Best Guess Water Vapor Profiles for the RHUBC-II Campaign

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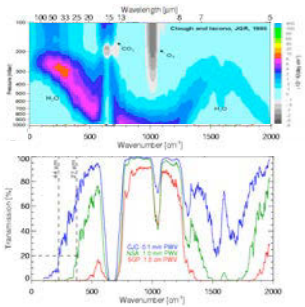
The Radiative Heating in Underexplored Bands Campaign in Chile (RHUBC-II)



Radiative cooling in the upper troposphere is dominated by water vapor in the far-IR (~300 cm⁻¹). Surface spectral measurements under typical conditions (bottom panel, red) provide no information about the associated radiative processes, while those in very dry locations do (bottom, blue).

Motivation:

- Mid- and upper-tropospheric radiative cooling have important atmospheric effects
  - e.g. impacts vertical motions of the atmosphere
- Occurs primarily in water vapor absorption bands that are opaque at the surface
- Approximately 40% of the OLR comes from the far-IR

Need to validate water vapor absorption models in these normally opaque bands.

To address this gap in our knowledge, we need:

- Spectrally resolved measurements in these bands
  - were not previously available, now are
- A very dry location so the bands are not opaque
- Good characterization of the water vapor field above the spectral measurements

Ultimate goal: Improved RT code (RRTM) in dynamical models

RHUBC-II Campaign – Atmospheric Radiation Measurement Program

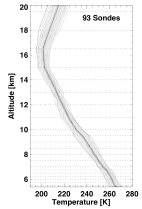
- Held in location with extremely low water vapor: Atacama Desert, Chile
  - high altitude site – Cerro Toco (5350 m)
- July – November 2009
- Key Instruments
  - Vaisala **RS-92** radiosondes – 144 launches
  - G-band Vapor Radiometer Profiler (**GVRP**) – 15 channels on side of 183.3 GHz WV line
  - **SAO FTS** – zenith radiance from 300-3500 GHz (resolution 3 GHz)
  - U. Cologne **HATPRO** – 7 channels from 22.2 -31 GHz, 7 channels from 51-58 GHz
  - NASA LaRC Far- R Spectroscopy of the Troposphere (**FIRST**) – 100-1600 cm^{-1} (res. 0 6 cm^{-1})
  - CNR (Italy) Radiation Explorer in the Far-IR (**REFIR-PAD**) – 100-1400 cm^{-1} (res. 0.5 cm^{-1})
  - U. Wisc. Atmospheric Emitted Radiance Interferometer (**AERI**) – 550-3000 cm^{-1} (res. 0.5 cm^{-1})

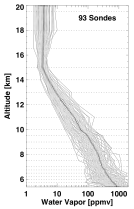
Turner and Mlawer, The Radiative Heating in Underexplored Bands Campaigns (RHUBC), *Bull. Amer. Met Soc.*, 91(7), 911-923, 2010

Original and Initial Adjustment of Sonde Water Vapor Profiles During RHUBC-II

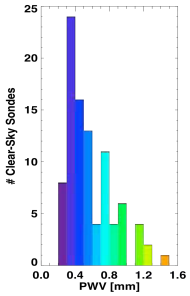
Sonde Measurements During RHUBC-II

Sondes provide an initial determination of the water vapor field above the site, but have known issues.





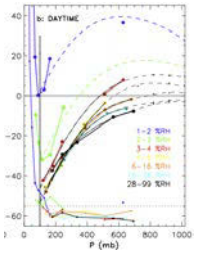
Individual and average water vapor (right) and temperature (left) profiles measured by RHUBC-II sondes.



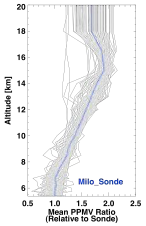
Water vapor column amounts (PWV) measured by radiosondes during RHUBC-II. (The PWV for US Standard atmosphere is 14.3 mm.)

Sonde Biases

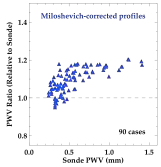
The well-known biases in RH measurements by Vaisala sondes (RS92) were analyzed by Miloshevich et al. (2009) with respect to frost-point hygrometer measurements. However, the RHUBC-II conditions and sonde batches were different than in that study.



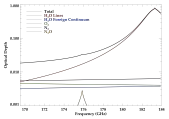
Daytime mean percentage bias of RS92 sondes relative to frost-point hygrometer measurements. This is the basis for the 'Milo' correction.



On average, the Milo correction leaves the near-surface water vapor unchanged and increases it higher up. The effect on PWV is a net increase of ~10%.



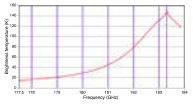
GVRP Measurements on the 183.3 GHz WV Line



GVRP measurements give an accurate WV column amount and some limited information on WV profile.

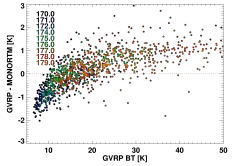
(top) Calculated MonoRTM optical depths in GVRP simulation

(right) Calculated brightness temperatures and GVRP channel centers

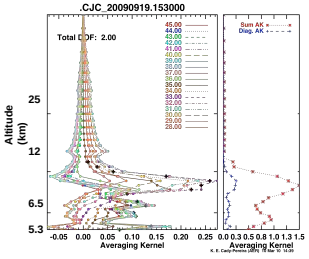


Retrieval of Water Vapor Profiles Using GVRP Measurements - 183.3 GHz Water Vapor Line

An analysis using MonoRTM calculations demonstrated issues with measurements from certain GVRP channels. Therefore, the 173 GHz, 181 GHz, and all channels measuring < 11K were not used in the retrieval (following Rodgers (2000)).

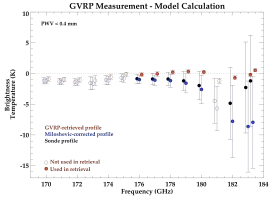


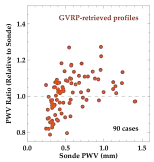
Model-measurement residuals (using scaled sonde profiles) indicated disagreement when the BT < ~11K . No uncertainty in the model is large enough to explain this disagreement.



Example of an averaging kernel -- indicates that the GVRP provides 2 pieces of information, roughly one near the surface and one ~10 km. A scale factor is retrieved for the WV amount in each layer.

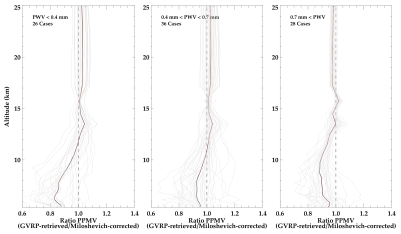
Retrieval Results



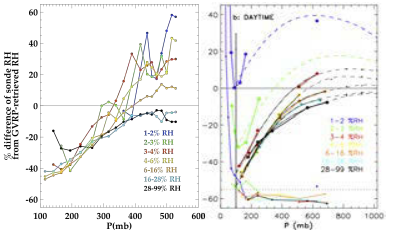


The retrieval produces WV prof les that resu t in residuals with sma l biases and standard deviations across a l GVRP channels used in the retrieval.

For three ranges of PWV, the plots below show the retrieved vertical scale factors relative to the Milo-corrected sondes, which are used in the retrieval as the initial guess and prior.



This study | **Miloshevich et al. Fig 9b**

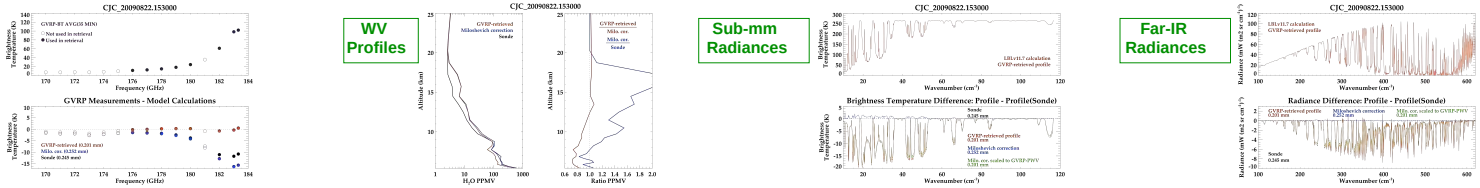


The biases in sonde RH values for this study are compared to those in Miloshevich et al. A similar pattern is found, but the RHUBC-II sondes have a greater moist bias for P > ~400 mb.

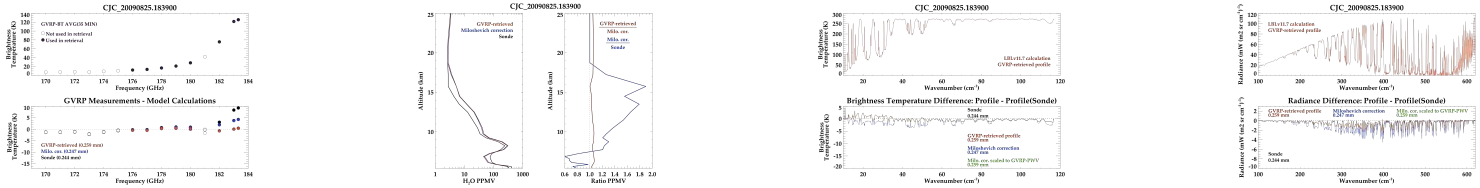
Retrieved Water Vapor Profiles: Three Cases Studies

GVRP Residuals | **WV Profiles** | **Sub-mm Radiances** | **Far-IR Radiances**

8/22/09, 1530
PWV = 0.201 mm



8/25/09, 1839
PWV = 0.259 mm



9/19/09, 1420
PWV = 0.247 mm