Width of the 183 GHz water vapor line

Vivienne Payne, Jennifer Delamere, Karen Cady-Pereira, Eli Mlawer, Jean-Luc Moncet and Tony Clough

(AER)

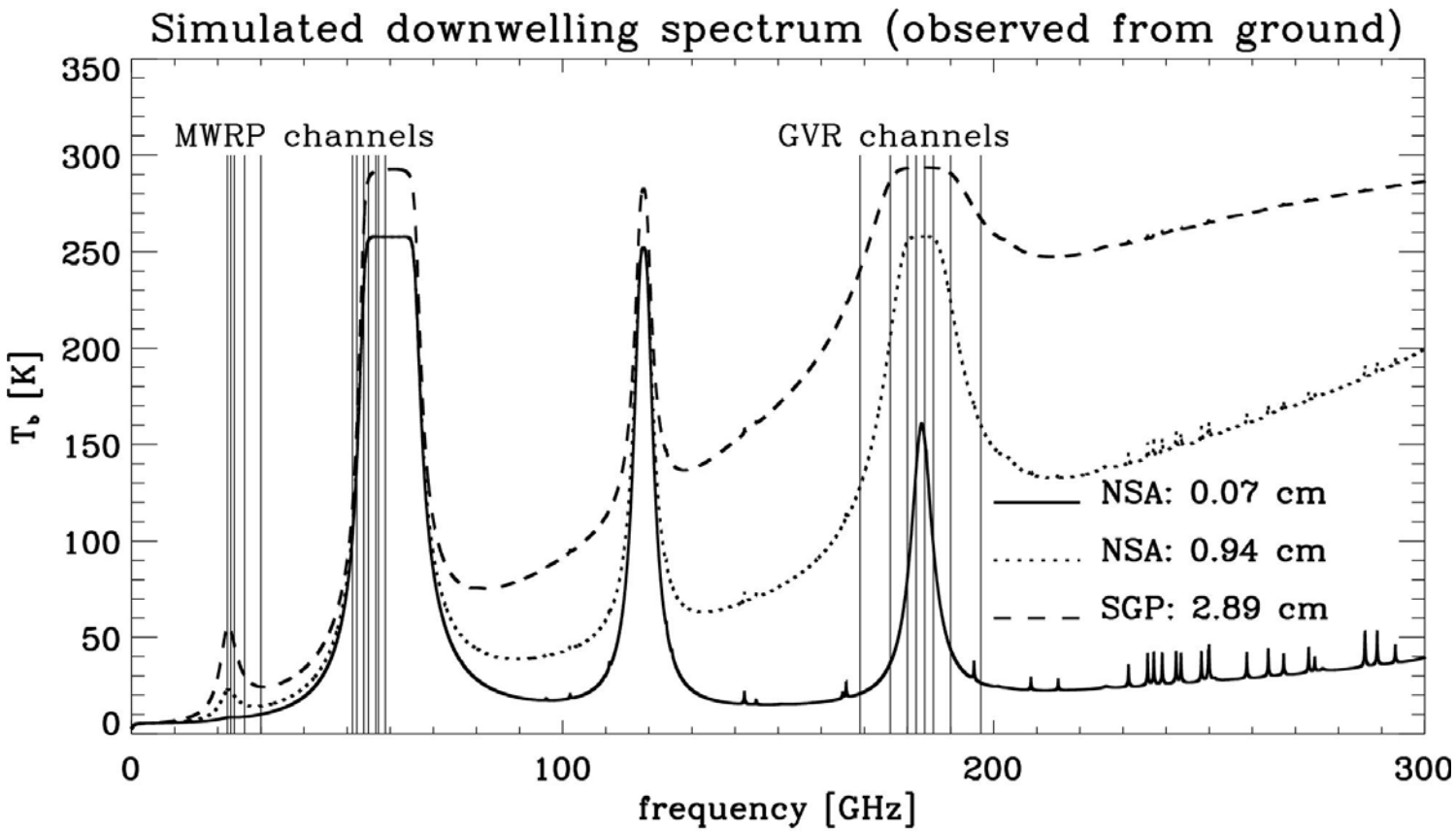
Bob Gamache

(U Mass Lowell)

Contents

- The 183 GHz line
- Datasets
- Sensitivities
- Retrievals and error analysis
- Summary/Conclusions

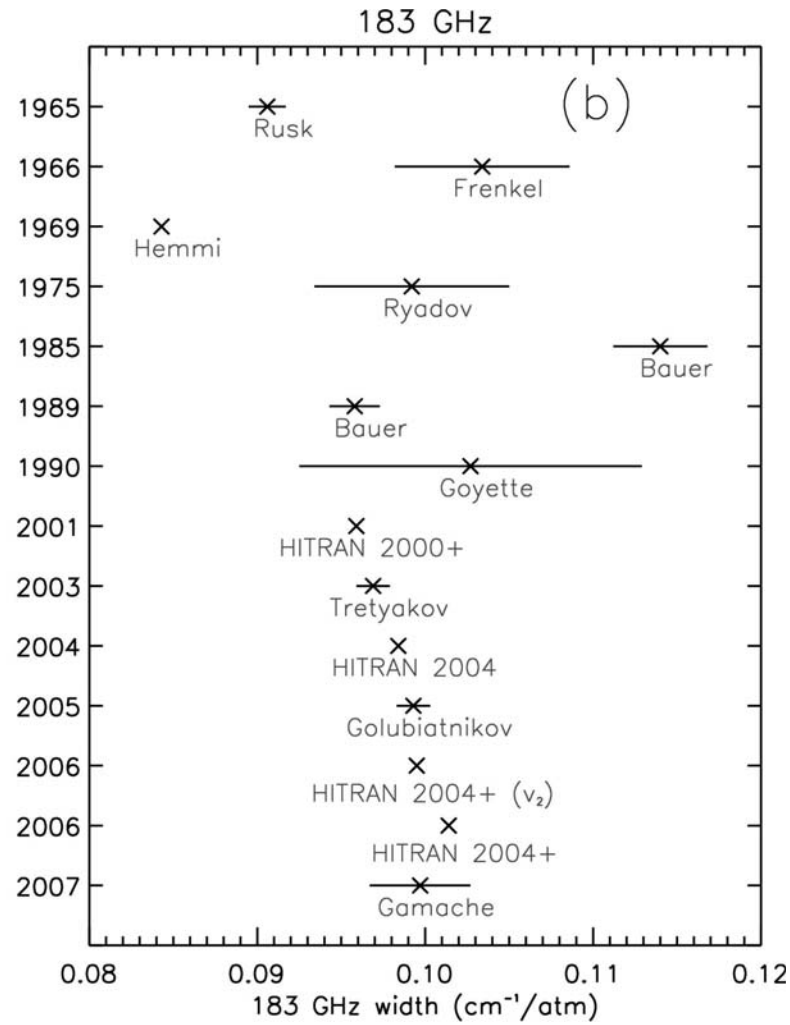
The 183 GHz water vapor line



- 183 GHz line provides high sensitivity to water vapor at low PWV
- Importance for water vapor and CLW measurements

Spectroscopic parameters of the 183 GHz line

- Line intensity
  - Known to better than 1%
- Width
  - HITRAN 2000+ value ~5% different from most recent HITRAN update
  - (~3% PWV error at ~0.2 cm PWV)
- Temperature dependence of width
  - HITRAN 2000+: 0.64 (unrealistic)
  - HITRAN 2004+: 0.77
  - Gamache calculations: 0.77



- Use model/measurement comparisons
- Determine best value of 183 GHz width

(Payne et al. (2007), submitted to IEEE TGRS)

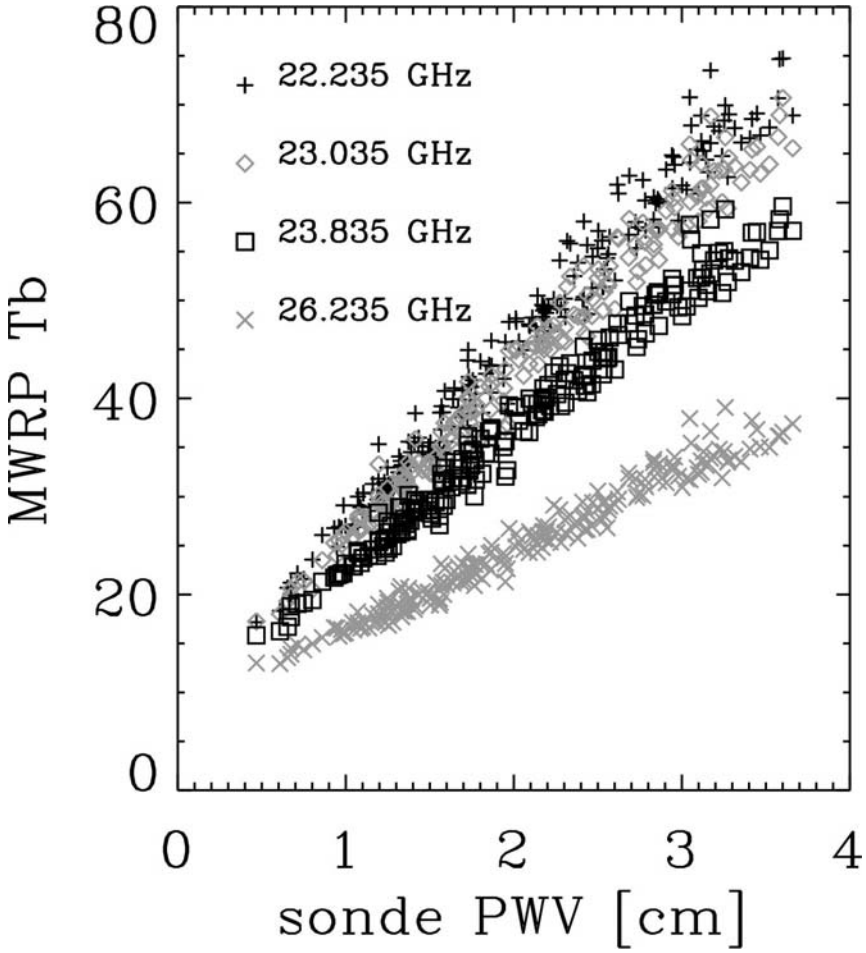
- **Model: MonoRTM**
- **Measurement: GVR at NSA**

GVR dataset

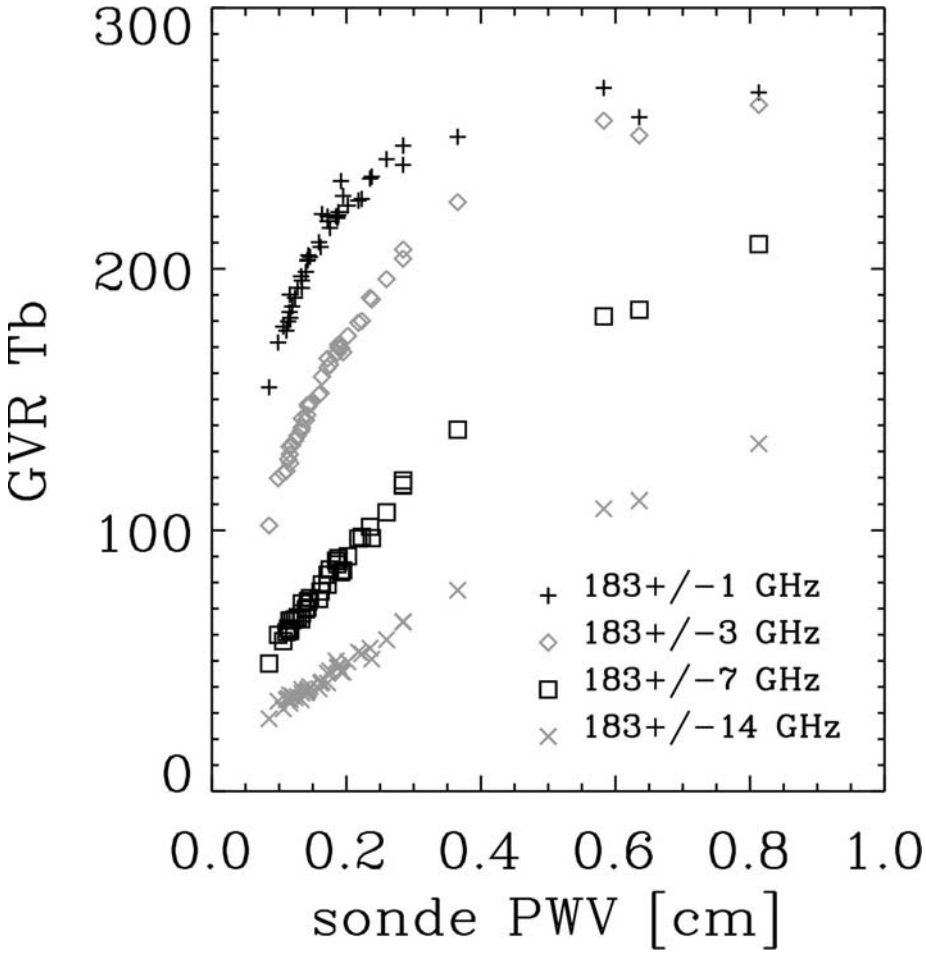
- **G-band Vapor Radiometer:**
  - **Manufacturer: ProSensing (ARM SBIR)**
  - **Operating continuously at the NSA**
  - **4 double sideband channels**
    - » **183+/-1, 3, 7, 14 GHz**
- **Date range used: January to May 2007**
  - **Includes RHUBC campaign**
    - » **Provided a large number of clear-sky sondes**

Response of Tb to PWV

SGP

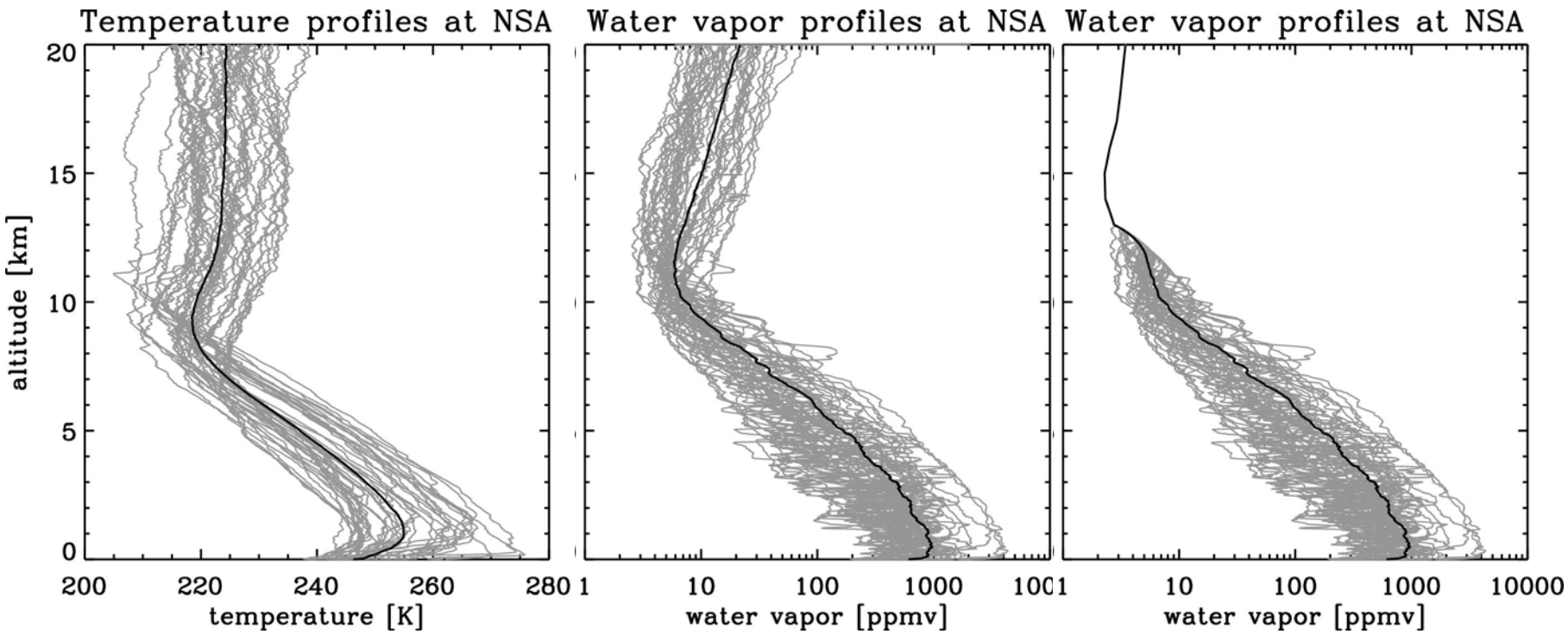


NSA



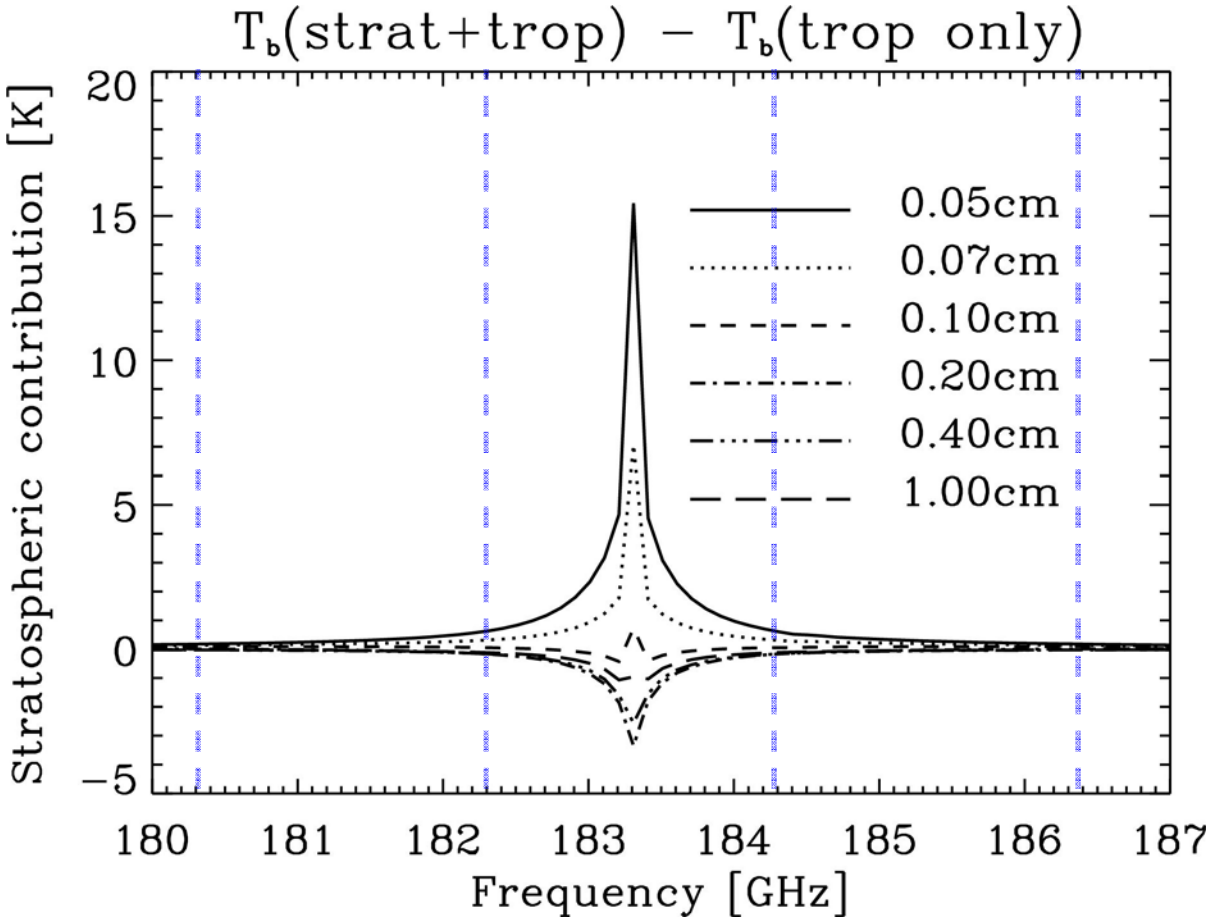
Radiosonde profiles

- **PWV range: 0.07 to 0.8 cm**
- Sonde RH values “bottom out” at 10-12 km
  - Leads to unrealistic H_2O values in stratosphere
  - Stratospheric values set to climatological values
- Tower data added at bottom of profile



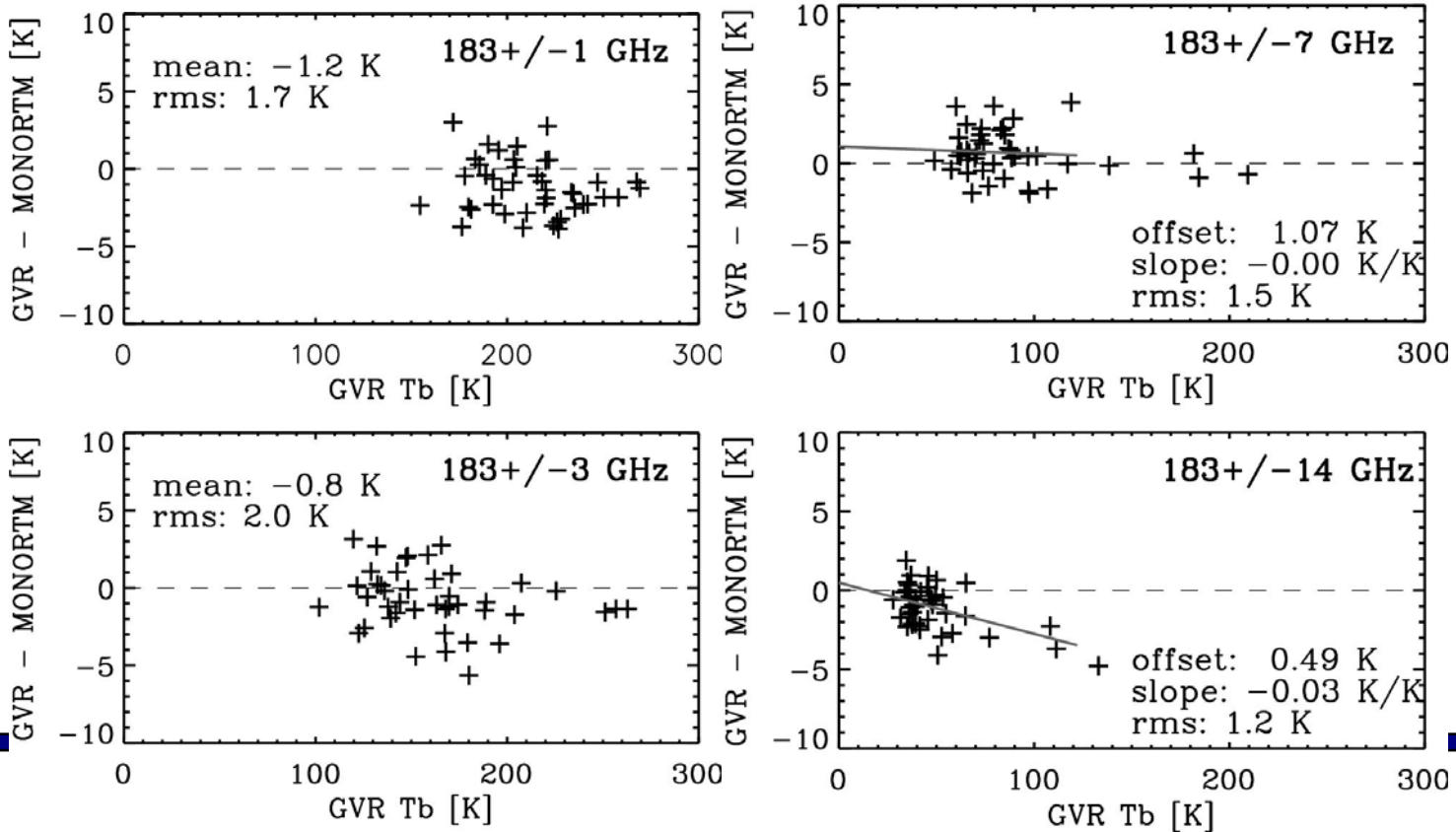
Sensitivity to the stratosphere

- **Sensitivity to stratosphere is small at GVR channel frequencies**

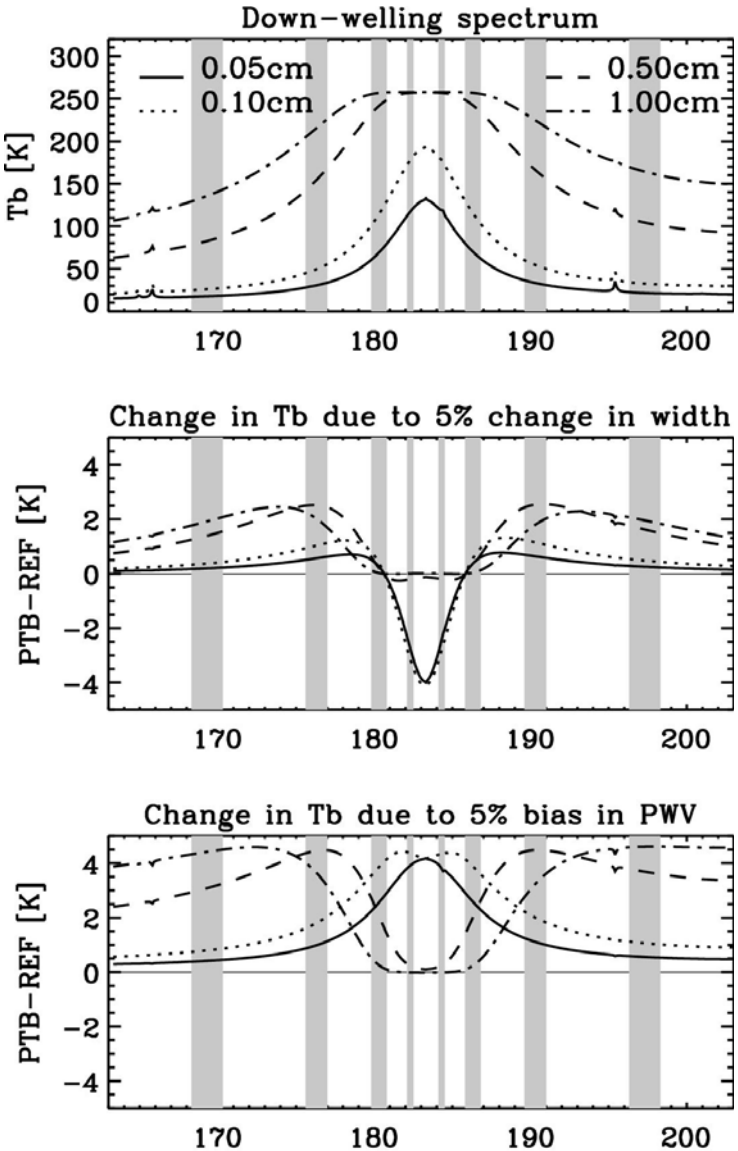


Direct sonde comparisons

- **GVR data averaged over 35 minute "window" around sonde launch**
  - **Data spikes removed from averaging**
  - **GVR measures every 10 seconds, so noise in averaged data is low**
- **Scatter in comparisons is mainly from sondes**
  - » **PWV uncertainty**
  - » **Profile uncertainty**
- **43 "cloud-free" cases (ceilometer data used for cloud clearing)**



Sensitivities



- **"Pivot point": +/-2 GHz**
  - **183+/-3 channel is least sensitive to the width**
  - **183 +/-1 channel is inside the pivot point**
  - **Different response to width, PWV**
  - **Crucial for information on width**

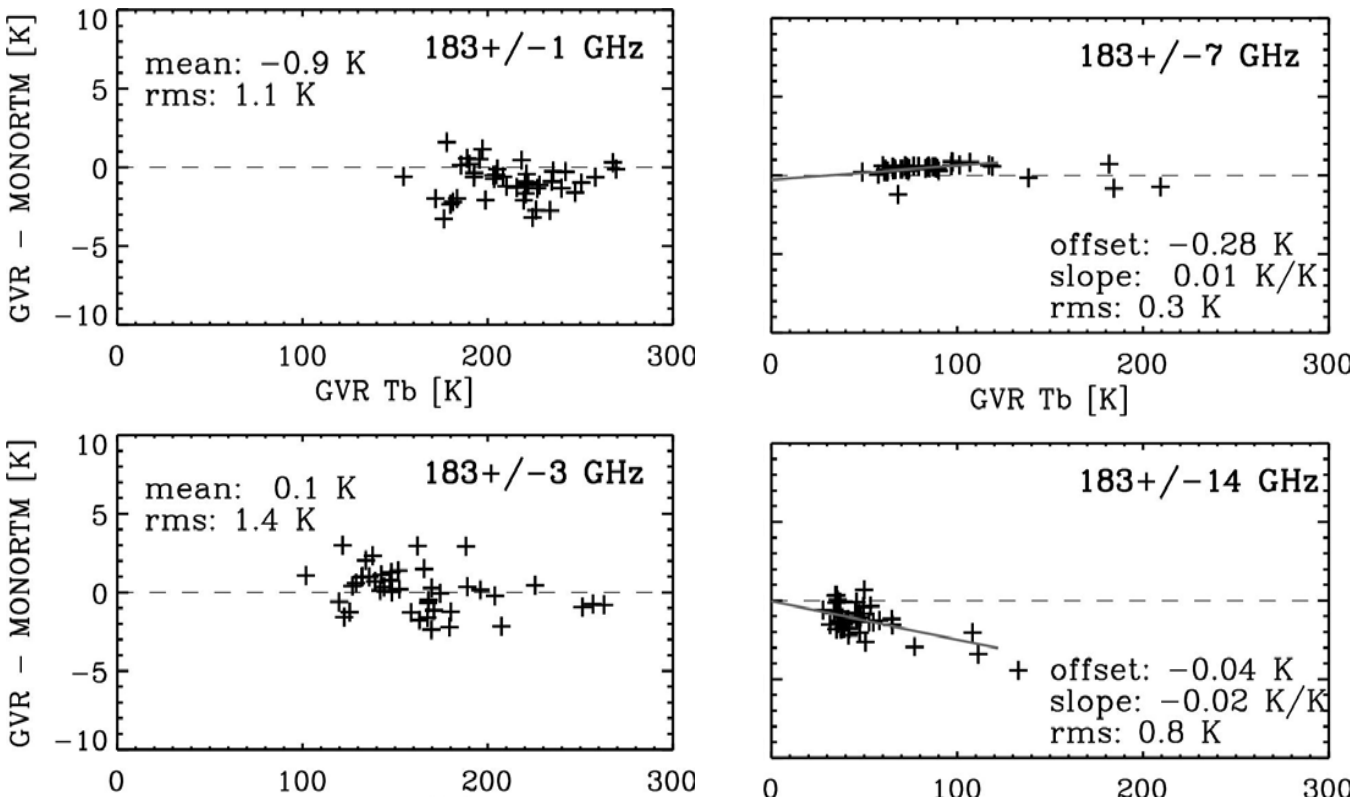
- **Sensitivity to profile shape as well as PWV**
  - **Sonde is the best profile estimate we have**

Retrieval approach

- **Optimal estimation approach**
  - **Use of *a priori* constraints (5% on width)**
  - **Use Gamache value as initial guess and *a priori***
  - **Retrieve PWV scaling for each sonde**
  - **Retrieve width based on all points at once**
  - **Iterative approach**
    - » **Details in paper submitted to IEEE TGRS**

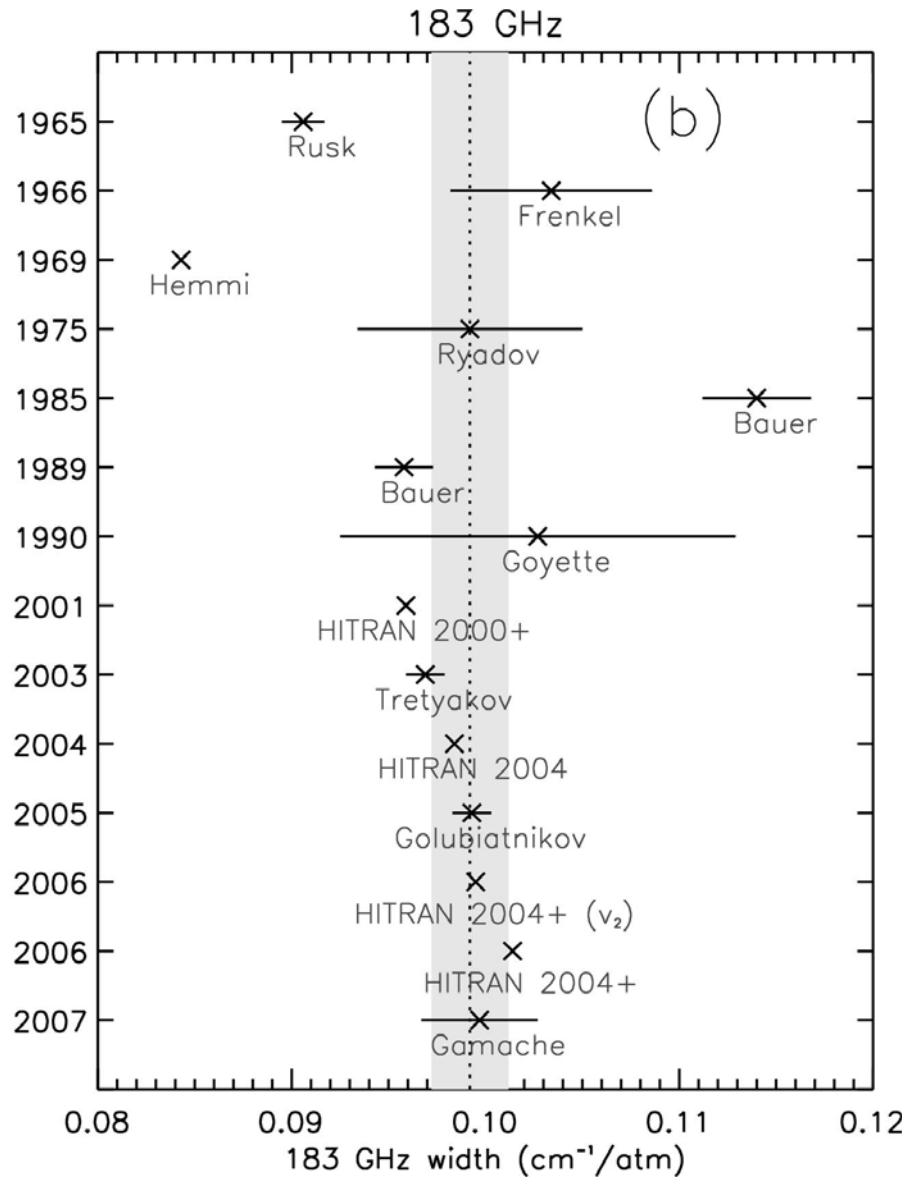
Retrieval result

- **Width value: 0.0992 cm^{-1}/atm**
  - **Estimated uncertainty: 2%**
- **Remaining issues with residuals:**
  - **Scatter on 183 +/-1, +/-3 GHz channels**
  - **Slope at 183 +/-14 GHz**



Width results for the 183 GHz line

Error source	Contribution
Random retrieval error	0.1 %
1 K temperature uncertainty	0.3 %
3 % continuum uncertainty	0.6 %
10 % column ozone uncertainty	0.02%
1.5 % PWV uncertainty	1.5 %
Water vapor profile shape uncertainty	0.4 %
Total	**2 %**



Summary/Conclusions

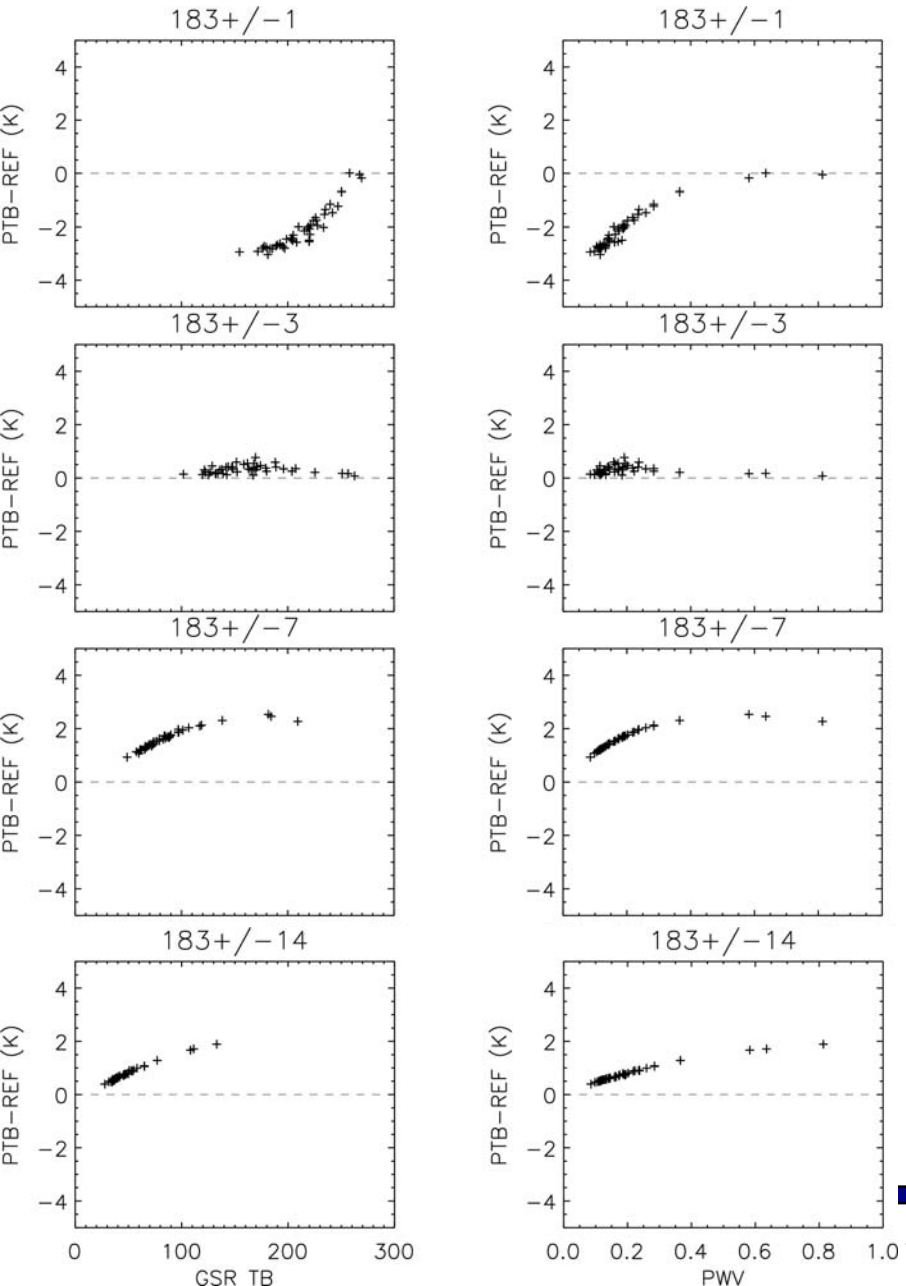
- **Width value: 0.0992 cm^{-1}/atm**
  - **Estimated uncertainty: 2%**

- **Improved estimates of atmospheric water vapor for dry conditions**

- **Demonstrated improvement for NSA AERI_ex QME**

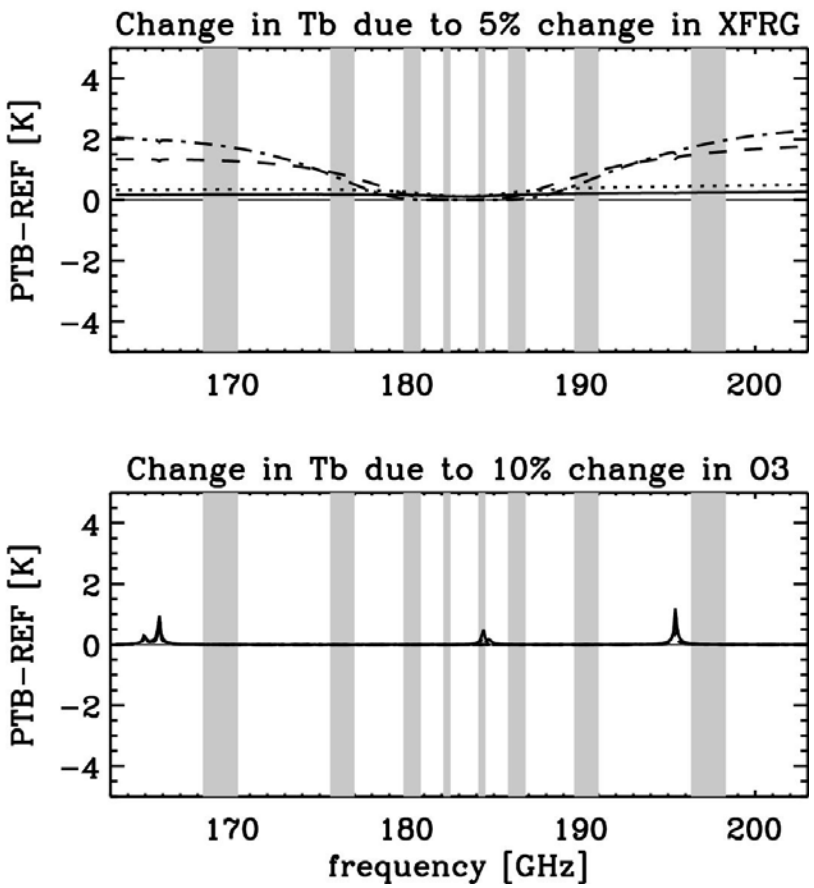
Backup slides

Sensitivities



Changes in modeled T_b for a 5% change in width

Sensitivities



Retrieval approach

- **Iterative approach**
  - **Assume that sonde represents tropospheric H2O profile shape well**
  - **Use direct comparisons, determine “zero PWV” offset for each channel**
    - » **At zero PWV, no sensitivity to width or water vapor**
    - » **Should account for uncertainties in instrument calibration**
  - **Use 183 +/-3 GHz channel to obtain a first pass at a PWV scaling factor**
    - » **This channel is least sensitive to the width**
    - » **Only retrieve for points where Tb < 180 K (try to limit extent of non-linearity)**
  - **All channels used to obtain a first estimate of the width**
  - **Use 183+/-7, 14 channels to obtain a second pass at PWV scaling**
    - » **Brightness temperature threshold of 100 K**
  - **Re-retrieve the width**