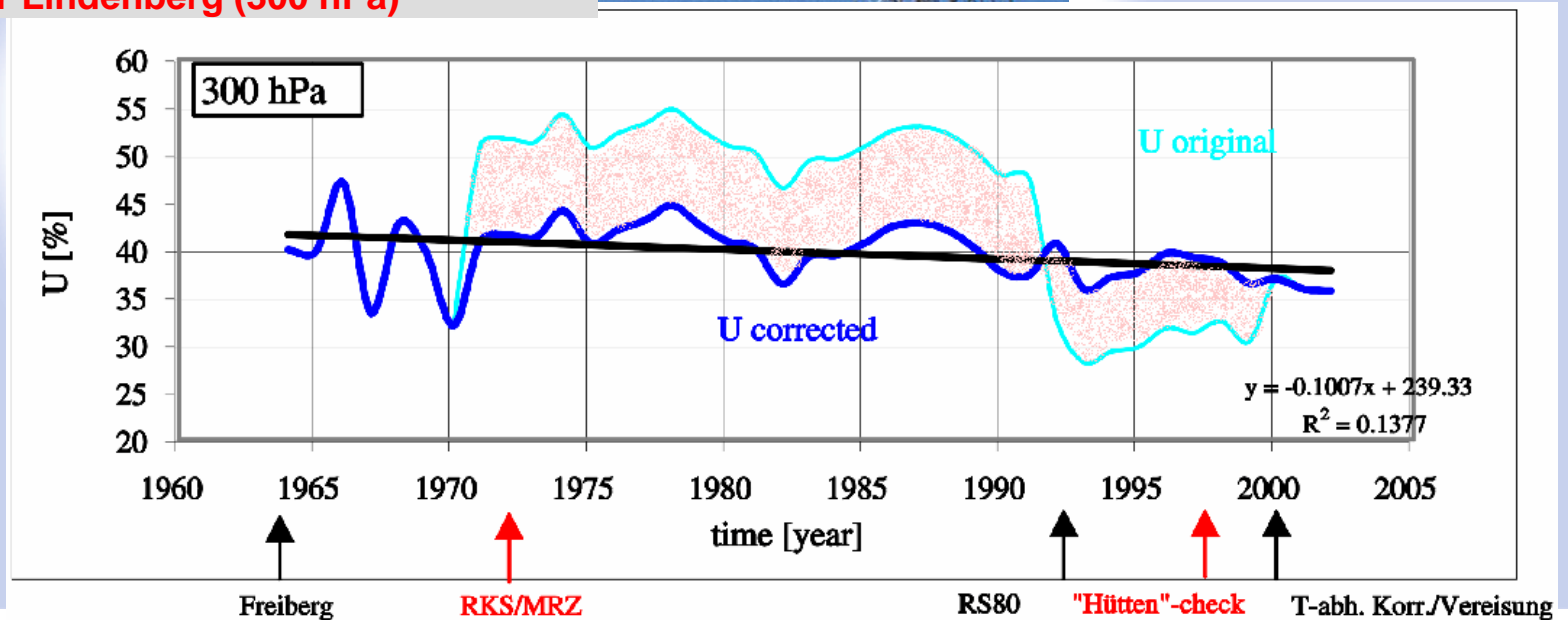


Homogenized time series of relat.humidity U[%]
over Lindenberg (300 hPa)

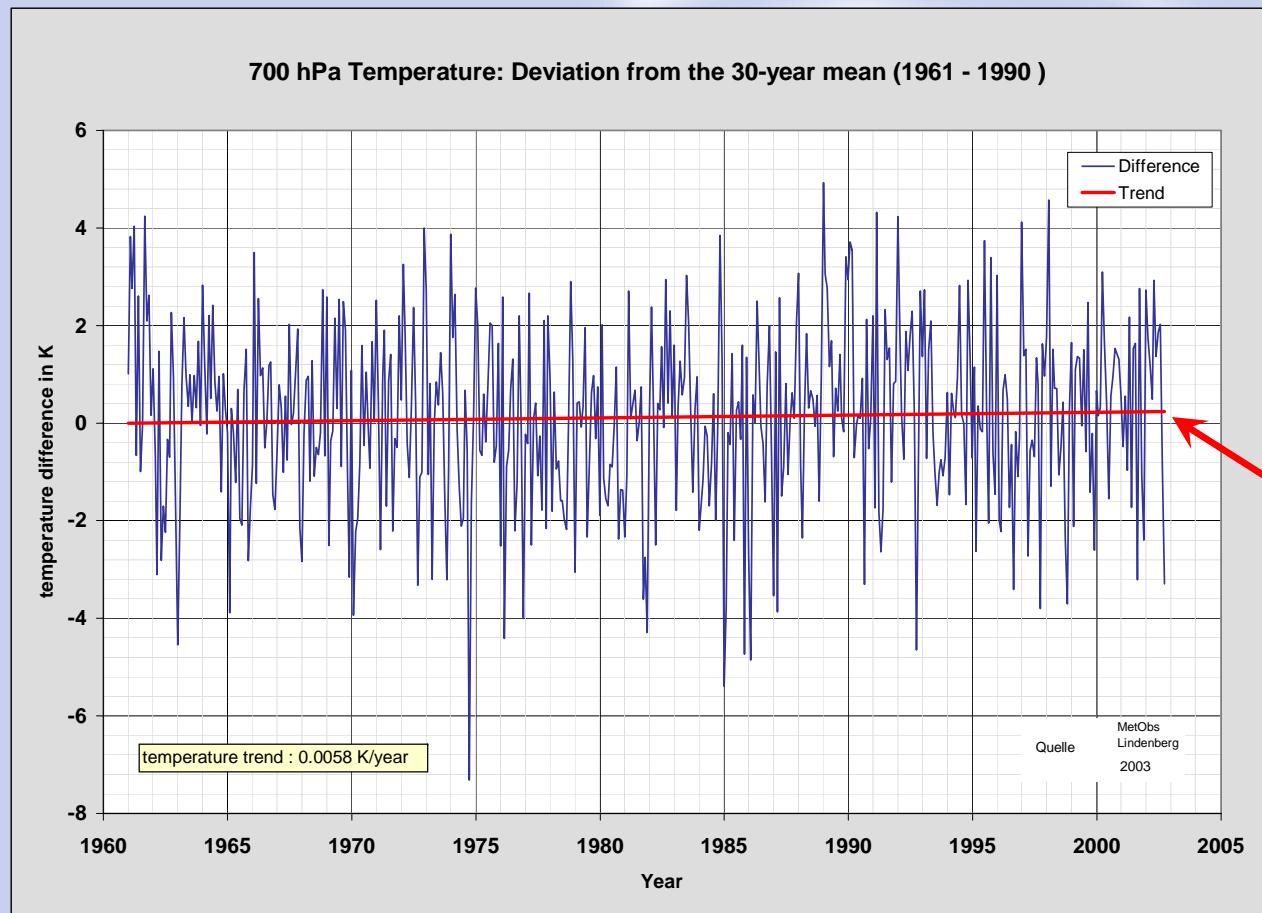
AeroSta:

4 times daily (operational):

P, T, U and wind, up to $z = 35\text{km}$



Long Time Series of Aerological Measurements



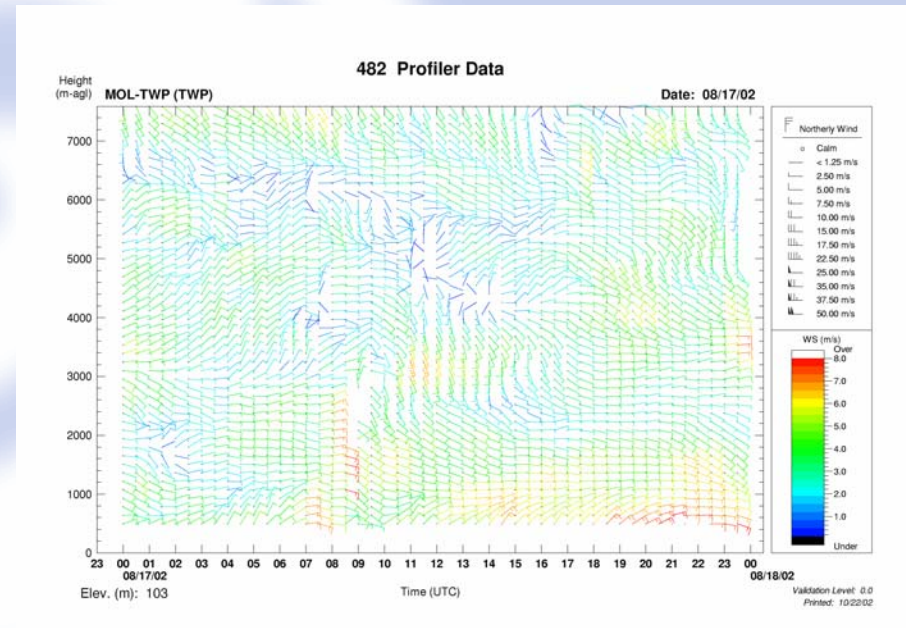
Trend for 700hPa:

→ 0.24 K / 40 yrs

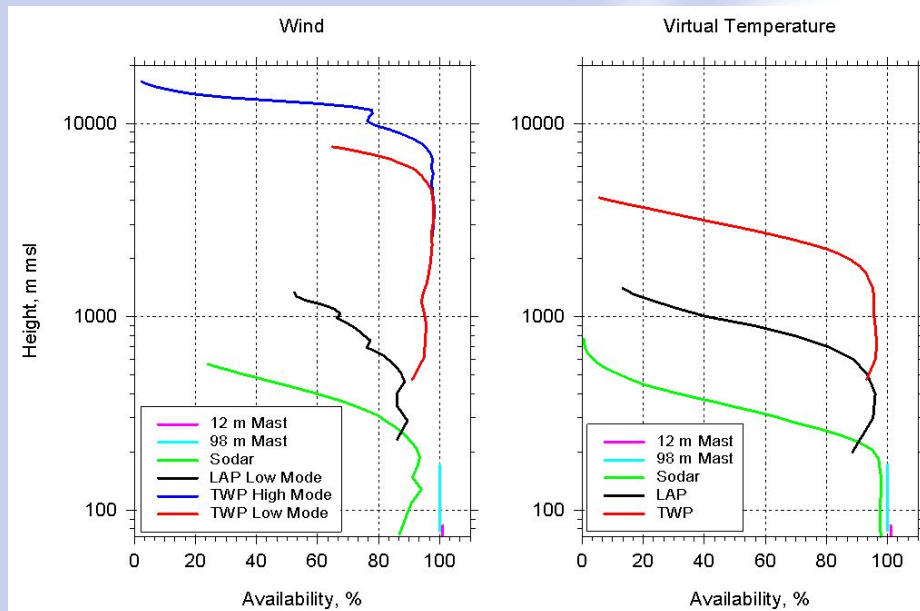
Predict. of IPCC:

→ 0.60 K / 100 yrs

Wind Profiler Measurements: Operational Aspects

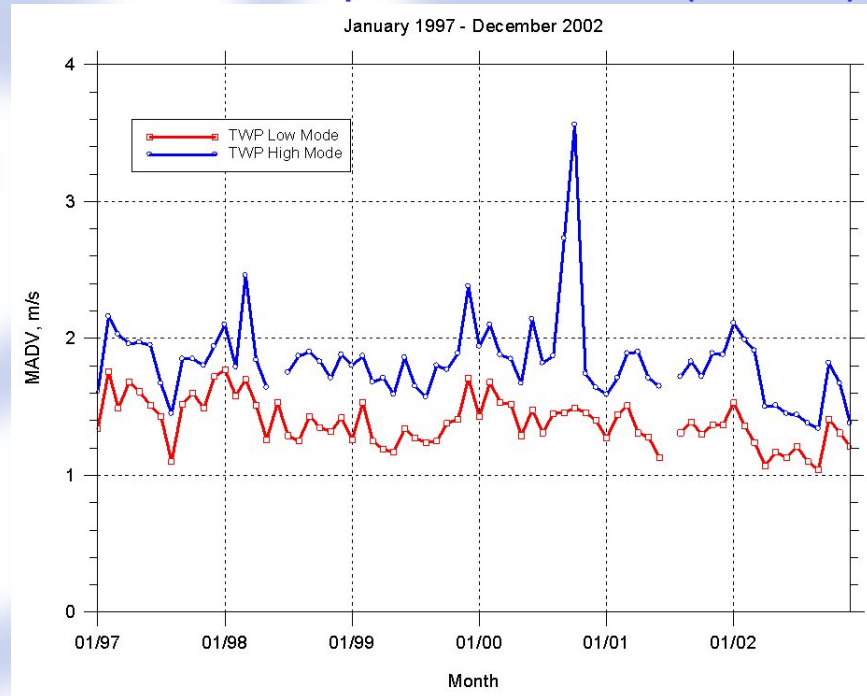


Wind Profiler Measurements: Quality Assessment



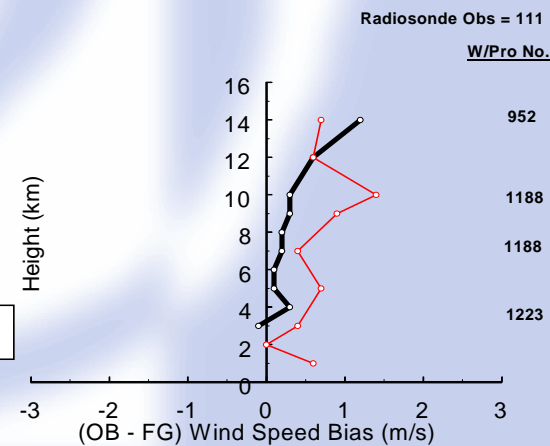
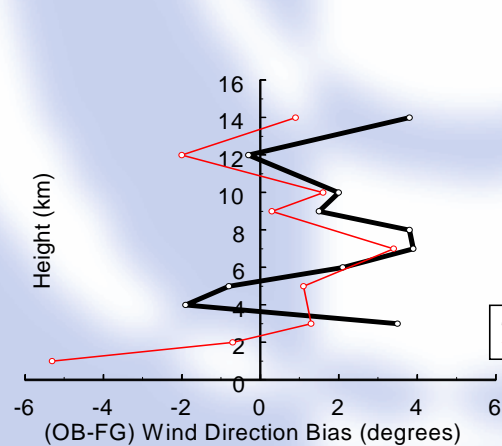
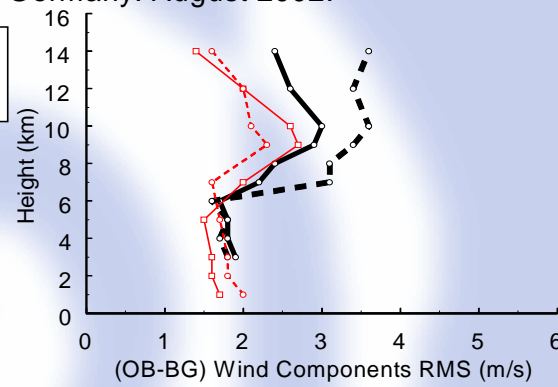
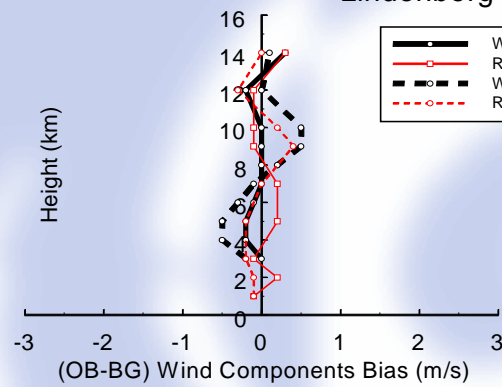
Vertical range for all different wind-profiling systems at MOL

Monthly average difference vector (MADV) of the WPR measurements compared to rawinsondes (1997-2002)



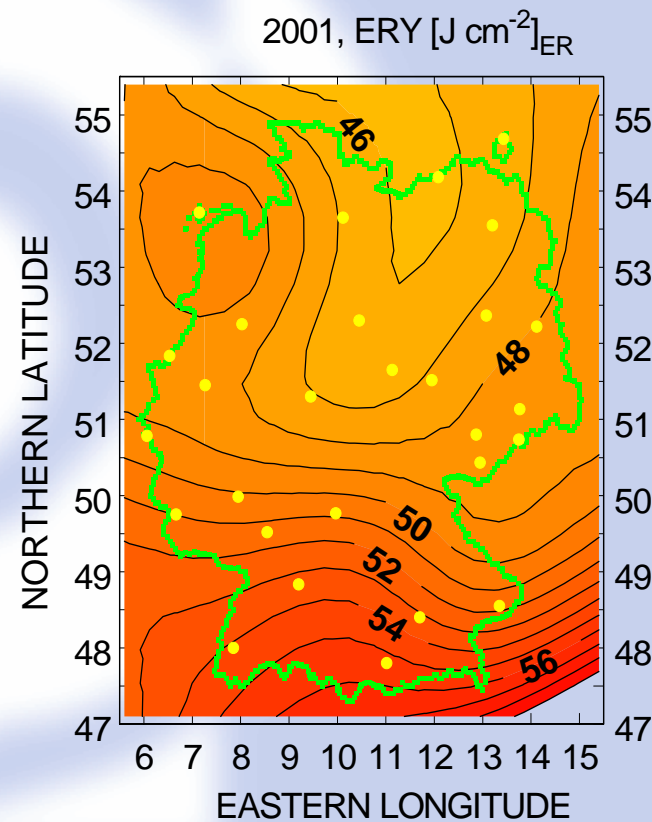
Wind Profiler Measurements: Quality Assessment

Comparison of Wind-Profiler/Radiosonde v UK Model Wind Measurements.
Lindenberg 10394, Germany. August 2002.

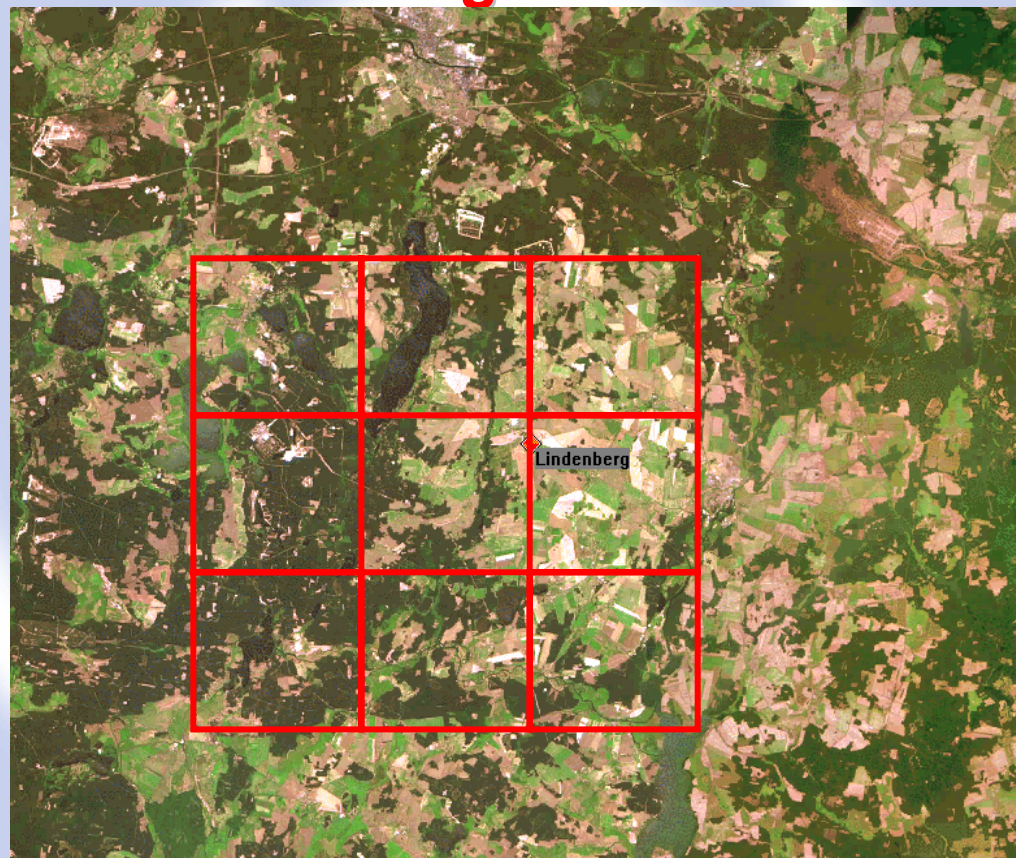


Radiosonde results are from the nearest Upper-Air site and statistics are converted to approximate heights from standard pressure levels.

National Radiation Measurement Network: Annual UV-B Index



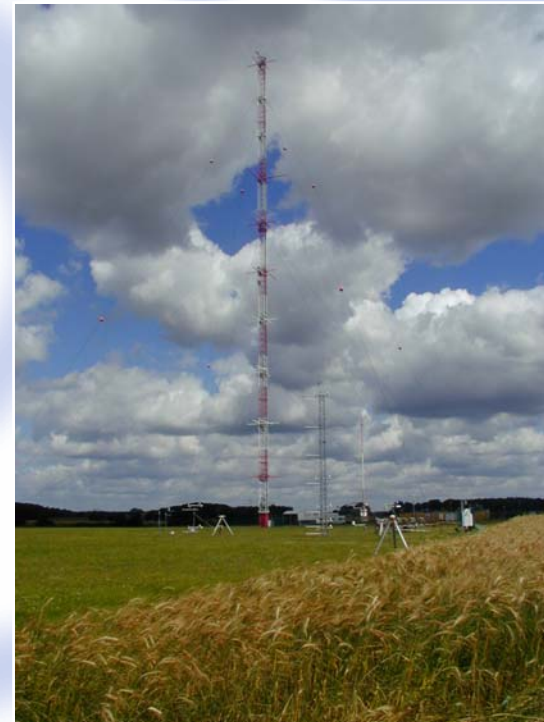
Land - Atmosphere Interaction over Heterogeneous Terrain



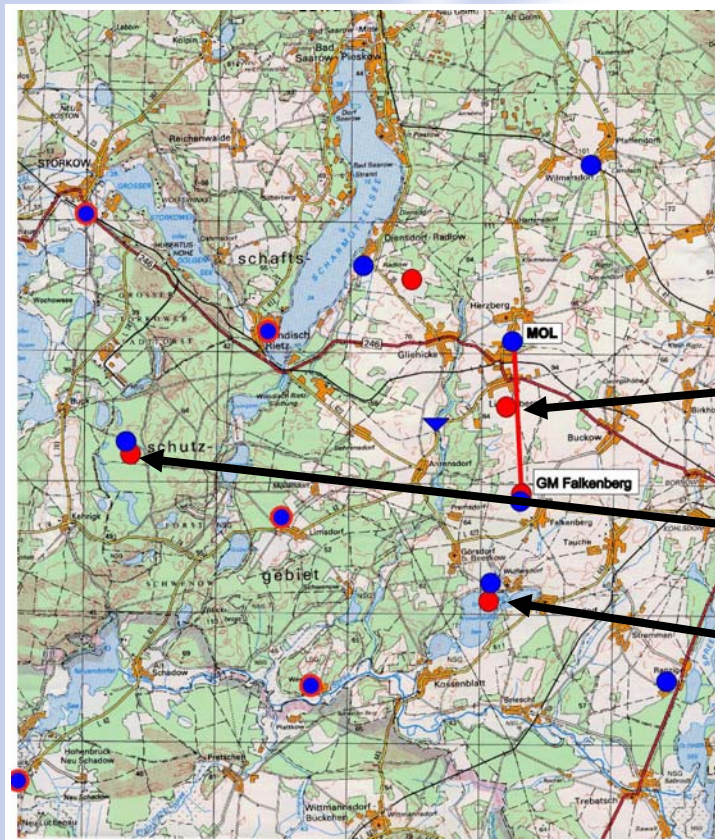
The 7 x 7 km² grid elements
around Lindenberg Observa-
tory of the operational
HiRes-NWP model „LM“
of the DWD

Experimental studies of land surface - atmosphere interaction processes

The boundary layer field site in Falkenberg



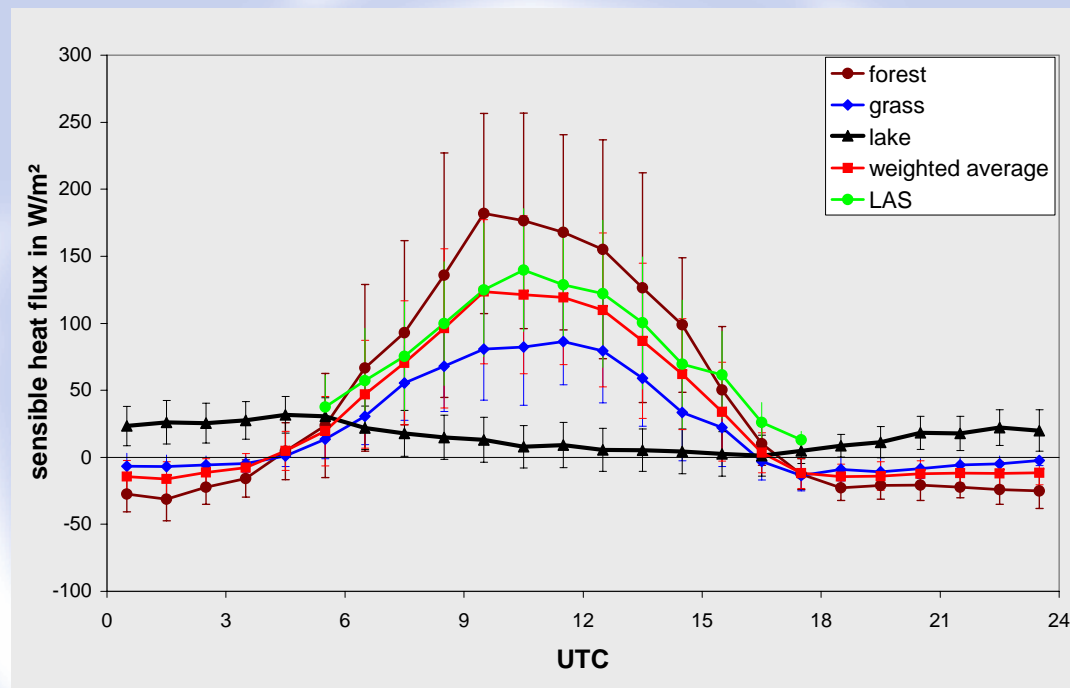
Experimental studies of land surface - atmosphere interaction processes



Network of micro-meteorological / flux stations



Area - Averaged Fluxes



Mean diurnal cycle of sensible heat flux during the LITFASS-98 experiment for the wind direction sector 150...300 deg: different surfaces vs. area - average

MOL: Reference Site in International Programs

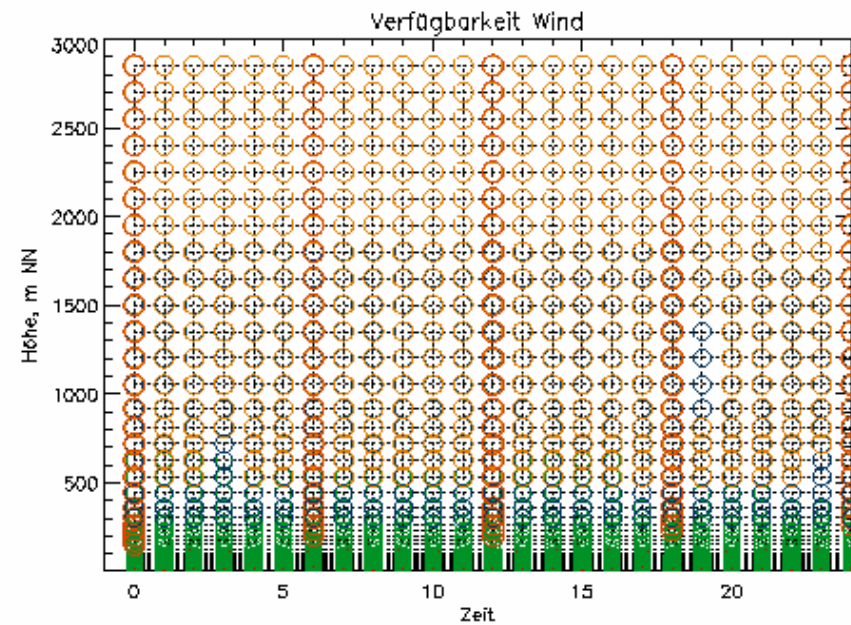
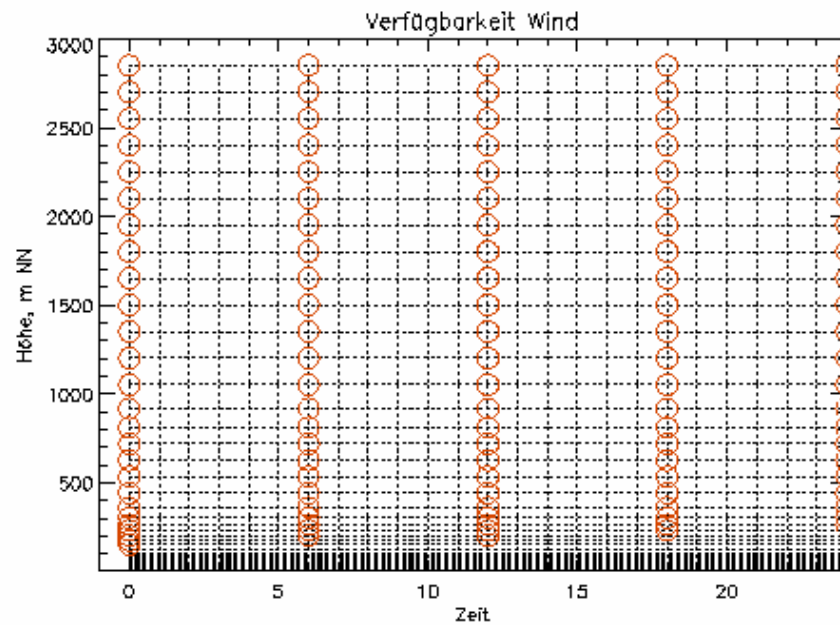
European Windprofiler
Network



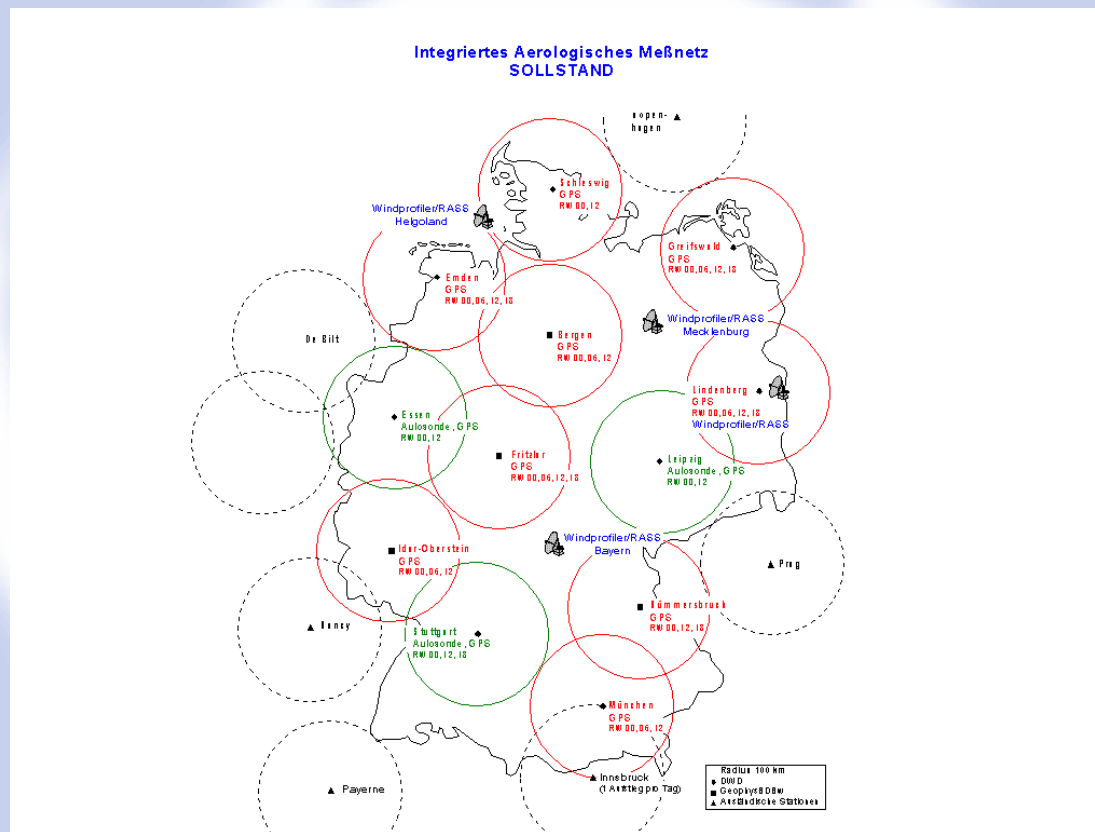
Ground based remote sensing: Enhanced data availability

Data availability
Radiosonde

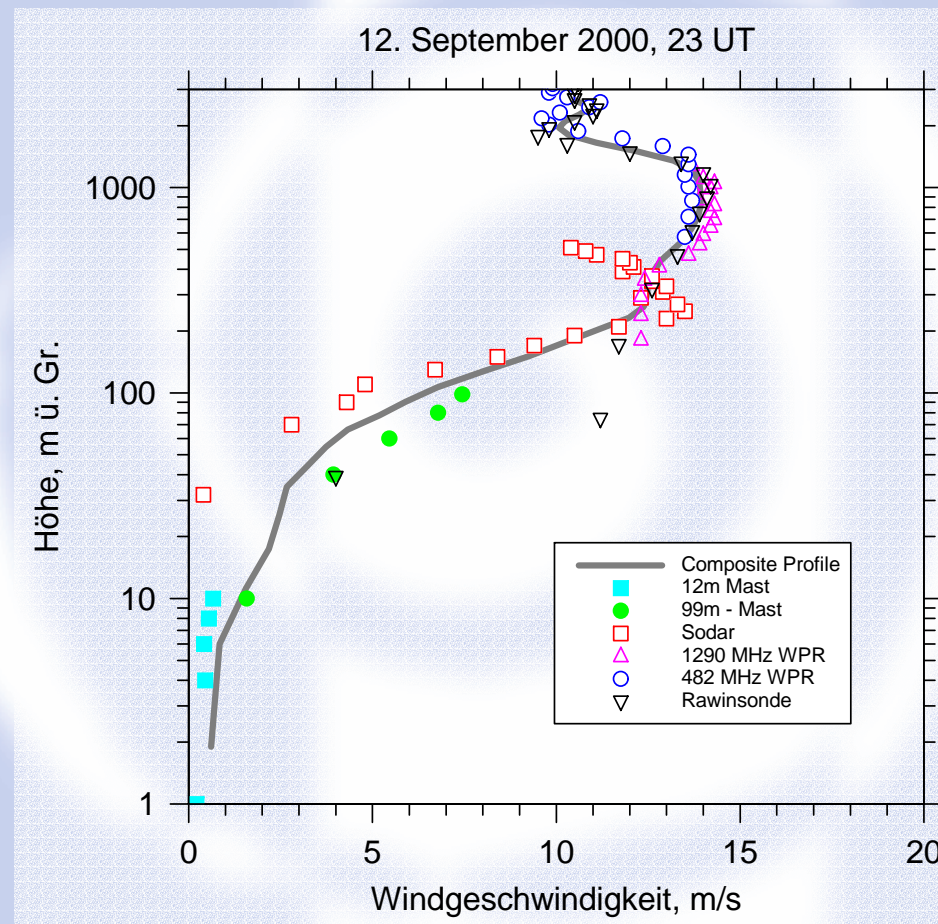
Data availability
Remote sensing systems



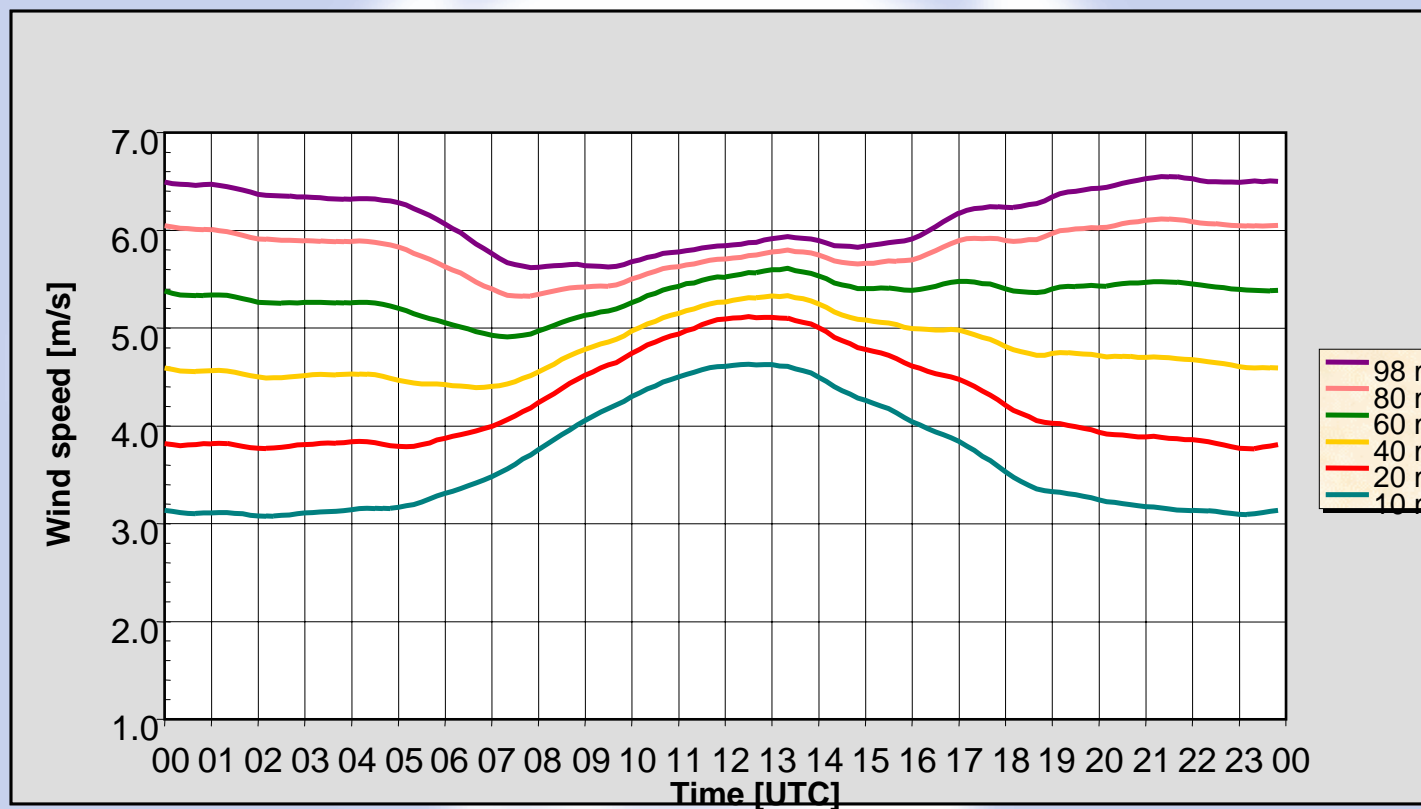
Future: Wind Profilers as a Part of the Aerological network of DWD



Composite Profiling: Wind



Long-Term Measurements at GM Falkenberg: Diurnal Cycle of Wind Speed - Annual Average 2000



Long-Term Measurements at GM Falkenberg: Precipitation and Soil Moisture 2000 / 2001

