



Outcomes of a workshop aimed at improved understanding of biases found in analysis of 183 GHz observations

Hélène Brogniez, Stephen English & Jean-François Mahfouf

She did all the hard work!

Many thanks to all the participants from:
LATMOS, Institute Pierre Simon Laplace, EUMETSAT, Météo-France, NOAA, JPL, ECMWF, Met Office, CNRM, CNR-ISA, CNES, CSU, Universities of Hohenheim, Albany and Maynooth, NASA, Russian Institute of Applied Physics.



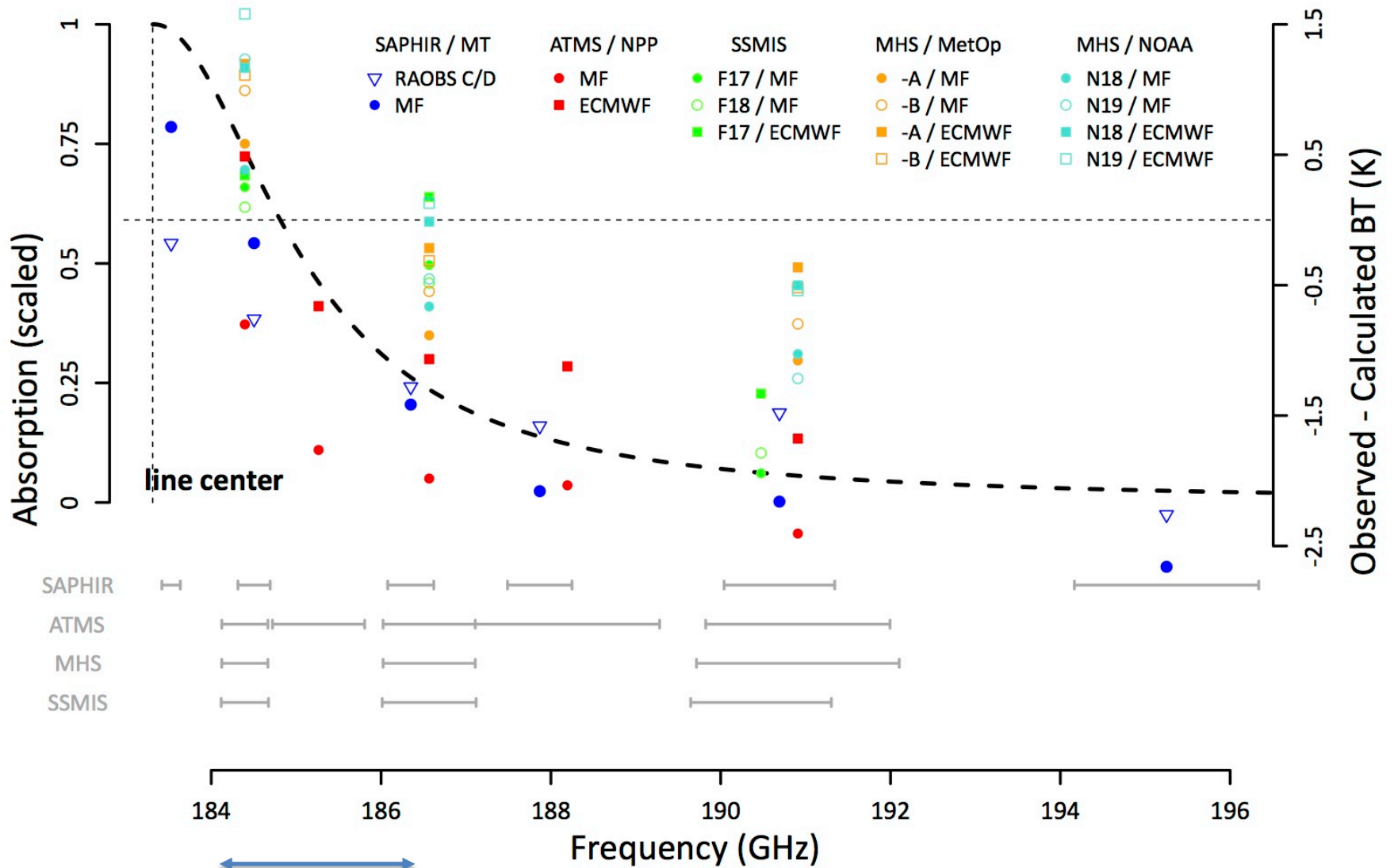
And thanks to these organisations for support and endorsing the activity:



Global Energy and Water Exchanges Projec



What was the issue we discussed in Paris in June?



P. Chambon, A. Geer, H. Brogniez

What did we conclude?

- There is a large bias.
- We don't know why.

But we had some ideas:

- Biases in reference used (RAOBs, NWP short range forecast)
- Spectroscopy and/or Radiative Transfer
- Instrument biases
- Errors in analysis technique / approach to comparisons (e.g. clouds)

We organised into working groups to look at these aspects.

In this talk I will summarise some (but not all!) the considerations and recommendations.

Topic 1: “Reference” Uncertainty

Assess the absolute and relative accuracy of existing “references” for RH

$$\text{Uncertainty (u)} = \text{inaccuracy (a)} + \text{imprecision (p)}$$

closeness to the true value

reproducibility of the measurement

RAOBS : uncertainties in RH(p) from the calibration procedures, the calibration corrections, time-lags and (for some probes) the solar radiation heating

⇒ for the Vaisala RS92-SGP
(the most common probe)

u < 6% RH

+ dry bias of 5%RH at night, when $T < -40^{\circ}\text{C}$

[e.g. Nash et al, 2011; Dirksen et al., 2014]

GNSS Receivers: estimation of the atmospheric Total Column Water Vapour with uncertainty

u < 2% (< 1mm) TCWV

+ systematic dry bias of 2.0mm at moist conditions

[e.g. Ciesielski et al, 2014; Tong et al., 2015]

Lidars: DIAL and Raman lidars gives RH(p) until clouds, over a few km

⇒ DIAL : “self-calibrating”

a < 3% in Lower Troospheric RH & < 6% in UTH

⇒ Raman lidar : need calibration

a < 5%

[e.g. Behrendt et al, 2007; Wulfmeyer et al., 2015]

Topic 1: “Reference” Uncertainty

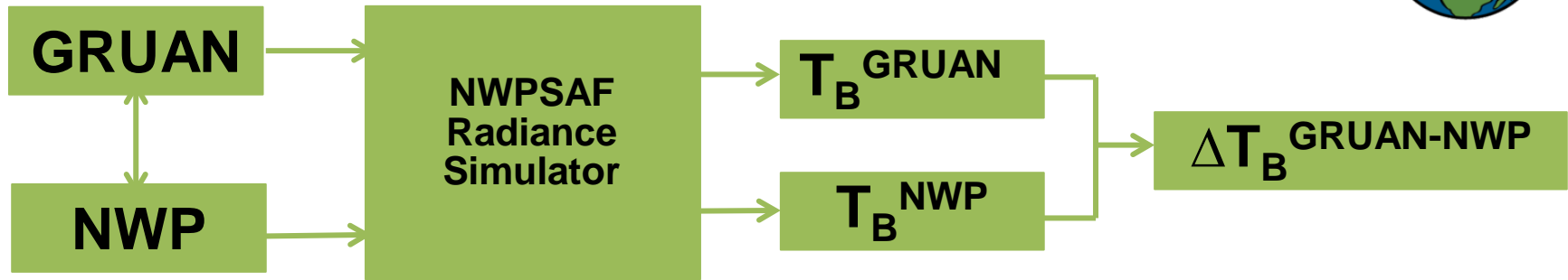
⇒ GCOS Reference Upper-Air Network

[Dirksen et al, 2014; Bodeker et al., 2015]



Traceability to SI standards and characterization of uncertainties.

⇒ Gap Analysis for Integrated Atmospheric ECV for Climate Monitoring (Horizon 2020)



Bill Bell poster
12p.02 Monday

Statements

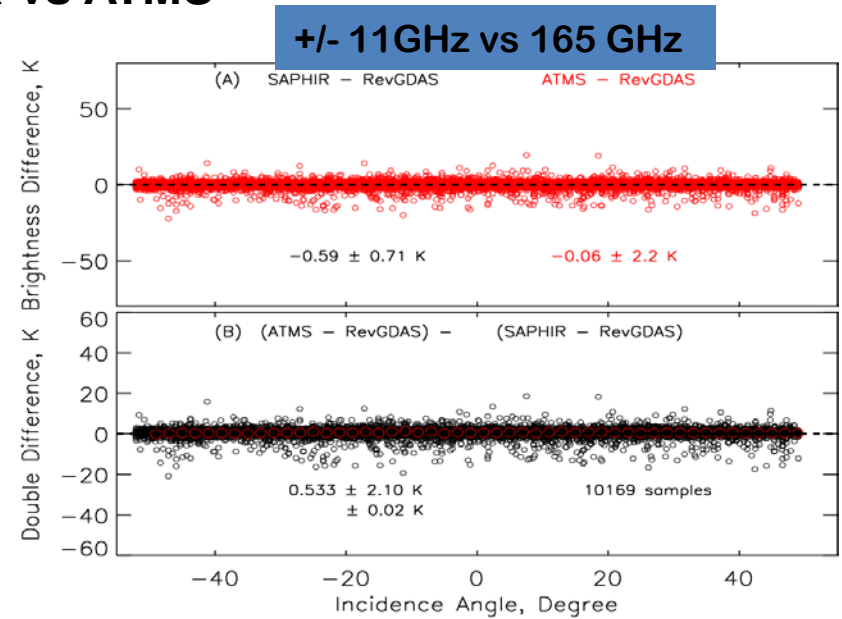
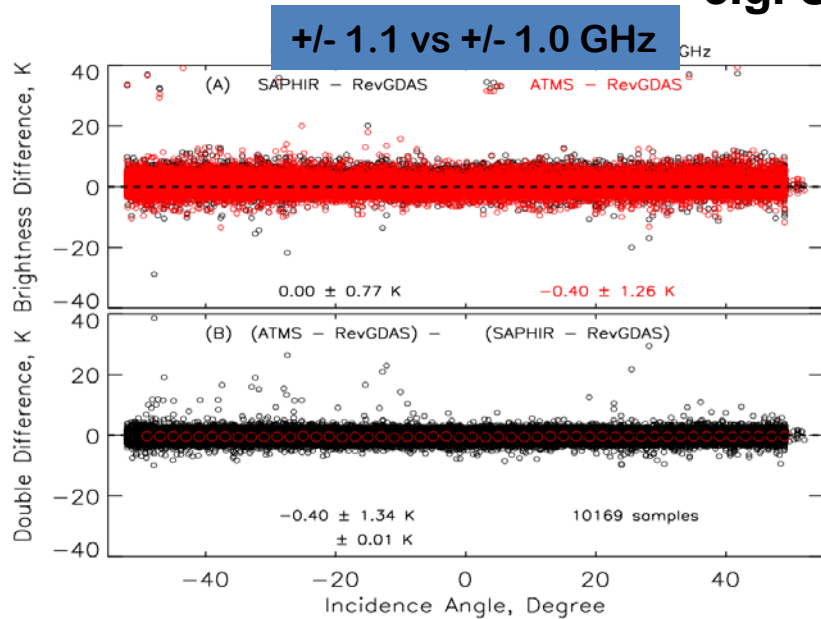
- The next WMO upper air intercomparison campaign should include the new Vaisala RS41 probes.
- Further confirmation needed (e.g. from UCAR dropsonde archive, and further intercomparison).

RAOB uncertainty has been estimated. RAOBS biases can only explain discrepancies in the centre of the line and therefore can't explain the observed biases, in particular the spectral gradient of bias.

Topic 2: Space-borne Instrument biases

X-CAL sensor intercomparison exercise (GPM)

e.g. SAPHIR vs ATMS



[Wang et al -GPM XCAL; Moradi et al., 2015]

Statements

- There is a consistency between the various 183GHz sounders. [Berg and Sapiano, 2013]
- ATMS, the 4 MHS (NOAA and MetOp), SAPHIR and GMI are within 1K for each channel.
- Calibration errors of SSMIS due to emissive reflector and solar intrusions -> different.
- Measured Spectral Response Functions needed (GSICS, WMO SATURN, ITWG, GEWEX...).
- Pitch and roll maneuvers to aid in space characterization (as done for GMI and past TOVS missions) are useful. ITWG has already recognised their value.

Instrument bias is unlikely to explain the observed behaviour, in particular the spectral gradient.

Topic 3: Radiative Transfer Biases

RT model Intercomparison exercises, have shown an agreement of 0.5K (183.31 \pm 1 GHz) 1.5K (183.31 \pm 3 GHz) and 2.5K (183.31 \pm 7 GHz). *[Garand et al., 2001; Melsheimer et al., 2005; Buehler et al., 2006]*

And similar biases in IR channels to the MW biases, though with important differences.

[M. Matricardi, ECMWF, dedicated analysis for the 183GHz workshop]

Spectroscopy: There is absorption by H₂O, O₂, N₂, O₃, and N₂O close to 183 GHz.

- Tests show only H₂O matters. Uncertainty in spectroscopic parameters [$u_{foreign}$ (3%), u_{self} (15%), $u_{temp\ exponent}$ (15%) & $u_{pressure\ shift}$ (20%)] found to **be too small to explain observed biases.**

[Payne et al., 2008]

Continuum: There are significant differences between lab and field measurements of the continuum.

- Lab studies have resulted in **unambiguous detection of water vapor dimer absorption**
- **leads to** variations of 0.5 – 1K in upward looking observations. This may be a contributing factor.

[M. Tetryakov]

Radio Occultation Spectrometer: ATOMMS (Active Temperature, Ozone, Moisture System

- Measured opacity in the wings of the 183 GHz line is higher than MPM93 and AM6.2 which translates into a too high BT, **consistent with the observed radiometric bias.**

[Kursinski et al., 2012]

New/continuing lab measurements are strongly encouraged and exploring new line shape parameterisations should be performed.

We encourage stronger coordination between calibration/instruments experts and RT modelers to ensure the RT simulations are really consistent with what is actually measured.

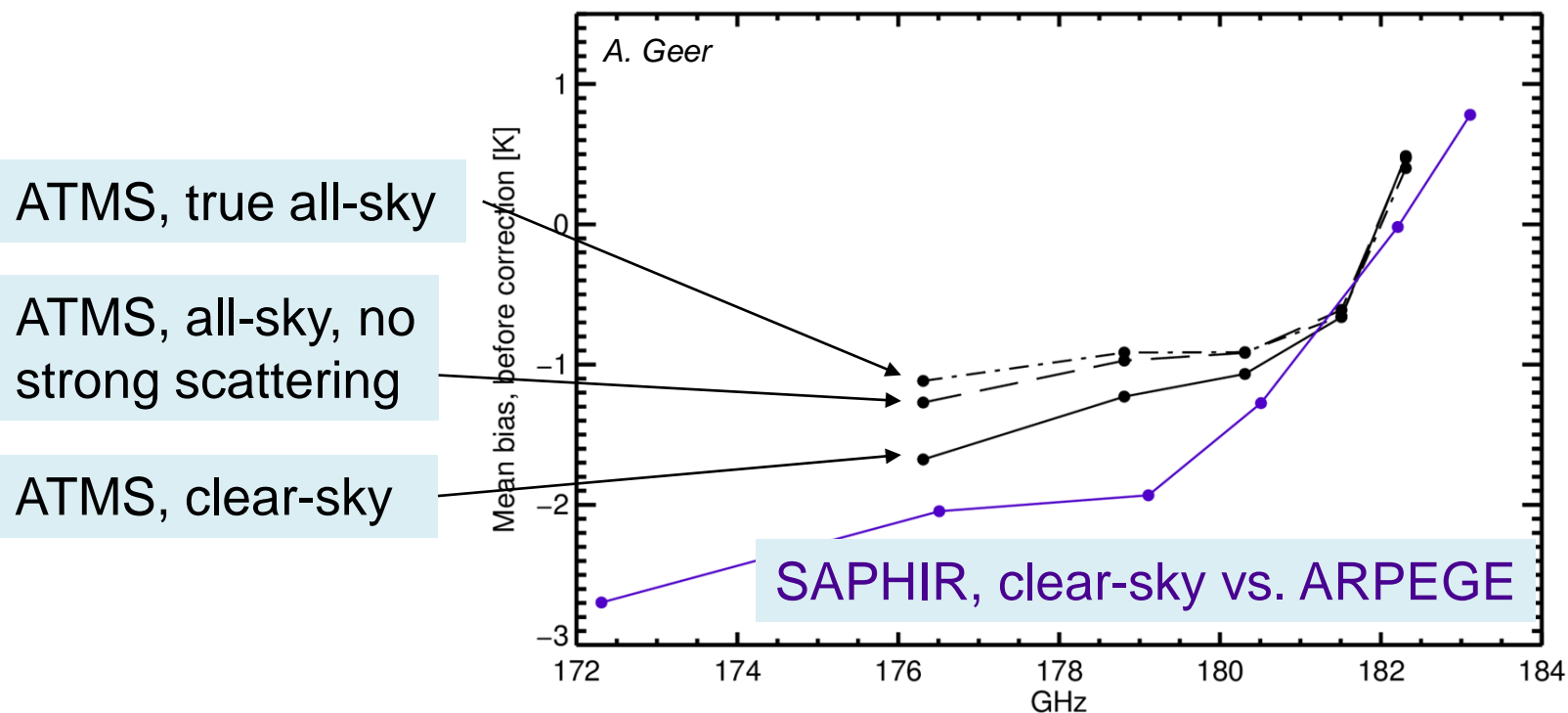
Topic 4: Errors from analysis techniques

- DA systems calibrate to radiosonde so are radiosonde and NWP references equivalent?
- Clear sky approach may introduce biases due to undetected cloud. All sky solves this.

Statements

- Analyses of ATMS Temperature Data Records shows TDR to SDR conversion doesn't explain the bias.
- All-sky results show some but not all the bias may be due to undetected clouds. More characterization of the size of this source of bias is needed.

Undetected cloud unlikely to explain the bias but could be a small contributing factor meaning the bias arising from other sources (e.g. spectroscopy) could then be consistent with the remaining bias.



Summary

- **There is a real, consistent and large bias in the shape of the 183 GHz line against the “best” current references available.**
- **The cause remains unknown, but potential contributing factors have been assessed**
- **RAOB uncertainty has been estimated. RAOB biases can only explain discrepancies in the centre of the line.**
- **Undetected cloud and instrument calibration errors unlikely to explain the bias but could be a factor in combination with biases arising from other sources.**
- **New/continuing lab measurements are strongly encouraged. Development and/or evaluation of new line shape parameterisations is needed. Can ITWG endorse?**
- **We encourage stronger coordination between calibration/instruments experts and RT modelers to ensure the RT simulations are really modeling what is actually measured. Can ITWG endorse and guide how to do this?**