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

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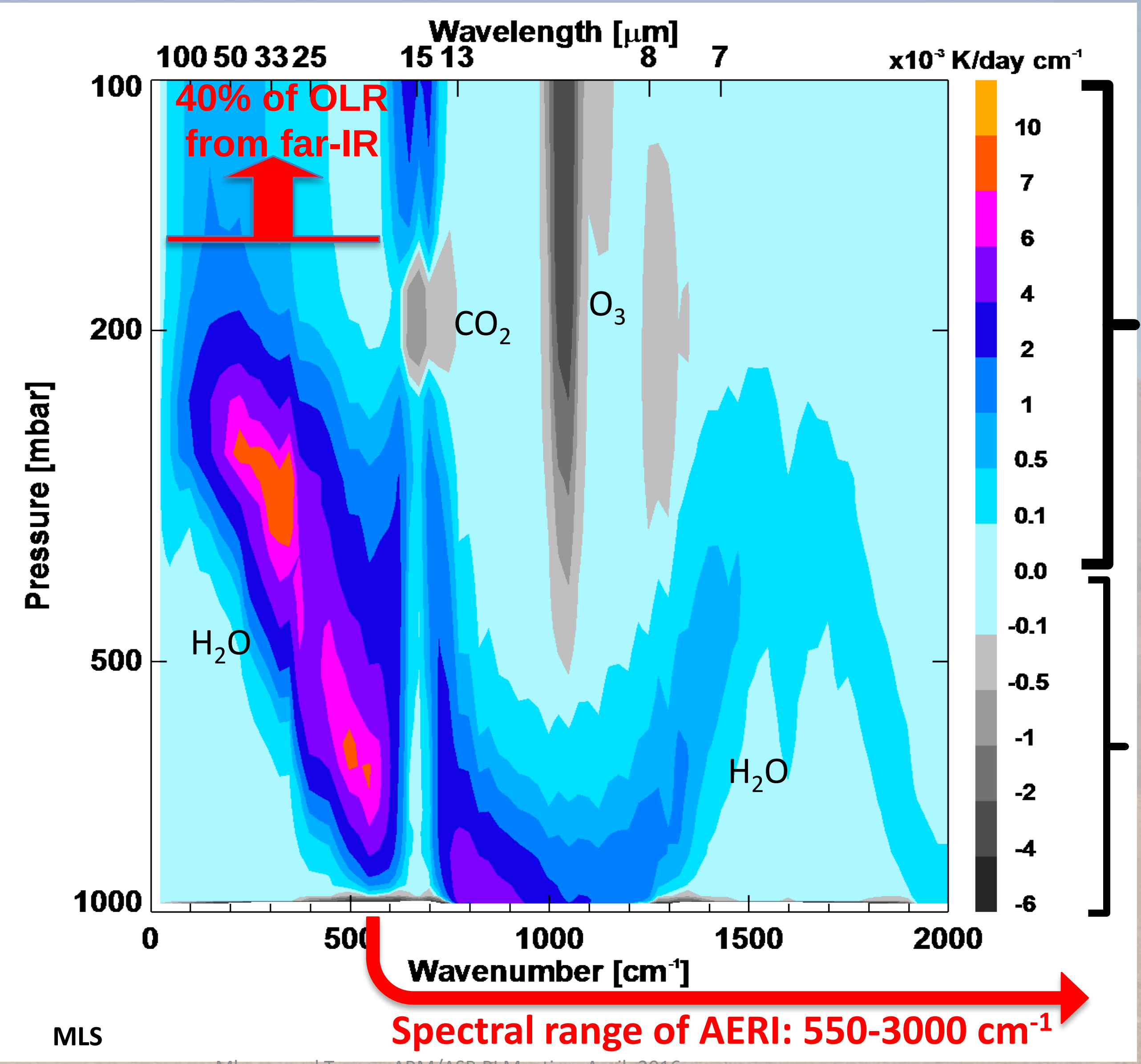
# Overview of Clear-sky Infrared Radiative Processes

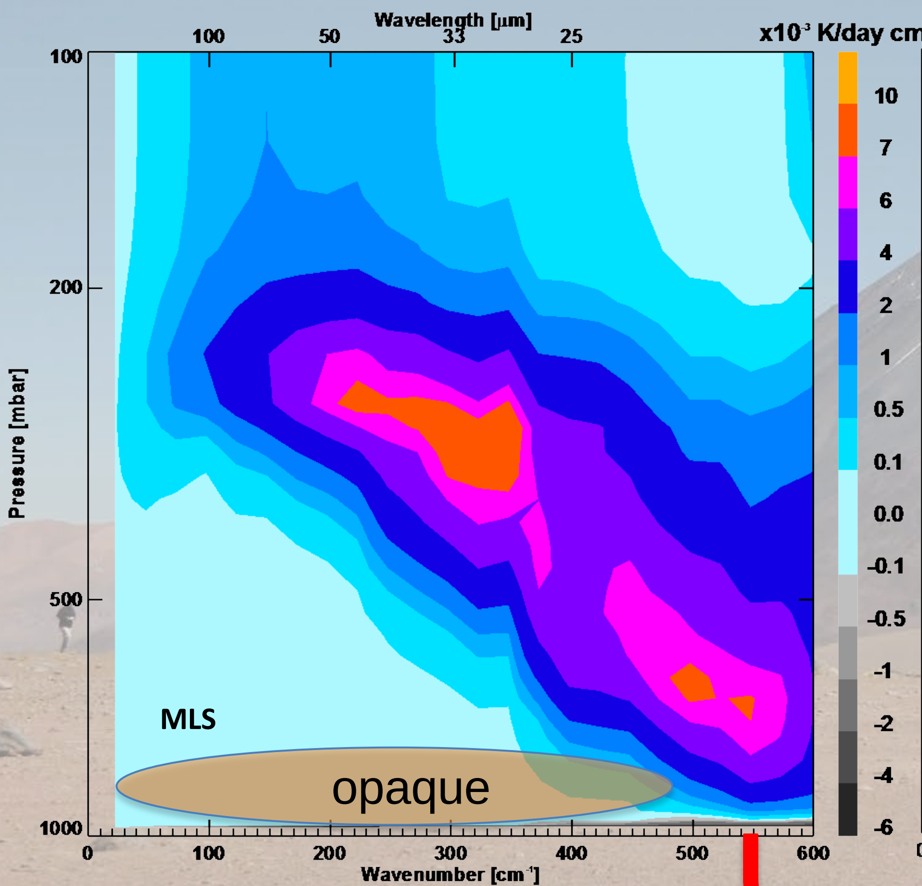
Spectral Cooling Rates (troposphere)

"Clough Plot"

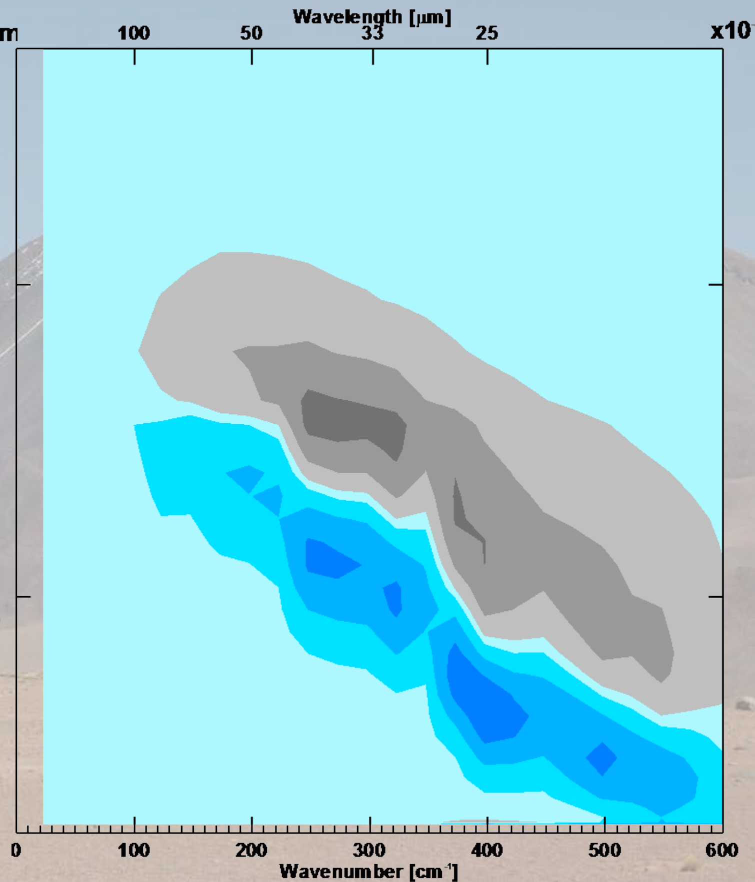


# Far-Infrared Radiative Processes

Cooling rates due to $H_2O$ lines and $H_2O$ continuum




Impact on cooling rates of turning off $H_2O$ continuum




(Spectral range of AERI

(imaginary)

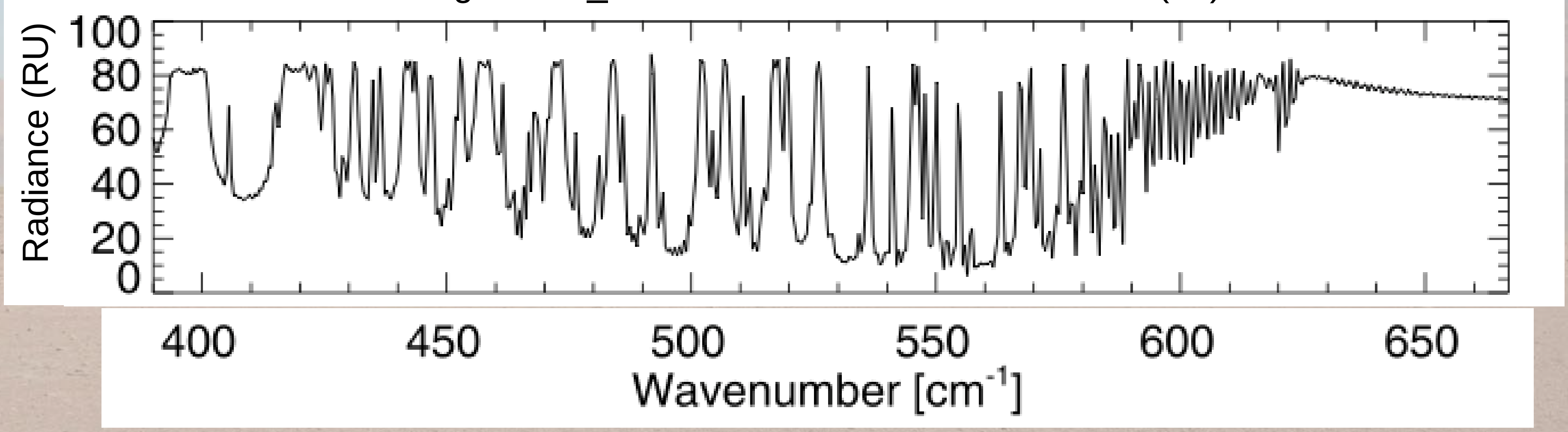
Radiative Heating in Underexplored Bands Campaign - I

# RHUBC-I

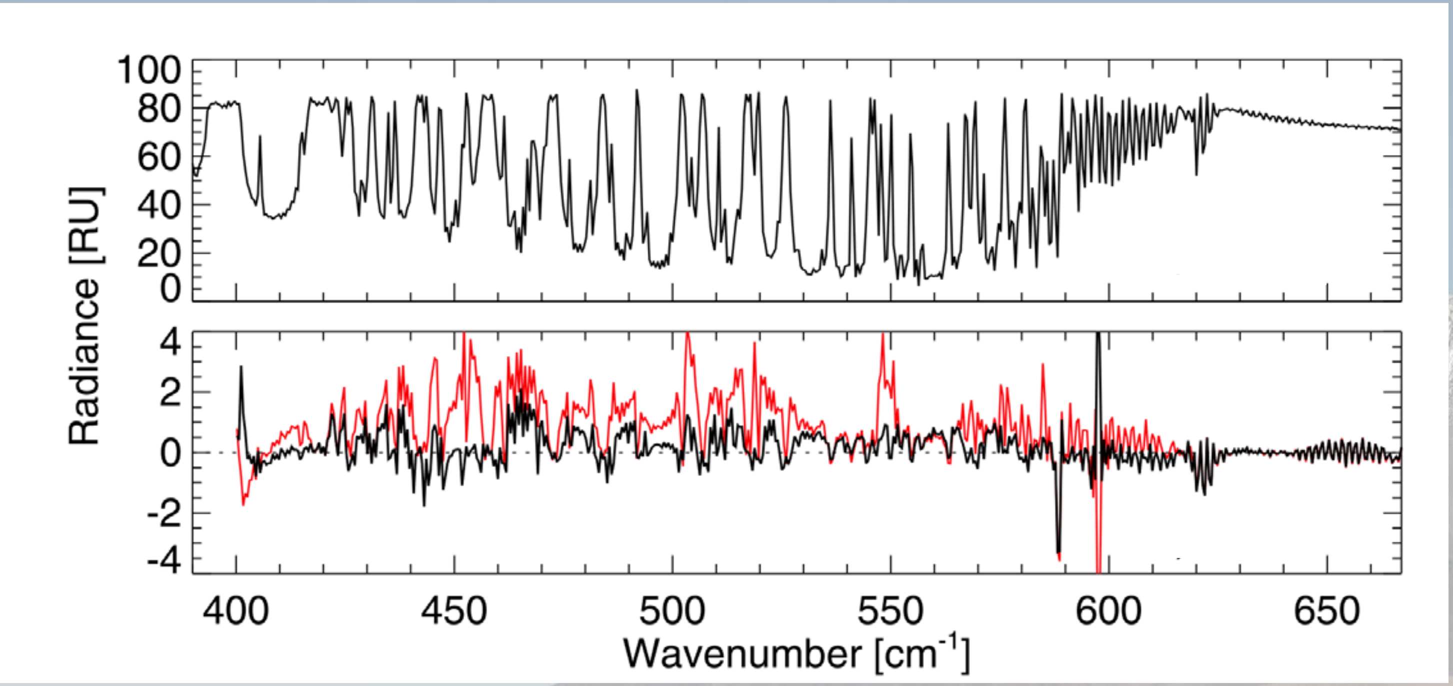
**Goal: Improve knowledge of $H_2O$ spectroscopy from 400-600 $cm^{-1}$**

- 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




AERI_ER Measurements

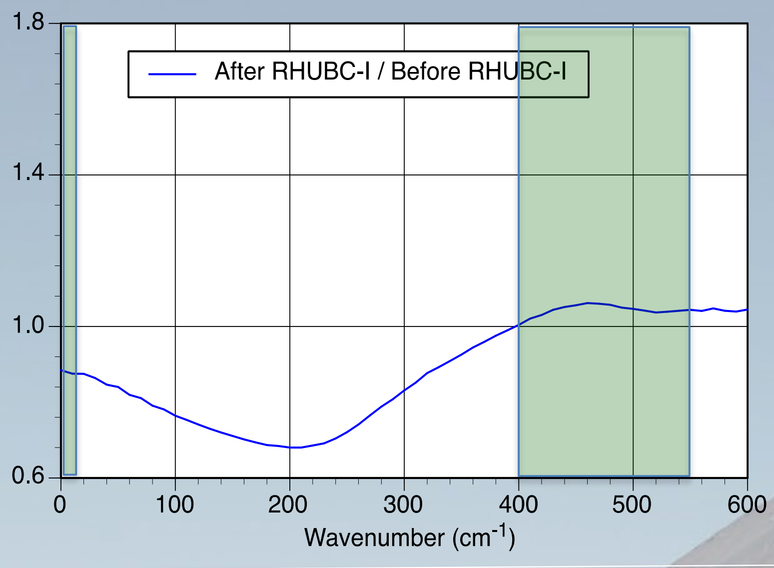
AERI – LBLRTM residuals before RHUBC-I

Residuals after RHUBC-I

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

- adjustments to water vapor foreign continuum
- foreign-broadened line widths for 42 $H_2O$ lines were adjusted

# RHUBC- I:  Results



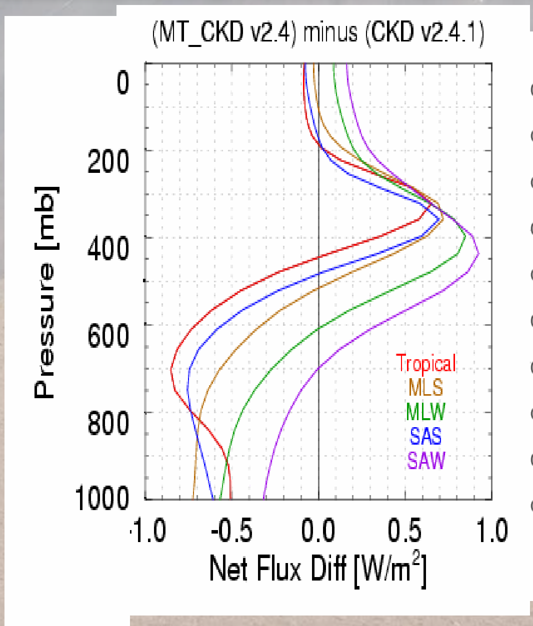

Modifications to $H_2O$ foreign continuum from RHUBC-I

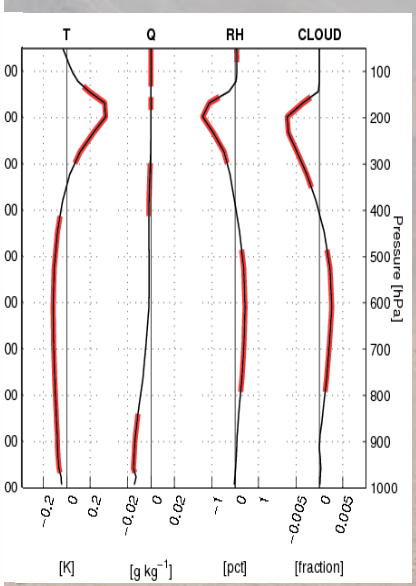
- new model – MT_CKD_2.4
- new measurements used to develop model from spectral regions indicated in **green**

❖ Revised continuum leads to significant changes in net flux

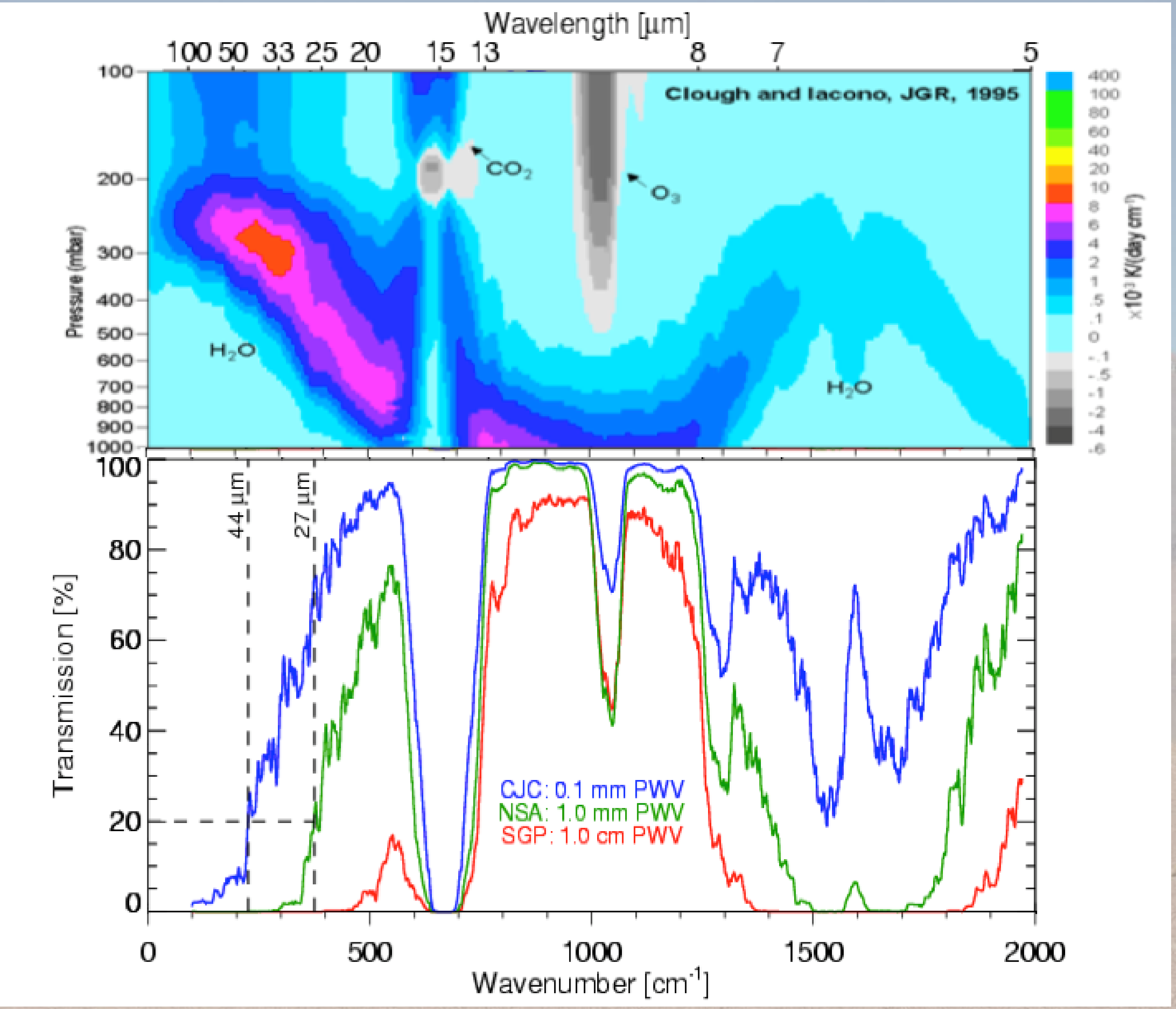
❖ RRTMG updated with MT_CKD_2.4, 20-yr simulation performed with CESM v1 (Turner et al., 2012)

- statistically significant changes in temperature, humidity, and cloud fraction



# Moving Past RHUBC-I



# Radiative Heating in Underexplored Bands Campaign - II

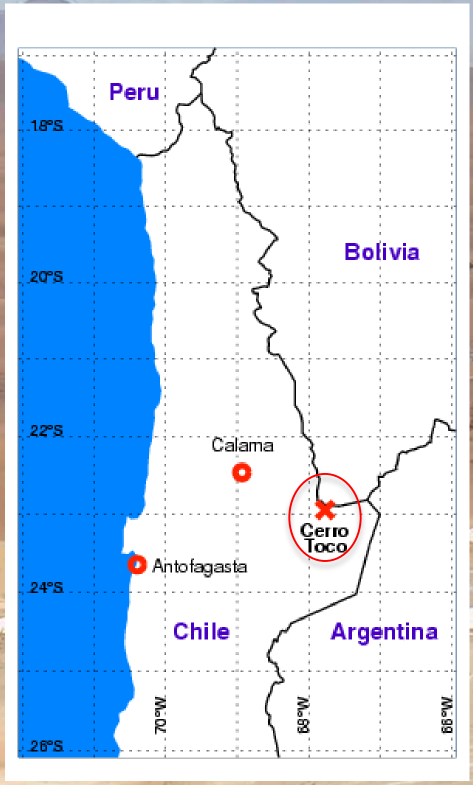
## RHUBC-II

- Cerro Toco, Chile (23ºS, 68ºE, 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 $H_2O$ (GVRP)

**Major issues in RHUBC-II analysis:**

Specifying accurate atmospheric profiles (temperature and $H_2O$) above the radiometers given that RHUBC-II radiosondes were blown east off cliff by consistent 30 m/s winds

- also, sonde $H_2O$ measurements have known inaccuracies (as much as 60%) in dry conditions

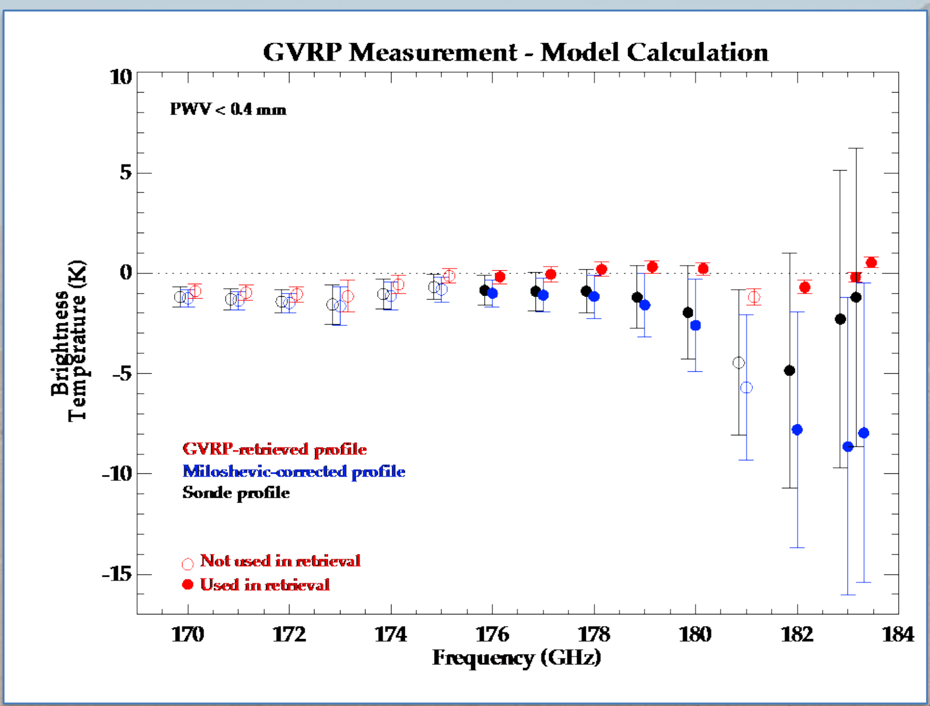


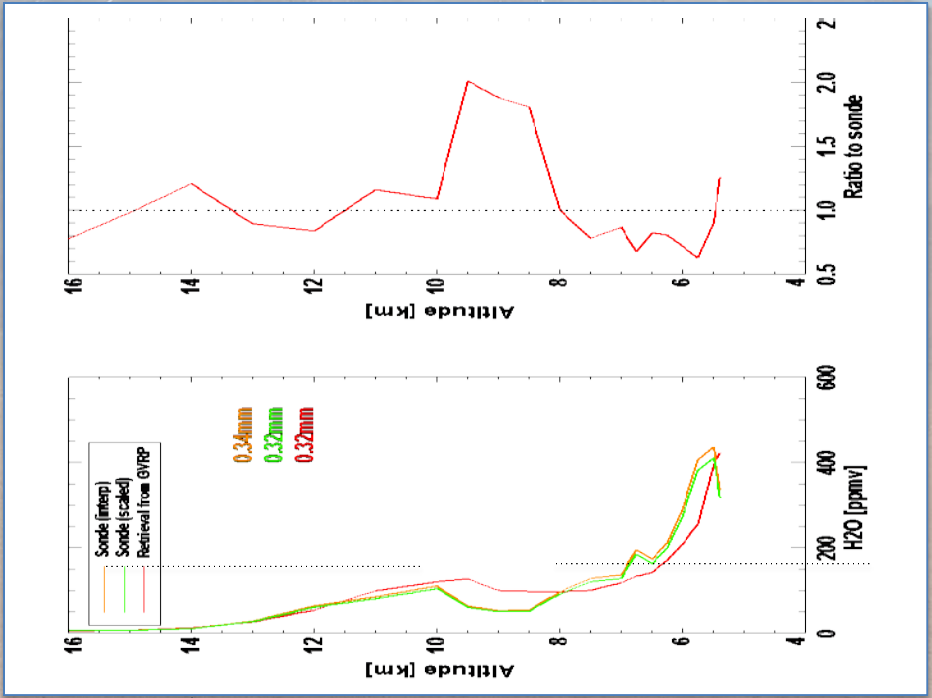
# RHUBC – II:  Analysis

Determining ‘best guess’ temperature and $H_2O$ profiles

- **Temperature** – (at each AERI measurement time) blend together:
  - surface - met tower measurement
  - below 3.0 km – combine AERI T retrievals from two strong $CO_2$ bands
  - above 3.0 km – radiosonde observation (interpolated to time)
- **$H_2O$** – retrieve $H_2O$ profile using GVRP (183 GHz) and sonde measurements

## Example of GVRP Retrieval of H2O Profile



# RHUBC – II: Analysis

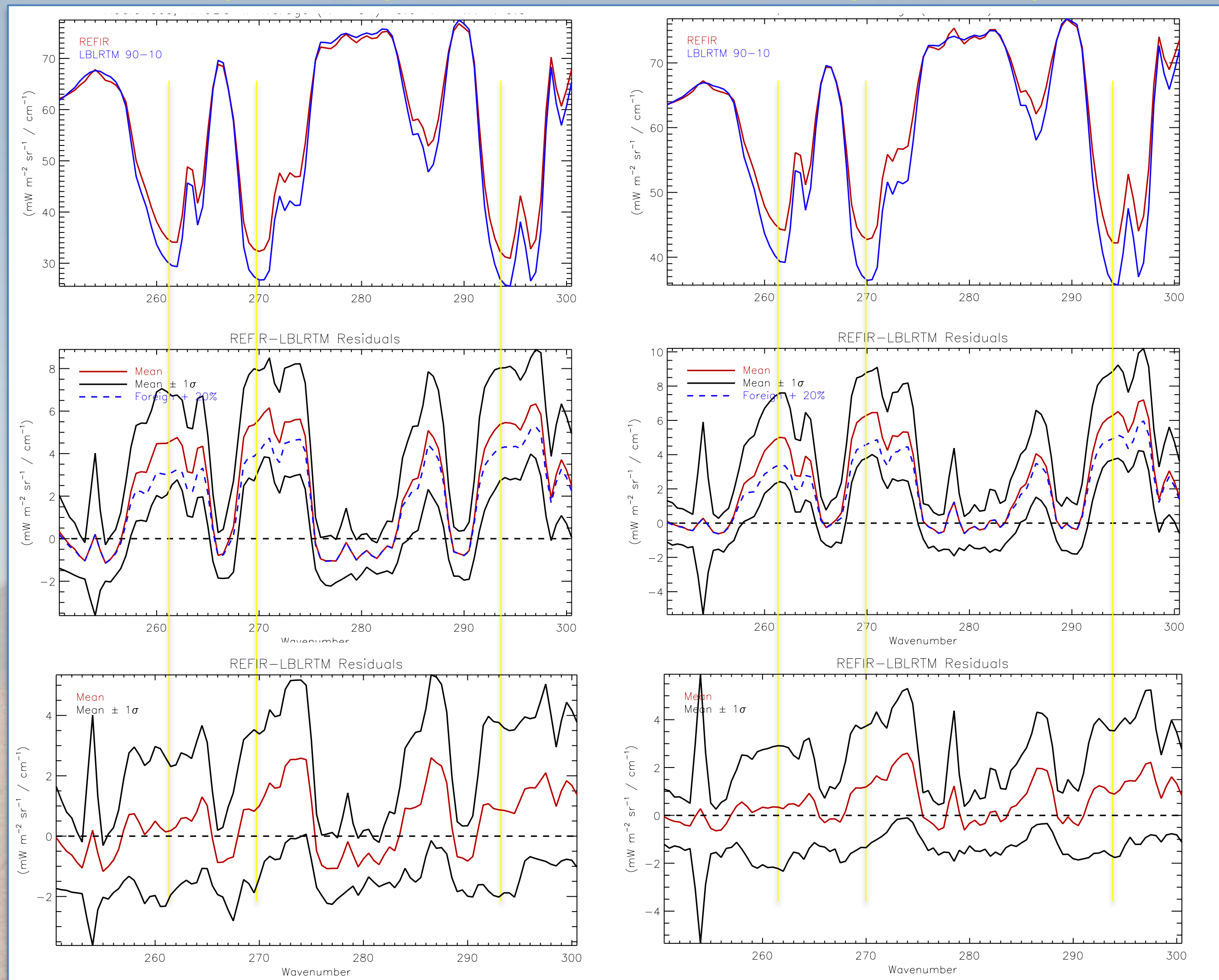
Observed radiances (REFIR)
LBLRTM calculation (MT_CKD_2.4)

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

Residuals (REFIR-LBLRTM) with modified foreign continuum
+- 1 stdev

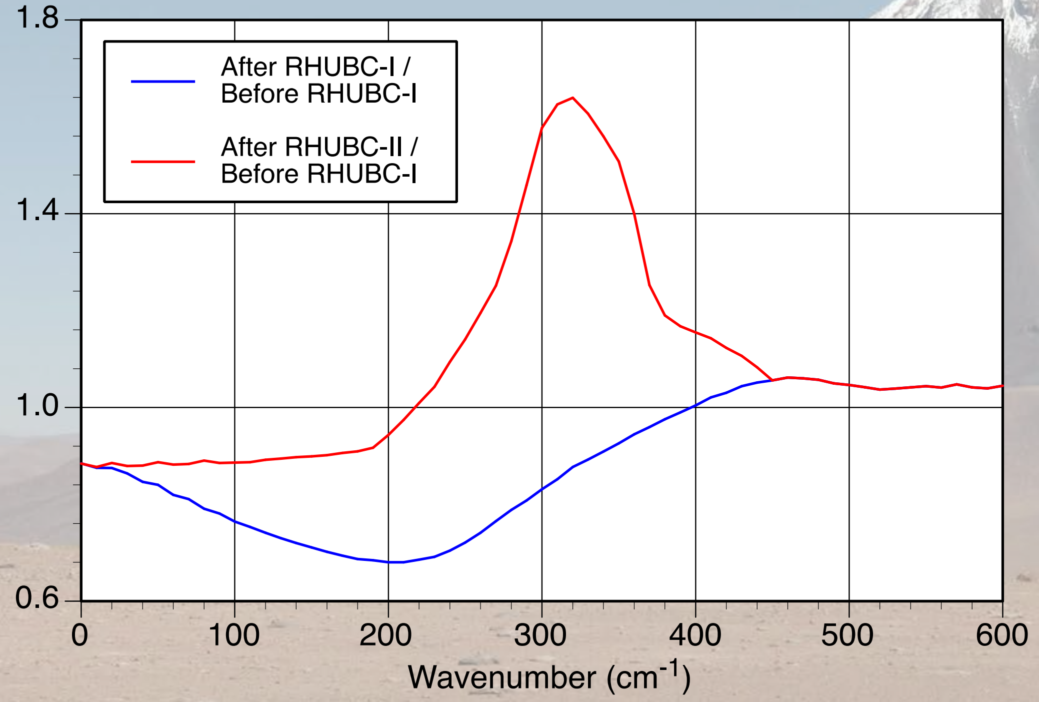
0.0 mm < PWV < 0.3 mm (34 cases)

0.3 mm < PWV < 0.5 mm (122 cases)



# RHUBC – II: Analysis

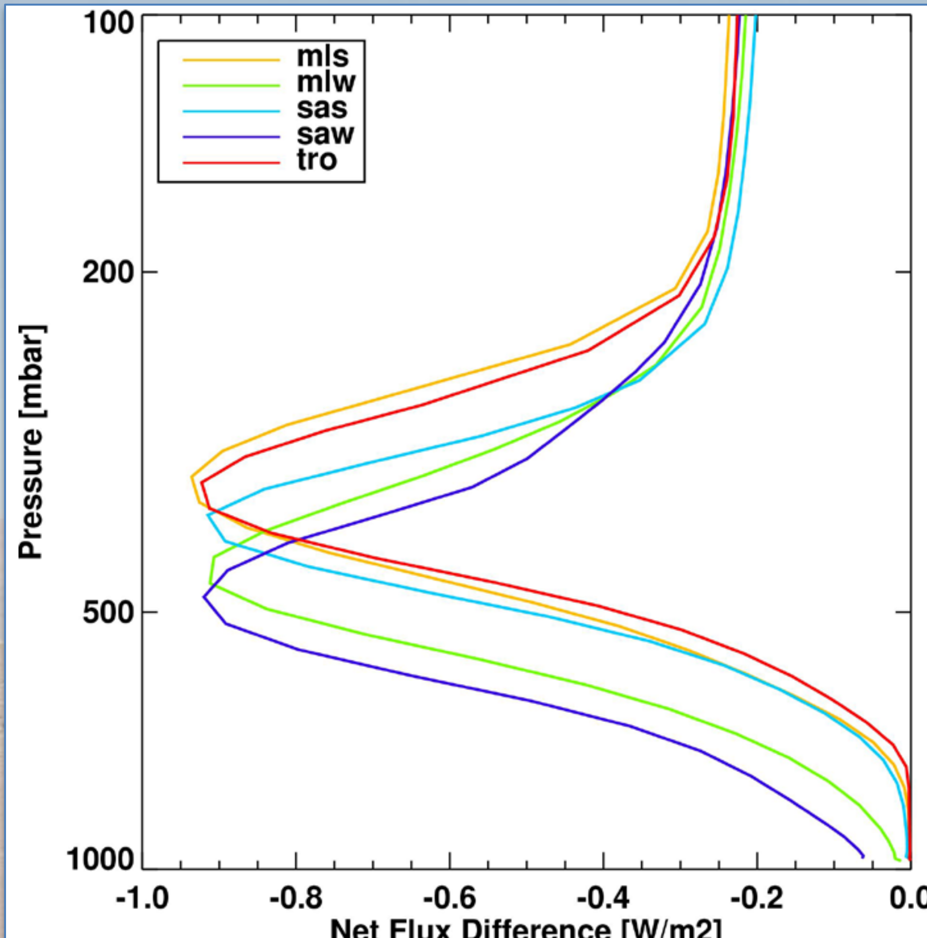
**RHUBC-II: the $H_2O$ foreign continuum between 200-400 $cm^{-1}$ is much larger than in recent versions of MT_CKD**



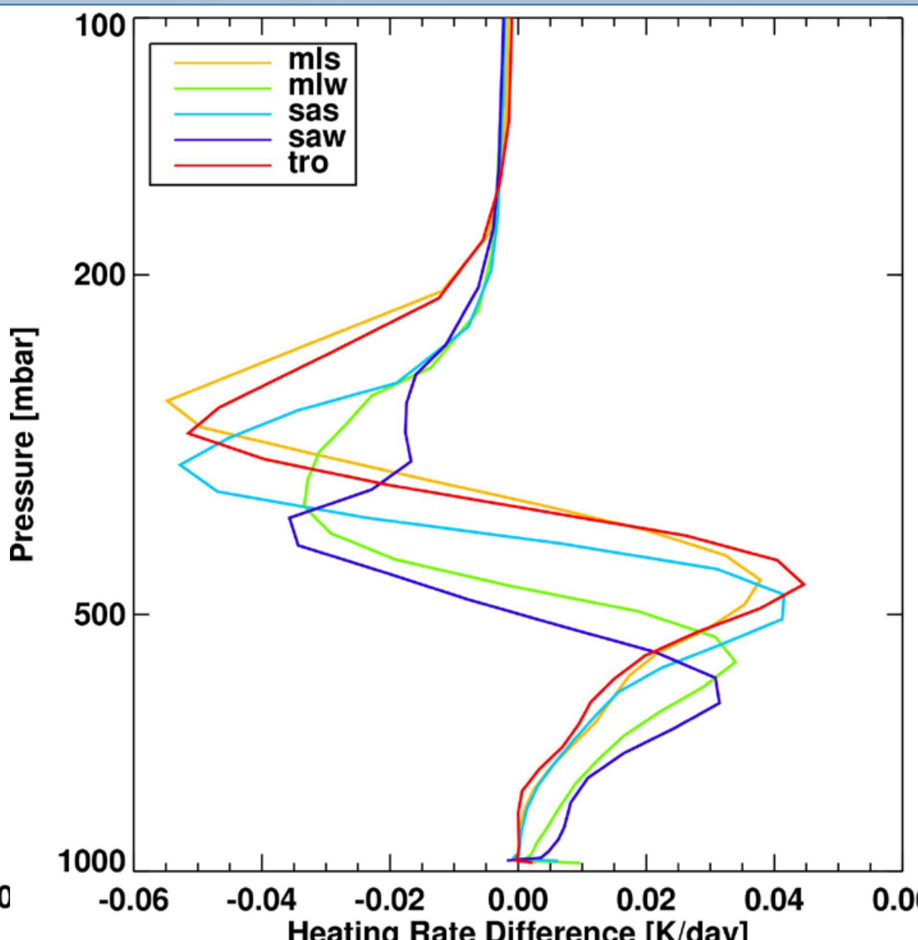
# RHUBC – II: Analysis

## Effect of foreign continuum derived from RHUBC-II (wrt MT_CKD_2.4)

### Net Flux




### Heating Rates



# Summary

- RHUBC-II analysis leads to a large increase in $H_2O$ 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

<u>Next steps</u>

- Test new continuum on RHUBC-I data
- Adjust $H_2O$ far-IR line widths as needed
- Create new version of MT_CKD, implement in LBLRTM and RRTMG
- Paper

<u>Possible future steps</u>

- AERI data from RHUBC-II may provide unique information on spectroscopy of $H_2O$ fundamental band (1300-1900 $cm^{-1}$) and $\nu_4$ band $CH_4$ (1250-1350 $cm^{-1}$)