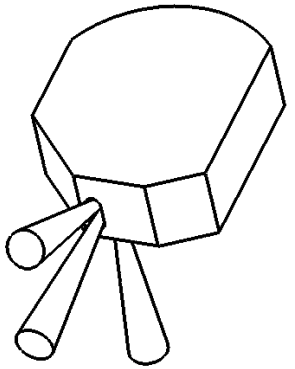
Spectroscopic issues in the data analysis of REFIR-PAD measurements performed during the 2009 ground-based campaigns



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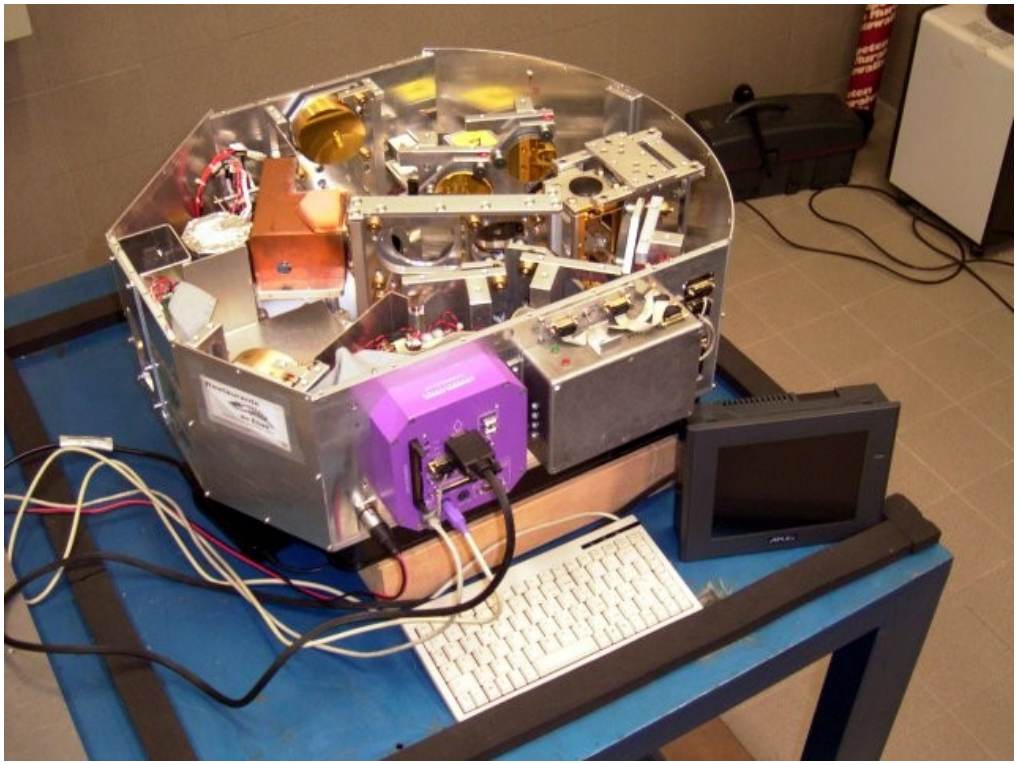
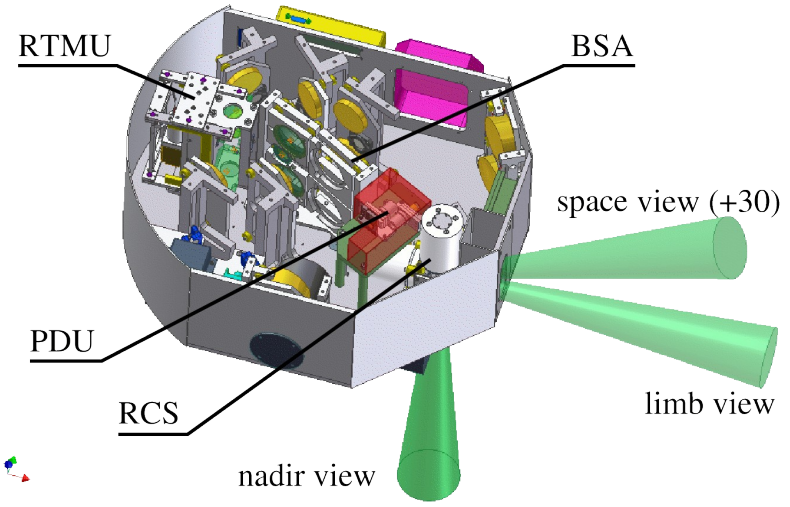
Outline

- Overview of the REFIR-PAD instrument
- Analysis of spectrally resolved DLR
- Summary of 2007-2008 results
- The 2009 ground-based campaigns
- Analysis of the fitting residuals
- Conclusions

The REFIR-PAD instrument



Compact, self-contained FTS with 100-1500 cm^{-1} spectral range and 0.5 cm^{-1} spectral resolution

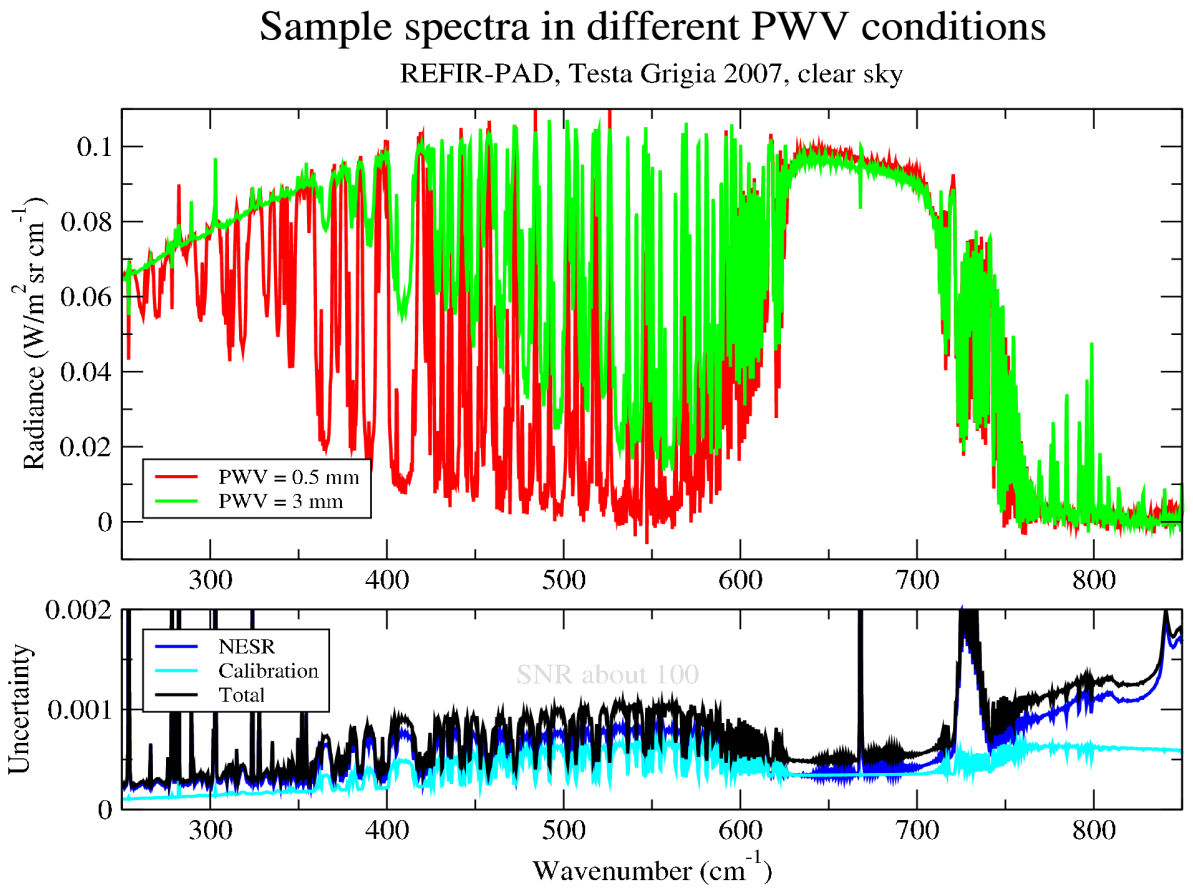


Instrument overview

- Room temperature optics and detectors (DLATGS pyroelectric)
- Suitable for balloon-borne and ground-based measurement
- Autonomous or remote controlled operation (wired or wireless ethernet link)

REFIR-PAD in the ground-based measurement configuration

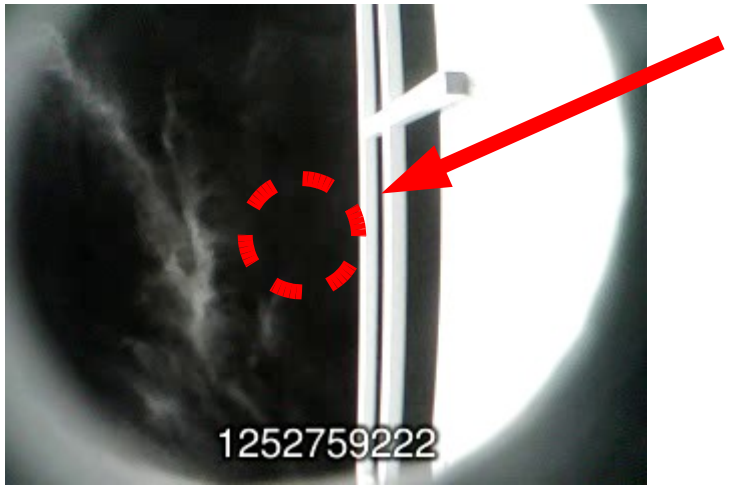
Level 1 products



- NESR component obtained from measurement noise through error propagation
- Calibration component also obtained through error propagation assuming a 0.3 K error in the BB temperatures

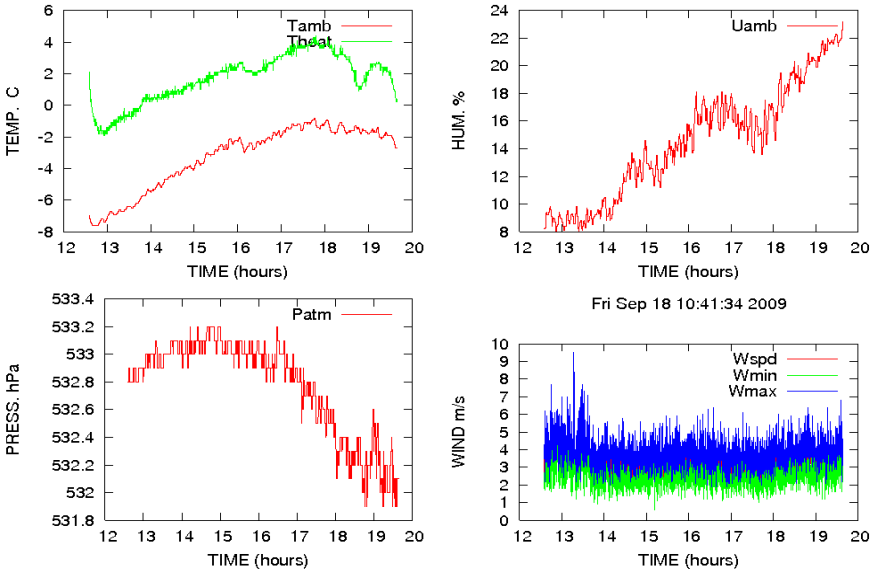
$$NESR = \sqrt{\frac{1}{N} + \frac{2}{n}\left(\frac{S}{S_h - S_c}\right)^2}\frac{\Delta S}{F_1}$$

Auxiliary data

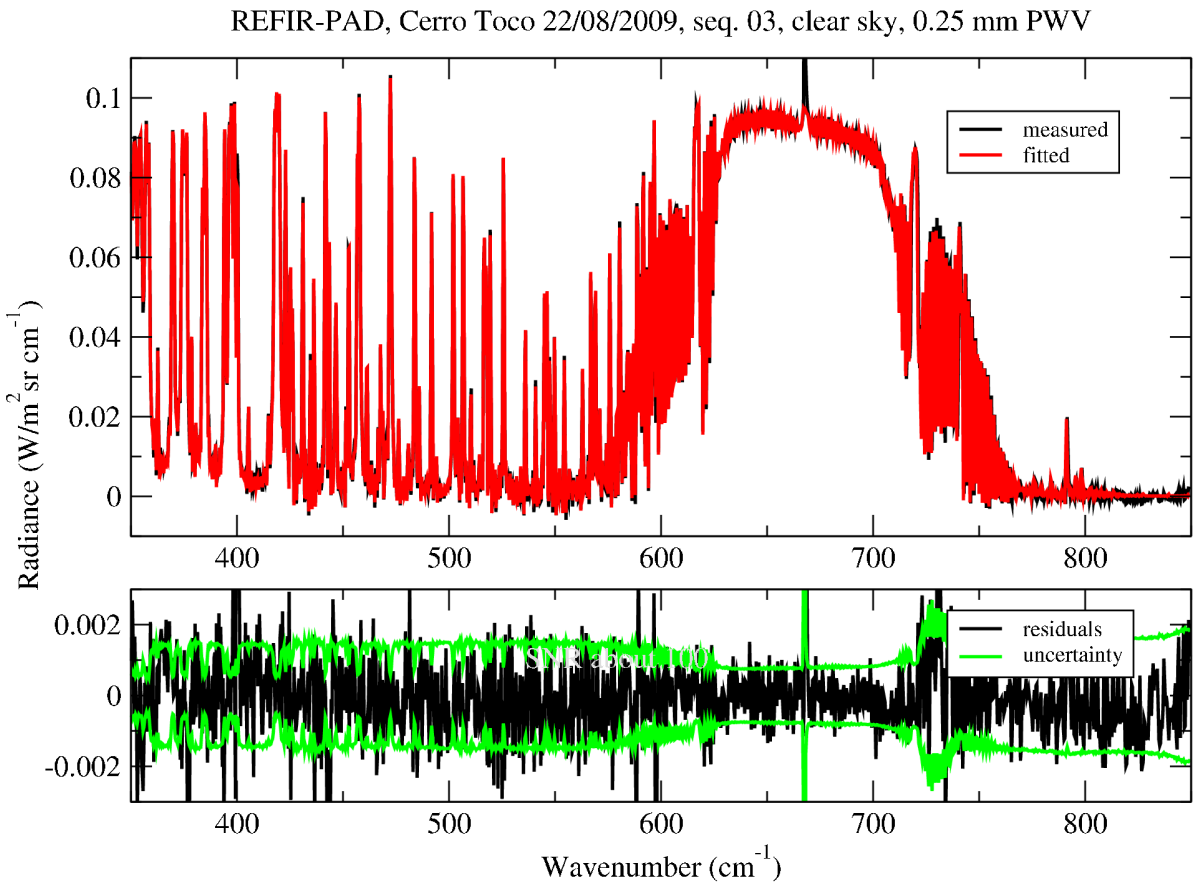


- IR webcam (low pass filter @850 nm) monitors cloud cover

- Vaisala WXT520 meteo station provides local atmospheric variables

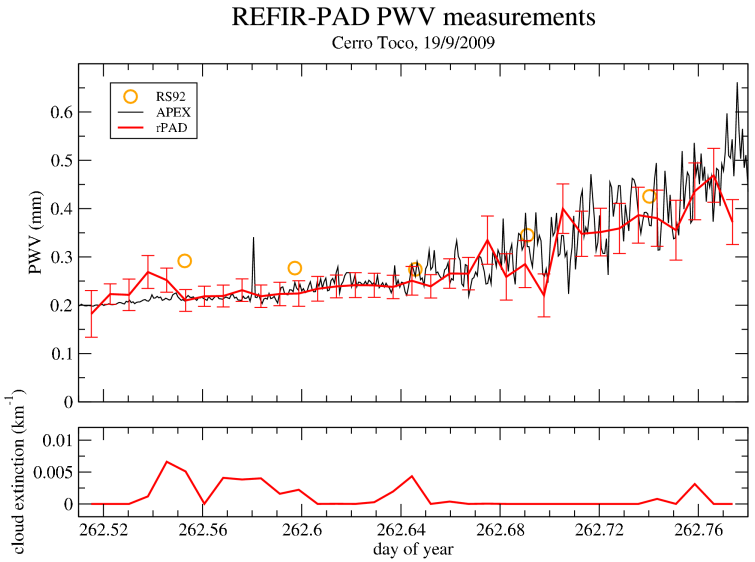


Level 2 data analysis



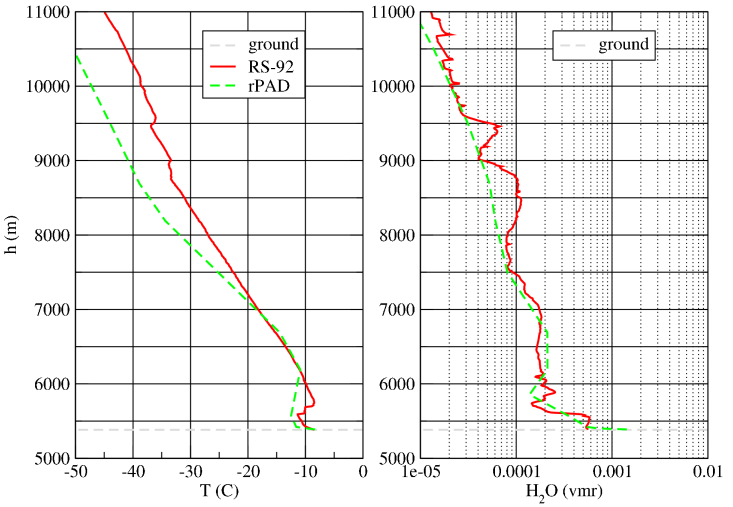
- LBLRTM forward model
- MINUIT routines (from CERN) to perform χ^2 minimization
- Fitted variables: atmospheric profiles (H_2O, T), cloud optical thickness, ILS, frequency correction

Level 2 products



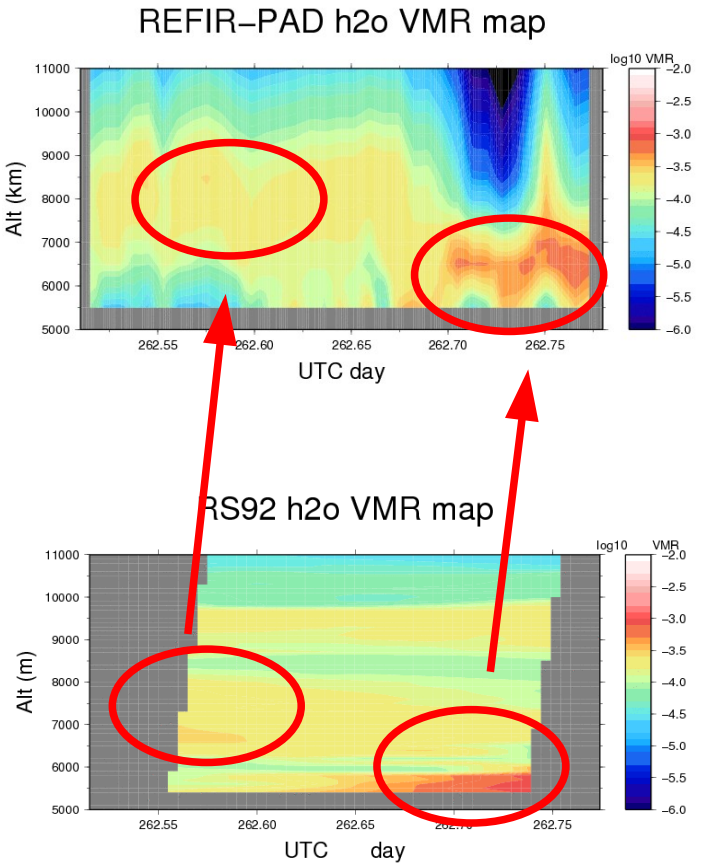
- Integrated water vapor column, cloud optical thickness

- Vertical water vapor and temperature profiles



Water vapor profile

- RS-92: high vertical resolution, but low time resolution
- REFIR-PAD: better suited to resolve the evolution in time of the atmospheric state (but with a lower resolution of the vertical structure)

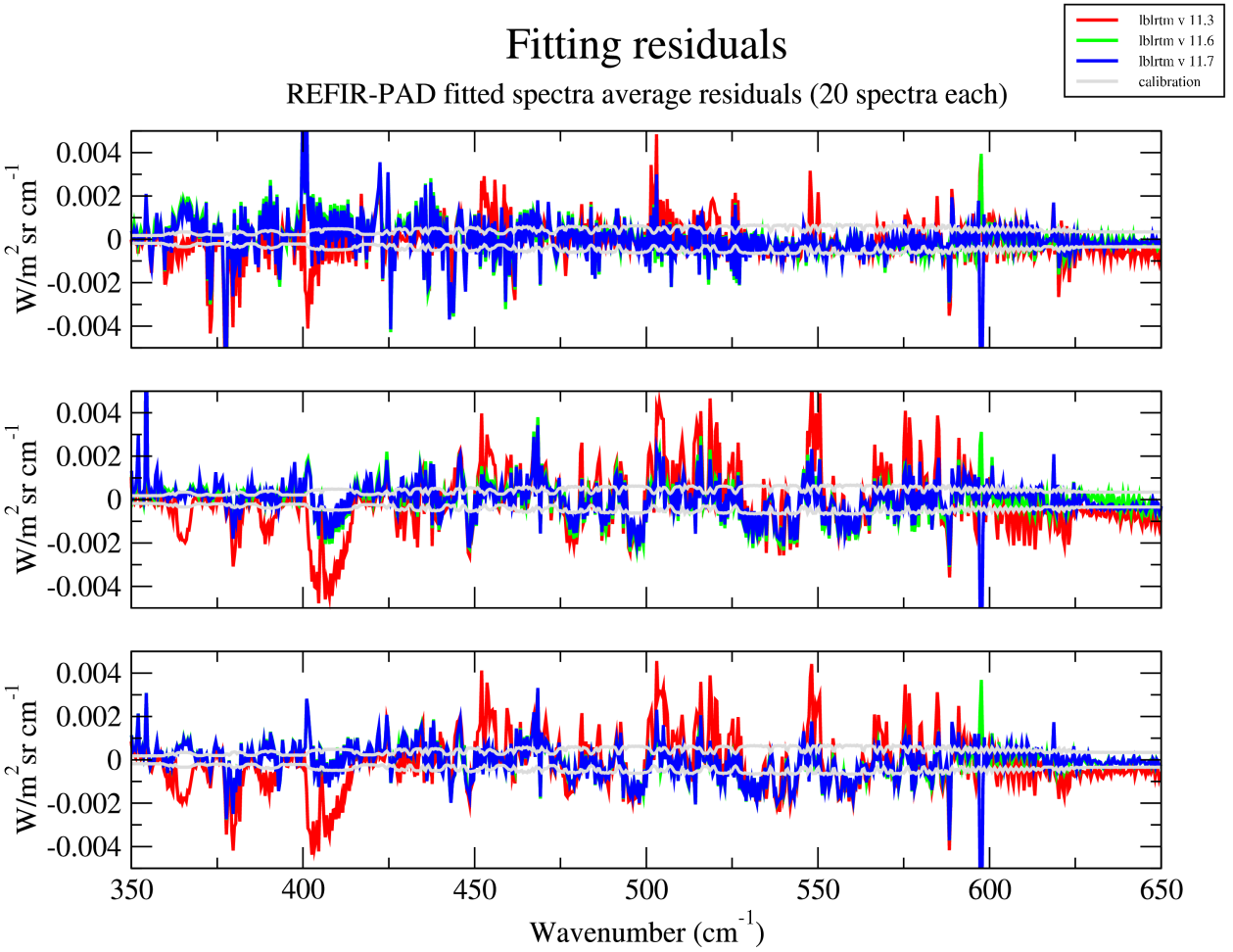


Results from 2007-2008

- 0.5-4.0 PWV range
- LBLRTM v11.3

Sensible improvements in the 350-450 cm^{-1} region with LBLRTM v11.6-v11.7

Residuals still above calibraton uncertainty in the 450-550 cm^{-1} region for high PWV (2-3 mm)

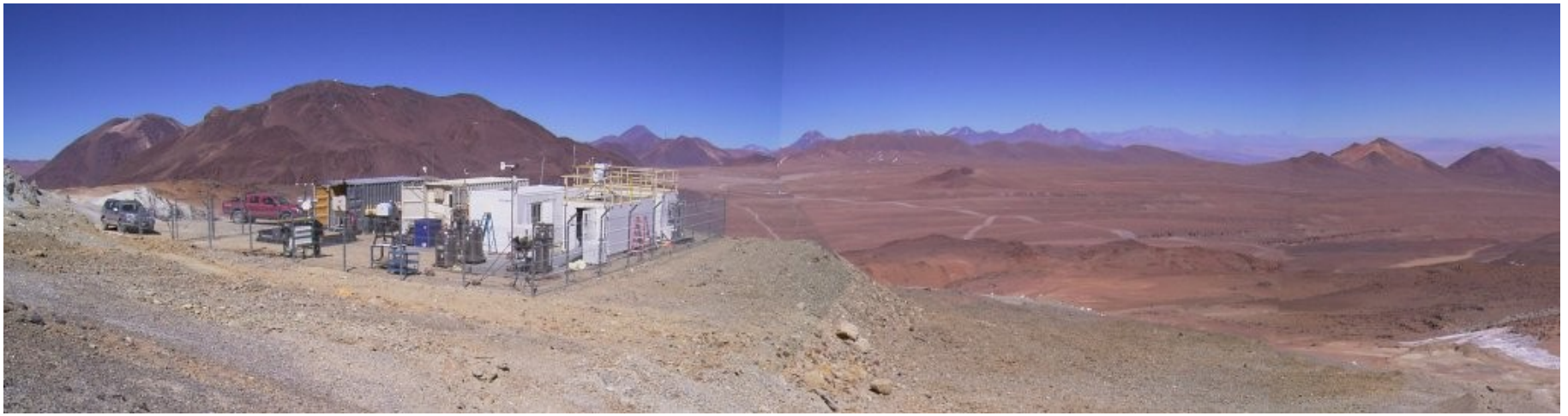


2009 measurements (I)

April 2009, Pagosa Springs Staging Facility (PSSF), Colorado, 2330 m a.s.l.

- High PWV measurements (PWV ~ 4-8 mm)

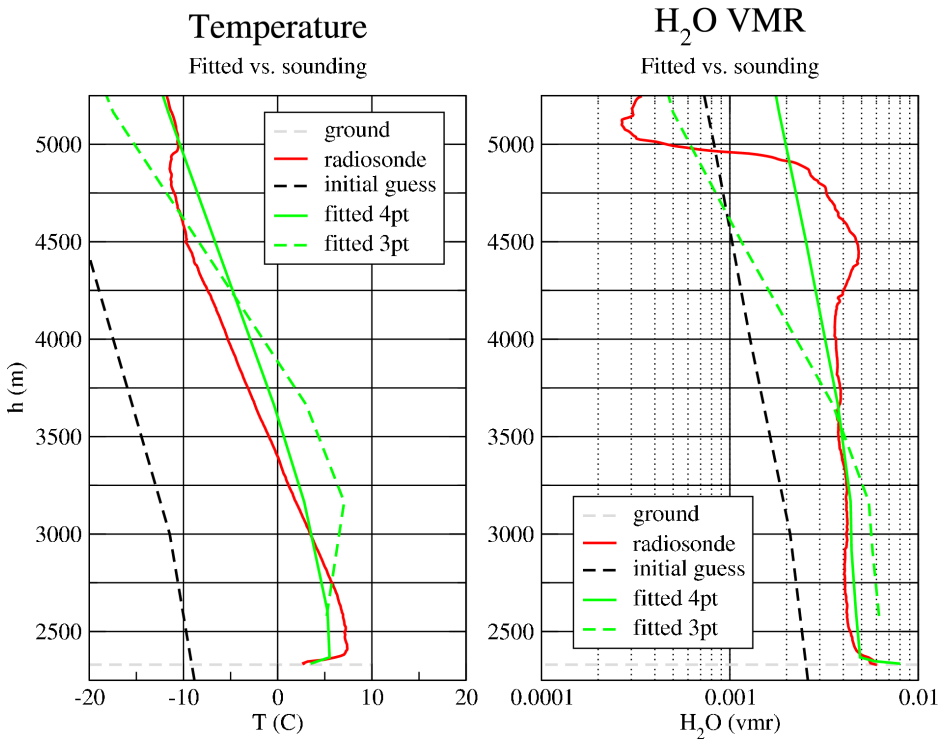
2009 measurements (II)



August-October 2009, RHUBC II Campaign, Cerro Toco, Chile, 5383 m a.s.l.

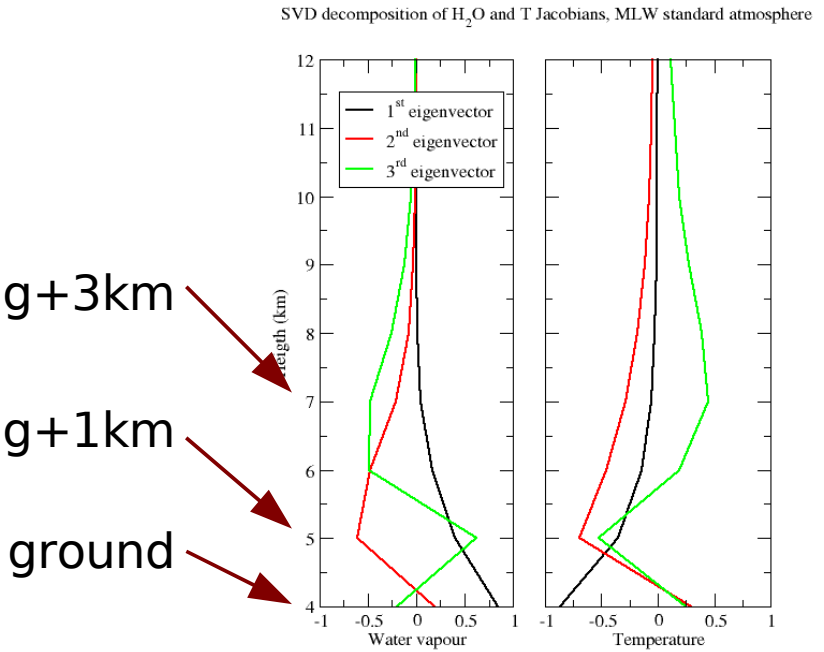
- Extremely dry conditions (PWV < 0.2 mm)
- About 3 months of operation (2 unattended)

4 points fitting

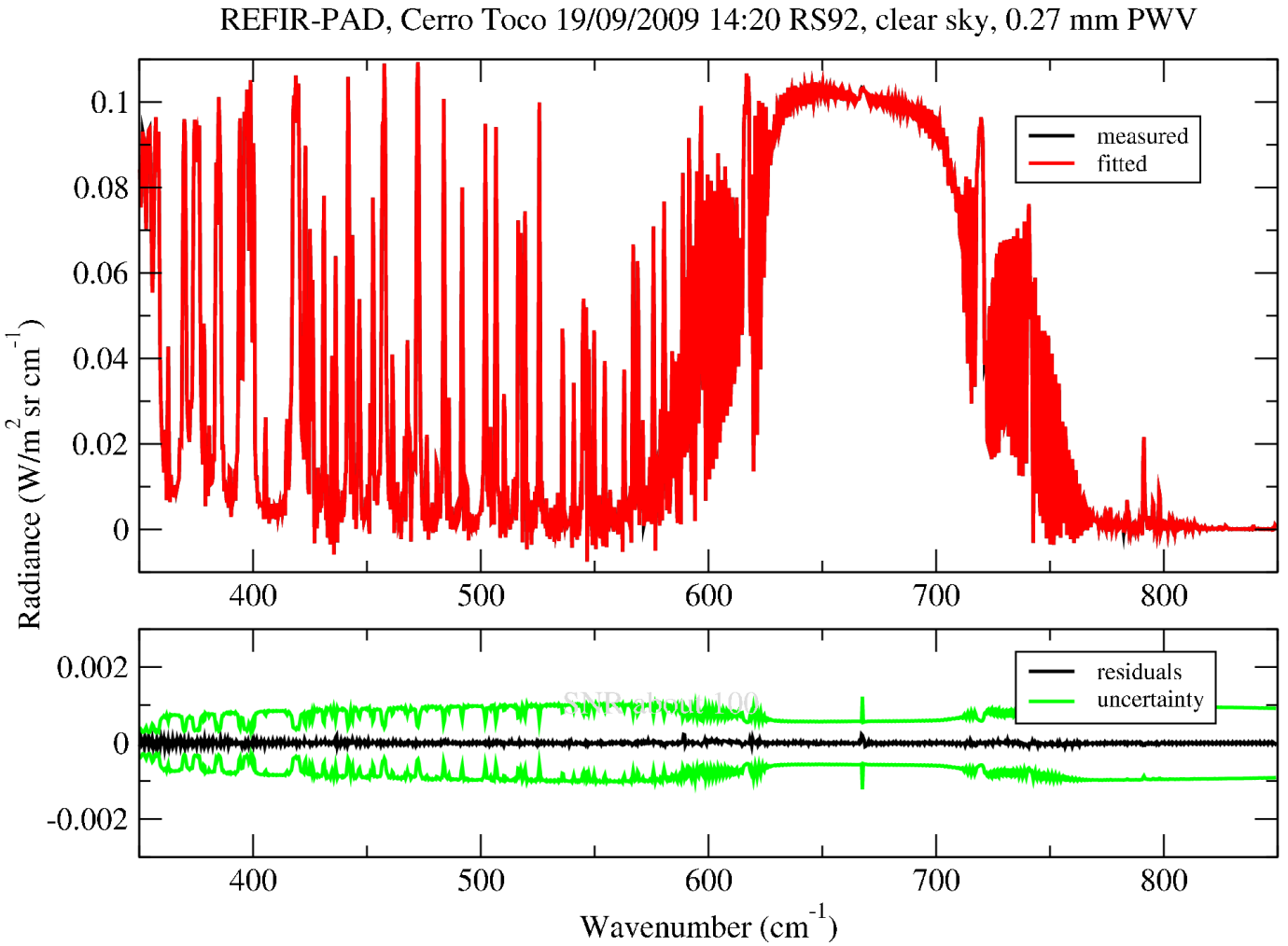


- Added 1 fitted point 50 m above ground to take into account for surface effects

- Fitted points unevenly spaced to reflect weighting functions behaviour with height



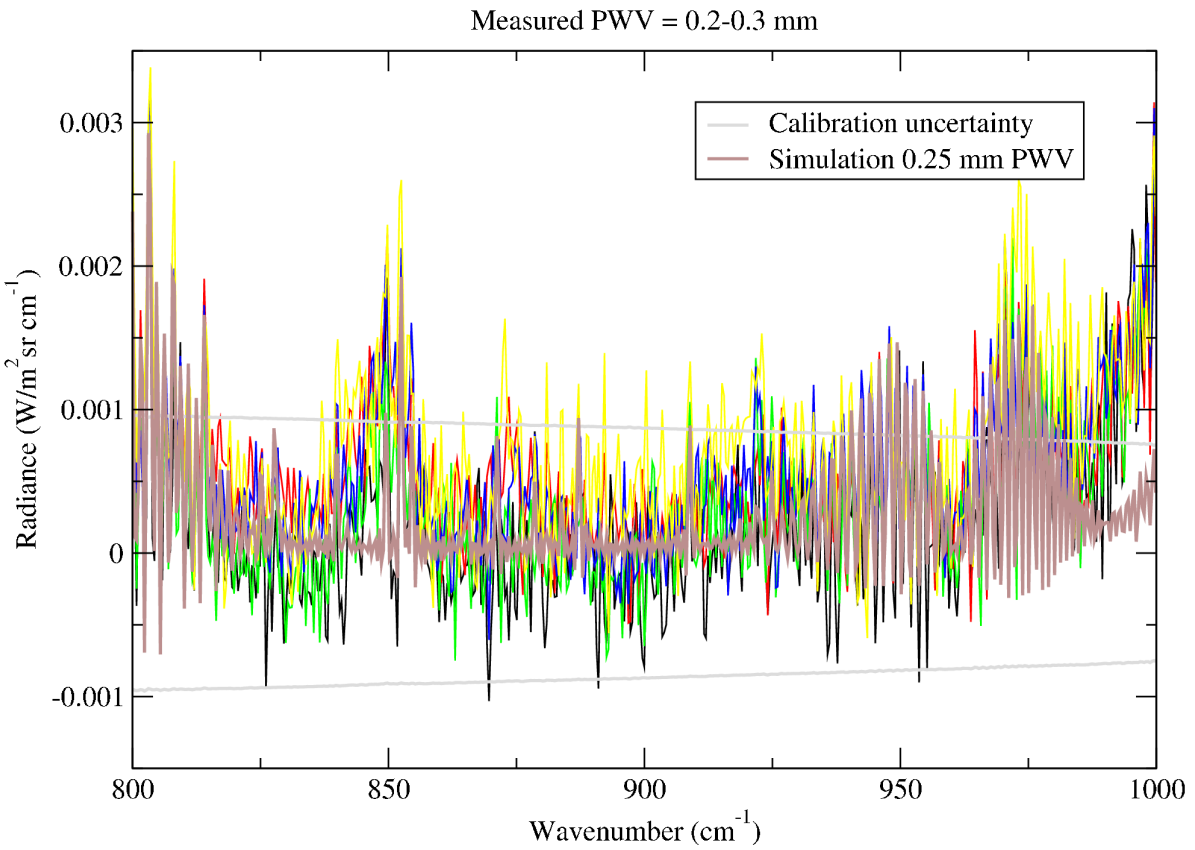
Analysis of synthetic spectra



- LBLRTM simulated spectrum
- atmosphere from radio-sounding
- no error or noise

No significant residuals due to fitting process (χ^2<<1)

Radiometric calibration

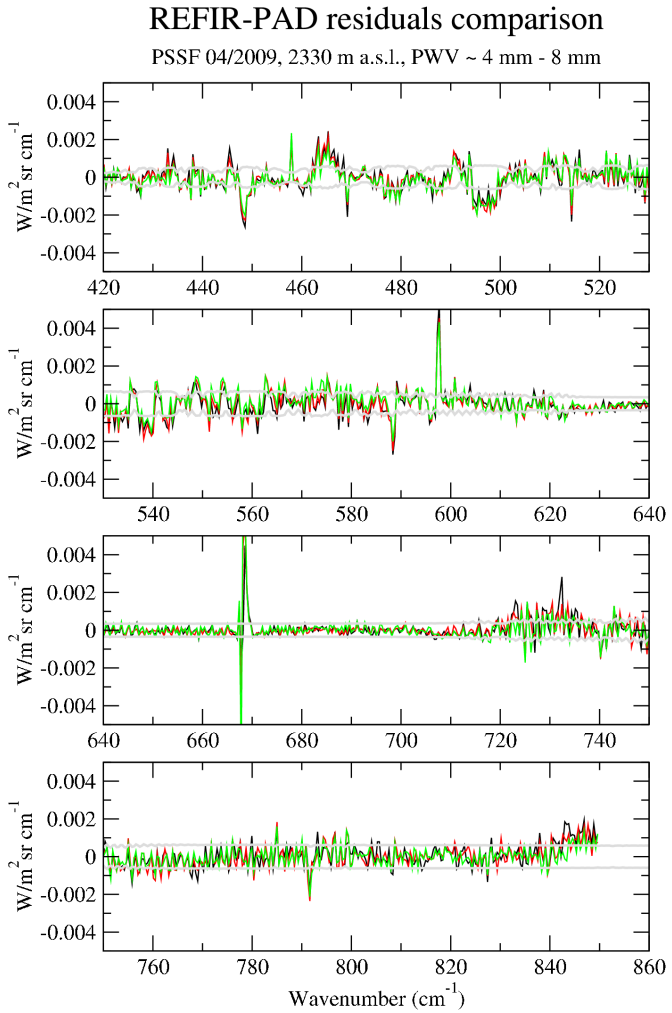


Calibration uncertainty (gray) corresponds to ±0.5K @ 280K

Radiometric accuracy measured in the 860-930 cm^{-1} region:

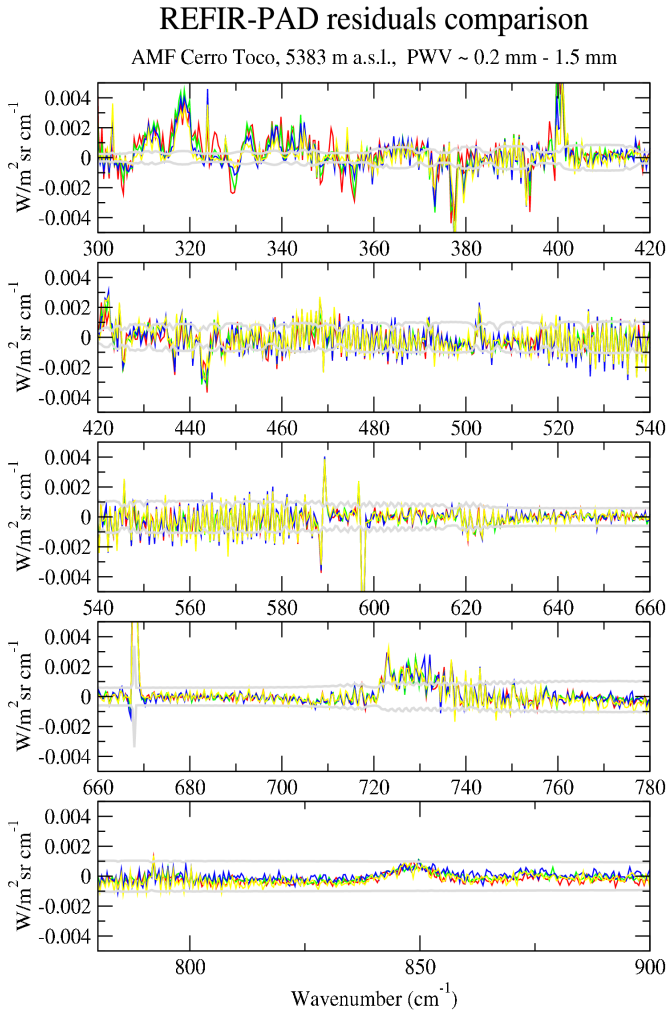
- ≈0.25K RMS
- >0.25K mean

Residuals (high PWV)



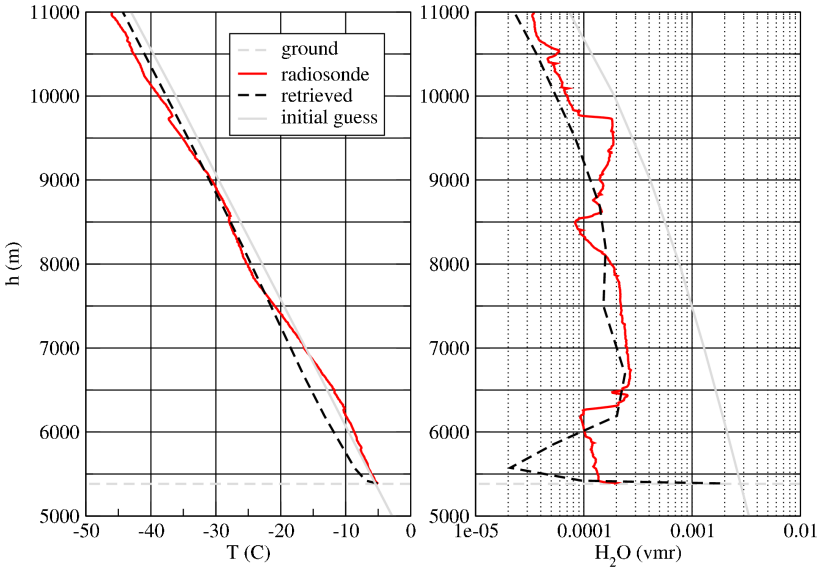
- features in the 450-550 cm^{-1} range significant above calibration uncertainty
- above 550 cm^{-1} model is validated with the REFIR-PAD measurement accuracy
- Spurious effects: CO_2 ν2 Q-branch (667 cm^{-1}), BS absorption (730 and 850 cm^{-1})

Residuals (low PWV)



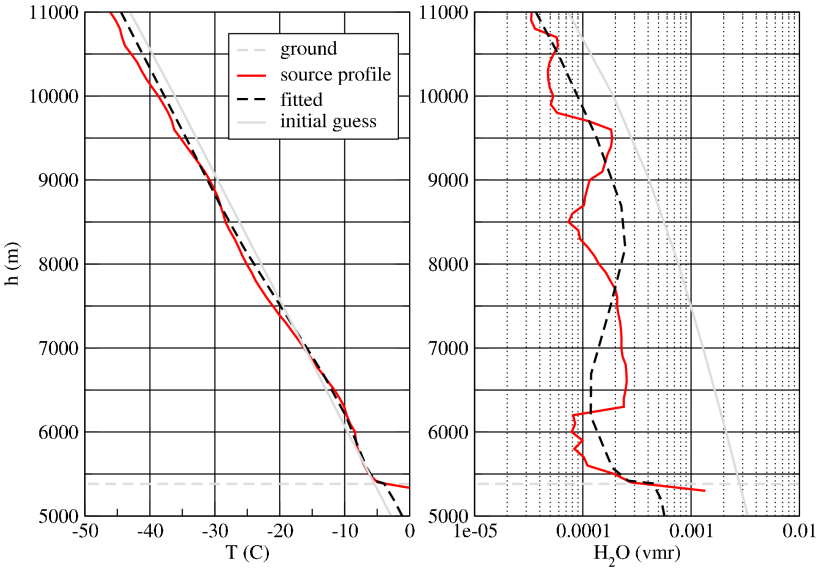
- features in the 300-400 cm^{-1} range significant above calibration uncertainty
- above 400 cm^{-1} model is validated with the REFIR-PAD measurement accuracy
- Spurious effects: CO_2 ν2 Q-branch (667 cm^{-1}), BS absorption (730 and 850 cm^{-1})

Fitting issues



Actual measurement: T and H_2O errors at lower altitudes

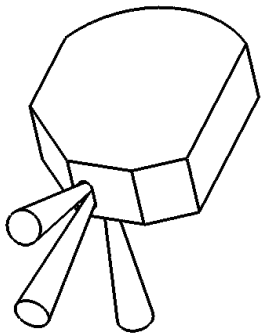
Simulated spectrum (with random noise added): profiles are correct



Conclusions

REFIR-PAD FTS performances:

- FM validated in the 550-850 cm-1 range
- Residuals above calibration error
  - in the 300-400 cm^{-1} range for PWV < 1 mm
  - in the 450-550 cm^{-1} range for PWV > 2 mm



http://fts.ifac.cnr.it