# Experiences with humidity and temperature operational radiosonde measurements by the new RS92 validated by Lindenberg Reference-FN-radiosondes at the Lindenberg GUAN-station (10393)

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## The Lindenberg FN-Method

Examinations by SODEN and LANZANTE [4] show that there are large systematical differences between the specific sensor types (comparison of satellite data and data of radiosondes in upper troposphere). Therefore, and due to the noticed „break" in the Lindenberg upper air humidity data set [1], the Lindenberg Observatory has tried to improve humidity measurements by operational radiosondes. Since 1999 precision (reference) humidity radiosondes have been launched once per week using the Lindenberg reference sonde (FN-method, modified RS90 radiosondes). The reference humidity radiosondes using the FN-method have an accuracy in measurement of relative humidity of +-1 % within the atmosphere [3]. Using these accurate measurements a four stage correction algorithm for RS80A - humidity measurements has been developed at Lindenberg Observatory [2] . This algorithm was used to correct the Lindenberg RS80A humidity soundings.

**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"

$$F_N = \frac{\overbrace{F_H(U\%) - F_M(U\%)}^{0\ \text{to}\ 200\,\text{Hz}}}{\underbrace{F_H(100\%) - F_M(100\%)}_{\Delta F}} = 0.00 \ldots 1.00 = \frac{e}{e_w} \times 100 = \text{RH (relative humidity)}$$

$\Delta F$: sensor specific individual difference, about 200 Hz; from 100 % RH ventilated box

*Fig.1:Shematic explaination of the FN-method (see also[2])*

## Problem of icing / contamination

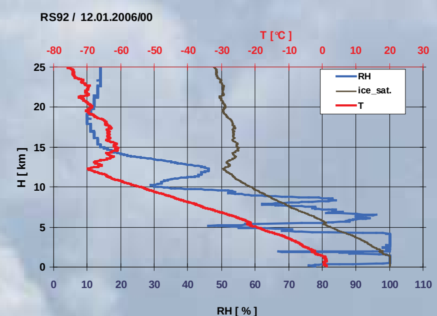


*Fig.2a:Problem of icing / water vapour contamination*

In Fig. 2a the relative humidity (RH) in 16 km height -that is about 4 km above the tropopause- is 13% RH wich is approximatly 10 % RH higher than the climatological mean value of 3%RH for -63°C (see Fig. 2b). The water vapour contamination results from the water accumulation of the radiosonde / balloon package during flight in water vapour supersaturated regions in the troposphere. In this case the humidity data have to be deleted for all temperatures lower than -10°C and higher than 4 km.

This criterium was used to make the decision whether the sounding data are contaminated by water vapour or not.

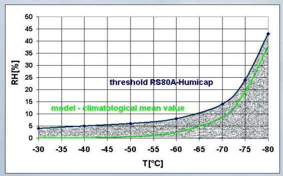


*Fig.2b:Criterion for incorrect measurements of relative humidity at lower stratosphere*

## Icing / water vapour contamination cases:

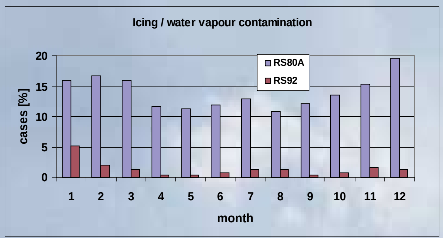


*Fig.2c:Improvements by use of RS92 radiosonde regarding to icing / water vapour contamination (compared to RS80)*

Using the two humidity sensors used in RS92 (one sensor is heating, the other is measuring) the icing / water vapour contamination cases reduced to about 10% of RS80 icing / water vapour contamination cases.

## Temperaatur error by different solar radiation correction

The day-night-temperature-difference of former RS80 (1993-2003) and of present RS92 (2004-2006) is given in the following figure:

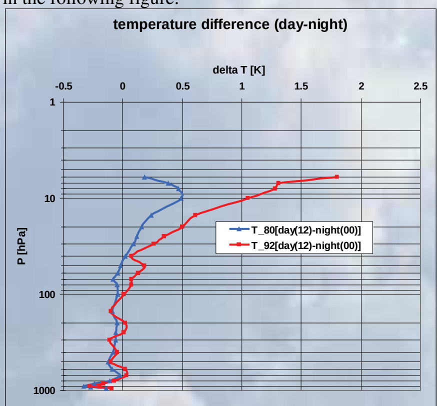


*Fig.3: Day-night-differendces of temperatures for RS80 and RS92*

The RS92 gives higher daytime temperatures compared to RS80. The day-night comparisons show larger differences above 30 hPa for the RS92. The RS92 temperature correction above 30 hPa is still under evaluation of the Lindenberg Observatory.

## Improvement of humidity measurement by RS92

A small dry bias of 1 to 0.5 %RH near the ground (1000-700 hPa) is shown in Fig. 4. The standard deviation of differences between RS92 and FN-Sondes has been halved compared to differences RS80cor / FN.

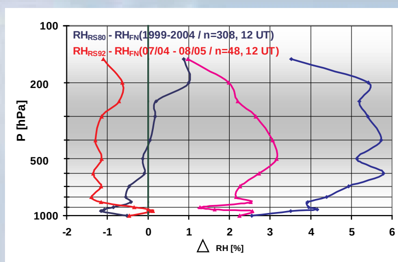


*Fig.4: Differences of corrected RS80 and RS92 to FN at daytime*

## Unsolved problem of humidity solar radiation error for polymer sensors

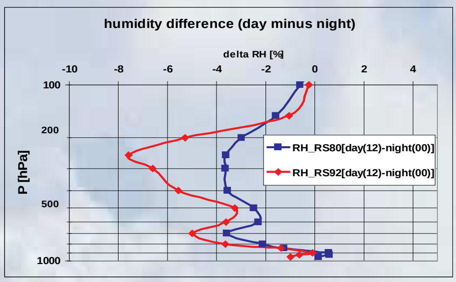


*Fig.5: Day-nigth-diff. of RS80 (1993-2003) and RS92 (2004-2006)*

In the upper troposphere the day-night-difference of relative humidity for the RS92 has doubled related to former RS80.

## Use of ascent and descent data

The new RS92 can be used for ascent and descent measurements. The example Fig.6 shows a 30%RH-difference between ascent and descent measurement in heigth of 6 km wich is typical for the humidity field in the free atmosphere. Here, the time gap was 50 min at a horizontal distance of 12 km. This very variable humidity field was confirmed by the cloud structure (cloudradar).
The temperature differences between ascent and descent were maximum +-0.3 K over the height range 0 - 12 km.

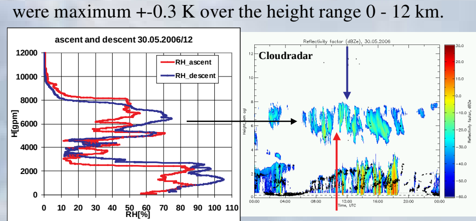


*Fig.6: Ascent and descent humidity measurement with RS92*

## References:

[1]*Adam, W., H. Dier and U.Leiterer; 2005*: 100 years aerology in Lindenberg and first long-time observations in the free atmosphere. Meteorol. Z.,14,5,597-607
[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.