Comparison of AMSU-B Brightness Temperature with Simulated Brightness Temperature using Global Radiosonde Data

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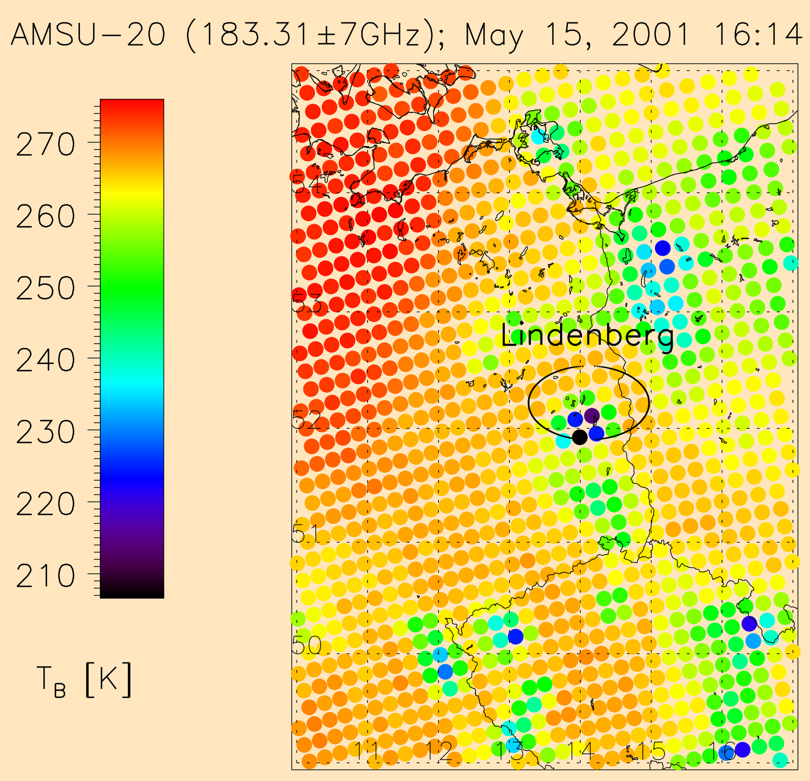
Introduction

Upper tropospheric humidity (UTH) is a crucial parameter for meteorology and climate research. There are two global and continuous data sets for this parameter, one from polar orbiting meteorological sensors, the other from synoptic meteorological radiosondes. The basic idea of the study is to compare satellite and radiosonde data. A radiative transfer (RT) model is used to generate simulated AMSU measurement from the radiosonde data.

The aims of the study are, to develop a robust methodology for such a comparison and to pave the way for a systematic comparison of all stations in the global radiosonde network to satellite data. This will allow an intercomparison and quality control of the different radiosonde stations, assuming that the satellite instrument's properties are stable during a few orbits.

Lindenberg Radiosonde Data



The Meteorological Observatory Lindenberg (MOL) - 52° 22′ N, 14° 12′ E.

- High Resolution Not Corrected(HRNC)
- High Resolution Corrected(HRC)
- Low Resolution Corrected(LRC)

Corrections for HRC / LRC:

- Dry bias correction
- Elimination of data affected by sensor icing
- Time lag correction

LRC - only standard and significant levels of HRC

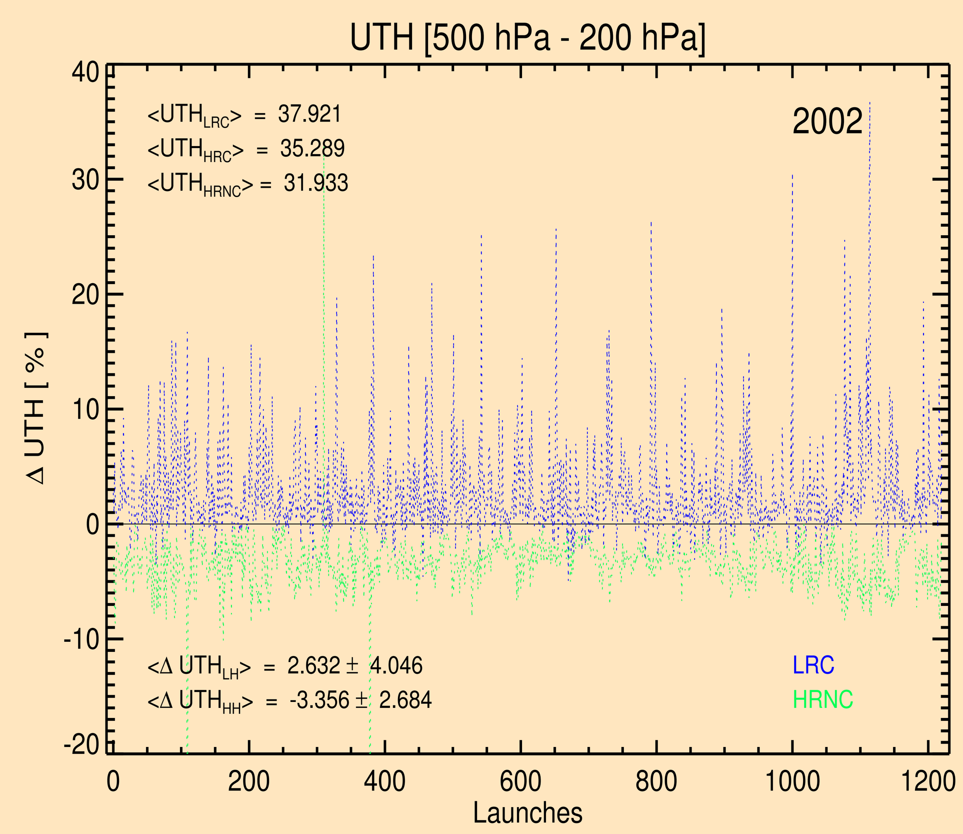
Average Upper trpospheric Water Vapor Content, 2002 [$kg\,m^{-2}$]

- LRC - 0.745
- HRC - 0.721
- HRNC - 0.698

Average Total Water Vapor Content, 2002 [$kg\,m^{-2}$]

- LRC - 16.712
- HRC - 16.660
- HRNC - 16.476

- LRC has wet bias
- HRNC has dry bias



ARTS - Atmospheric Radiative Transfer Simulator [1]

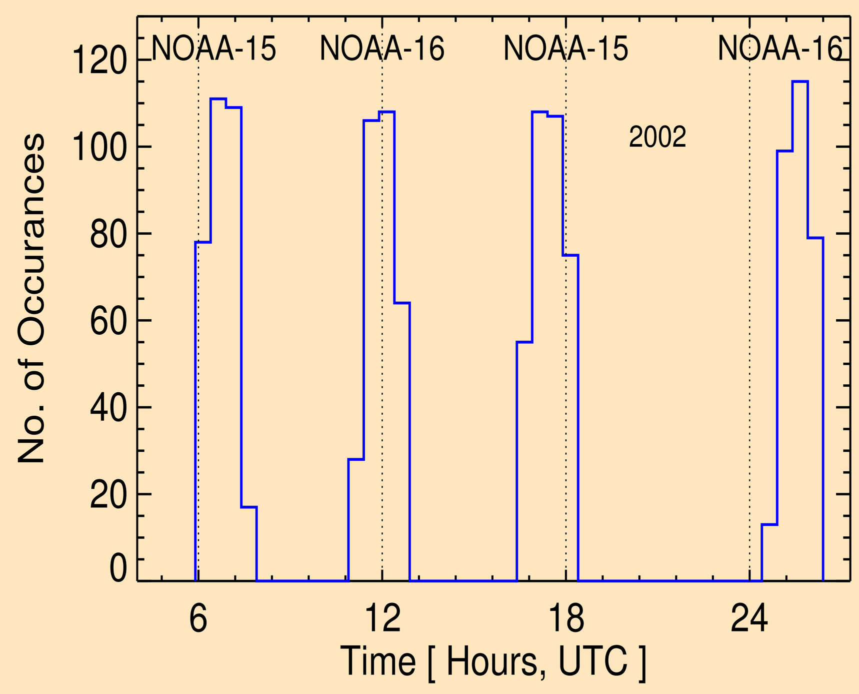
ARTS is used to simulate brightness temperature for AMSU-B channels. The clear-sky version of ARTS is used in this study. A cloudy version, which can handle scattering due to cirrus clouds has been developed and is being validated.

The table below shows the effect of cutting the profiles at 100 hPa. Simulations for the ECMWF 60-level data set [2] were used to assess this. The difference in brightness temperature in mK is given in the table (GN: Global profiles, nadir view, GON: Global profiles, most off-nadir view, MN: Midlatitude profiles, nadir view, MON: Midlatitude profiles, most off-nadir view).

Ch.	GN	GON	MN	MON
16	01±42	32±74	-30±34	-33±57
17	12±19	32±29	-7±15	0±26
18	81±31	130±57	60±25	90±47
19	27±9	46±16	18±6	31±11
20	20±9	38±14	10±8	23±10

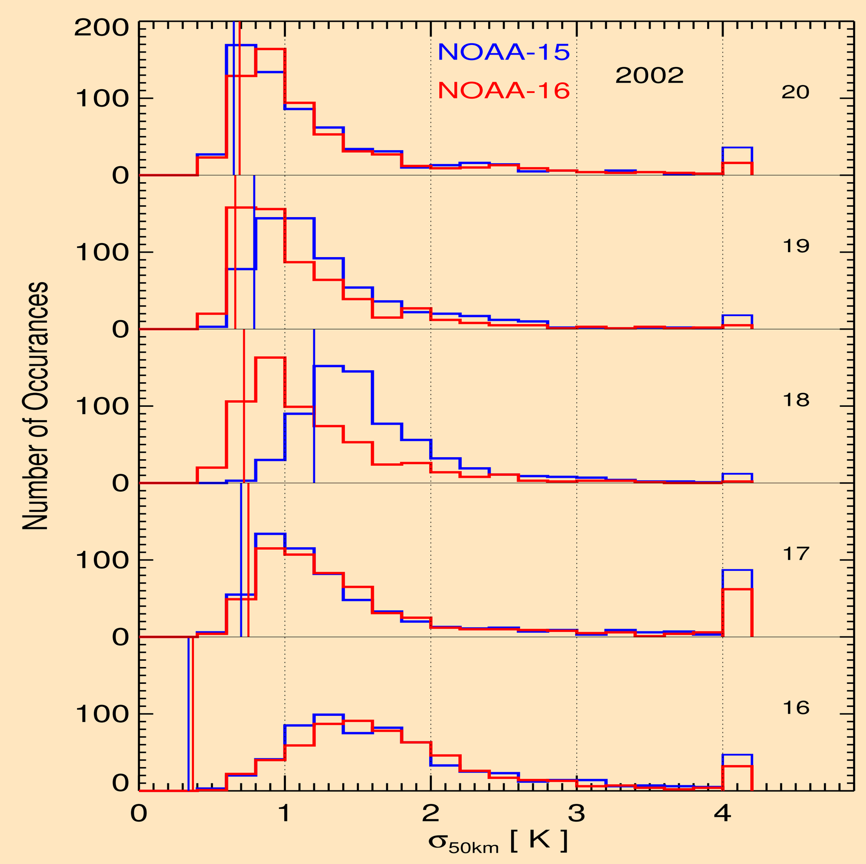
- Absorption Models:
  - H_2O, N_2, O_2 - PWR-98, PWR-93, PWR-98
- Same viewing angle
- Surface emissivity = 0.95
- Profiles were cut at 100 hPa [see table]

Selecting Matches



- AMSU radiance in a target area, a circle of 50 km radius (mean of all pixels in the circle)
- Radiance is simulated with mean looking angle of the circle
- At least 12 pixels should be in the circle
- Displacement, D of air parcel ≤ 50 km
- D = Ave. wind speed x Time diff.
- Radiosonde time - half an hour before synoptic hour

Error Model



Sources of error for the comparison are:

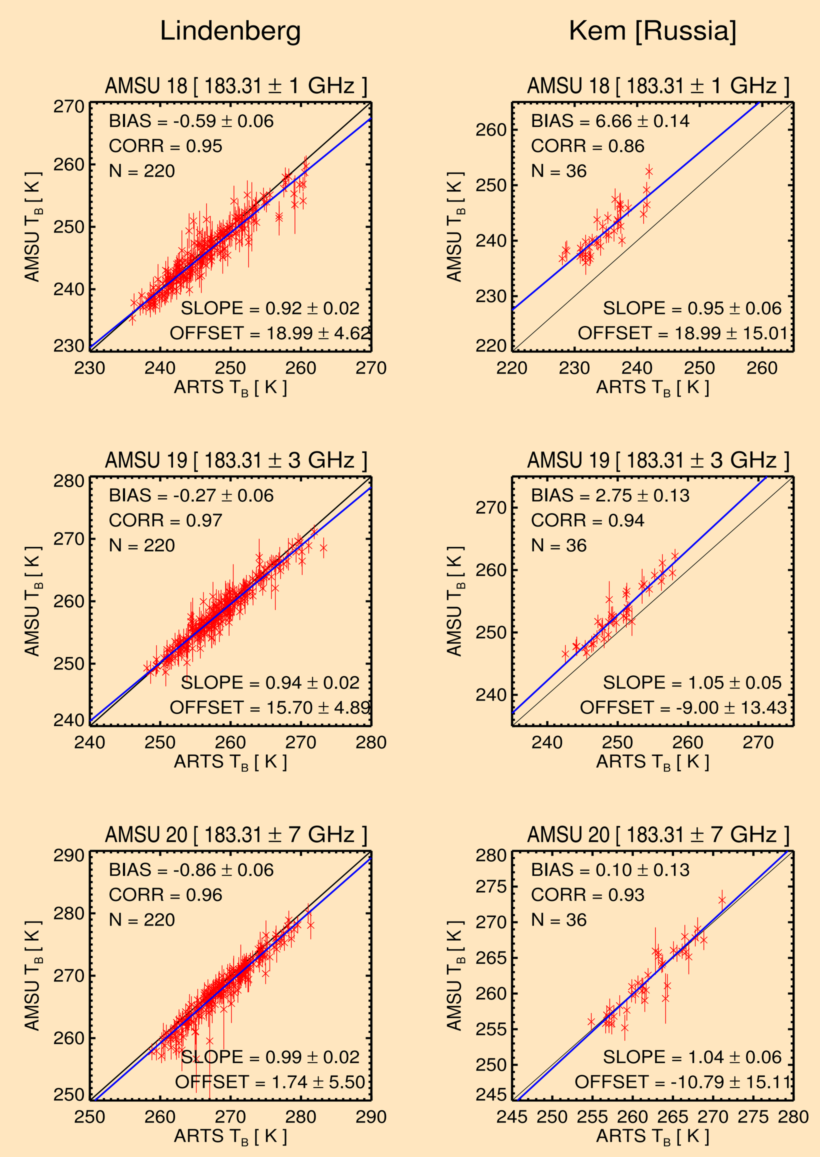
- Radiometric noise of the AMSU measurement
- Sampling error, due to atmospheric inhomogeneity
- Radiosonde measurement error in humidity and temperature
- RT model error (systematic)
- AMSU calibration error

$$\sigma(i) = C_0 + \sigma_{50\mathrm{km}}(i)$$

$$C_0 = 0.5\,\mathrm{K}$$

$\sigma_{50\mathrm{km}}$ - standard deviation of the pixel brightness temperatures in the target area of 50 km circle around the station

Results



Type	Ch.	Bias	Slope	Offset	Corr
HRC	18	-1.36±06	0.90±0.01	24.34±3.17	0.95
	19	-0.93±06	0.95±0.01	11.76±3.50	0.95
	20	-1.20±06	0.99±0.01	02.81±3.90	0.95
HRNC	18	-2.06±06	0.91±0.01	20.32±3.26	0.94
	19	-1.21±06	0.96±0.01	09.49±3.55	0.94
	20	-1.36±06	0.98±0.01	03.45±3.90	0.95
LRC	18	-0.85±06	0.82±0.01	44.43±2.93	0.93
	19	-0.76±06	0.89±0.01	26.87±3.31	0.94
	20	-1.16±06	0.95±0.01	11.31±3.78	0.95

$$\mathrm{Bias} = \frac{\sum_i (\mathrm{T_{B_{AMSU}}}(\mathrm{i}) - \mathrm{T_{B_{ARTS}}}(\mathrm{i}))/\sigma^2(i)}{\sum_i \sigma^{-2}(i)}$$

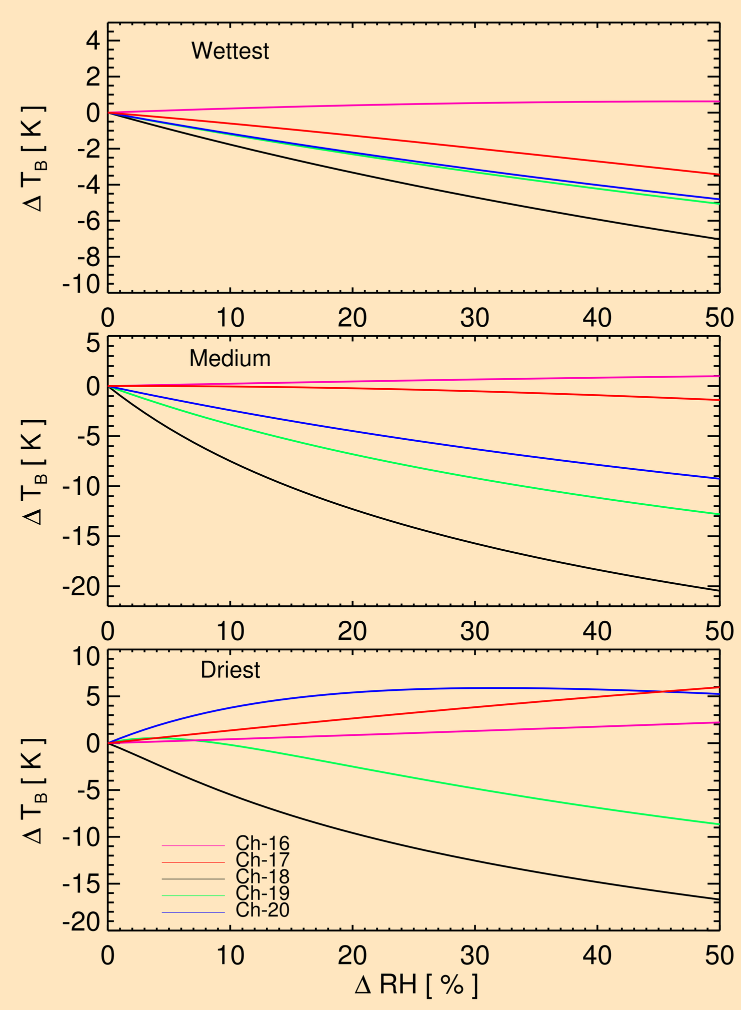
$$\mathrm{T_{B_{ARTS}}^{correct}} = \mathrm{Offset} + \mathrm{Slope} \times \mathrm{T_{B_{ARTS}}}$$

- Small dry bias in HRC compared to AMSU
- Dry bias in HRNC compared to HRC
- Wet bias in LRC compared to HRC

Figure shows comparison of two types of humidty sensors. Data is taken from BADC.

- Lindenberg - RS80 - Vaisala
- Kem - goldbeater's skin

Sensitivity



Total Water Vapor Content [$kg\,m^{-2}$]

- Wettest - 43.08
- Medium - 16.67
- Driest - 1.91

This figure can be used to translate back the bias in brightness temperature to bias in relative humidity in the Upper Troposphere.

- A bias of 7 K for Kem compared to Lindenberg implies that there can be about 12 - 15 % wet bias in RH [3]

In very dry cases channel 20 shows opposite behavior compared to channel 18

Future plans:

- Make collocated data set for available stations in the BADC radiosonde archive
- Analyze quality of the humidity data

References

[1] S. A. Buehler, P. Eriksson, T. Kuhn, A. von Engeln, and C. Verdes. ARTS, the Atmospheric Radiative Transfer Simulator. submitted 2003. Preprint at: http://www.sat.uni-bremen.de.

[2] F. Chevallier. Sampled databases of 60-level atmospheric profiles from the ECMWF analysis. Research report no. 4, EUMETSAT / ECMWF, 2001.

[3] B. J. Soden and J. R. Lanzante. An Assessment of Satellite and Radiosonde Climatologies of Upper-Tropospheric Water Vapor. *J. Climate.*, 9:1235–1250, 1995.