Evaluating the Accuracy of the Far-infrared Spectral Observations, Water Vapor Measurements, and the Radiative Transfer Model in Extremely Dry, Clear-sky Periods During RHUBC-II

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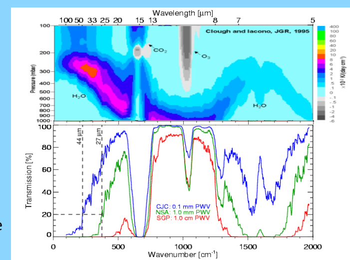
Background

- Water vapor (WV) absorption largely drives the radiative heating profile
- Radiative heating profile modulates vertical motion and hence atmospheric circulation
- WV strongly absorbs in far-IR (15 to 100 µm, or 100 to 660 cm^{-1})
- Far-IR WV absorption dominates radiative heating profile in mid-to-upper troposphere
- Far-IR is underexplored due to lack of observations
- Translates into uncertainty in radiative transfer models in far-IR (esp WV continuum)
  - *Radiative Heating in Underexplored Bands Campaigns conducted to collect data*
    - RHUBC-I in Barrow, Alaska, USA in Feb-Mar 2007 (min PWV ~1.0 mm)
    - RHUBC-II in Atacama Desert, Chile in Aug-Oct 2009 (min PWV ~0.2 mm)
- DOE (ARM) sponsored, supported by NASA, Italian National Research Council, and the German Science Foundation
- Overview article: Turner and Mlawer, BAMS, 2010

Cooling Rates and Transmission



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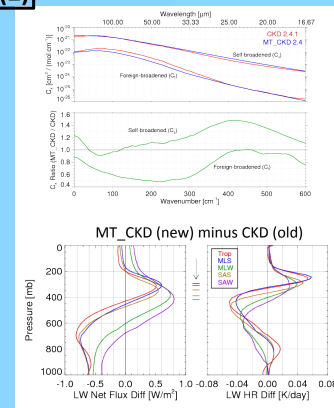
RHUBC-I Results



- R-I data and new observations at 150 GHz (5 cm^{-1}) resulted in modified WV continuum model
- Both self- and foreign-broadened components modified, but at low water vapor amounts the foreign-broadened component dominates
- Systematic impact on LW net flux and heating rate profiles
- PWV too high during R-I to fully evaluate in middle of far-IR

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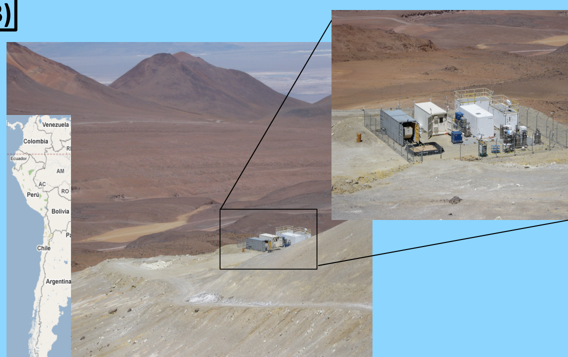
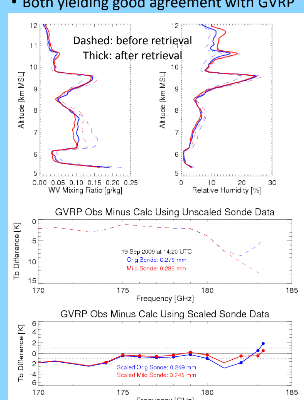


RHUBC-II Analysis (ongoing)

- Harsh, mountainous terrain
- High altitude (530 mb, ~5350 m)
- PWV 5x drier than R-I
- Need to improve WV profile accuracy
- Improved WV profiles used to drive far-IR rad transfer models
- Compare calcs with spectral obs
  - *REFIR-PAD (Italy)*
  - *FIRST (NASA)*
  - *AERI (ARM)*
  - *SAO-FTS (Smithsonian)*
- Closure study evaluates
  - *Spectral radiance observations*
  - *Radiative transfer models*
  - *Water vapor & temp profiles*

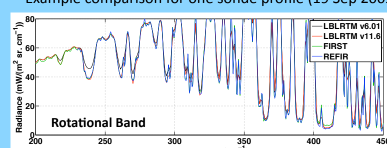
a) Retrieving the WV Profile

- Use GVRP (170-183 GHz) obs
- Optimal estimation framework
- Two starting points:
  Original & "Miloshevich-corrected" sonde
- Both yielding good agreement with GVRP



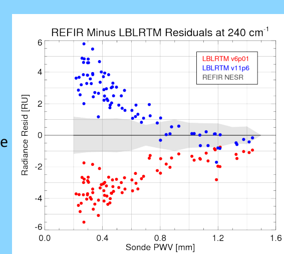
b) Spectral Comparison

- Forward calcs use LBLRTM with different WV continuum models
- Match spectral resolution and response functions
- Identified issues with temperature profile
  - Hypothesize this is related to orographic influences
- Example comparison for one sonde profile (19 Sep 2009)



c) Analysis of larger dataset

- Obs minus calc residuals over range of PWV offers insight
- Figure shows impact of changes to WV continuum in one small spectral region (41 µm)
  New cntnm (MT_CKD)
  Orig cntnm (CKD)



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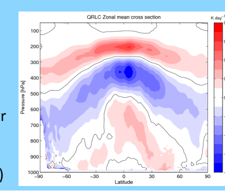
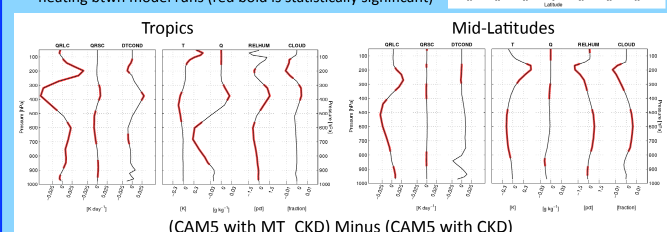
Impact on GCM Simulation

- CESM v1.0 (released 2010) has CAM5 embedded
- CAM5 uses RRTM, which was built from LBLRTM calculations
- RRTM in CAM5 has CKD WV continuum; easy to replace to use MT_CKD WV continuum
- Performed 22-yr simulation with CESM/CAM5
  - Fixed ocean
  - Removed first 2 yrs as spin-up

a) Zonal Heating Rate Profiles (HRPs)

- Zonally-averaged HRP differences very similar to standard atmosphere results above
- Vertical HRP difference maintained shape over entire 20-yr period (no trends)
- Temp and WV profiles adjusted to maintain vert. diff. in heating btwn model runs (red bold is statistically significant)

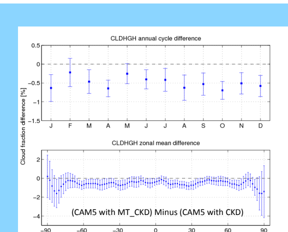




(CAM5 with MT_CKD) Minus (CAM5 with CKD)

b) Impact on Cloudiness

- Difference in vertical motion not significant
- Change in RH profile is significant
- Resulted in change in high-level cloud amount (decrease for modified CAM5 with MT_CKD)
- All seasons
- Most latitudes
- Change in mid-level cloud amount also (slight increase), but often not significant
- No significant change in precip



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