COST 723

Deutscher Wetterdienst

Meteorological Observatory Lindenberg - Richard-Aßmann-Observatory

DWD

USE AND CORRECTION OF HISTORIC AEROLOGICAL MEASUREMENTS

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Introduction

With the development of the first radiosondes (the beginning of the 1930s) the sounding of the atmosphere got a decisive boost. Meteorological parameters as pressure, temperature, humidity and wind could now be measured in situ and analyzed immediately. In Lindenberg aerological measurements were carried out by kites and thetered balloons in the period 1905-1942. Since 1947 (resumption of radiosonde ascents) six types of radiosondes have been used:

1947 -1957:	LANG-Sonde *(Germany)*
1957 -1971:	FREIBERG-Sonde *(Germany)*
1971 -1986:	RKS-Sonde *(Russia)*
1986 - 1992:	MARZ-Sonde *(Russia)*
1992 -2004:	RS80-Sonde *(Finland)*
01.07.2004:	RS92-Sonde *(Finland)*

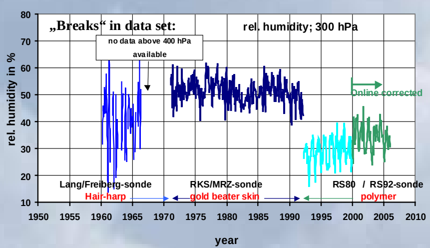
Usage of different types of sondes resulted in modifications of measurement sensors, methods, and evaluation procedures. The measurement sensors were improved over the years related with respect to their precision, their protection against radiation, and their inertial behavior. The Lindenberg aerological station is one of the 161 stations in the **G**COS **U**PPER **A**IR **N**etwork of the WMO (GUAN).

Humidity in the free Atmosphere

Humidity, in form of water vapor or clouds, influences all atmospheric radiative processes within the spectral range of solar and terrestrial radiation. Furthermore, water operates in the atmosphere by its chemical properties and its ability to wash out aerosols. Therefore, determination of atmospheric humidity within gaseous, liquid and solid state has got a significant interest in aerology, similar to measurement of temperature, wind, and pressure.

For measurement of humidity within the history of aerology, primarily four different sensor types have been used

- hairhygrometer	kites and sondes LANG and FREIBERG
- goldbeaterskin	Russian sondes RKS and MARZ
- carbonhygristor	sondes GRAW and VIZ, not in Lindenberg
- polymersensor	sondes RS80, RS90, RS92 from Finland



The Lindenberg FN-Method

Examinations by SODEN and LANZANTE [4] show that there are huge large systematical differences between the specific sensor types (comparison of satellite data and data of radiosondes in upper troposphere). For this reason and due to the noticed „break" in the Lindenberg data set within measurements of humidity on change of measuring instruments, Lindenberg Observatory has tried to improve humidity measurements with operational radiosondes since 1995. Since 1999 precision humidity radiosondes have been launched once per week using the Lindenberg reference sonde (FN-method, modified RS90 radiosondes). Precision humidity radiosondes using the FN-method reach an accuracy in measurement of relative humidity of 1 % within the atmosphere [3].

The FN-method: F_M(100 %): frequency (F) information in 100 % RH ventilated groundcheck box (700 s)
F_H(U%): frequency (F) - information in heated state (60 s)
F_M(U%): frequency (F) – inf. in measuring state (160 s)
U% RH of ambient air
e: water vapor partial pressure
e_w: saturation water vapor partial pressure

Idea: use of standardized frequencies F

during radiosonde-flight „in situ calibration"

$$F_N = \frac{\overbrace{F_H(U\%)-F_M(U\%)}^{0\ \text{to}\ 200\text{Hz}}}{\underbrace{F_H(100\%)-F_M(100\%)}_{\Delta F}} = 0.00\ldots1.00 = \frac{e}{e_w}\times 100 = RH\ \text{(relative humidity)}$$

ΔF: sensor specific individual difference, about 200 Hz; from 100 % RH ventilated box

Correction of RS80-A-Humidity

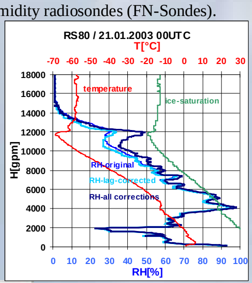
An adjustment method for measurement of humidity with RS80-A-humicap sondes has been developed as a result of a comparison of RS80 routine sondes and the reference humidity radiosondes (FN-Sondes).

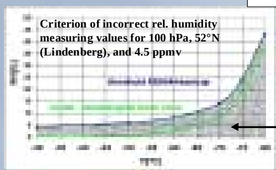
The adjustment method for RS80 humidity uses the following steps (see [1],[2]):

1. ground check adjustment for 100 % relative humidity

2. lag correction (dependent on humidity gradient and temperature)

3. temperature dependent adjustment for temperature <-15°C





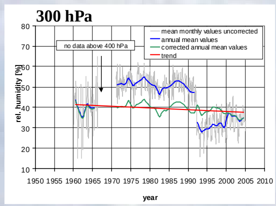
4. deletion of measured data for relative humidity in case of icing of humidity sensor.

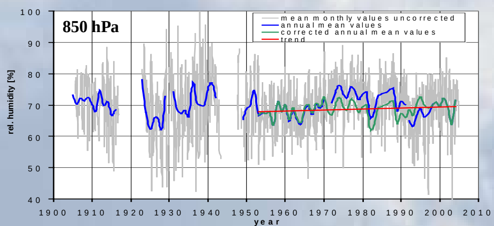
Range of climatological justified RH-values (gray)

Since 2000 all adjustments for RS80-humicap sensors for the evaluation of humidity have been made in real-time.

Homogenization

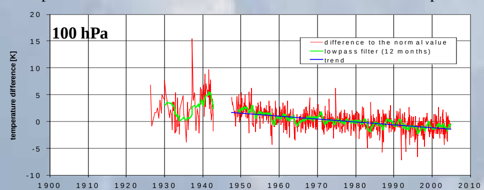
By analysing the gradient of relative humidity within similar measuring sensors and by determining the regression line, past measurements have been amended. It was possible to homogenize the time series of water vapor dispersion as the most important green-house gas in the atmosphere over Lindenberg. A first draft of the time series of relative humidity for more than 50 years has been created.

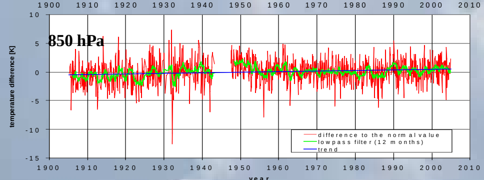




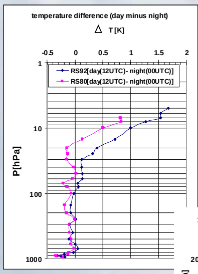
Measurement of Air Temperature

The air temperature is one of the most important indicators to describe the structure of the atmosphere. Today the temperature profile determined by radiosondes is still the backbone of the numerical weather forecast. Furthermore, long series of temperature measurements in the atmosphere are used to derive tendencies for the climatic development.



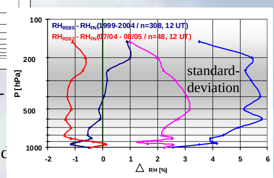


Differences of polymer-sondes



Temperature: RS92 gives higher daytime temperatures compared to RS80. The day-night comparisons show bigger differences above 20 km for the RS92.

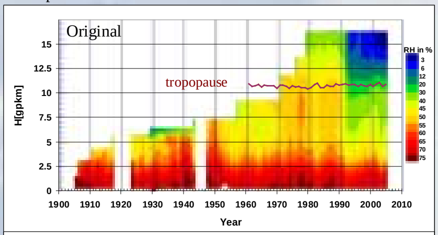
The RS92 temperature-correction above 30 hPa is still under evaluation of the Lindenberg Observatory.

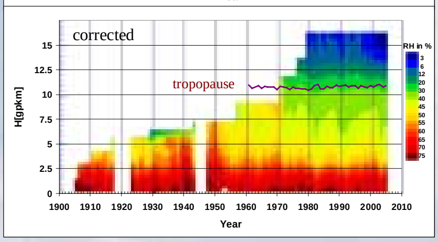


Humidity: The standard-deviation of differences between RS92 and FN-Sonde is halved compared to differences RS80/FN.

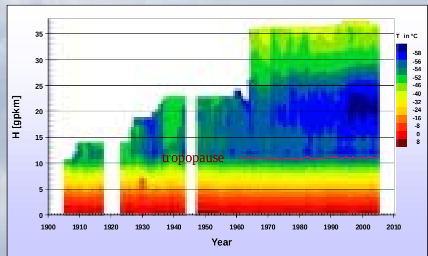
Results

The original and the corrected humidity values at different atmospheric levels:





Heigth-time cross-section of temperature over Lindenberg:



References:

[1]*Leiterer, U., H. Dier and T. Naebert; 1998*: Improvements in Radiosonde Humidity Profiles Using RS80/RS90 Radiosondes of Vaisala. – In: Papers presented at the WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation (TECO-98), WMO Instruments and Observing Methods Report No 70. WMO/TD-No. 877, 215-219.

[2]*Leiterer, U., H. Dier, D. Nagel, T. Naebert, D. Althausen, K. Franke, A. Kats, F. Wagner; 2004*: A Correction Method for RS80-A Humicap Profiles and their Validation by Lidar Backscattering Profiles in Tropical Cirrus Clouds. - In:- Journal of Atmospheric and Oceanic Technology (JTECH), Vol. 22, No. 1, 18-29, 2005.

[3]*Nagel, D., U. Leiterer, H. Dier, A. Kats, J. Reichardt and A. Behrendt; 2001*: High Accuracy Humidity Measurements Using the Standardized Frequency Method with a Research Upper-Air Sounding System. Meteorol. Z. 10, 5, 395-405.

[4]*Soden, B.J. and J.R. Lanzante; 1996*: An assessment of satellite and radiosonde climatologies of upper-tropospheric water vapor. J. Climate, 9, 1235-1250.

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