Investigation of gas absorption models from 22 to 60 GHz observed at low water vapor concentrations in the Atacama Desert in Chile

Gerrit Maschwitz[1], Ulrich Löhnert[1], Susanne Crewell[1], Thomas Rose[2], Dave D. Turner[3]
[1] Institute for Geophysics and Meteorology, University of Cologne, Germany (Contact: Gerrit Maschwitz, gmasch@meteo.uni-koeln.de)
[2] Radiometer Physics GmbH (RPG), Germany, [3] Atmospheric and Oceanic Sciences Department, University of Wisconsin - Madison, USA

1. Campaign – RHUBC-II

The Atmospheric Radiation Measurement (ARM) program is conducting the second phase of the Radiative Heating in Underexplored Bands Campaign (RHUBC-II) in Aug – Oct 2009 at a site on Cerro Toco (5320 m), which is located in the Chajnantor Plateau in Chile. The primary focus of RHUBC-II is to characterize and improve the accuracy of water vapor (WV) absorption models (near-infrared to sub-mm wavelengths) using high-spectral-resolution radiance observations in spectral regions that are normally opaque at lower altitudes due to strong water vapor absorption.

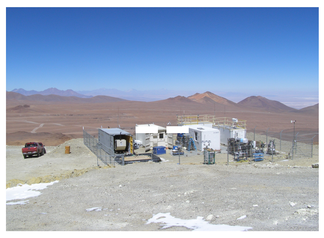
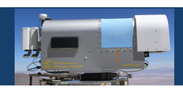


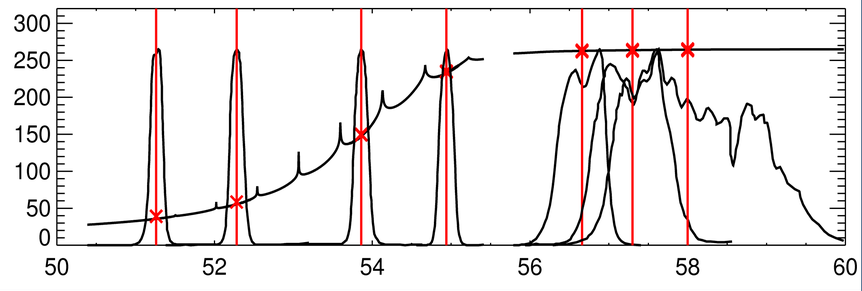
Figure 1: RHUBC-II site

2. Radiometer – HATPRO



The microwave radiometer HATPRO-G2 (Humidity and Temperature Profiler) – measures atmospheric radiation along the 22.24 GHz water vapor line and the oxygen absorption complex centered around 60 with a total of 14 channels. The frequency channels have been designed with sharply well characterized band pass filters, allowing high accuracy TB measurements. Observed and simulated TB along the oxygen complex are compared and used to evaluate the existing oxygen absorption models.

Figure 2: plotted are the bandpass filters' traces for the oxygen channels, the mean spectrum calculated by the R98 model (input: 5 RS on 09/13/09), HATPRO measurements (X) at nominal mid-frequencies



3. Model vs. Measurement

Measured TB's are compared to TB's calculated with different absorption models.

For the lower oxygen channels measured and modeled bright-ness temperatures (TB) differ up to **4 K**. (see Fig. 3).

Convolving the traces of HATPRO's sharp band pass filters (Fig. 2) mak modeled and measured TB's more comparable. TB differences are reduced by up to **1 K** for the most sensitive oxygen channels on the flank of the O2 line.

The discrepancy between model an measurement at O2-channels on 09/13/09 is representative for all RS lauched during the campaign (Fig. 5)

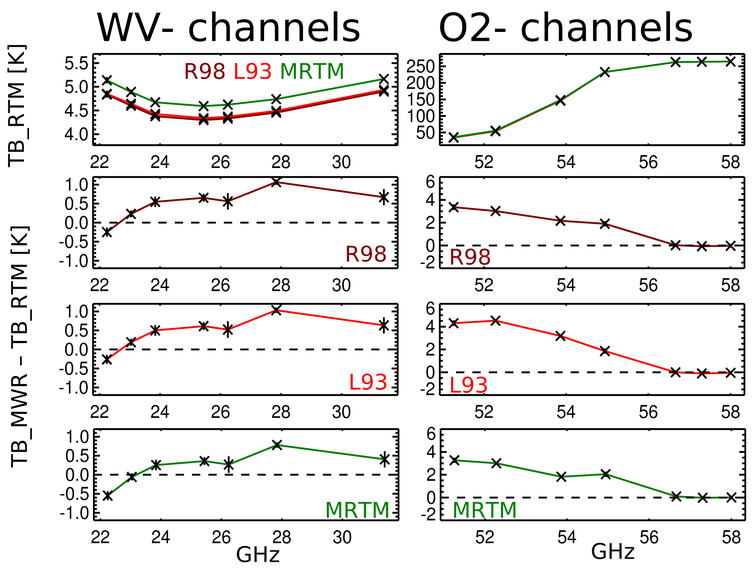


Figure 3: T_MWR: TB measures by HATPRO, T_RS : Tbs calculated at HATPRO mid-frequencies using different 5 RS on 09/13/09 absorbtions models (R98: Rosenkranz'98, L93: Liebe 93, MRTM: MonoRTM).

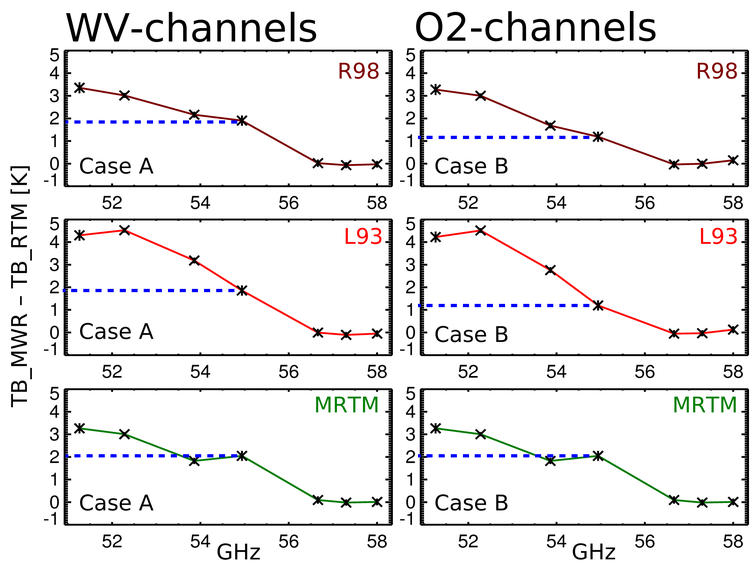


Figure 4: TB differences between HATPRO measurement (TB_MWR) and modeled TB_RS (from 5 RS on 09/13/09).
Case A: TB_RS is calculated at HATPRO's mid-frequencies,
Case B: TB_RS's are convolved with the traces of HATPRO's band pass filters (see Figure 2),
difference on the TB axis for 54.94 GHz channel (--)

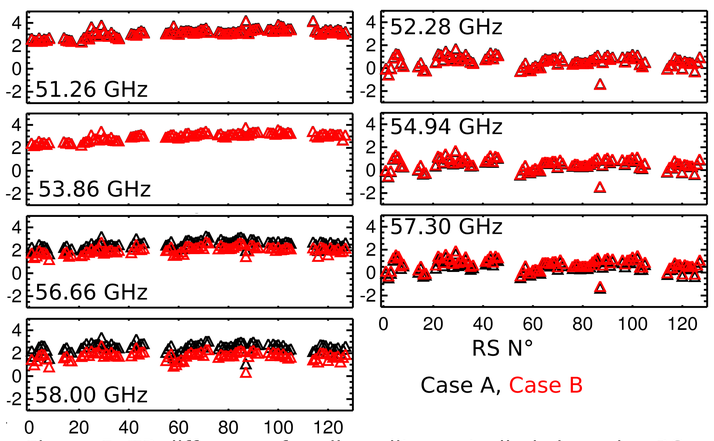


Figure 5: TB difference for all quality controlled clear sky RS (model used: R98, extension atmosphere: SDS),
Case A: Calculated at mid_frequencies,
Case B: Convolved with traces of band pass filters

4. Radiosonde Profiles

126 radiosondes were collected to feed different absorption models.

How sensitive are the modeled TB's to biased RS measurements?

For the O2-channels biases RS profiles can only explain a TB difference of up to **0.5 K** to HATPRO measurements. (Fig. 6)

Different standard atmospheres were used to extend the RS profiles beyond the the tropopause. The effect is negligable (Fig. 7)

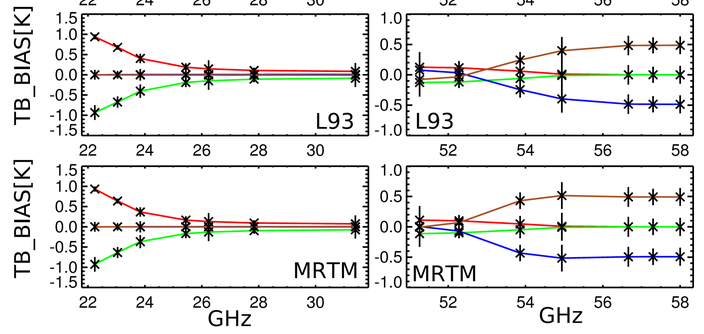


Figure 6: RS profiles were modified in four ways: q=0, q=2*q_RS, T = T_RS + 0.5 K, T = T_RS - 0.5 K, TB_BIAS = TB(T_RS, q_RS) – TB(T, q) is plotted for HATPRO channels and different absorption models.

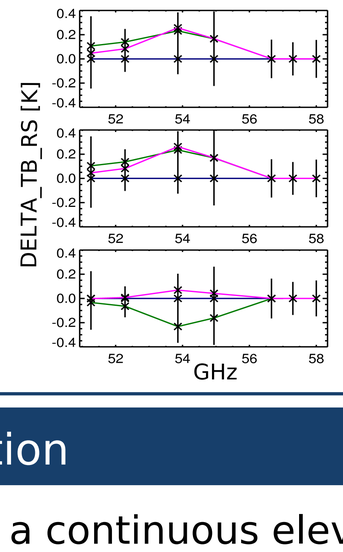


Figure 7: Differences between modeled TB_RS's resulting from different extension atmospheres: Mean atmosphere, Payerne(CH), Standard atmosphere tropical/dry stratosphere.
Reference: Standard atmosphere subtropical/dry stratosphere,
Error bars: std.dev from 5 RS of 09/13/09.

5. Sky Tipping Calibration

HATPRO was operated in a continuous elevation scanning mode. A tipping curve procedure will be applied to recalibrate the lower oxygen channels (51.26 GHz and 52.28 GHz), which are transparent at low oxygen concentration at 530 mb. This allows to test the initial absolute liquid nitrogen calibration and examine possible drifts of detector voltages.

6. Outlook

Measured and modeled brightness temperatures show a difference of several K for the lower O2-channels. Oxygen absorption models can be modified for in the microwave spectrum around 60 GHz, when other errors from radiosondes and radiometer calibrations are well characterized.

References:

Microrad 2010 conference in Washington, DC, USA, 1-4 March 2010