

Evaluation of the RTTOV IR/MW underlying spectroscopy in the frame of the C3S project on early satellites



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Motivation

- A consortium leads by SPASIA with the University of Reading, CNRM, UK Met Office and ICARE is involved in the C3S 311c Lot1 "Satellite data rescue" project (2018-2021).
- The first step of the project is to rescue, reformat, and uniformize infrared and microwave satellites observations of the 1970 and 1980s. The second step is to prepare the satellite observation operator RTTOV (Saunders et al., 2018) to simulate these instruments based on the best knowledge about the instrument spectral response function or pass-band. The final step is to work on O-B statistics in order (1) to improve the knowledge about the instruments (ISRF or pass-band) and (2) to prepare the correction bias of these instruments for the next ERA-6 reanalysis.

RTTOV Workpackage objectives

- **Objective 1:** Provide the RTTOV clear-sky coefficients for all instruments listed in Table 1.
 - **Objective 2:** Provide a global evaluation of the RTTOV coefficients based on a large profile dataset.
- Current validation of RTTOV coefficients is based on the comparison between LBL simulations versus RTTOV on the 83 training profiles used for coefficient generation. A more reliable validation will use the independent 25000 diverse profiles dataset of the NWPSAF at 137 levels (Eresmaa and McNally, 2014).
- **Objective 3:** Provide RTTOV coefficients for a pseudo hyperspectral IR instruments (from 200 to 3000 cm^{-1}) with a boxcar SRF at 0.5 cm^{-1} width to study potential SRF shift in O-B.
 - **Objective 4:** Provide forward model errors based on underlying spectroscopy variability or improved spectroscopy.
- In clear-sky simulations, unknowns coming from the underlying spectroscopy is the main source of forward modeling errors.

Name	Platform	IR channels	V7 pred.	V8 pred.
IRIS-D	Nimbus-4	400-1600 cm^{-1}	No	Yes
MRIR	Nimbus-2 and 3	4	Yes	Yes
THIR	Nimbus-4 to 7	2	Yes	Yes
SIRS	Nimbus-3 and 4	7 (+6)	No	Yes
HRIR	NIMBUS-1 to 3	1	No	Yes
MW Channels				
SMMR	NIMBUS-7	10	Yes	No
SSM/T2	DMSP F11-F15	5	Yes	No
MSU	TIROS-N-NOAA-14	4	Yes	No
SSM/I	DMSP F8,F10-15	7	Yes	No
SSMIS	DMSP F16-F19	24	Yes	No

Table 1. List of instruments studied in the C3S project

Results for objective 2: global evaluation of clear-sky RTTOV errors

- The Figures 1 and 2 (left) show results of the map of the difference between RTTOV and LBL models (LBLRTM for IR and AMSUTRAN for MW, respectively). The use of the NWPSAF 137 levels diverse profile dataset allow to show the global distribution of the differences. The figures 1 and 2 (left) are latitudinal plots of the errors for 2 channels in SIRS and one channel on SMMT/2. For SMMT/2 the slight dependency to the integrated water vapour content is shown.

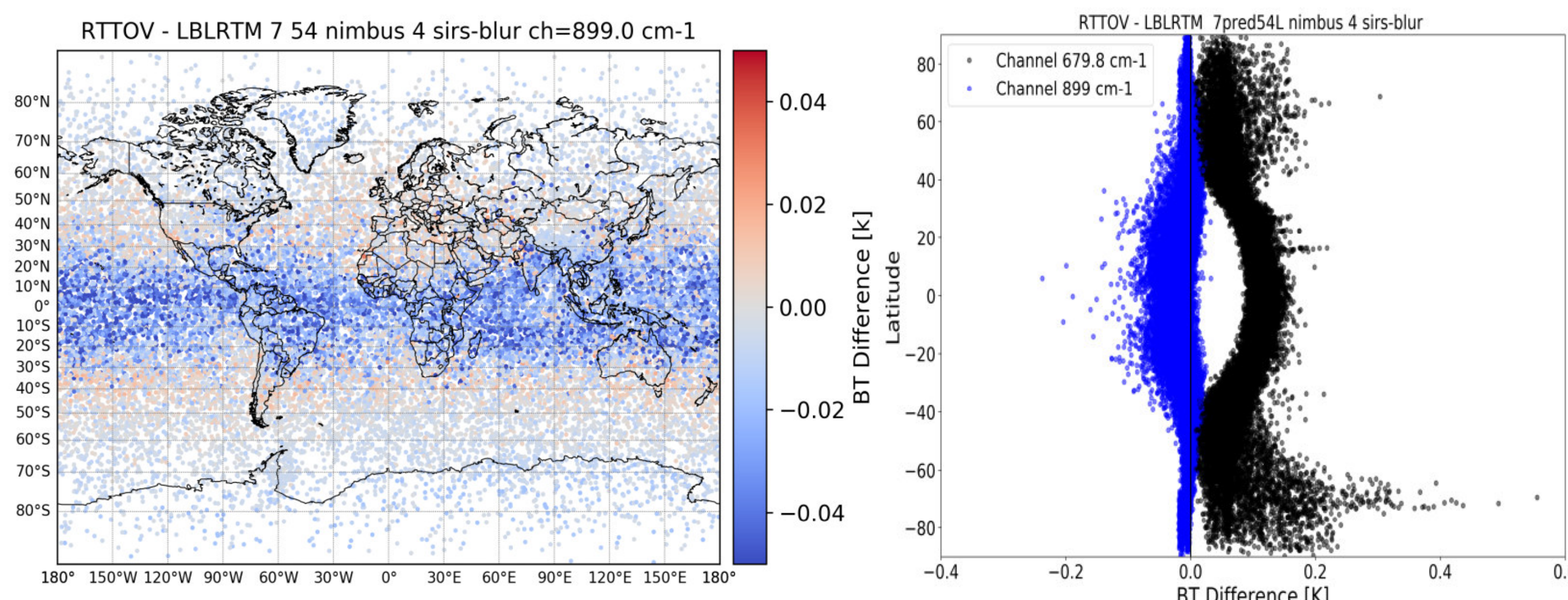


Figure 1. (left) map of RTTOV minus LBLRTM from the NWPSAF 137 levels diverse profile dataset for SIRS window channel. (right) latitudinal difference for CO2 and window channel

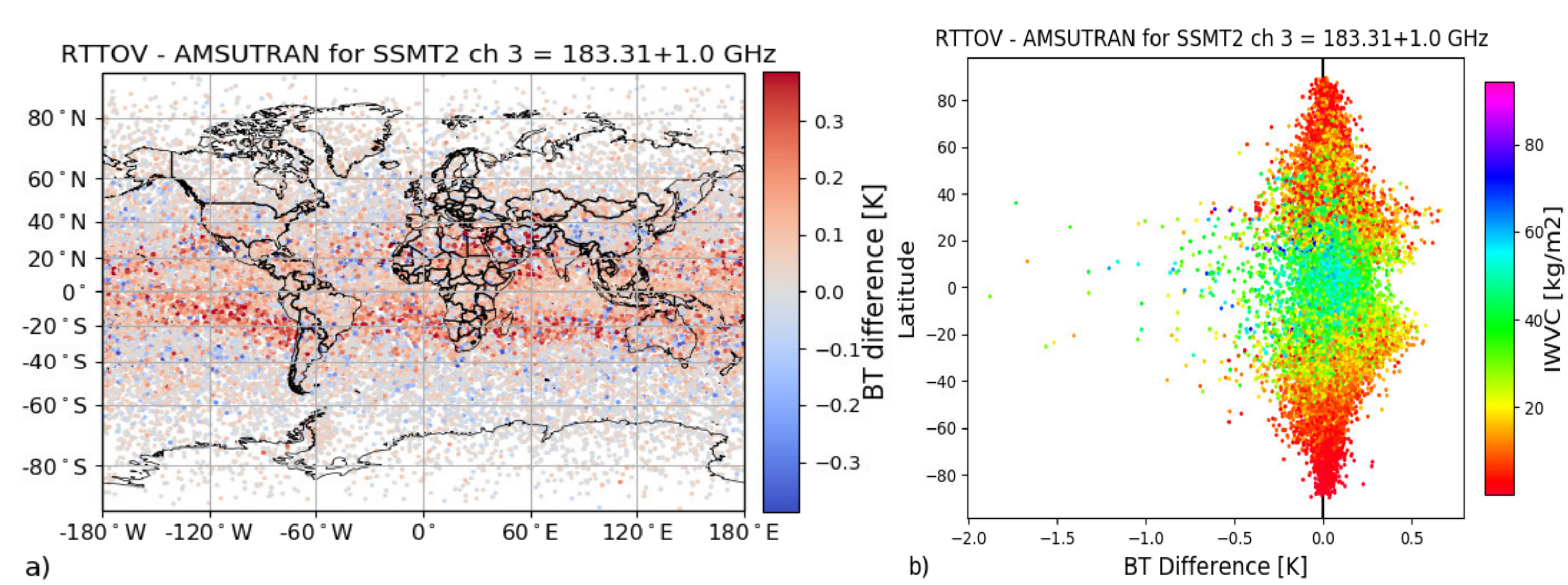


Figure 2. (left) map of RTTOV minus AMSUTRAN from the NWPSAF 137 levels diverse profile dataset for SSMT2 channel 2. (right) latitudinal difference as function of integrated water vapour content.

Results for objectives 3&4: spectroscopy effects

- The Figure 3 show the BT difference for SSMIS channels due to alternate RTTOV coefficients with new MW/sub-mm spectroscopy that have been developed for a EUMETSAT project. In this new spectroscopy, the water vapour and ozone were updated with AER. Mean and standard deviation are below 0.2K.
- The Figure 4 show an example of the radiance spectrum at the TOA simulated by RTTOV for the pseudo IR instrument.
- The Figure 5 (left) show an example of the TOA BT difference due to a spectral shift of the ISRF channel 8 of SIRS by step of 1 cm^{-1} between +/- 5 cm^{-1} . As this channels is centered on the CO₂ absorption band (see in black on Figure 5 (right) the mean BT), any shift on both side as positive strong effects up to 8K in mean.
- The Figure 6 compare the standard deviation of the BT difference due 3 different versions of LBLRTM (11.1, 12.2 and 12.8) to the IRIS and IASI noise. We can see that the strong noise of IRIS make the observations insensible in mean to the underlying spectroscopy, where as IASI is sensible in the water absorption band above 1200 cm^{-1} .

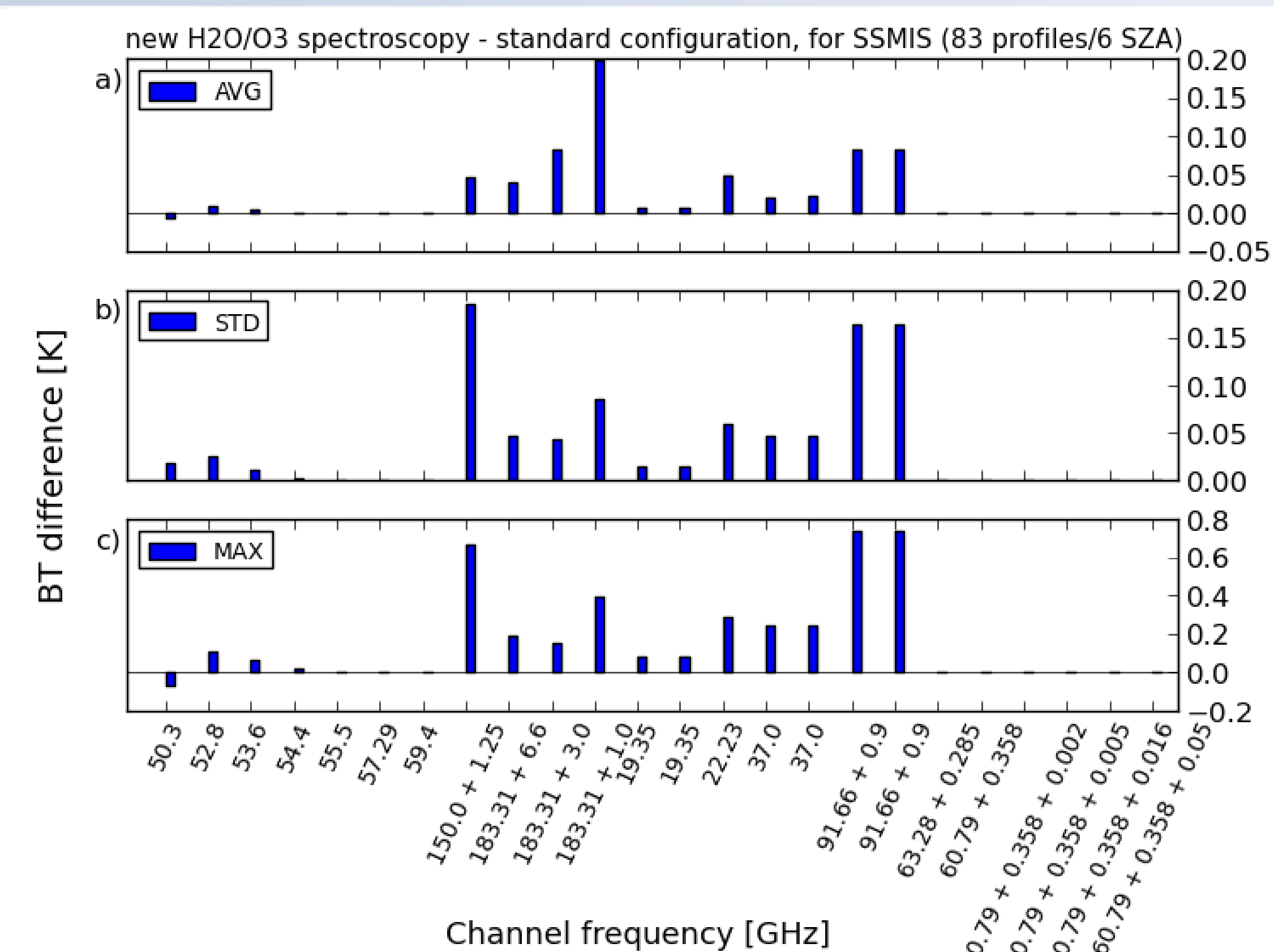


Figure 3. BT difference between RTTOV and new spectroscopy for SSMIS

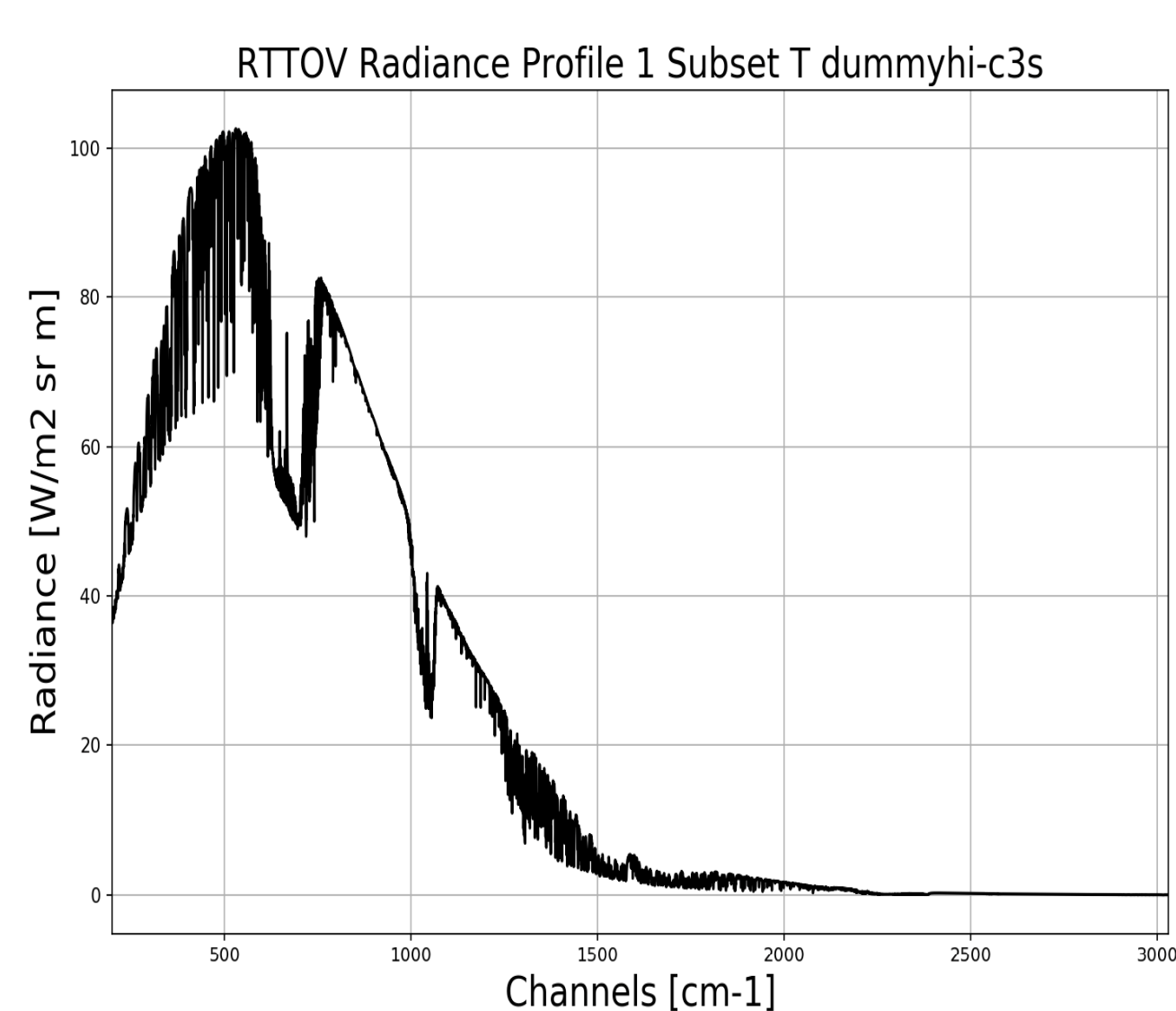


Figure 4. Example of the pseudo IR spectrum.

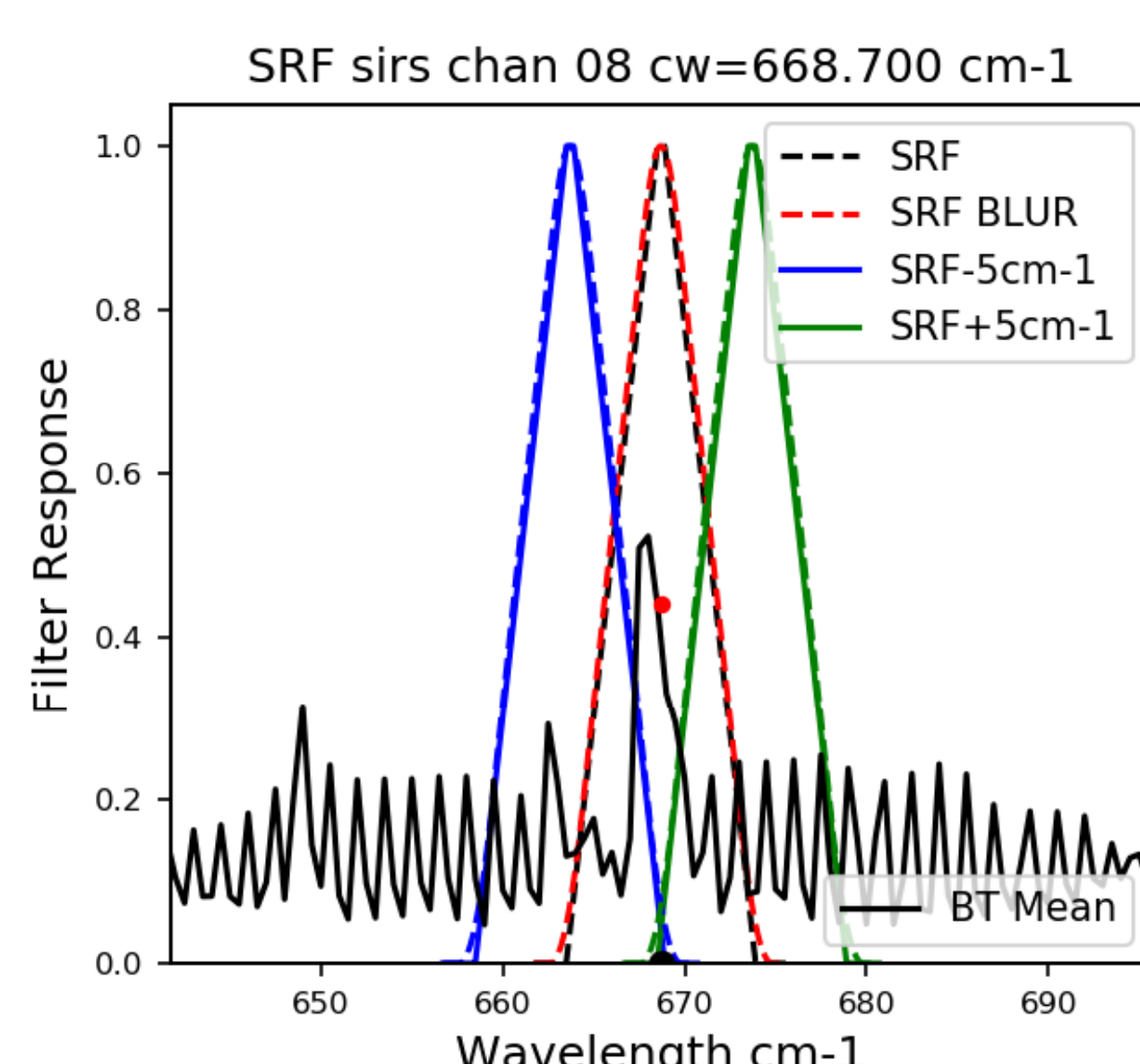
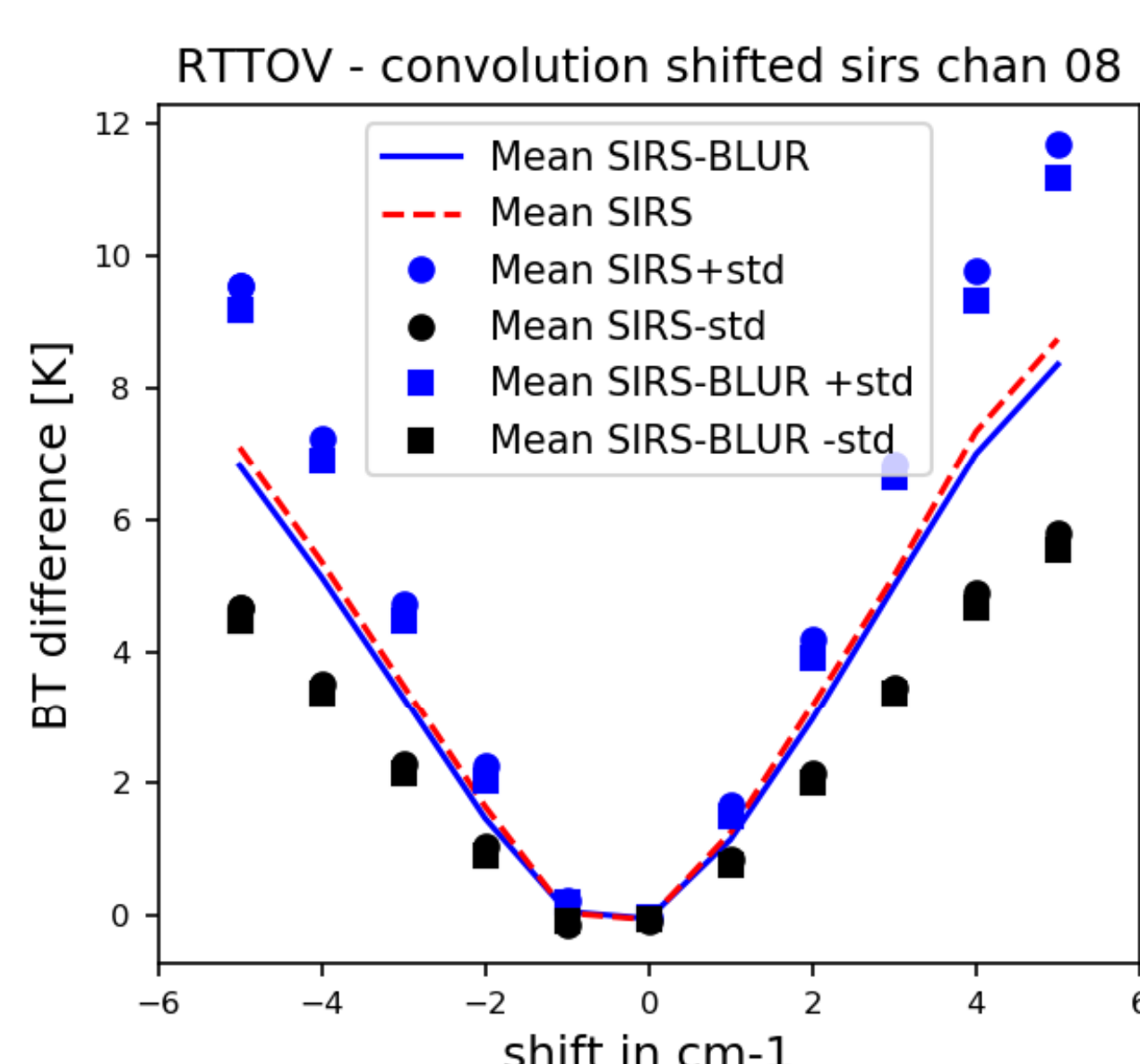


Figure 5. (left) spectral shift effect on the TOA BT for SIRS channel 8. (right) The 3 SRF (-5 cm^{-1} , nominal, +5 cm^{-1}) are overplotted over the radiances (in black).

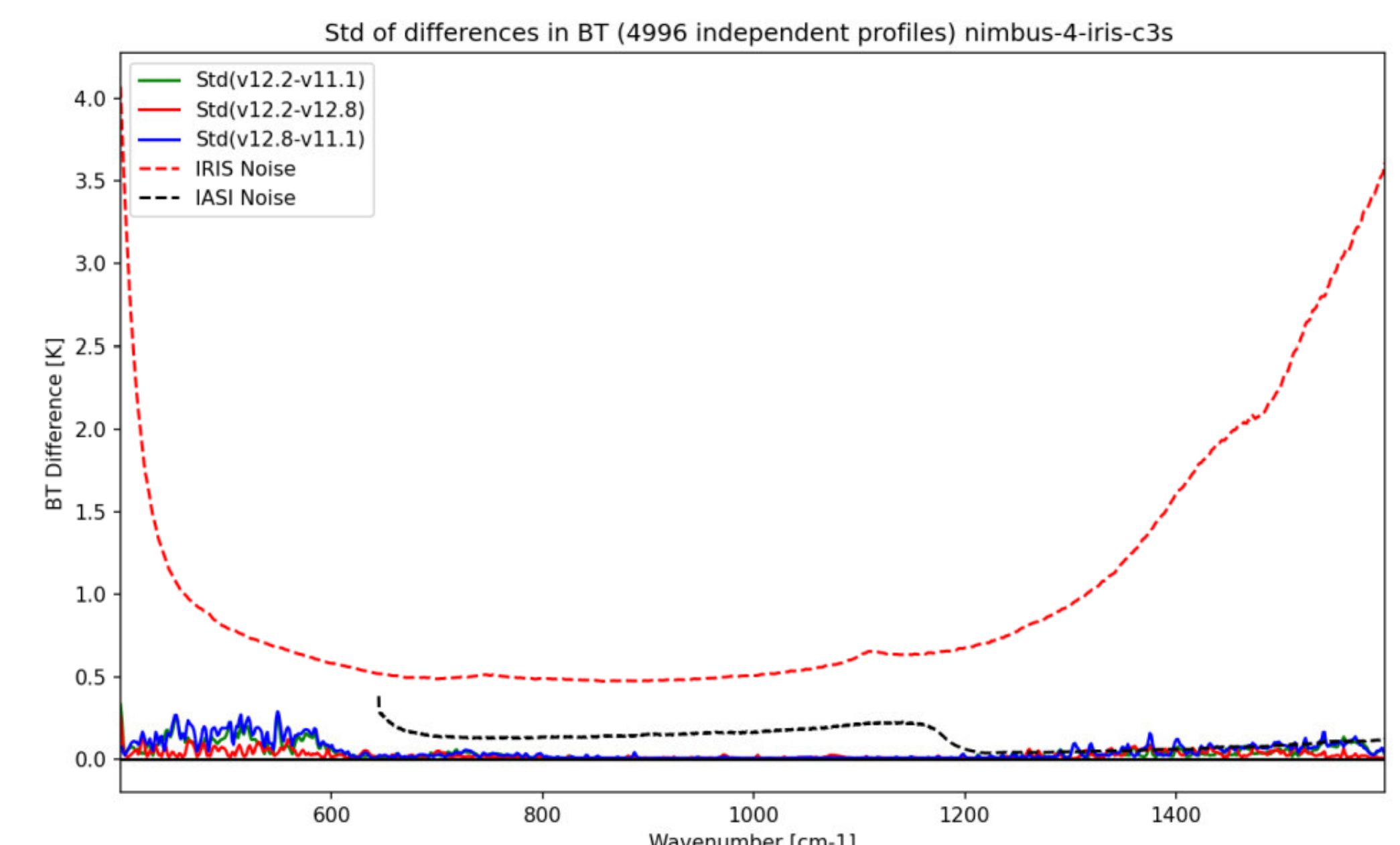


Figure 6. Comparison between the IRIS and IASI noises and the standard deviations due to different LBLRTM versions. Example of the pseudo IR spectrum.

References:

Saunders, R., Hocking, J., Turner, E., Rayner, P., Rundle, D., Brunel, P., Vidot, J., Roquet, P., Matricardi, M., Geer, A., Bormann, N., and Lupu, C.: An update on the RTTOV fast radiative transfer model (currently at version 12), Geosci. Model Dev., 11, 2717-2737, <https://doi.org/10.5194/gmd-11-2717-2018>, 2018.

Eresmaa R. and McNally A: Diverse profiles dataset from the ECMWF 137-level short-range forecasts, 2014. See: <https://www.nwpsaf.eu/site/software/atmospheric-profile-data/>