Closure study between 183.31 GHz passive microwave and in-situ radiosonde measurements of water vapor in the atmosphere

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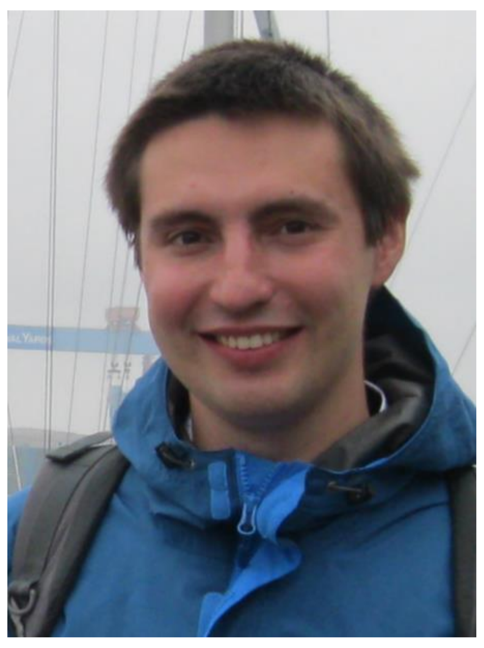

Introduction

Motivation: WV can be measured directly by means of radiosondes and remotely by passive satellite measurements. Recently on the dedicated “Joint workshop on uncertainties at 183 GHz (June 2015, Paris, France) [1]. It was identified that there is a systematic bias in water vapor information derived from satellite data. Possible sources of bias were identified and recommendations were made in order to better understand the causes.

Objective: following the formulated recommendations make a closure experiment of 183.31 GHz satellite and radiosonde measurements using latest spectroscopy model, high-quality radiosonde data after GRUAN-processing [4] and accurately controlling other influencing parameters.

Comparison method

The different nature of radiosonde and satellite measurements does not allow direct comparison. The forward model (ARTS - The Atmospheric Radiative Transfer Simulator [5]) is used to simulate top-of-atmosphere (TOA) Brightness Temperature (T_B), given the atmospheric profile from radiosonde measurements. Simulated T_B is compared to the measured T_B from satellite-based passive microwave sensors (Fig. 1)

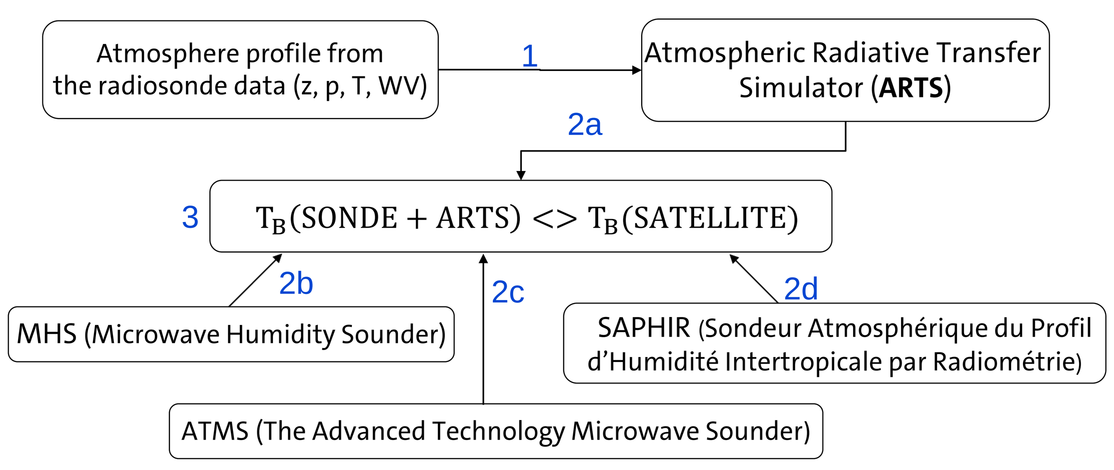

Fig.1. Flowchart of steps to compare radiosonde measurements and satellite measurements

Near the WV absorption line (183.31 GHz) magnitude of T_B depends on the WV amount.

– T_B measured at the center of the line depends on the amount of WV in the upper troposphere (8-10 km)

– T_B measured at the wings of the line depends on the WV in the lower troposphere (0-3 km).

Measuring the T_B in different places around the WV absorption line we can derive information about the WV profile.

In the Fig. 2. presented the positions of:

- Green boxes – MHS sounding channels;
- Pink boxes – ATMS channels
- Violet boxes – SAPHIR channels; [3].

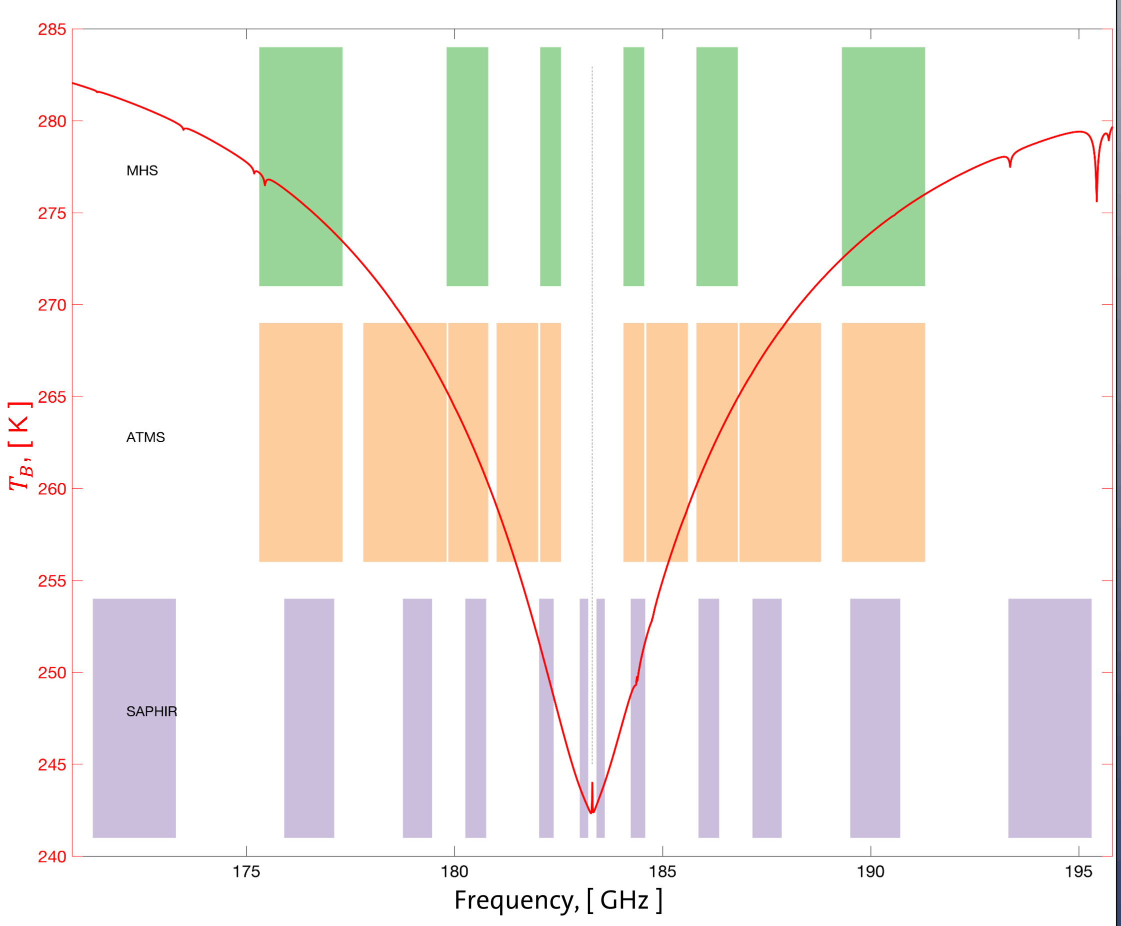

Fig.2. Spectrum and position of measuring channels near the WV absorption line centered at 183.31 GHz

Collocation of point (radiosonde) to area (satellite) measurements

The satellite’s measurement duration is several seconds per pixels. Satellite flew over the area of the radiosonde launch in several minutes. Radiosonde ascent lasts for 1.5-2 hours, and during ascent it can drift up to 100 km from the launch point.

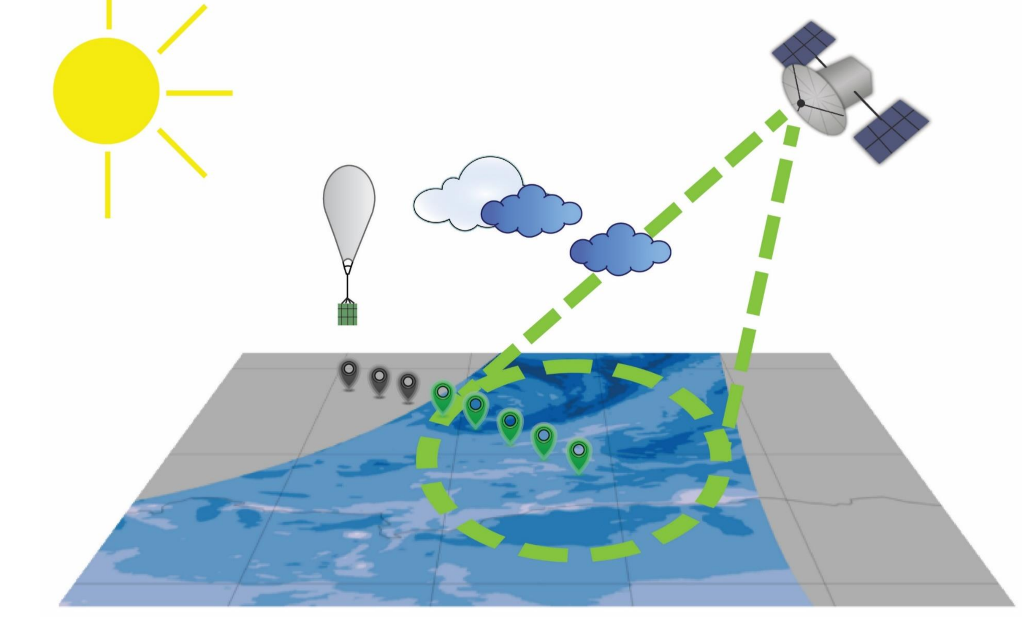

Fig.3. Area satellite measurements and point-profile measurements of radiosonde

Selection of the data

We have applied the following filters [2] to the data:

Satellite data:

- Time difference ± 2 hour from the radiosonde launch time
- Target area concept: as T_B of pixels that surround the closest match point can differ a lot we compute the mean value of all the pixels whose centers are closer than 50 km from the average position of the radiosonde launch point (black circle on Fig. 4)
- Cloud filter: $T_B(183.31 \pm 3) - T_B(183.31 \pm 1) > 0$

Radiosonde:

- Drift during ascent from the launching point < 15 km
- Average position of the radiosonde between 700 and 300 hPa

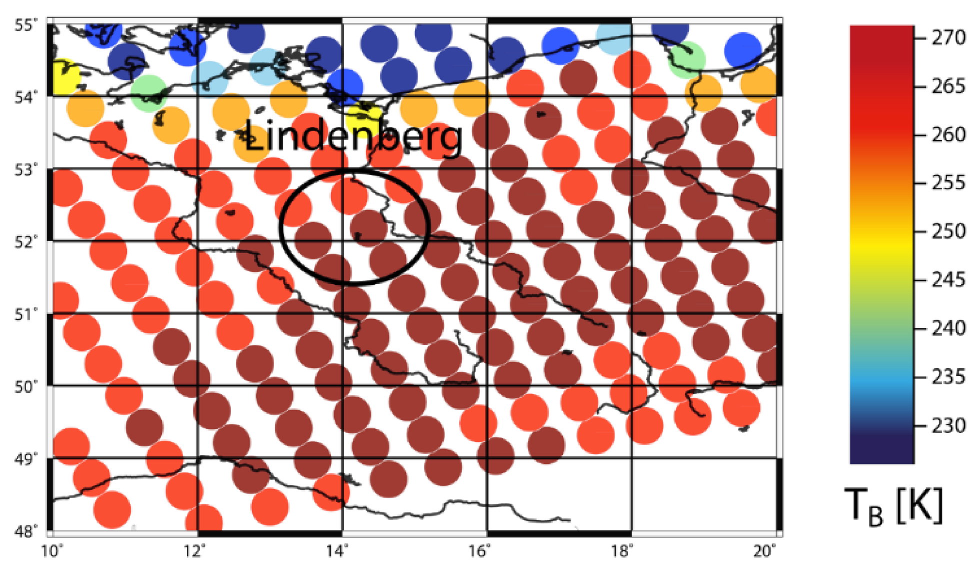

Fig.4. MHS pixels around the Lindenberg radiosonde launching site. Target area concept

Comparison of selected data

Using radiosonde profiles as input for ARTS we obtained T_B for all MHS, ATMS and SAPHIR channels. Comparison of simulated T_B (radiosonde-ARTS) and measured T_B(SAPHIR) is presented in Fig.5. Please note that on the Y-axis the T_B difference is presented: T_B(satellite) minus T_B(radiosonde). When the dot is higher than the null-line on the Y-axis satellite measured T_B is higher than simulated T_B and vice versa.

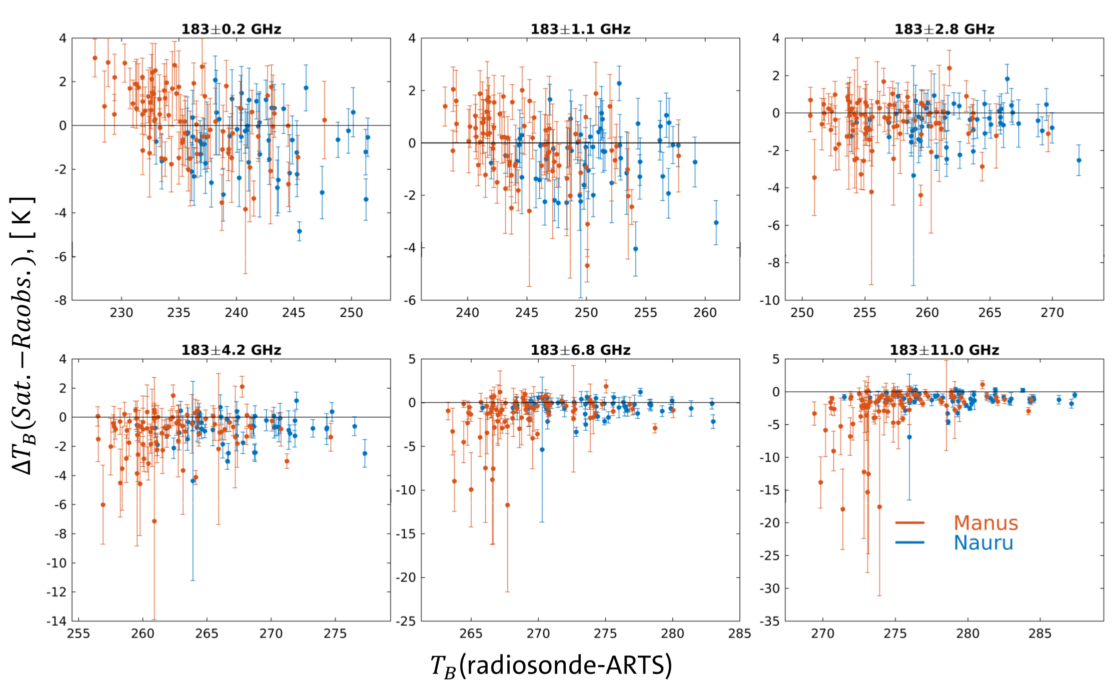

Fig.5. T_B comparison. (a subplot for each of the 6 SAPHIR channels). Errorbars represent the STD of T_B(sat.) in the target area (50km radius)

Results of comparison. Current state of affairs

Our first goal was to update the results of the comparison in the previous study [3]. Fig. 6 present study’s results (red and green lines). Black dotted line shows the results given in the previous study.

Please note that the MHS instrument is installed on several satellites. For this study, MHS data were taken from NOAA-18, MEOP-A and METOP-B satellites.

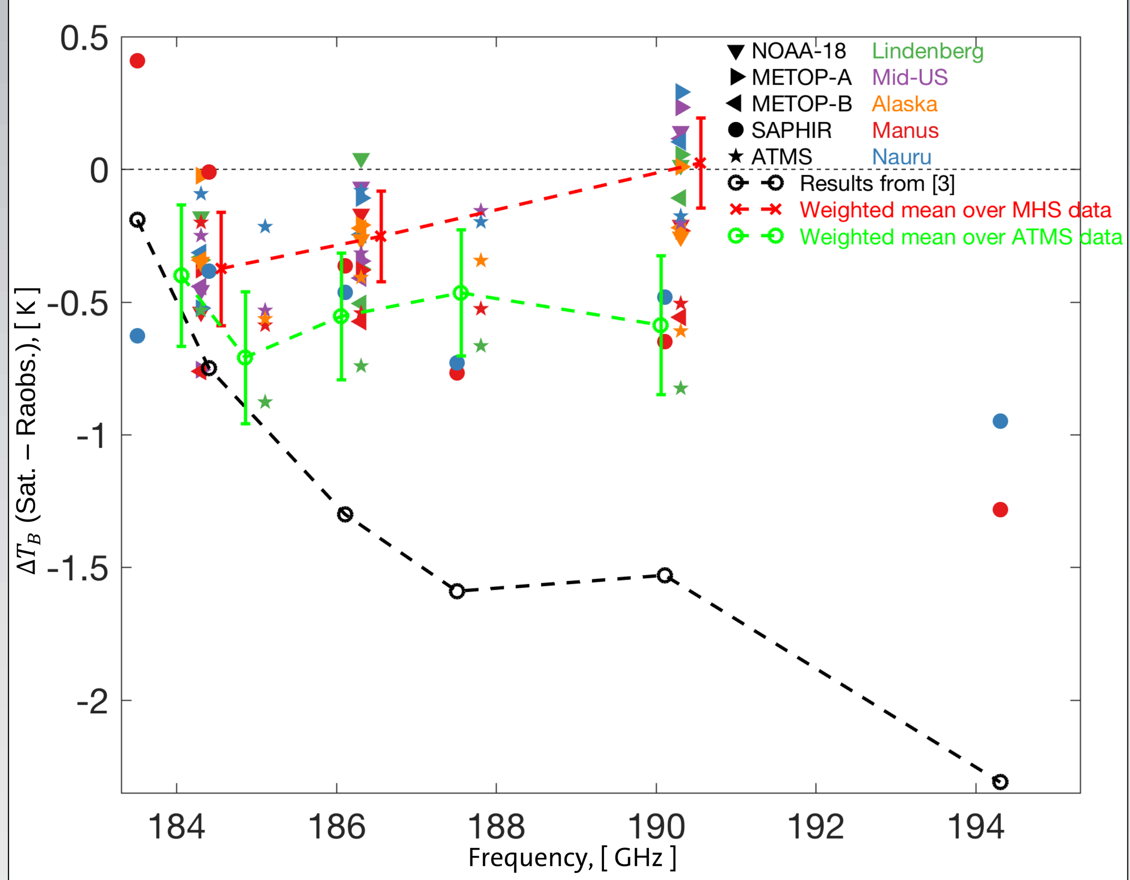

Fig.6. Mean value of T_B difference (measured (satellite) minus simulated (radiosondes). Errorbars show the 95% confidence interval for the mean, based on number of collocations.

Our study confirms the existence of differences, but reduces the absolute values of bias. All channels have a negative bias, showing that satellite T_Bs are colder than radiosonde T_Bs. The only positive difference occurs at the tropical Manus station for the SAPHIR channel at 183.31±0.2 GHz (red circle on Fig.6). Positive differences occur when SAPHIR T_B are very cold T_B < 230K.

Radiosonde-satellite collocated cases for stations and instruments are presented in the Table 1.

Table 1. Number of collocations selected for analysis for years 2012-2014

Station	Location		# of collocations		
	Lat	Lon	MHS	ATMS	SAPHIR
Lindenberg, Germany	52.21°	14.12°	1575	369	
Lamont, OK, USA	36.60°	-97.49°	824	199	
Manus	-2.06°	147.42°	232	45	84
Nauru	-0.52°	166.92°	101	23	56
Barrow, AK, USA	71.32°	-156.61°	273	70	

Discussion. Where did the residual difference come from?

The current system consists of four components: methodology of comparison, radiosounding, satellite-based measurements, radiative transfer (spectroscopy).

Methodology main points are surface emission filtering, cloud detection and filtering. Most efficient cloud filtering method is T_B difference. For this an increasing number of channels at 183.31 line is desirable.

Radiosondes have a well-known problem of dry bias at low temperatures $T < 30^0C$. Increasing the VMR at low temperatures influences inner channels.

New spectroscopy data on the WV line (air broadening, continuum values) are desirable.

Data on channels with two passbands that are widely separated 183.31±7.0 and 183.31±11 GHz are interesting.

References

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