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Investigation of gas absorption models from 22 to 183 GHz observed at low water vapor concentrations and 530 hPa in the Atacama Desert in Chile

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In August – October 2009 the Atmospheric Radiation Measurement (ARM) program conducted the second phase of the Radiative Heating in Underexplored Bands Campaign (RHUBC-II) at a site on Cerro Toco (5320 m MSL, 530 mb), which is located in the Chajnantor Plateau in Chile. The primary focus of RHUBC-II is to characterize and improve the accuracy of gas absorption models (near-infrared to submillimeter wavelengths) using high-spectral-resolution radiance observations in spectral regions that are normally opaque at lower altitudes. The microwave and submillimeter portion of the spectrum is covered by two radiometers: the GVRP (deployed by ARM) and the HATPRO-G2 (Humidity and Temperature Profiler – Generation 2) operated by the Institute for Geophysics and Meteorology of Cologne. Both instruments were continuously scanning in a fixed azimuthal plane to measure at different airmass values. Radiometric measurements were supported by 133 radiosondes launched during the campaign. Observations are used to address three points:

1)The HATPRO-G2 measures atmospheric radiation along the 22.24 GHz water vapor line and the oxygen absorption complex centered around 60 GHz with a total of 14 channels. The frequency channels have been designed with well characterized band pass filters, allowing high accuracy brightness temperature (TB) measurements. Due to the lower oxygen concentration at 530mb elevation scans can be used to recalibrate the lower frequency oxygen channels by applying the tipping curve procedure. TBs are simulated using clear sky radiosonde profiles. Their sensitivity to uncertainties of radiosonde profiles is studied. Observed and simulated TBs along the oxygen absorption complex are compared and used to evaluate existing oxygen absorption models. It is shown, that the exact consideration of the radiometer's band pass filters and the tipping curve calibration significantly reduce the difference between measured and simulated TBs.

2)The GVRP measurements of atmospheric TBs on 15 channels between 170.0 to 183.3 GHz are used to evaluate existing water vapor continuum models under non-saturated conditions at very low water vapor columns (< 1 kg m-2). Furthermore, continuous elevation scans are used to illustrate the temporal and spatial inhomogeniety of the integrated water vapor content.

3) Astronomical observations at submillimeter frequencies in the Cerro Toco region need to be corrected for atmospheric path delay fluctuations due to variable water vapor content (wet delay) and temperature variations (dry delay). HATPRO-G2 is beneficial to estimate the dry delay fluctuation component. The wet delay is determined from GVRP measurements at 183.3GHz. Additionally, wet delays from HATPRO-G2 measurements at 22.24GHz are exploited at larger airmass values when possible at high enough signal to noise ratios.