

Radiative Heating in Underexplored Bands Campaign (RHUBC-II): Overview and Status

Eli Mlawer¹, Dave Turner², and
RHUBC-II Instrument PIs

Water Vapor Profiles for RHUBC-II (Ongoing)

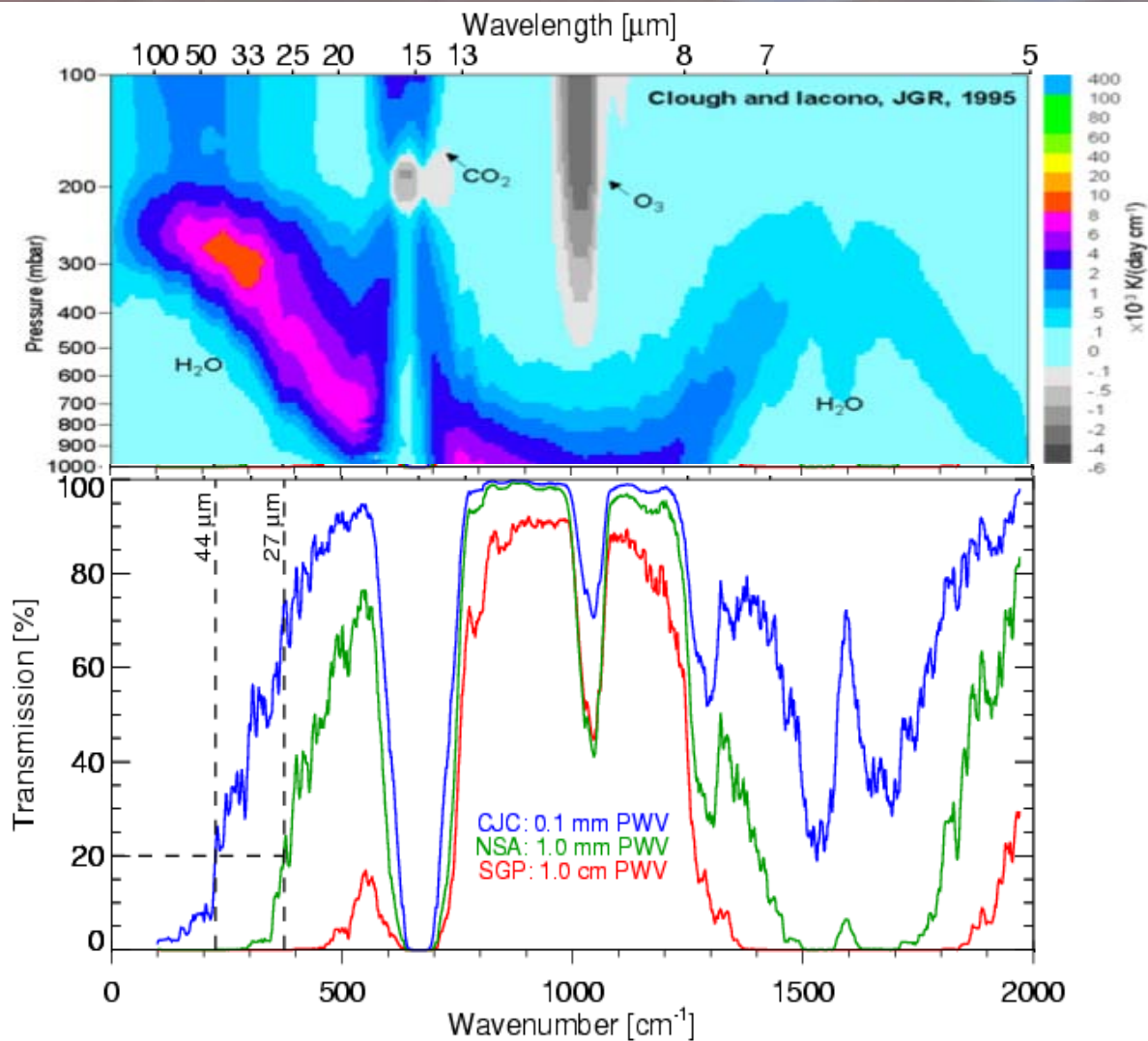
Eli Mlawer¹, Jen Delamere¹, Vivienne Payne¹,
Dave Turner², Maria Cadeddu³, Mike Exner⁴



¹AER, Inc. ²NOAA-NSSL ³ANL ⁴Radiometrics, Inc.
Mlawer et al., Radiation Break-out, ASR Working Group Meeting, Boulder, October 2010



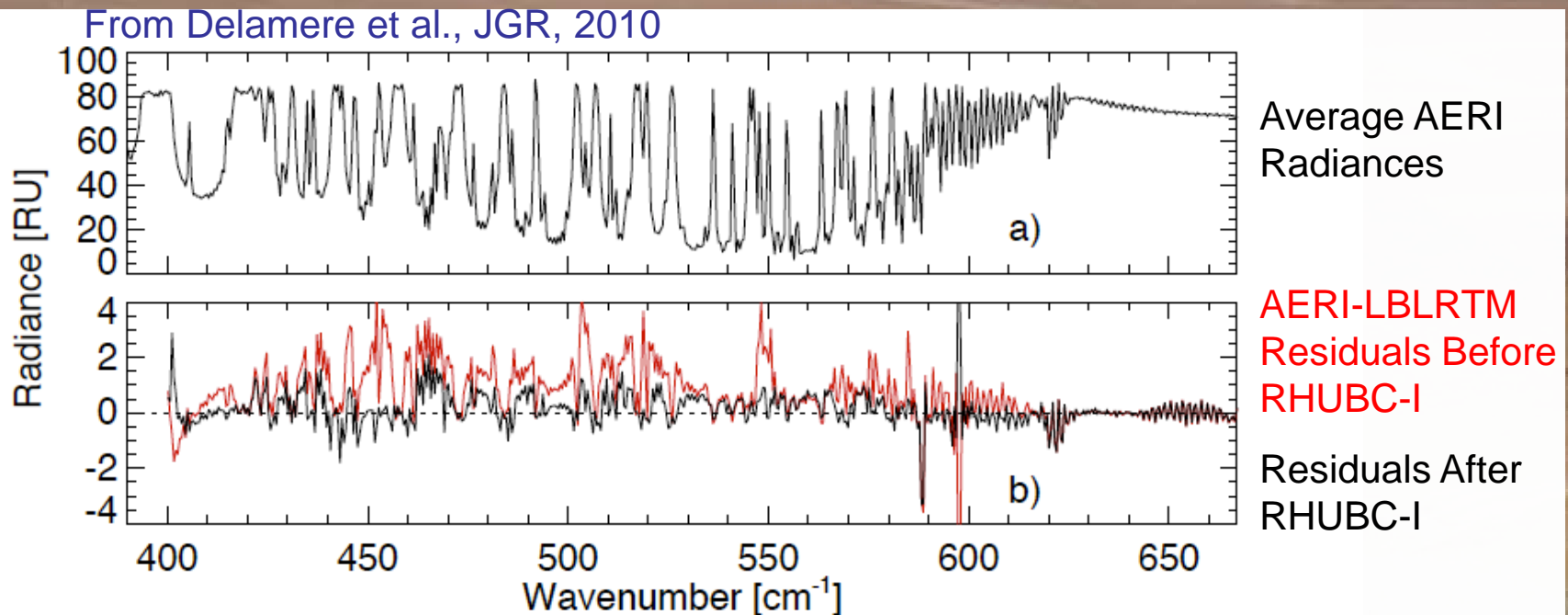
Transmission in the Infrared



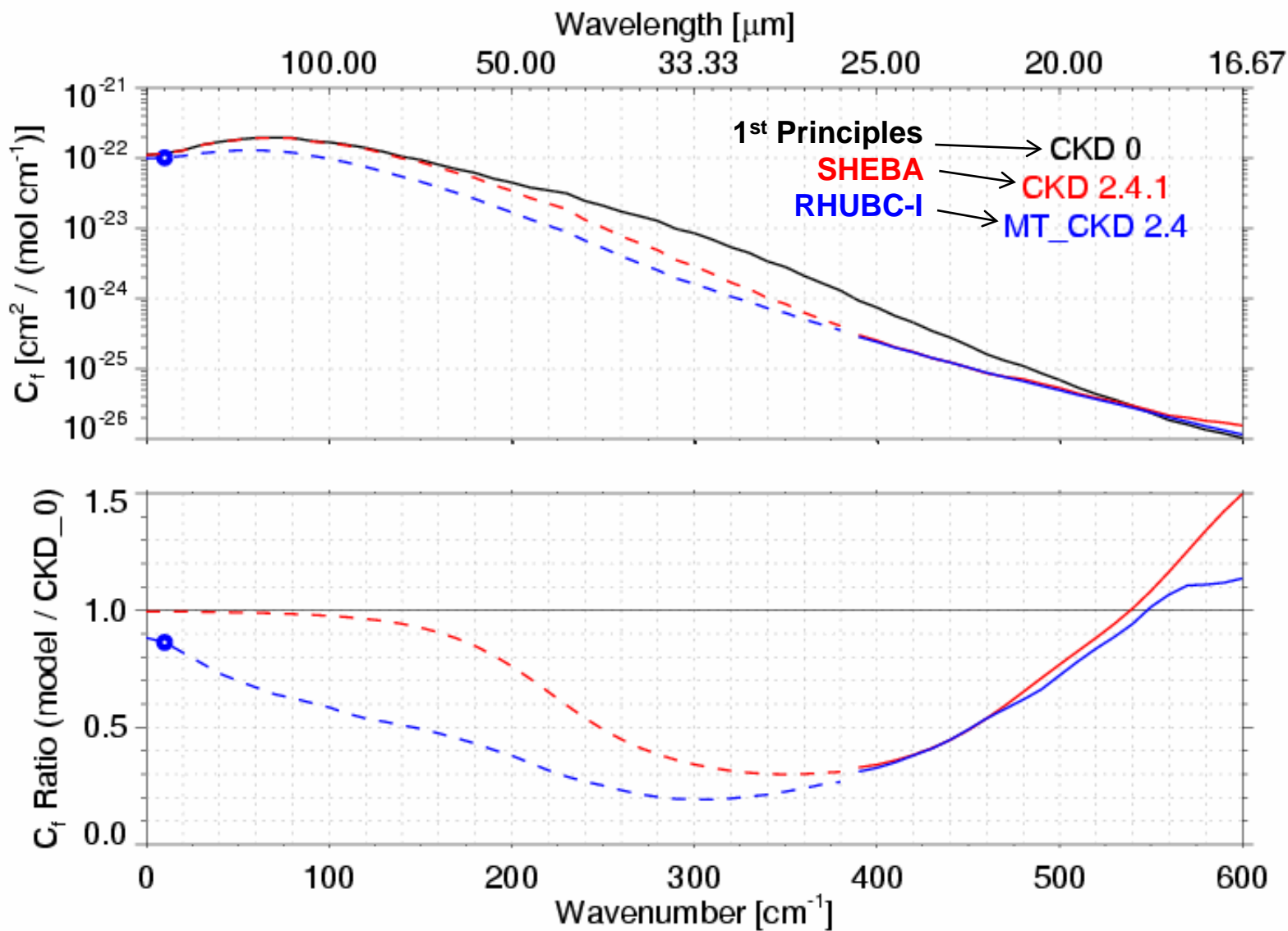
RHUBC-I Details

ARM North Slope of Alaska Site, Barrow, AK (71°N, 157°E, 8 m MSL)

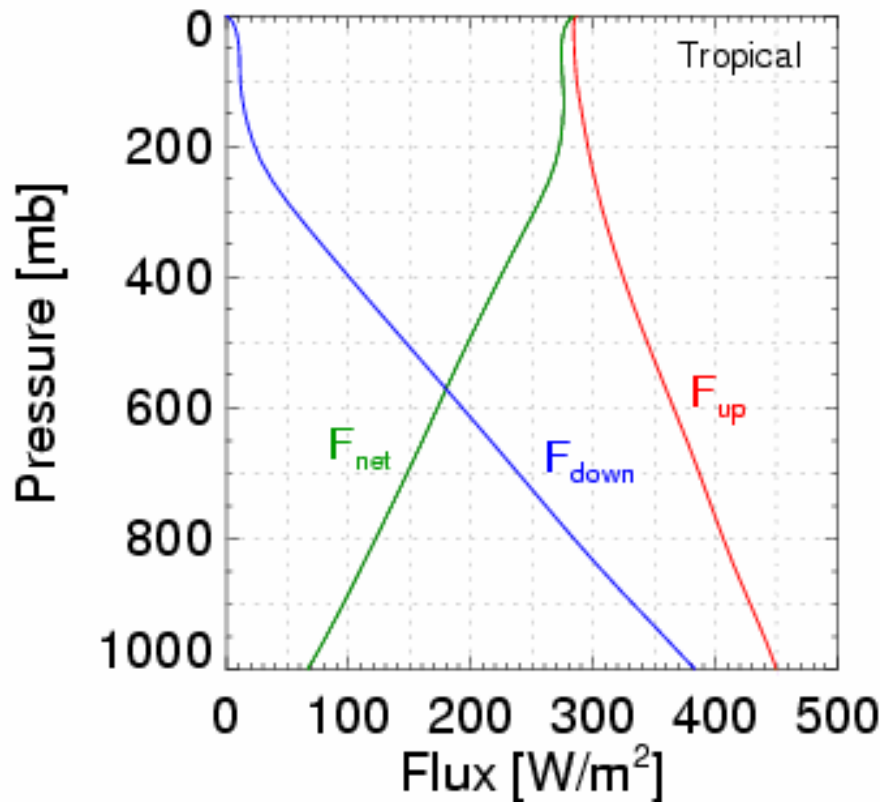
- February - March 2007, 70 radiosondes launched
- Minimum PWV: 0.95 mm (observed)
- 2 far-IR / IR interferometers
- 3 sub-millimeter radiometers for PWV observation



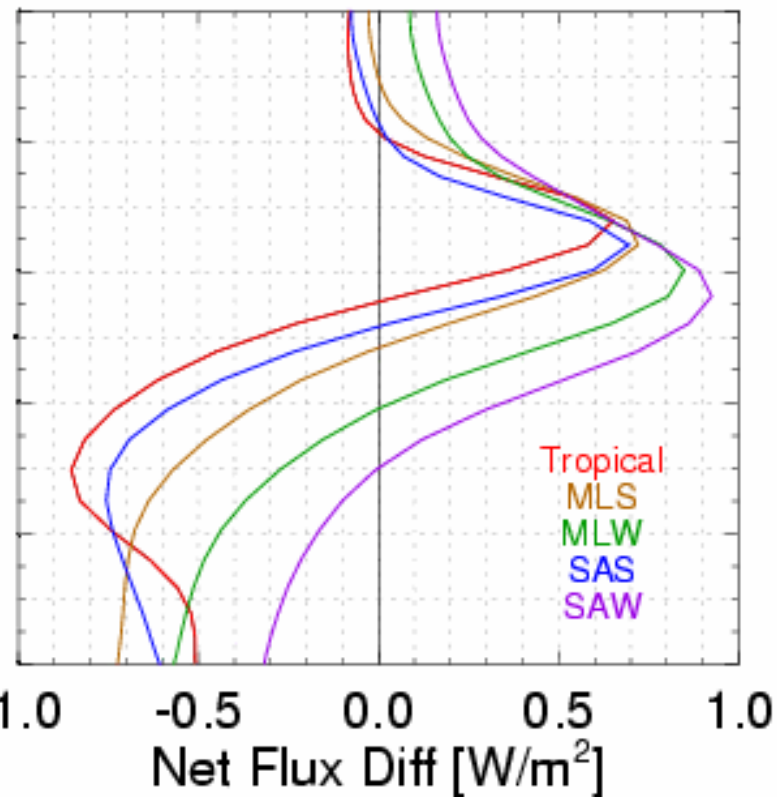
Uncertainty in the WV Cntnm in Far-IR



Impact on Net Flux Profiles



(MT_CKD v2.4) minus (CKD v2.4.1)



Results in important difference in radiative heating rates.

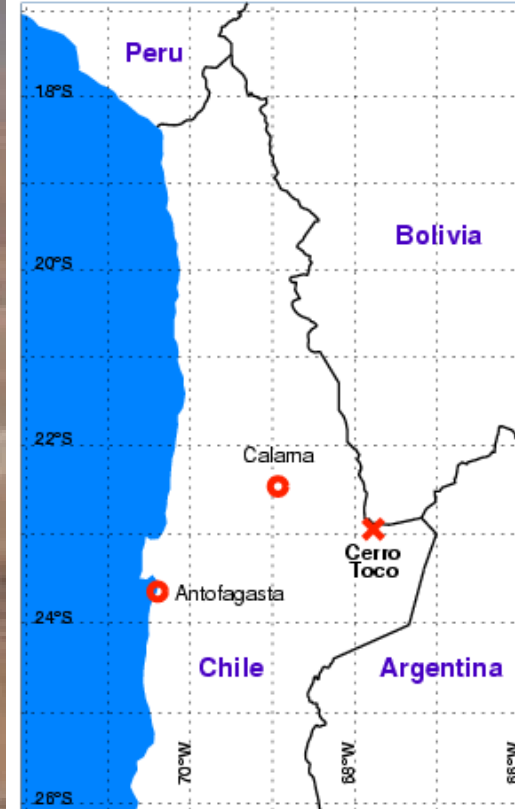
RHUBC-II Details

August - October 2009, 144 radiosondes

- Minimum PWV: ~ 0.2 mm
- 3 far-IR / IR interferometers
- 1 sub-millimeter radiometer for PWV
- 1 sub-millimeter FTS
- 1 near-IR FTS
 - High-spectral resolution from $1.0 \mu\text{m}$ to $3000 \mu\text{m}$
- Lidar for cirrus detection

Overview paper: Turner and Mlawer, BAMS,
July 2010

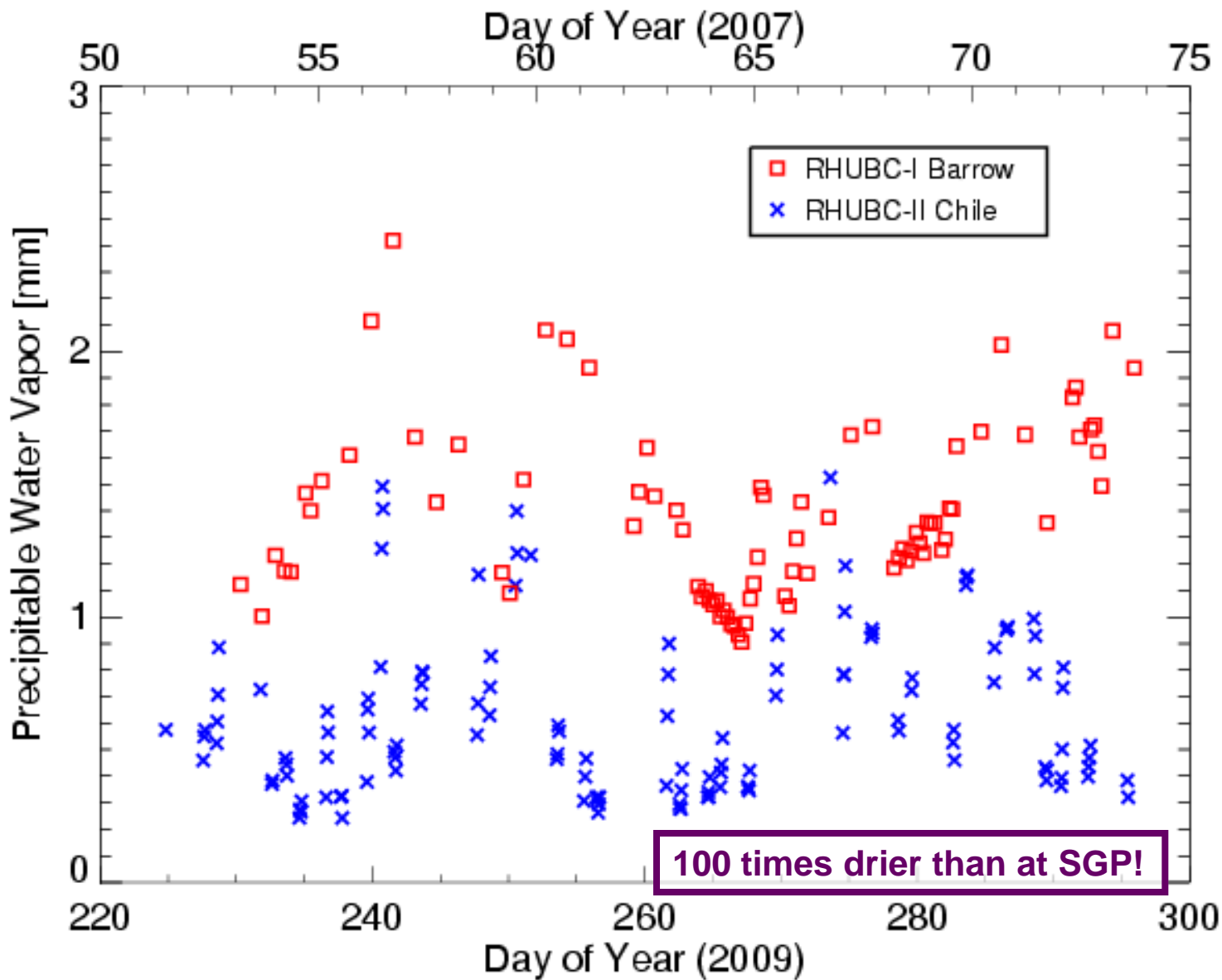
site elevation: 5340 m



Additional support from:
NASA
Italian Research Foundation
Smithsonian



Radiosonde Observed PWV



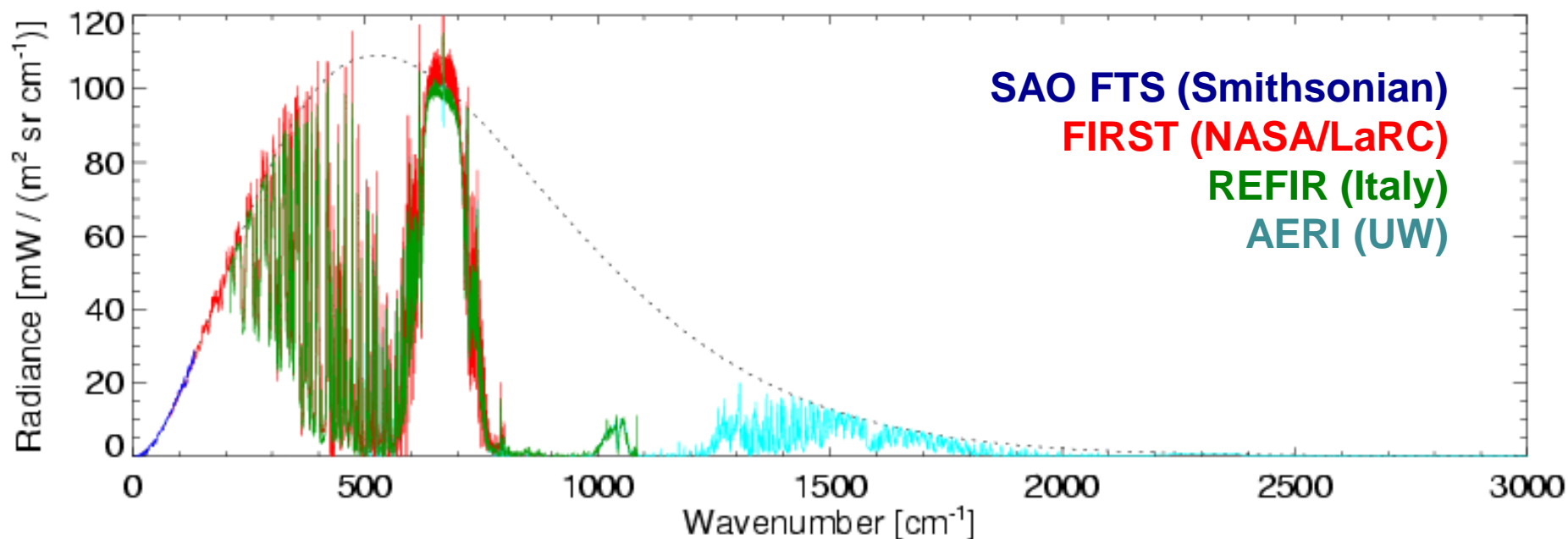
100 times drier than at SGP!



Spectral Observations

170 GHz (5.6 cm^{-1}) to $3 \mu\text{m}$ (3000 cm^{-1})

First ever measurement of the entire infrared spectrum from 3 to $1780 \mu\text{m}$!

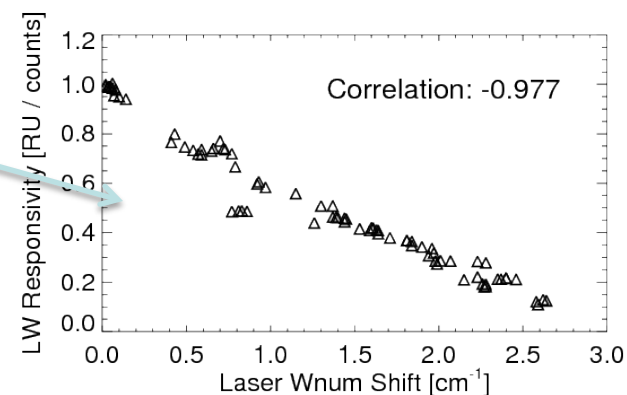
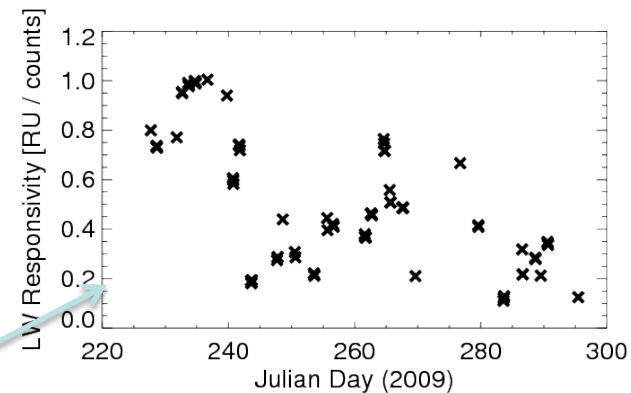


PRELIMINARY DATA



AERI Status (as of 7 Oct 2010)

- Instrument deployed in non-standard manner
 - No Stirling cooler; had to use LN₂ cooled detector
 - Open front end to view atmosphere at 1 and 2 airmasses to give more analysis options
- Initial version (v0) of data submitted 13 Jan 2010
- Subsequent analysis discovered:
 - Daily movement of the LN₂ dewar/detector, which resulted in off-axis detection
 - Impact: declining responsivity over IOP
 - Impact: shift of spectral calibration over the IOP
 - Applied an offset of 0.4K to the hot blackbody (HBB) to account for convection in this BB due to the open front end; this eliminated the negative radiance bias at 10 μm in clear sky scenes
 - Data reprocessed and archived as v1 on 23 Jul 2010



- NEW: Continued analysis demonstrated HBB temperature offset inconsistent with data in channel 2 (i.e., in 3-5 μm region)
- Current focus of research: declining responsivity requires a different treatment to correct for non-linearity of detector; could solve negative clear sky bias at 10 μm, impacts the 5-19 μm spectral region.
- Need to release an update (v2) in the near future

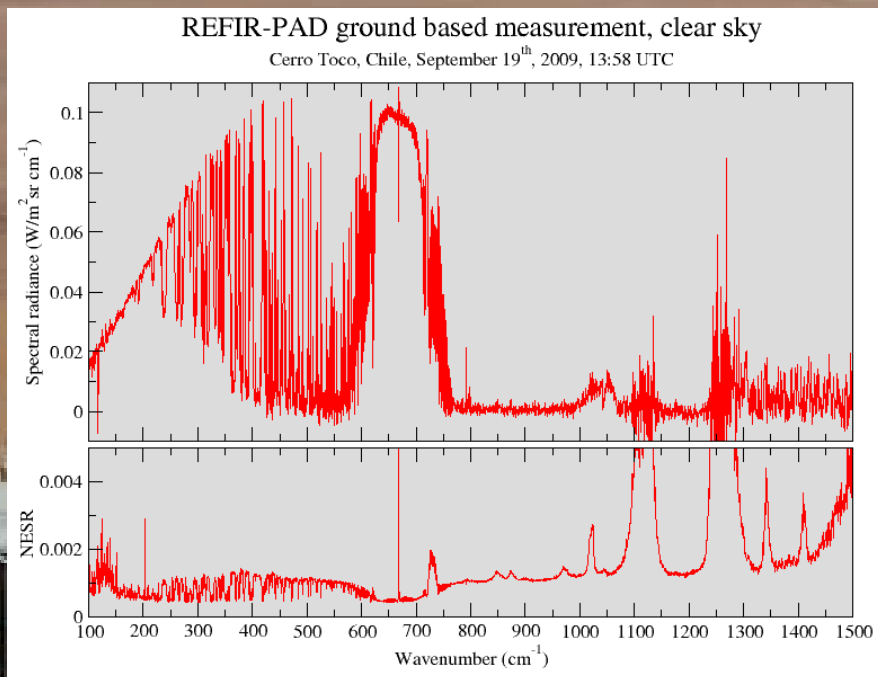
REFIR-PAD: 100-1400 cm^{-1} , resolution = 0.5 cm^{-1}

(Radiation Explorer in the Far InfraRed– Prototype for Applications and Developments)

- L. Palchetti and G. Bianchini - Istituto di Fisica Applicata “Nello Carrara” - CNR, Italy
- FTS, Mach-Zehnder configuration
- 2 un-cooled detectors
- 60s per scan, 5-min averaged scenes every 10 min

Level1 product in archive

- Calibrated spectrum with uncertainty
- About 30 spectra/day from Aug. 21st to Oct. 24th (37 days)



Current analysis

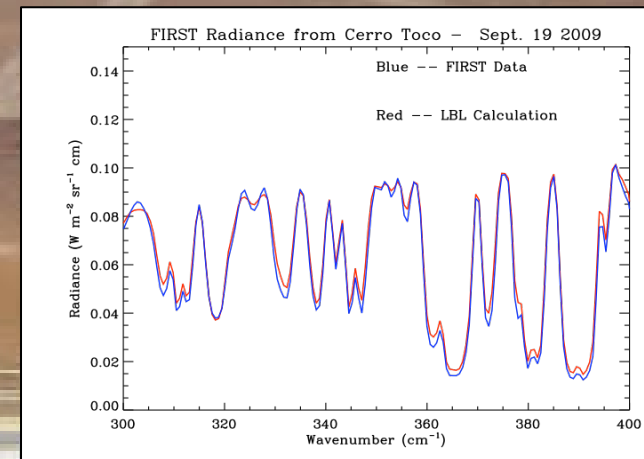
- Retrieval of PWV from the FIR
- Spectroscopy of WV in the FIR



FIRST: 100-1600 cm^{-1} , resolution- 0.643 cm^{-1}

(Far-Infrared Spectroscopy of the Troposphere)

- Marty Mlynczak/NASA Langley
- FIRST Instrument and Data Description
 - Fourier Transform Spectrometer
 - 6-minute sky view integration, 8.5 sec per interferogram
 - Calibration blackbodies 46 C and 12 C (Hot and Ambient)
- All data of scientific quality processed, delivered to ARM website, and available for use.
 - Twenty five days (8-12-09 to 10-17-09) and 399 6-minute average spectra
 - Corresponds to 2/3 of all recorded data
- Final data set delivered to ARM in March, 2010
- Preliminary analysis by FIRST team indicates possibility of minor adjustments to water vapor continuum 200 to 500 cm^{-1}



SAO Submm FTS: 300 GHz – 3.5 THz, resolution - 3 GHz



- S. Paine, Smithsonian Astrophysical Observatory
- Polarizing step-scanned interferometer
- Spectral coverage: LHe cooled bolometers
- 10 minutes / spectrum
- 58 days continuous operation
- Final calibrated data set (version 1) in ARM archive



HATPRO-G2: 7 channels each - ~22 GHz WV, ~60 GHz O₂

(Humidity and Temperature PROfiler - Generation 2)



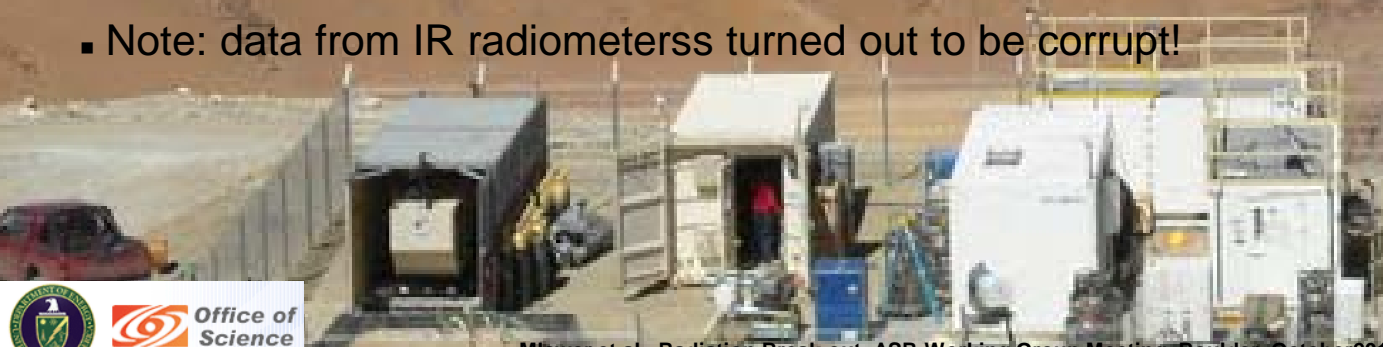
Instrument details

- PIs: S. Crewell, U. Löhnert, G. Maschwitz, contact: gmasch@meteo.uni-koeln.de
- Operated by the Institute for Geophysics and Meteorology, U. of Cologne
- Manufacturer: Radiometer Physics GmbH, Germany
- Microwave channels defined by precise bandpass filters
- Additional surface sensors, GPS clock and 2 scanning IR radiometers (11.1, 12.0 μm)



Data set

- Continuous scan pattern: 14(20) elevation angles in the 250°/70° azimuthal plane
- Aug15 – Oct 24 contains elevation angles, surface sensor data, brightness temperatures (0.5K accuracy) for all microwave channels
- Available on ARM archive. A QC'ed update for the 31.4 GHz channel is underway
- Note: data from IR radiometers turned out to be corrupt!



Water Vapor Profiles for RHUBC-II (Ongoing)



Mlawer et al., Radiation Break-out, ASR Working Group Meeting, Boulder, October 2010



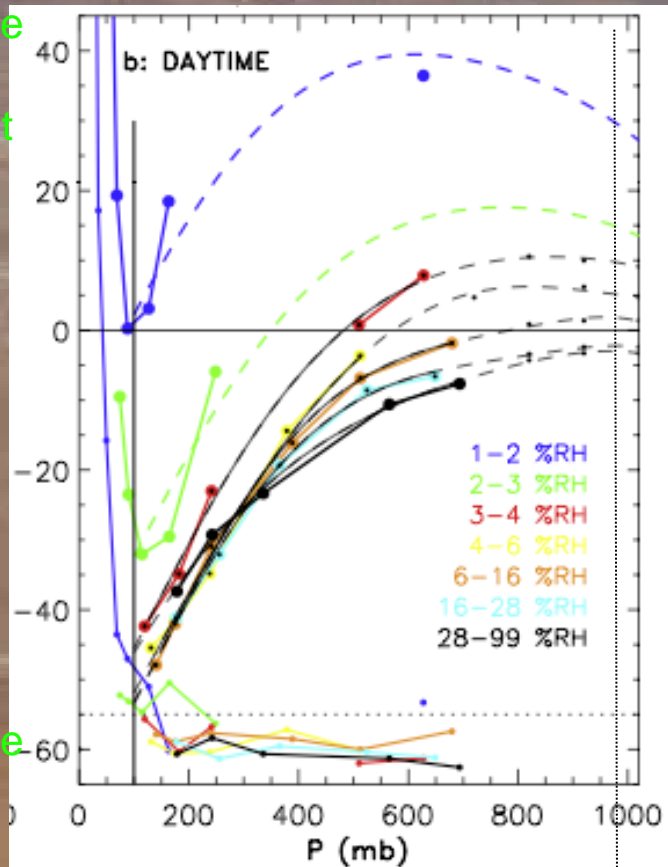
Impact of Miloshevich Adjustment on Sonde WV

From Miloshevich et al., 2009

Sonde too moist



Sonde too dry



Mlawer et al., Radiation Break-out, ASR Working Group Meeting, Boulder, October 2010



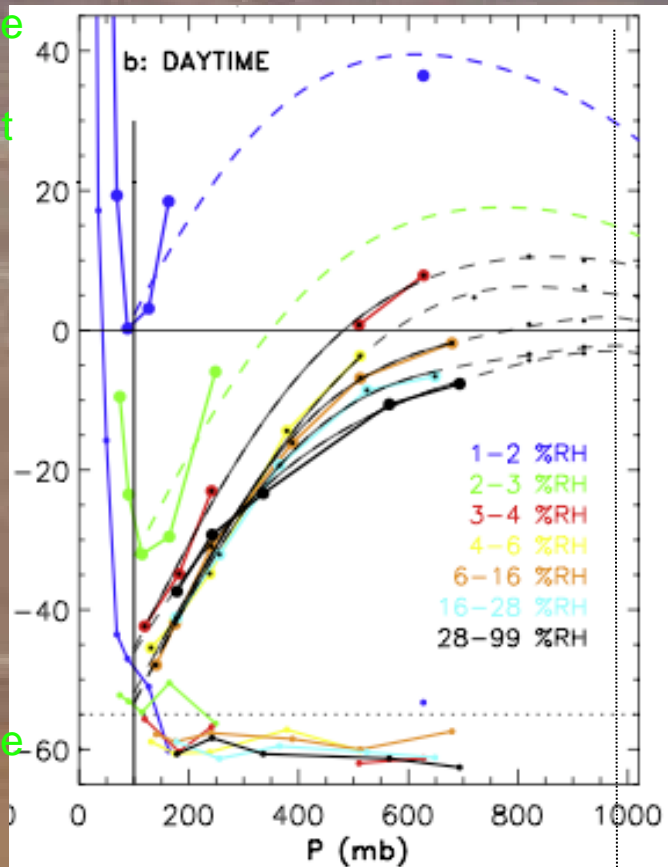
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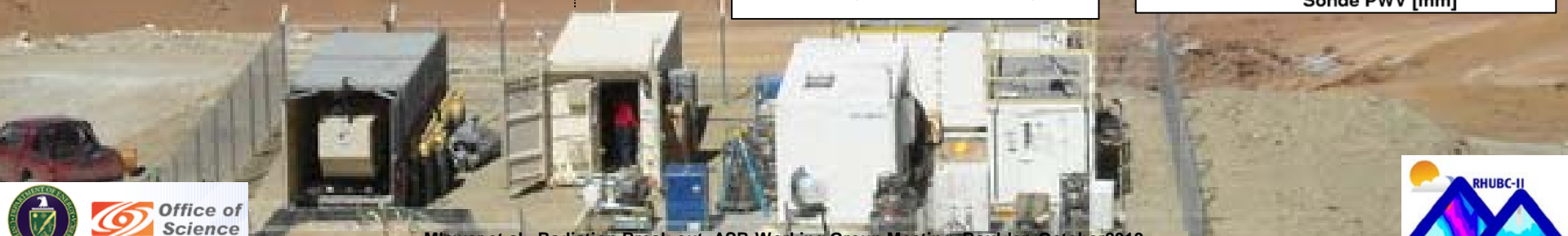
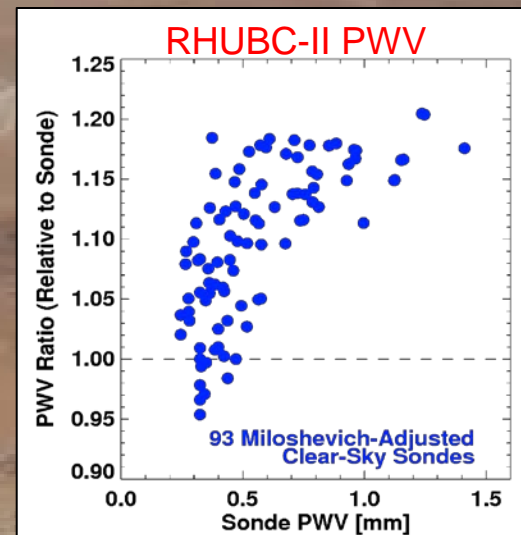
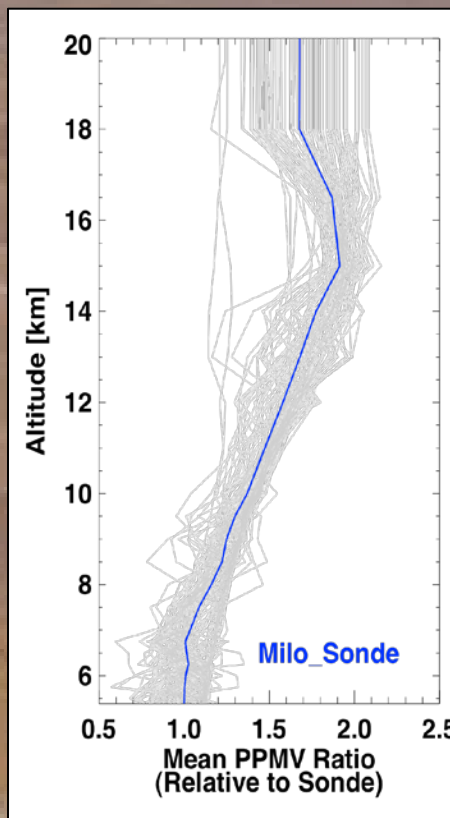
Sonde too moist



Sonde too dry

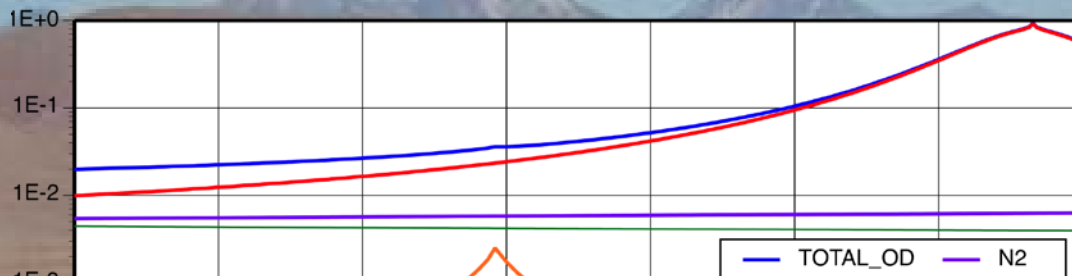


RHUBC-II Water Vapor Profiles



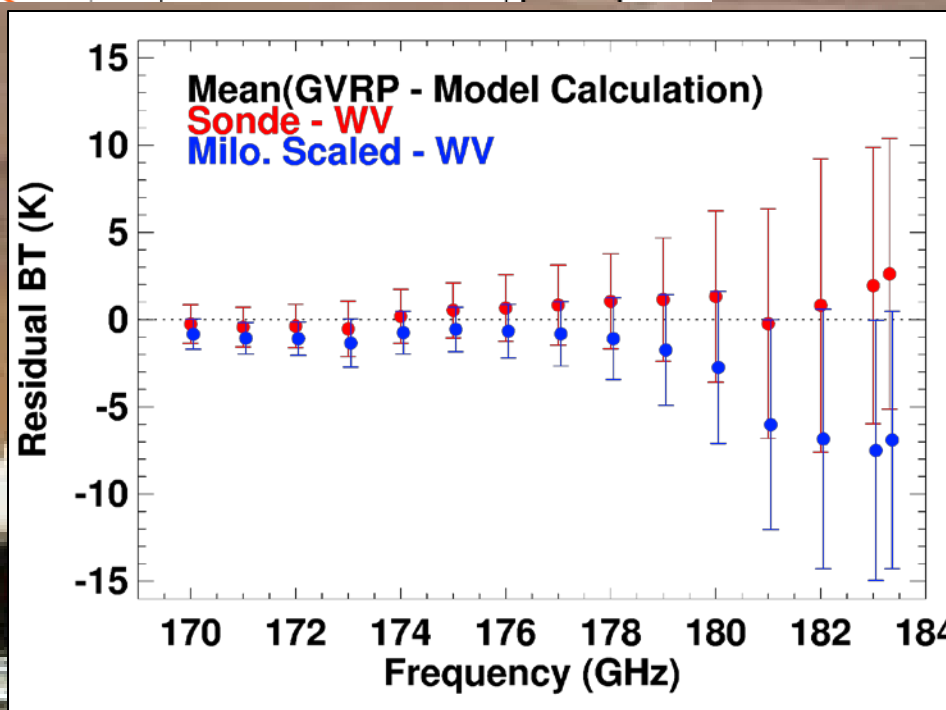
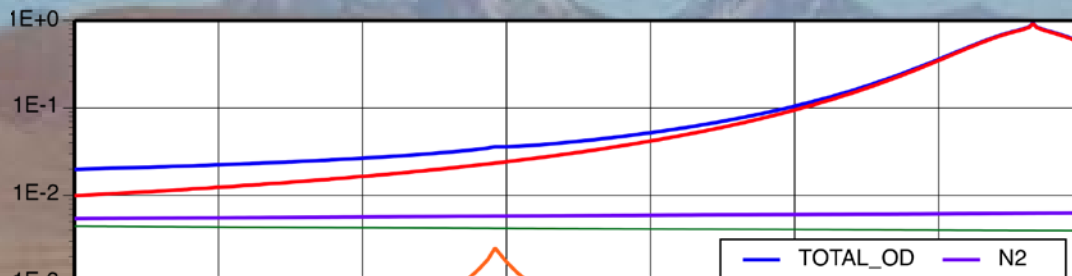
GVRP: channels centered at 170, 171, ..., 183, 183.3 GHz

Optical
Depths
for PWV
~0.3 cm



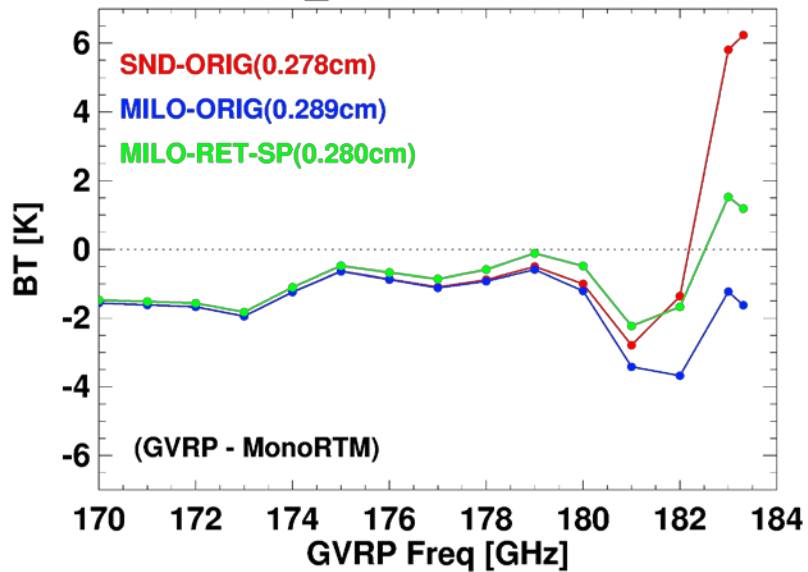
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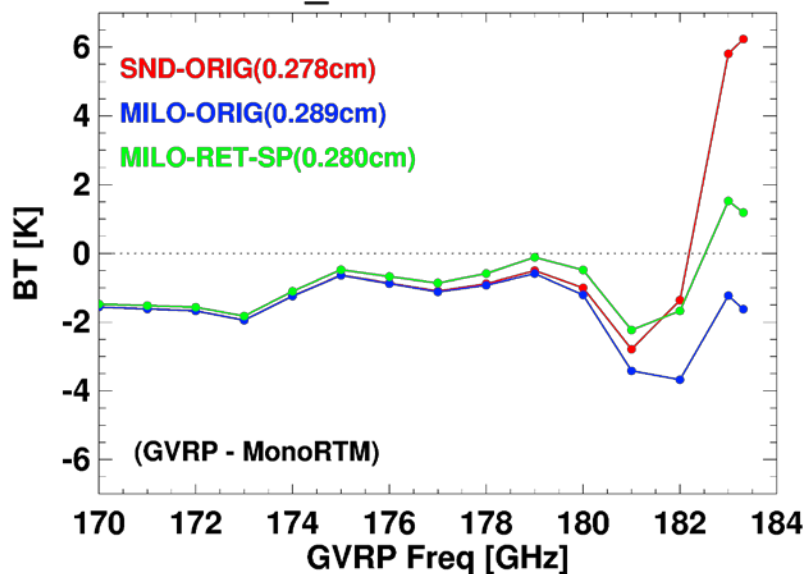
Scaling WV Profile (Milo.) to Agree with GVRP (as of a few months ago)

CJC_20090919.153000

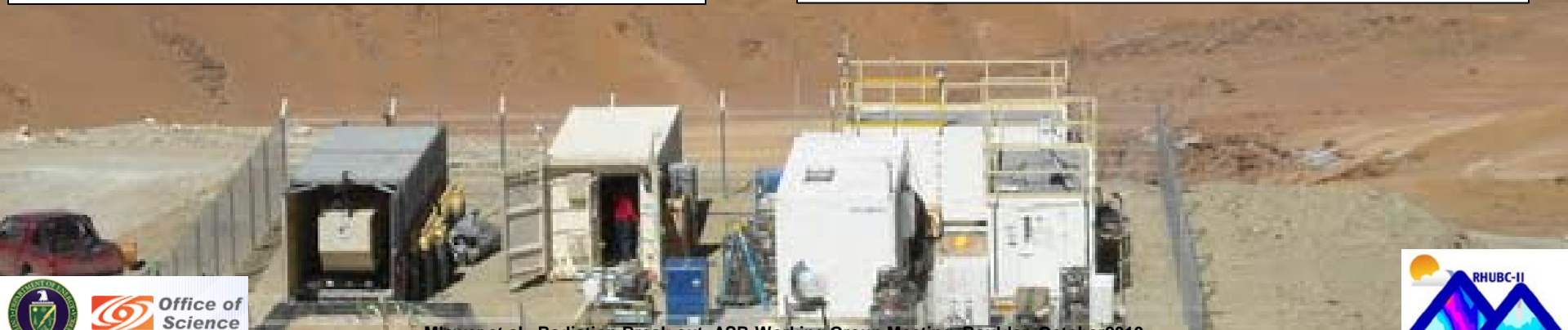
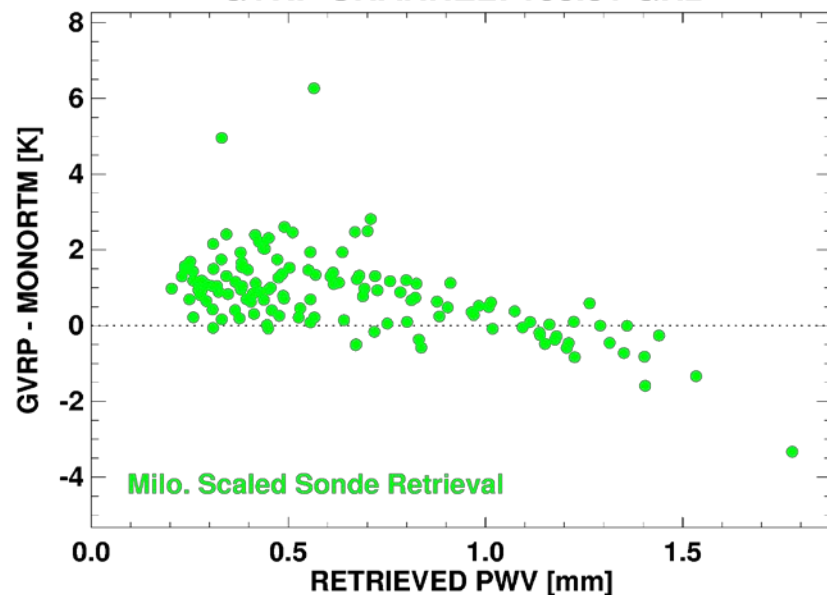


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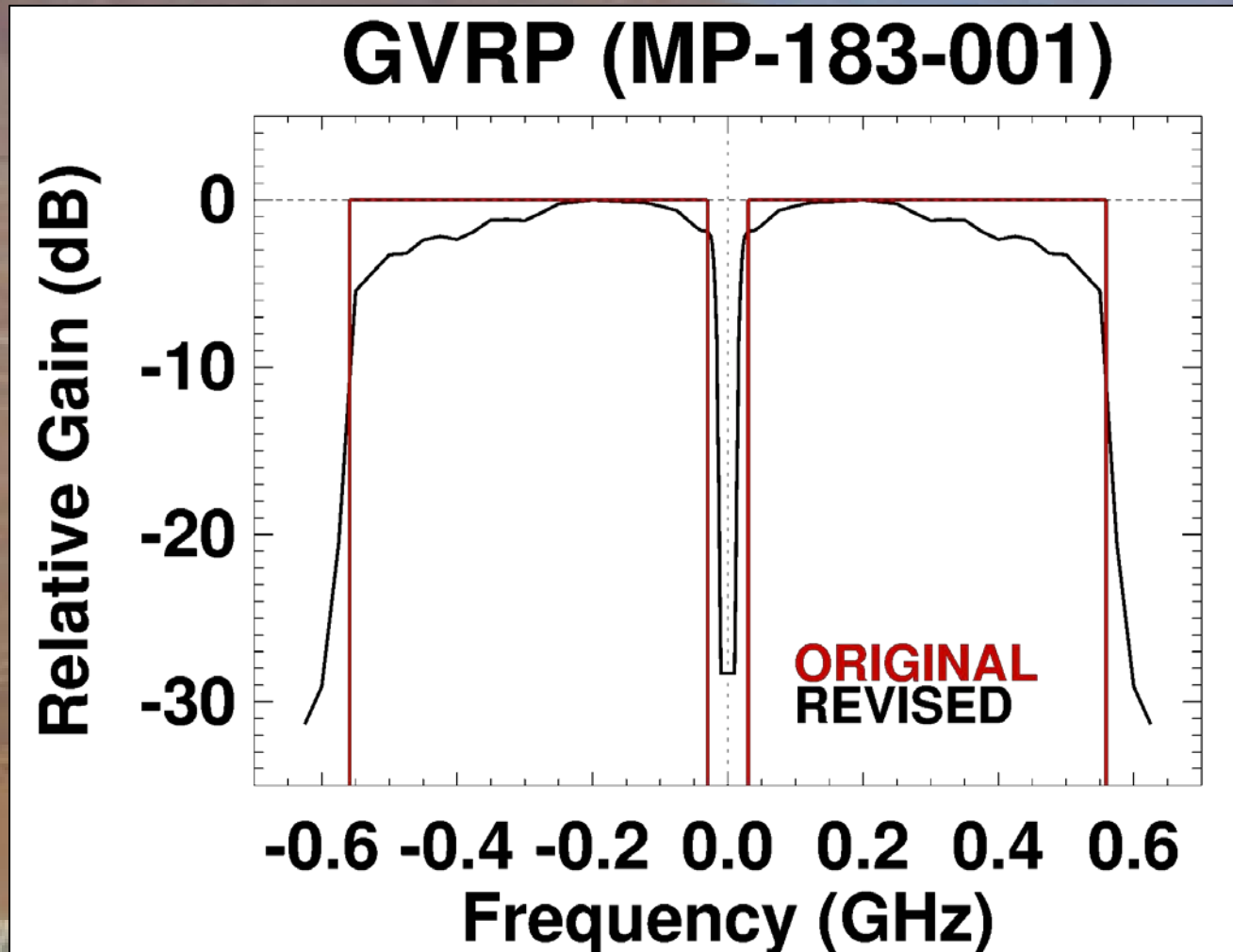
CJC_20090919.153000



GVRP CHANNEL: 183.31 GHz

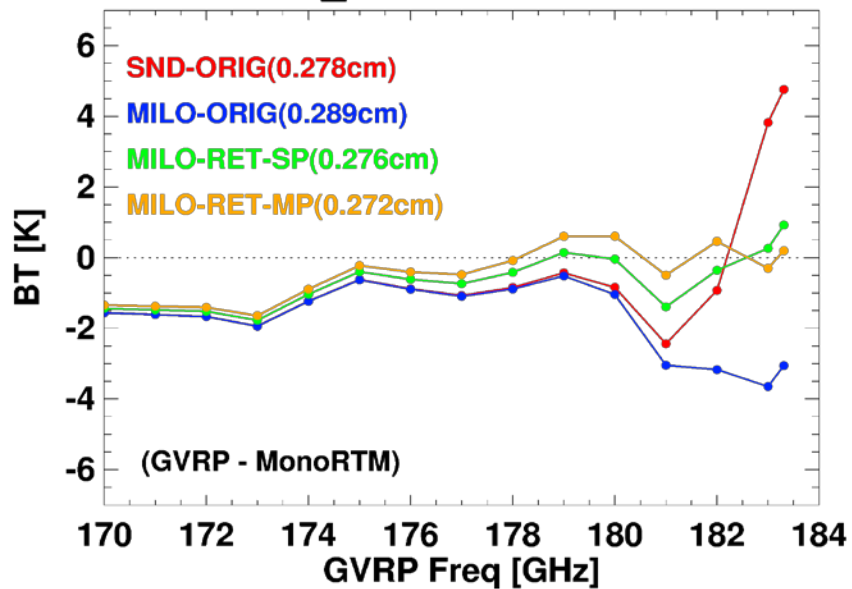


Modified GVRP Instrument Function



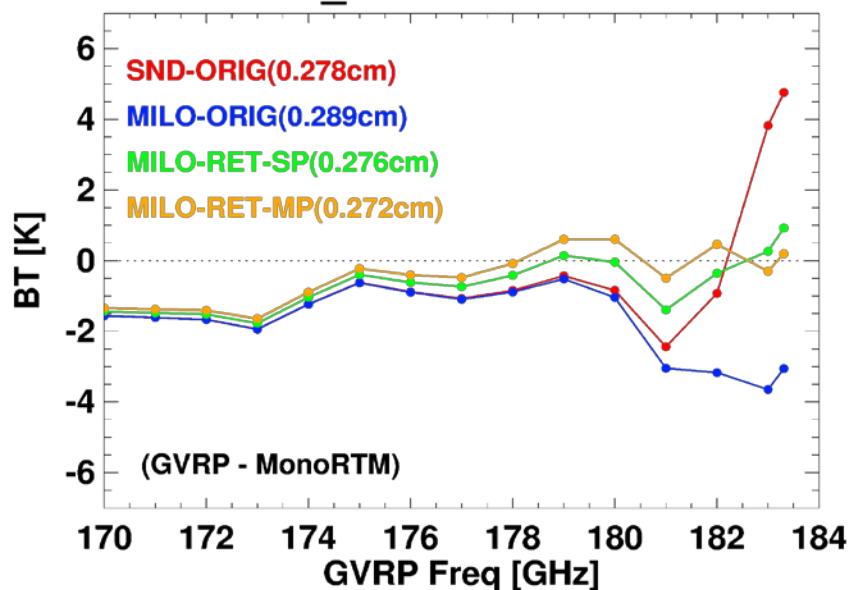
Current Water Vapor Retrievals

CJC_20090919.153000

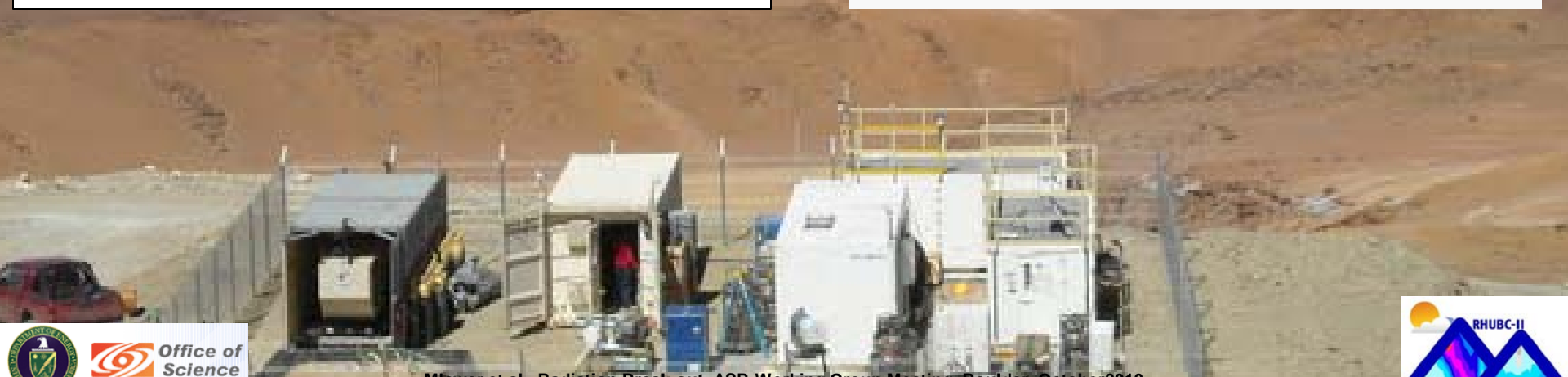
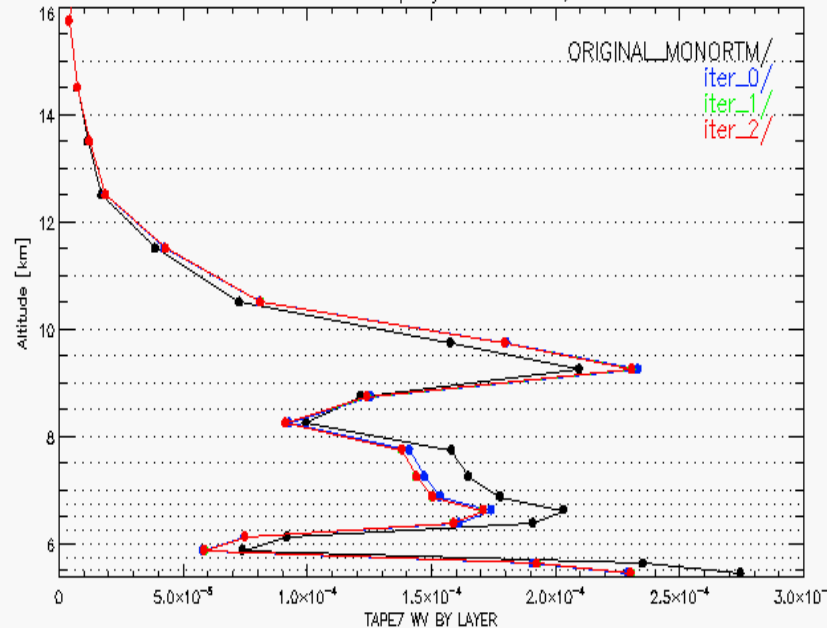


Current Water Vapor Retrievals

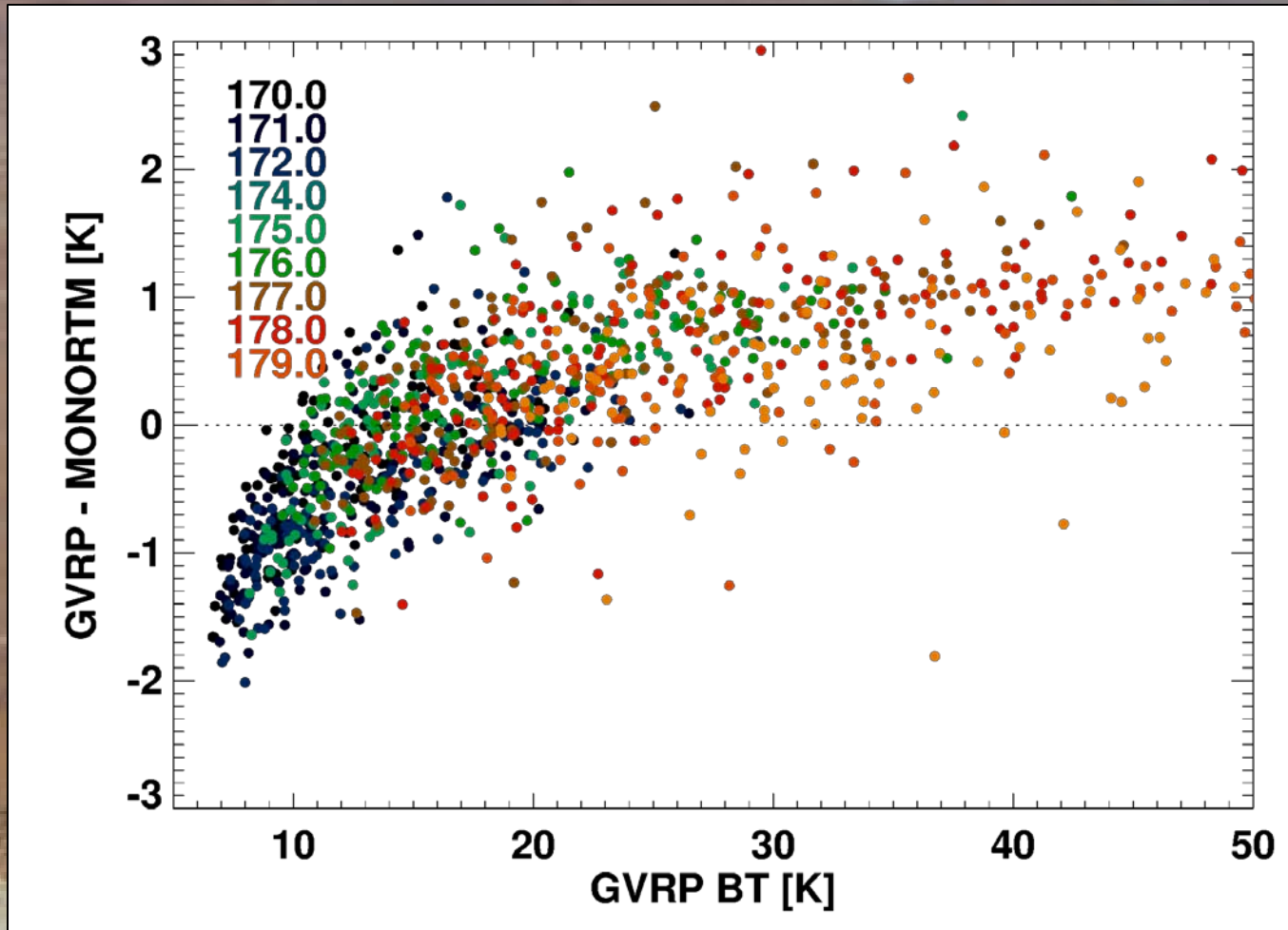
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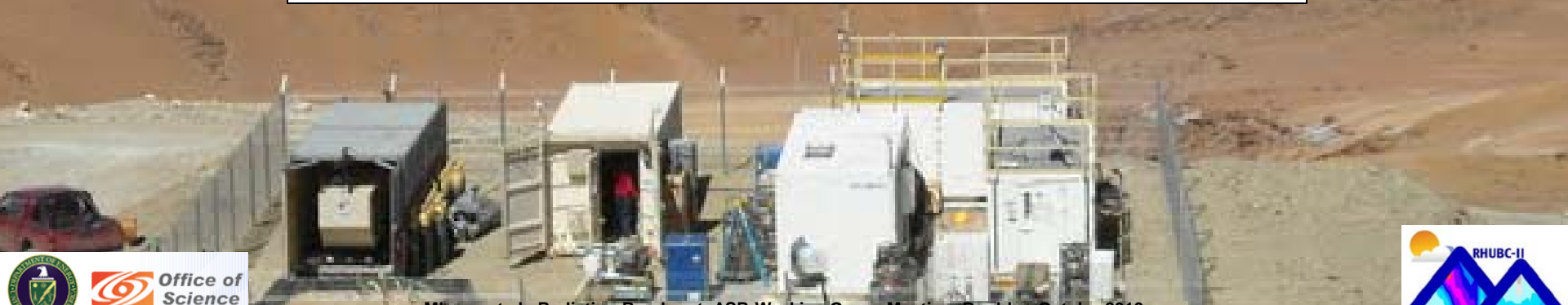
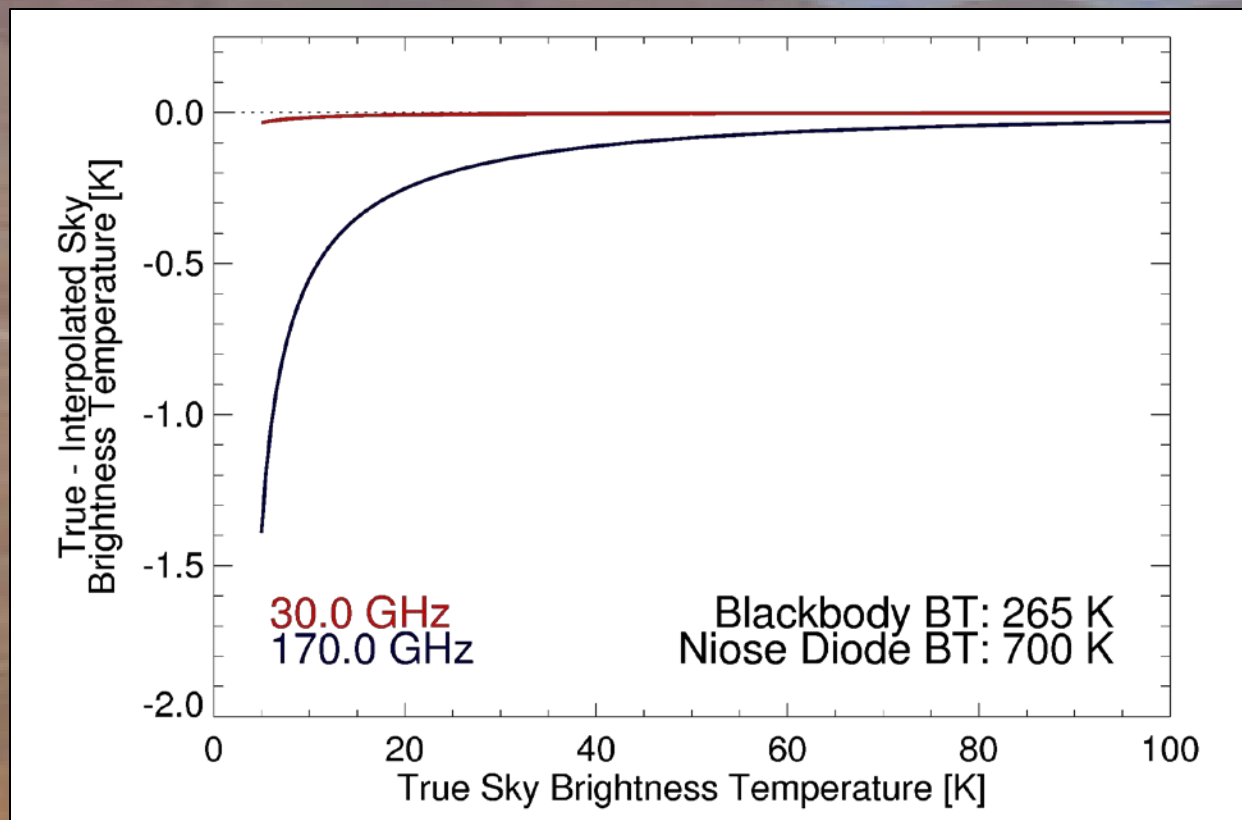
MP_t5sondes_milocorrections_allfreqs_hybridres_newwts;CJC_20090919.153000



GVRP-Model Residuals Depend on BT for All Channels



Error in Calibration Using Simplistic Analysis



Summary

- **Water vapor profile important for radiative closure analysis in sub-mm and far-IR**
 - **Determination of WV continuum, other spectroscopic parameters**
- **GVRP measurements can provide valuable information**
 - **Miloshevich et al. adjustments have questionable impact**
 - **Consistent positive residuals near line center for low PWV cases have been improved by utilizing more accurate instrument function**
 - **Consistent negative residuals in transparent channels for low PWV cases are not due to errors in radiative transfer model calculations**
 - **Reconsideration of calibration approach underway (Cadeddu and Turner)**
 - **Using current GVRP measurements, WV profile retrievals show significant decreases near surface and increases in mid-troposphere**



Averaging Kernel from Multi-level Retrieval – 9/19, 1530

.CJC_20090919.153000

