INVESTIGATION OF GAS ABSORPTION MODELS FROM 22GHZ TO 60GHZ AND ANALYSIS OF RADIOMETER CALIBRATION TECHNIQUES AT 530HPA

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From August – October 2009 the Atmospheric Radiation Measurement (ARM) program [1] conducted the second phase of the Radiative Heating in Underexplored Bands Campaign (RHUBC-II) in the Atacama desert on a site 5320m above msl (530hPa) [2]. A unique set of accurate radiative measurements of the middle-to-upper troposphere was collected and can be used to evaluate and improve existing gas absorption models. We concentrate on the microwave spectral range which is covered by the passive radiometer HATPRO-G2 (Humidity and Temperature Profiler – Generation 2) operated by the Institute for Geophysics and Meteorology of Cologne [3]. The 14 frequency channels have been designed with well characterized band pass filters, allowing accurate brightness temperature (TB) measurements. The instrument uses seven K-band channels along the rotational water vapor line at 22GHz to retrieve integrated information about the atmospheric water content. Seven V-band channels along the oxygen absorption complex at 60GHz are used to retrieve temperature profiles.

In general, a realistic simulation of atmospheric absorption and emission is essential for the retrieval development. TB measurements can be used to evaluate and improve gas absorption models. Particularly, temperature profiles derived from radiometric measurements show significant biases within the lowest 4km [4]. Careful data analysis is necessary to determine, whether these originate from inaccuracies in the radiometer calibration or uncertainties in the oxygen absorption line parameters [5]. Therefore, zenith TB measurements under clear sky conditions from 22GHz to 60GHz are compared to TB simulated with different absorption models. 61 radiosondes launched during RHUBC-II serve as model input. A substantial part of the comparison is the quantification of measurement errors. Whereas simulated TB are affected by uncertainties of radiosonde profiles, the uncertainty of radiometer measurements is dominated by the instrument's calibration. Therefore, the original liquid nitrogen calibration is compared to the tipping curve method [6]:

In the beginning of the campaign the instrument was calibrated by using liquid nitrogen as a cold target and an ambient internal load as a hot target. The uncertainty of the resulting calibration parameters is affected by inaccuracies in the assumed physical temperatures and emissivities of the calibration targets. In this contribution a detailed accuracy assessment allows us to differentiate between the different error sources.

The radiometer was continuously scanning in a fixed azimuthal plane to measure at different airmass values. These scans are used to apply the tipping curve calibration. At low altitudes only K-band channels can be calibrated by the tipping curve procedure. Fortunately, at 530hPa, the method can also be applied to the two most transparent V-band channels. For the first time, this allows an independent validation of the liquid nitrogen calibration. We show that the accuracy of the tipping curve method is limited by horizontal atmospheric inhomogeneities.

For both methods the accuracy of calibration parameters and their effect on measured TB is assessed. Furthermore, we show that the exact consideration of band pass filters significantly reduces the difference between measured and simulated TB.

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