Assessment of value of provision of spectral response functions from CGMS agencies

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Summary of CGMS paper

Abstract/Summary:

- Provision of precise spectral response functions (SRFs) for microwave and infrared instruments has been a CGMS Best Practise since CGMS-44
- Accurate SRFs are increasingly vital in the realm of spectrum management for microwave sensors
- New research shows potential benefits for NWP when accounting for measured SRFs on microwave sensors
- The paper reaffirms the worth of sharing SRF information and encourages agencies to follow the CGMS best practice

Paper: *CGMS-48-WMO-WP-04*
Prepared by Stephen English
[*Link to PDF*]

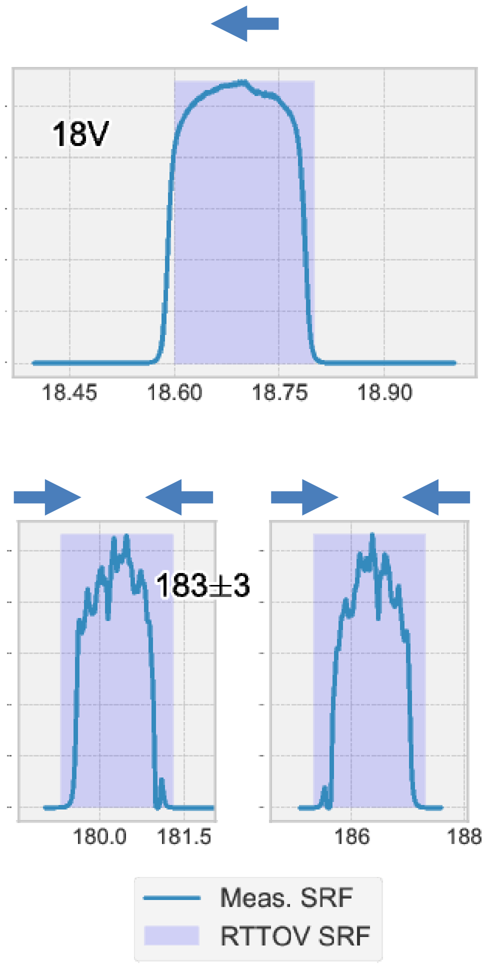
Background

The *Spectral Response Function (SRF)* defines a channel's sensitivity in frequency space

The true SRF can differ from the specification (e.g. on OSCAR), which is usually treated as an idealised 'top hat' function in RTTOV

CGMS guidelines suggest provision of pre-launch SRFs, with some microwave sensors' SRFs now available for public studies:

- ATMS (SNPP, NOAA-20)
- GMI (GPM)
- AMSU-A (NOAA-19)



Spectrum Management

Without precise SRF data, we don't know if RFI encountered is due to in-band emissions in the RR5.340 band or SRFs beyond spec

Pre-launch measured SRFs of GMI are shown, with unprotected parts of the SRF and RR5.340 protected bands

Due to SRFs slightly different from the specification, channels 1-5 of GMI extend slightly into unprotected spectral space

In contrast, ATMS (SNPP) has very little spectral power coming from outside protected bands

GMI

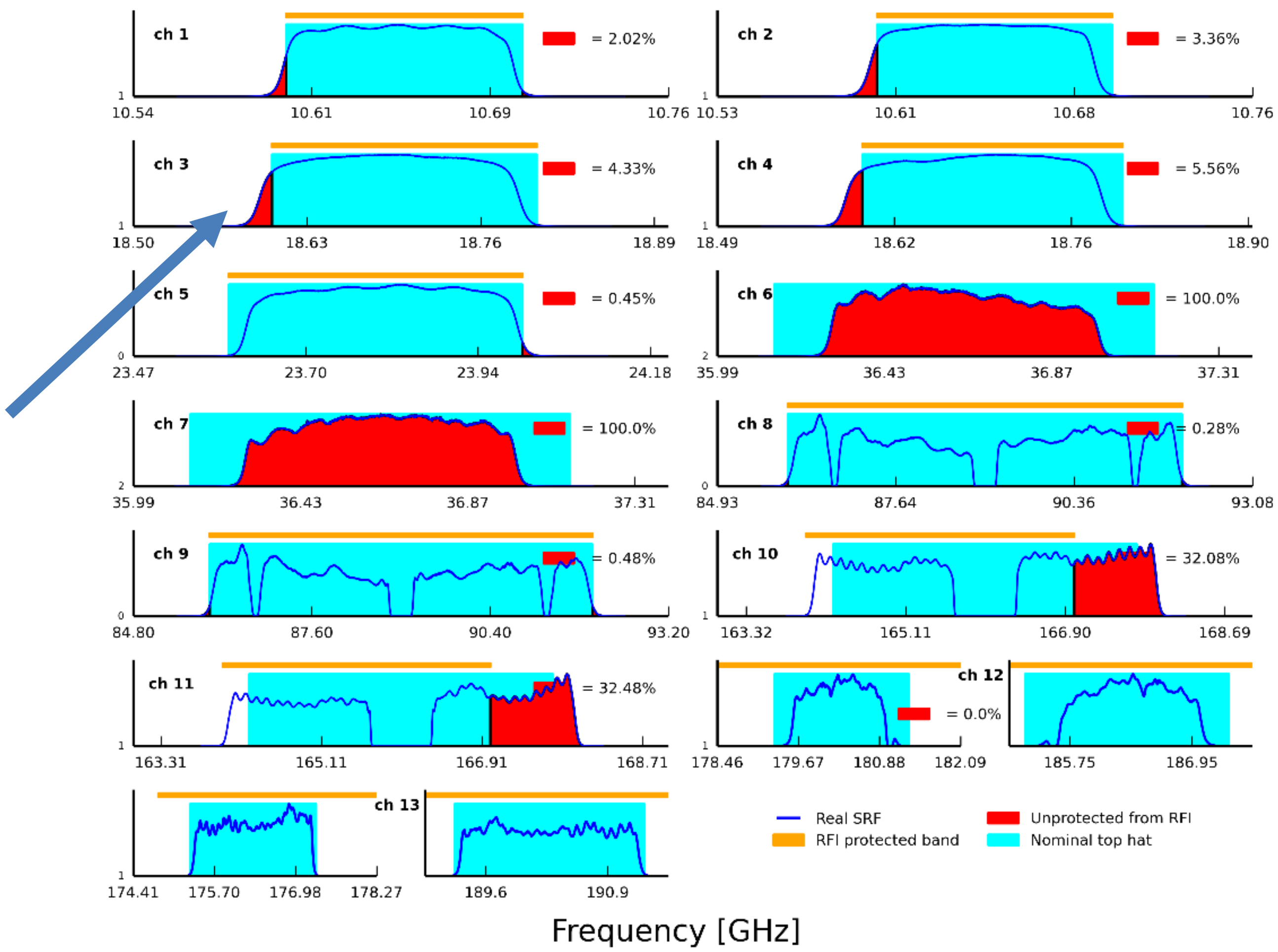


Fig. courtesy of E. Turner (Met Office)

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ATMS (SNPP)

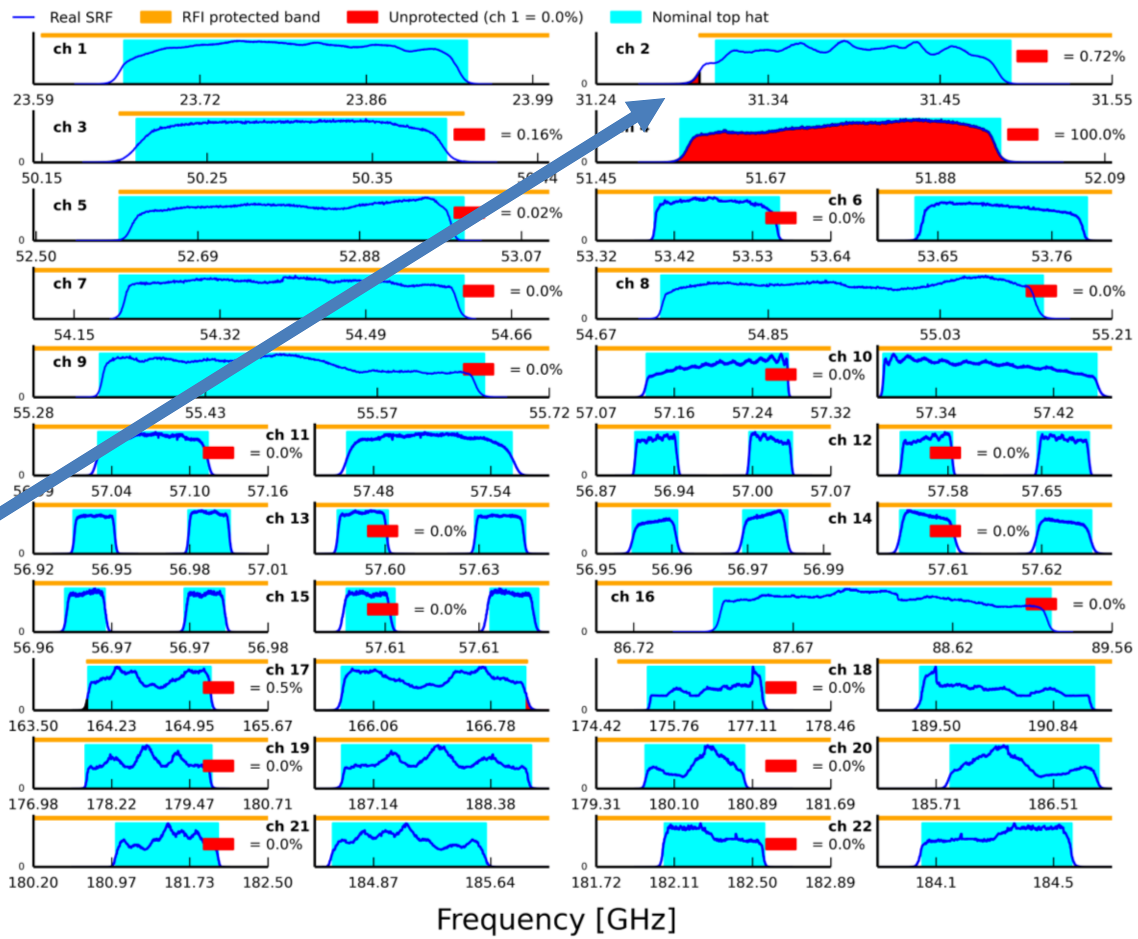


Fig. courtesy of E. Turner (Met Office)

NWP Application

Measured SRFs make possible more accurate radiative transfer modelling and thus improved data assimilation

The new RTTOV coefficients have been assessed in ECMWF's NWP system for four sensors, each via passive monitoring experiments and full assimilation experiments (TCo399 4D-Var) over several months

- **ATMS (SNPP & NOAA-20)**
- AMSU-A (NOAA-19)
- GMI (GPM)

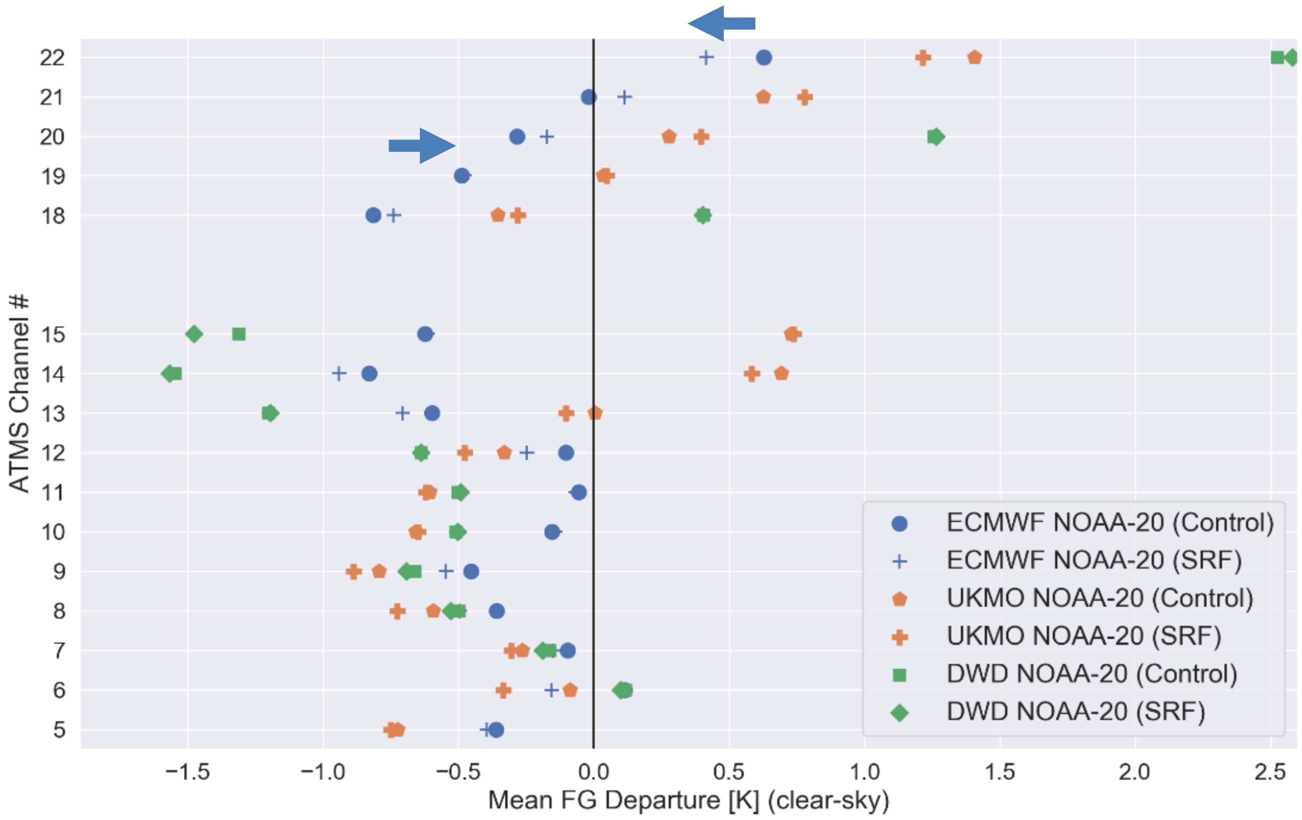
NWP Application

Using this SRF data with RTTOV permitted a collaborative study between ECMWF, Met Office, and DWD to assess commonalities in RT responses (shown)

Here we assessed measured **ATMS SRFs** in monitoring experiments – no analysis done

Improved mean(O-B) before bias correction is a common feature for 183GHz channels in the ECMWF system – true for ATMS and GMI

- c.f. Brogniez et al. (2016)



Duncan D. I., E. Turner, P. Weston, N. Bormann, R. Faulwetter, C. Köpken-Watts, 2019: Evaluation of using measured SRFs in the radiative transfer for microwave sounders at ECMWF, UK Met Office, and DWD. ITSC-22, Saint-Sauveur, 31 October – 6 November 2019.

NWP Application

Assimilation trials at ECMWF show some promise – global std(O-B) for tropospheric temperature channels on ATMS decreases

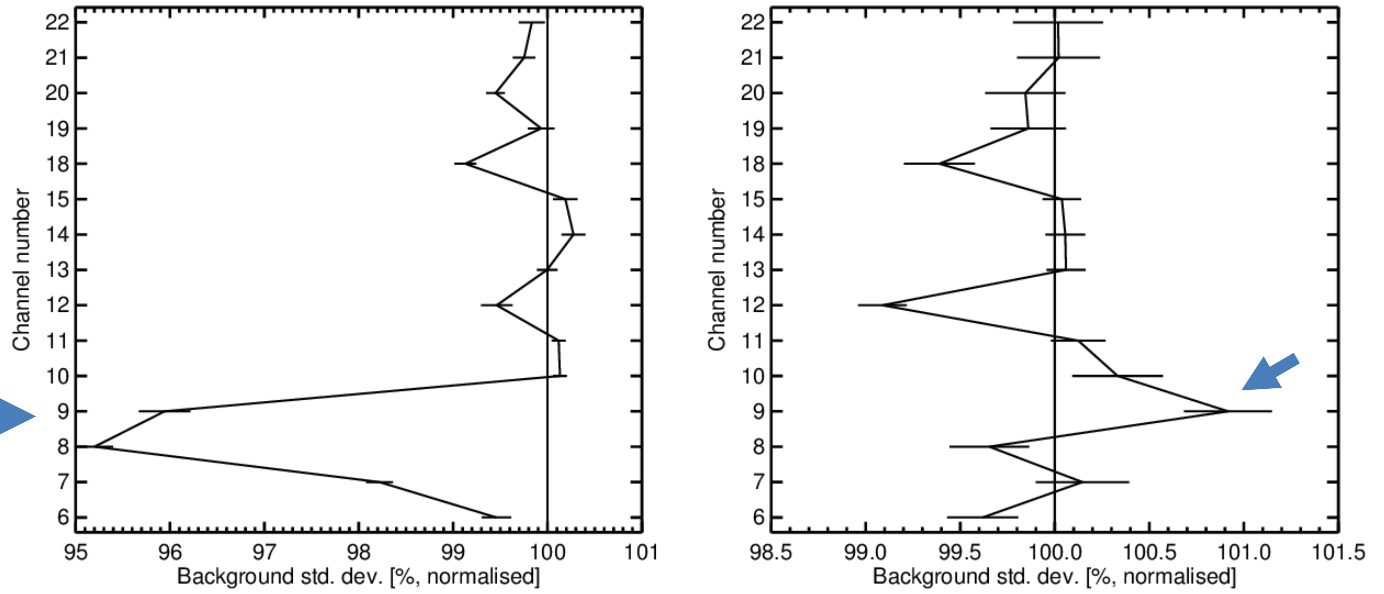
But results can be difficult to interpret:

- VarBC takes time to adjust, sometimes several weeks
- Channels with updated SRF might fight against similar channels (e.g. ATMS ch9 and AMSU-A ch8)
- Responses differ by region

The accuracy of SRF measurements is of *crucial* importance for channels where our assumed errors are already so small (e.g. ATMS ch9 std(O-B) is ~0.12K)

ATMS (NOAA-20)
N. Mid Lats.

ATMS (NOAA-20)
Tropics



ATMS measured SRFs - Control

NWP Application

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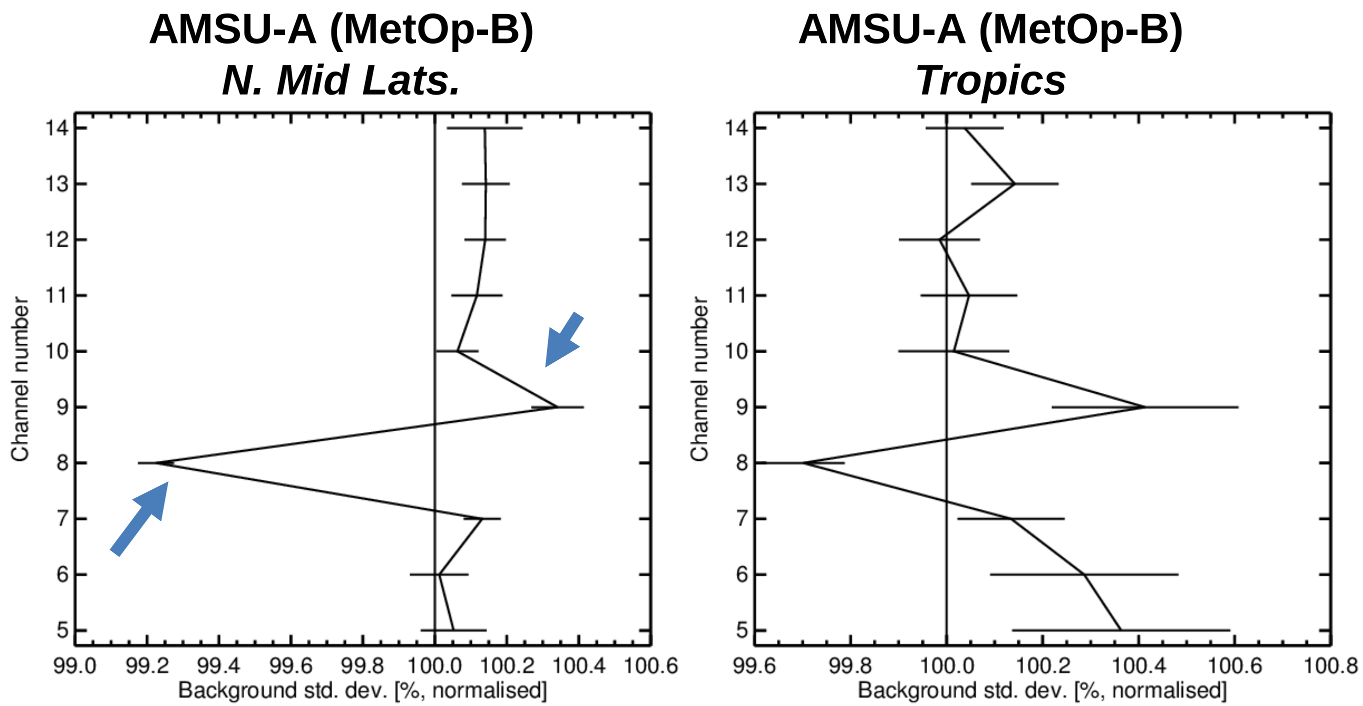


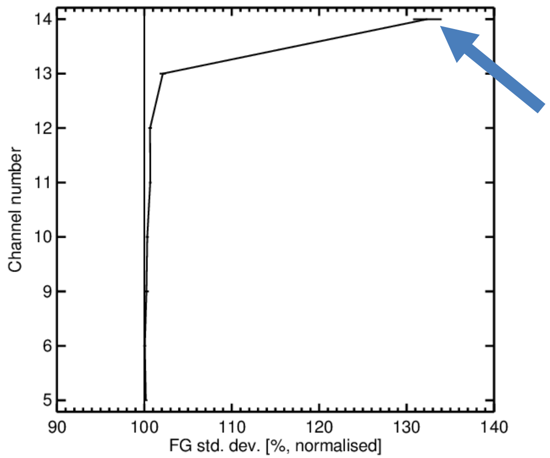
ATMS measured SRFs - Control

NWP Application

NOAA-19 AMSU-A channel 14 is a perfect example of needing accuracy and confidence in the measured SRF's quality

In monitoring and assimilation trials, use of the measured SRF for NOAA-19 AMSU-A caused degradation to stratosphere analysis and worse fits to all other sounders

AMSU-A (NOAA-19)



NOAA-19 measured SRF - Control

AMSU-A (NOAA-19)

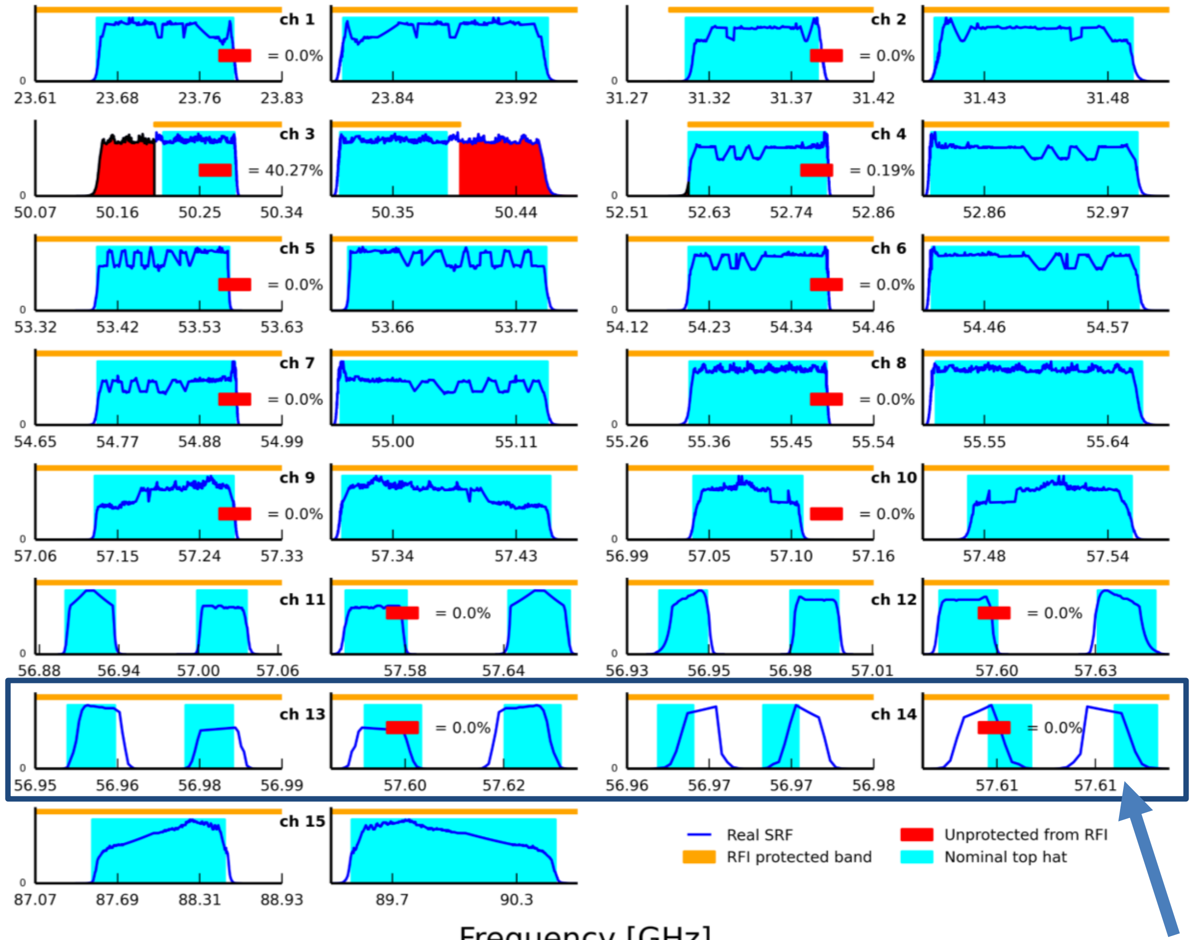


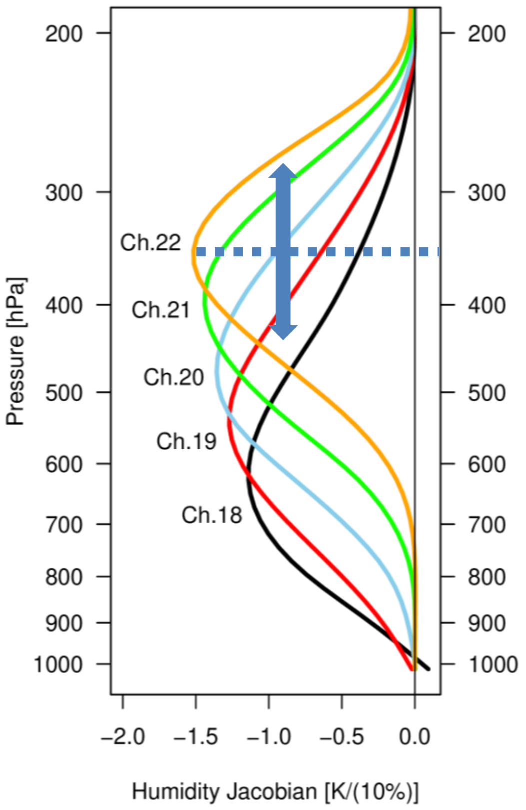
Fig. courtesy of E. Turner (Met Office)

To be considered by CGMS:

Actions proposed:

1. CGMS Members to endeavour that accurate Spectral Response Functions (SRFs) for all microwave and infrared instruments are measured and made available as described in CGMS Best Practise.
2. CGMS Members can also make available validated SRFs together with uncertainty information on their instrument calibration landing pages. Additionally, a document summarizing currently available SRFs and their status/accuracy as well as identifying any missing information can be provided.
3. WMO could establish links to this information through the relevant instrument entries in the OSCAR/Space database.

Discussion



A change in the SRF for sounders is ultimately a change in the *weighting function*:

- Vertical shift in peak of weighting function
- Change in width of weighting function

For MW imagers, SRF discrepancies will largely be dealt with in bias correction already

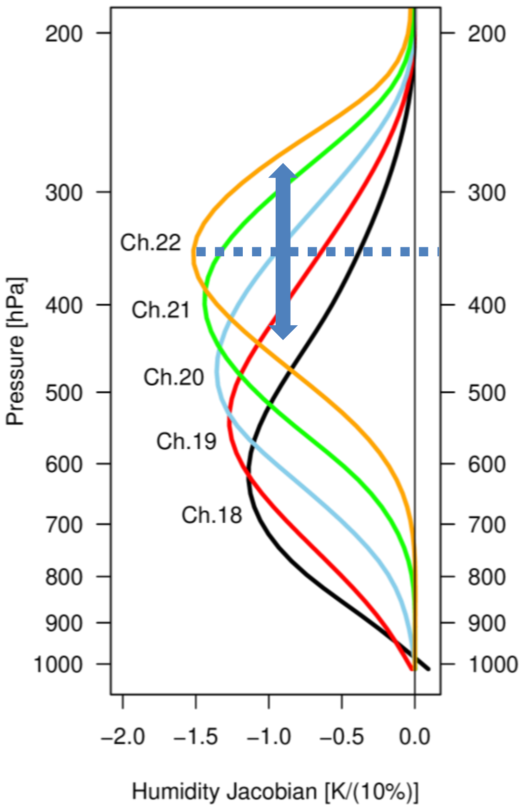
But for sounders, SRF uncertainty translates into weighting function uncertainty – this makes diagnosing problems more difficult

- Is measured SRF for ATMS ch9 correct, or is there a small model bias in tropopause?

In an NWP system, it may be challenging to change SRF coefficients for one sensor when there are several others with nearly identical sensitivities

- e.g. Ideally we'd change SRF specifications for all humidity sounding channels at once

Discussion

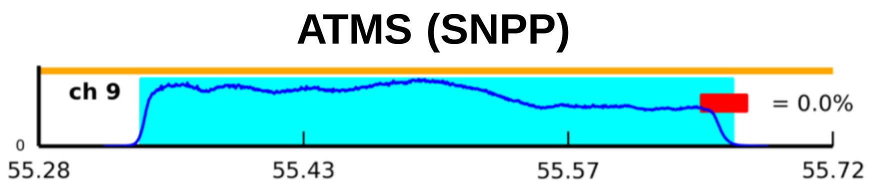


For example:

ATMS ch9 showed a large impact from new SRF, causing the weighting function peak to shift about 3hPa in the mean (more at nadir)

AMSU-A ch8 has an identical centre frequency and spec bandwidth, but ATMS ch9 is a single passband SRF while AMSU-A ch8 is two passbands

- This translates into ATMS ch9 peaking 10hPa higher with 20hPa narrower weighting function than AMSU-A ch8 (according to IFS output)
- Clashes between these two channels have been noted previously at ECMWF, and the SRFs were a prime suspect – but we never knew the cause



Conclusion

In satellite data assimilation for NWP, we are now at a point where SRF mis-specification is a first order error and a key impediment to better utilisation of microwave sounder data

It is not handled well by variational bias correction, making interpretation and diagnosis of errors quite challenging

The small details really matter!

ATMS (SNPP)