Evaluation of using measured SRFs in the radiative transfer for microwave sounders at ECMWF, UK Met Office, and DWD

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1. Introduction

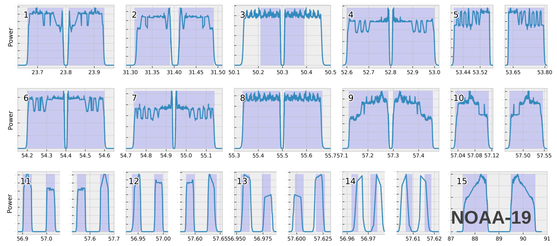
Spectral response function (SRF) data were measured for three currently operational microwave sounder instruments before launch. RTTOV coefficients were calculated for the following sounders:

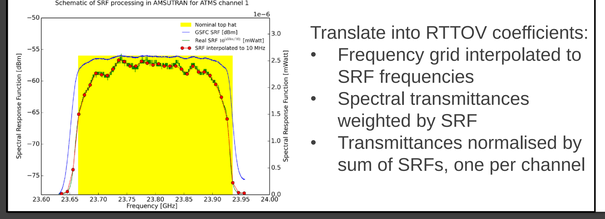
- AMSU-A on NOAA-19
- ATMS on SNPP
- ATMS on NOAA-20

To evaluate the new coefficients and whether measurement simulation is improved, O-B statistics are examined from three NWP centres. For all centres, ATMS observations are used after 3x3 averaging. All statistics use brightness temperatures (SDRs), excepting SNPP ATMS from UKMO, which uses antenna temperatures (TDRs).

2. Measured vs. top hat SRFs

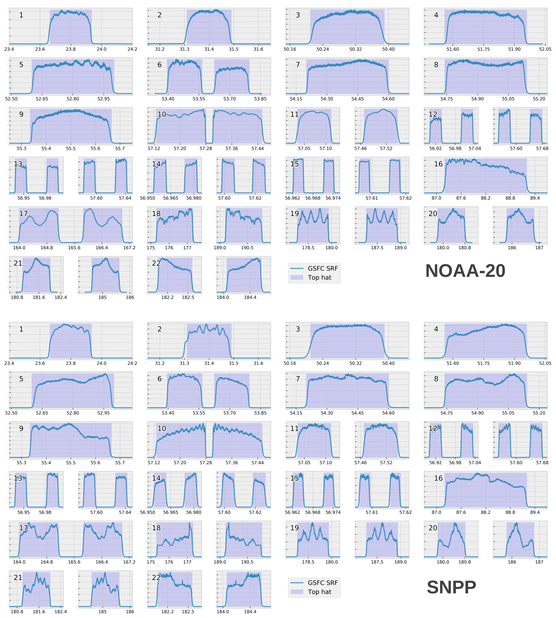
- Biggest shifts for NOAA-19 AMSU-A ch. 13 and 14
- Humidity channels for ATMS have subtle response shifts within bands (see ch. 18 and 20)
- Small differences seen for surface-sensitive channels





Translate into RTTOV coefficients:

- Frequency grid interpolated to SRF frequencies
- Spectral transmittances weighted by SRF
- Transmittances normalised by sum of SRFs, one per channel



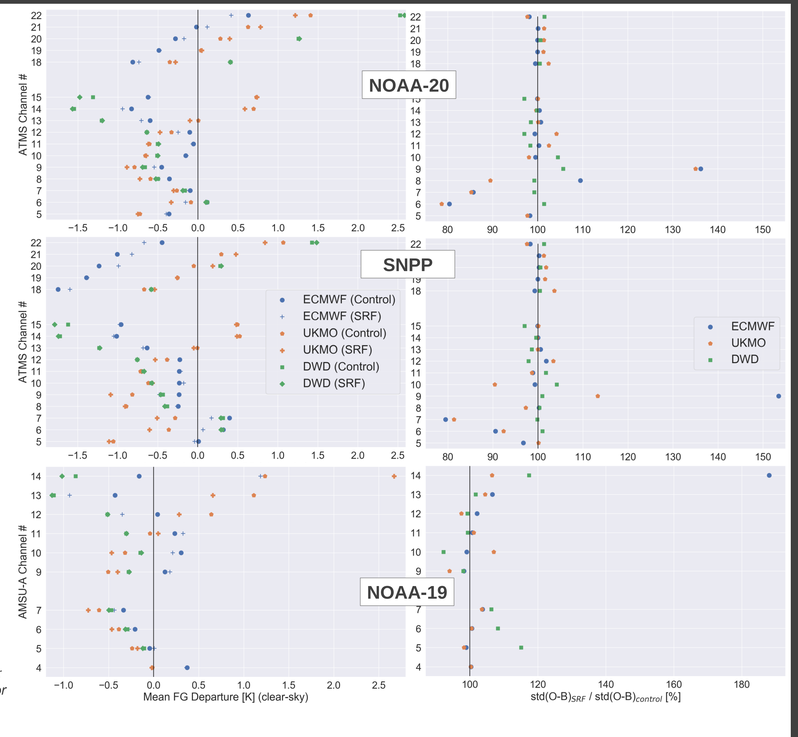
Measured SRFs (blue lines) compared with previous RTTOV SRFs assumed (shaded).

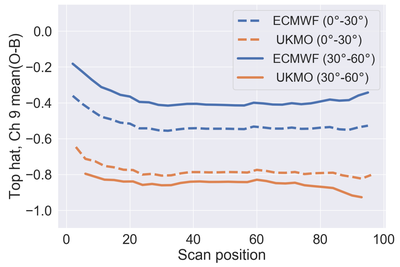
3. O-B statistics from 3 centres

Prior to bias correction, O-Bs are compared with “top hat” (control) and measured SRFs across three NWP centres. Data are limited to ocean-only and clear-sky, but selection was not harmonised between centres.

- Similar shifts in bias are observed between ECMWF and UKMO for most channels
- Smaller changes in bias and std(O-B) at most channels in DWD assimilation experiment
- Differences in the biases for the three centres indicate uncertainty due to model biases in these statistics
- Shifts in mean bias are smaller than total bias, and compared to differences between different centres
- ATMSs show similar response for each centre
- NOAA-19 stratospheric channels have large changes in bias for ECMWF and UKMO but less for DWD
- Humidity channels on ATMS are perhaps most promising, with biases moving closer to zero for many channels and decreasing std(O-B) for ch. 22

ECMWF and UKMO results are from Dec 2018, DWD results are from Jan/Feb 2019. For DWD these are from an assimilation experiment with all three sensors' SRFs changed. For ECMWF and UKMO the data were not interactive, i.e. no analyses were performed.





Scan biases before bias correction

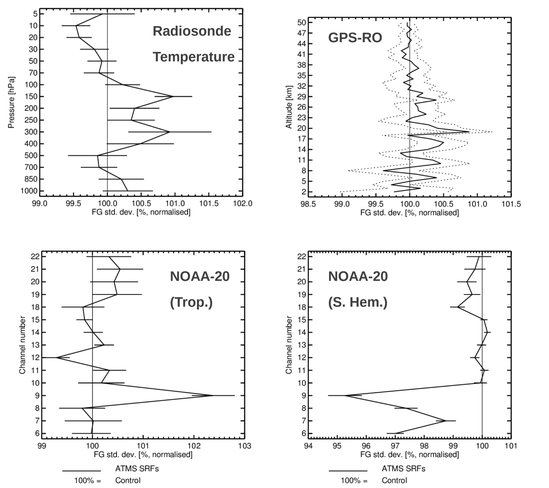
Biases by scan position for NOAA-20 ch. 9, for top hat and measured SRFs, as a function of latitude band

- Differences between centres and across latitudes
- Some channels have Tropics vs. mid-latitudes shift, associated with tropopause sensitivity
- Subtle features like a more abrupt shift at scan edge causes degraded fits for ATMS ch. 9 in the Tropics

4. Assimilation experiments

Separate assimilation experiments were conducted in the ECMWF system (CY46R1) for one month (Dec. 2018), and assimilation experiments were also carried out by DWD. ECMWF's assimilation with NOAA-19 gave stratospheric degradation, so we focus on assimilation with both ATMSs.

- Insignificant medium range forecast impact, albeit for a short assimilation trial
- Fits to background significantly improved for most ATMS channels in the extra-tropics
- ATMS ch. 9 is an outlier in the Tropics, caused by new scan position biases (see panel 3) and connected to degradation to sonde and GPS-RO fits
- Background fits to other observations show mixed results but degraded fits near the tropopause



Std(O-B)/Std(O-B)$_{ctrl}$ given as a percentage, where control uses top hat SRFs. Temp-T is radiosonde temperature. Statistics are for used data after bias correction.

Summary and conclusions

- The use of measured SRFs within RTTOV for 3 microwave sounders has been appraised in 3 NWP models
- Measured SRFs should permit better forward modelling of radiances – this is confirmed through O-B statistics for many channels considered, with some consistency in the results from the 3 centres
- However, changes compared to using idealised “top hat” functions were mostly small, and slight degradations were also apparent for some channels (e.g., ATMS ch 9), and these warrant further investigation
- Forecast impacts in assimilation experiments were mostly small (except for mean stratospheric changes from NOAA-19)
- Note SNPP results should be re-evaluated following the change in the reflector emissivity processing (implemented 15 Oct 2019)
- Measured SRFs are essential for any potential RFI investigations, and this aspect is not covered here

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