Far-IR Water Vapor Continuum Coefficients from the RHUBC-II Campaign

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Many other contributors:
Overview of Clear-sky Infrared Radiative Processes

Spectral Cooling Rates (troposphere)

“Clough Plot”

Mlawer and Turner, ARM/ASR PI Meeting, April, 2016

Spectral range of AERI: 550-3000 cm⁻¹
Far-Infrared Radiative Processes

Cooling rates due to H$_2$O lines and H$_2$O continuum

Impact on cooling rates of turning off H$_2$O continuum

Spectral range of AERI

Mlawer and Turner, ARM/ASR PI Meeting, April, 2016
RHUBC-I

Goal: Improve knowledge of \( \text{H}_2\text{O} \) spectroscopy from 400-600 cm\(^{-1}\)
- ARM North Slope of Alaska Site, Barrow, AK
- February - March 2007, 70 radiosondes launched
- Minimum PWV: 0.95 mm (observed)
- 2 far-IR / IR interferometers
  - spectral range of AERI extended to 400 cm\(^{-1}\) (AERI\_ER)
- 3 sub-millimeter radiometers for PWV observations

Average AERI\_ER radiances for RHUBC-I cases (17)
RHUBC-I: Results

Spectroscopic modifications from RHUBC-I (Delamere et al., 2009)

- adjustments to water vapor foreign continuum
- foreign-broadened line widths for 42 H$_2$O lines were adjusted
RHUBC-I: Results

Modifications to H$_2$O foreign continuum from RHUBC-I
• new model – MT_CKD_2.4
• new measurements used to develop model from spectral regions indicated in green

- Revised continuum leads to significant changes in net flux
- RRTMG updated with MT_CKD_2.4, 20-yr simulation performed with CESM v1 (Turner et al., 2012)
  • statistically significant changes in temperature, humidity, and cloud fraction
Moving Past RHUBC-I
RHUBC-II

- Cerro Toco, Chile (23°S, 68°E, altitude - 5380 m)
- August - October 2009, 144 radiosondes were launched
- Minimum PWV: ~0.2 mm (5x drier than RHUBC-I)
- 3 far-IR / IR interferometers (REFIR, FIRST, AERI)
  - REFIR (FTS) – 100-1400 cm\(^{-1}\)
  - 183 GHz radiometer for determining H\(_2\)O (GVRP)

Major issues in RHUBC-II analysis:
Specifying accurate atmospheric profiles (temperature and H\(_2\)O) above the radiometers given that RHUBC-II radiosondes were blown east off cliff by consistent 30 m/s winds
- also, sonde H\(_2\)O measurements have known inaccuracies (as much as 60%) in dry conditions
Determining ‘best guess’ temperature and H₂O profiles

- **Temperature** – (at each AERI measurement time) blend together:
  - surface - met tower measurement
  - below 3.0 km – combine AERI T retrievals from two strong CO₂ bands
  - above 3.0 km – radiosonde observation (interpolated to time)

- **H₂O** – retrieve H₂O profile using GVRP (183 GHz) and sonde measurements
RHUBC – II: Analysis

0.0 mm < PWV < 0.3 mm
(34 cases)

0.3 mm < PWV < 0.5 mm
(122 cases)

Observed radiances (REFIR)
LBLRTM calculation (MT_CKD_2.4)

Residuals (REFIR-LBLRTM)  
+- 1 stdev 
+20% foreign continuum

Residuals (REFIR-LBLRTM) with modified foreign continuum  
+- 1 stdev
RHUBC-II: the H$_2$O foreign continuum between 200-400 cm$^{-1}$ is much larger than in recent versions of MT_CKD
Effect of foreign continuum derived from RHUBC-II (wrt MT CKD 2.4)
Summary

• RHUBC-II analysis leads to a large increase in $\text{H}_2\text{O}$ foreign continuum in far-IR region
  - significant impact on fluxes, cooling rates, and (likely) simulations
• Latest in a long history of successful ARM/ASR radiative closure studies

Next steps
• Test new continuum on RHUBC-I data
• Adjust $\text{H}_2\text{O}$ far-IR line widths as needed
• Create new version of MT_CKD, implement in LBLRTM and RRTMG
• Paper

Possible future steps
• AERI data from RHUBC-II may provide unique information on spectroscopy of $\text{H}_2\text{O}$ fundamental band (1300-1900 cm$^{-1}$) and $\nu_4$ band $\text{CH}_4$ (1250-1350 cm$^{-1}$)