RTTOV for the C3S project on early satellite data rescue

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Motivation

■ A consortium leads by SPASCIA 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 to 1990s (see table 1 for satellites instruments). 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 (starting in 2023) of ECMWF.

RTTOV Workpackage objectives

■ **Objective 1**: Provide the RTTOV clear-sky coefficients for all instruments listed in Table 1.
Some coefficients already existed before the beginning of the project (HIRS, IRIS, PMR, SMMR, MVIRI, VTPR, MSU, SSU) but others needed to be calculated (HRIR, MRIR, SIRS, THIR) or improved (IRIS, SSU).

■ **Objective 2**: Provide a validation of the RTTOV coefficients 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 used the independent 25000 diverse profiles dataset of the NWP SAF at 137 levels (Eresmaa and McNally, 2014). The Figure 1 show the profiles (and mean value) of temperature, water vapor and ozone of the 83 training profiles (left) and of a subset of 5000 NWPSAF diverse profiles dataset.

■ **Objective 3:** Provide forward model errors based on underlying spectroscopy variability.
In clear-sky simulations, unknowns coming from the underlying spectroscopy is the main source of forward modeling errors. We proposed to study the variability of the spectroscopy by using the different version of LBL models.

Name	Platform	IR channels	V7 pred.	V8 pred.
HIRS-1	Nimbus-6	16	Yes	Yes
HIRS-2	NOAA-6 to 12 NOAA-14	19	Yes	Yes
HIRS-3	NOAA-15 to 17	19	Yes	Yes
HIRS-4	NOAA-18 & 19 METOP-A & B	19	Yes	Yes
MVIRI	Meteosat-1 to 7	2	Yes	Yes
IRIS-D	Nimbus-4	400-1600 cm^{-1}	No	Yes
VTPR	NOAA-1 to 4	32 (8 chan.*4)	Yes	Yes
MRIR	Nimbus-3	4	Yes	Yes
THIR	Nimbus-4 to 7	2	Yes	Yes
SSU	TIROS-N to NOAA-14	3	No	Yes
PMR	NIMBUS-6	9	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
SSMI(S)	DMSP F16-F19	24	Yes	No

Table 1. List of instruments studied in the C3S project

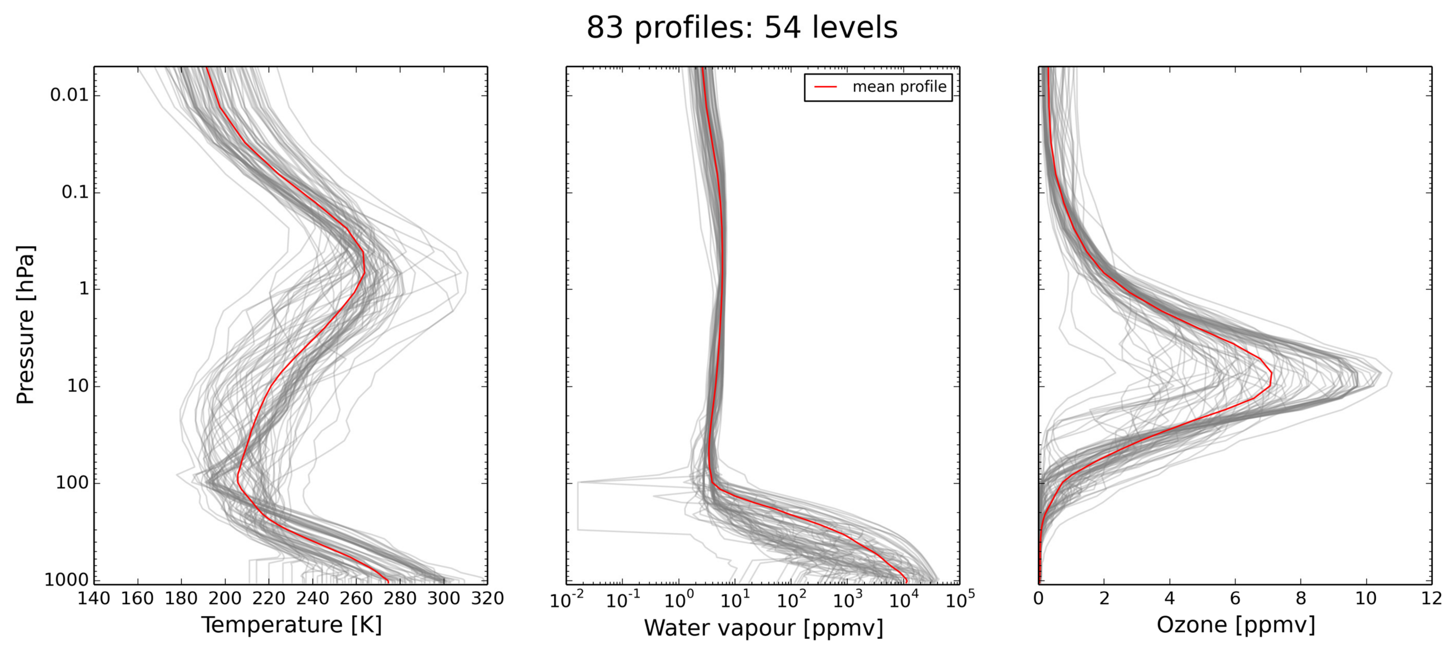
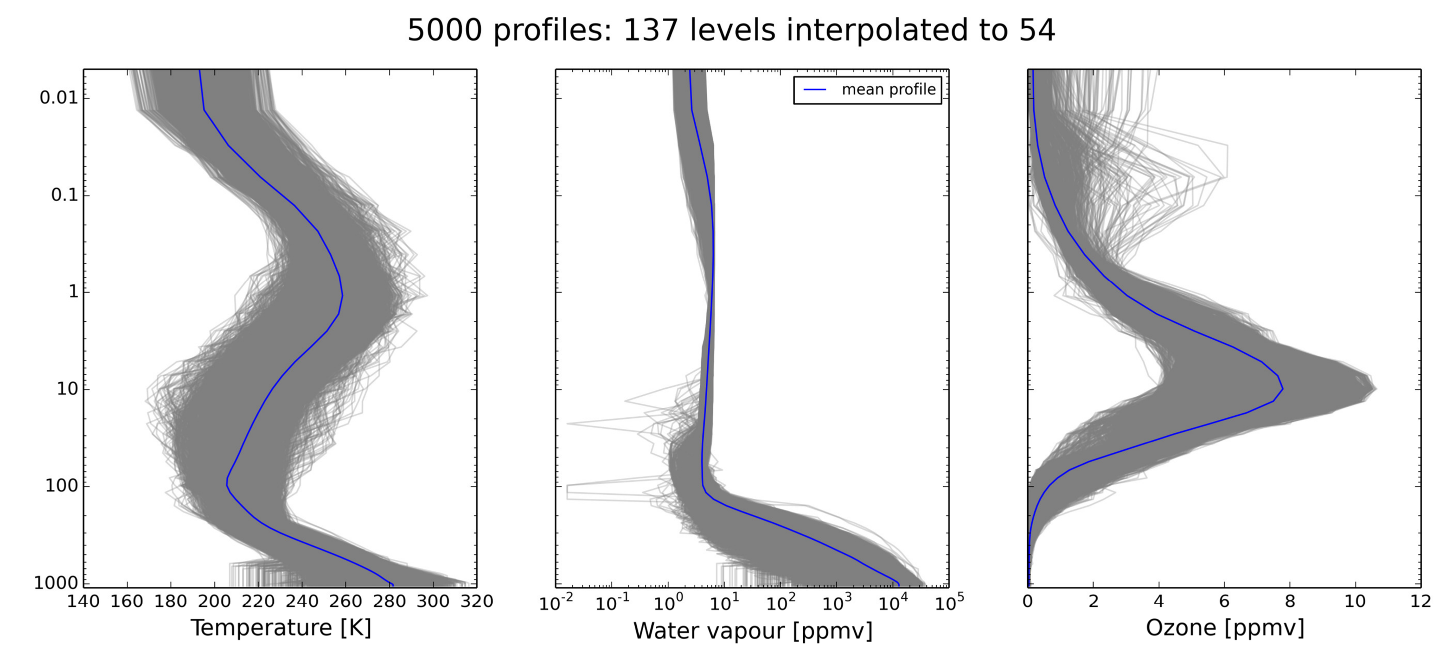


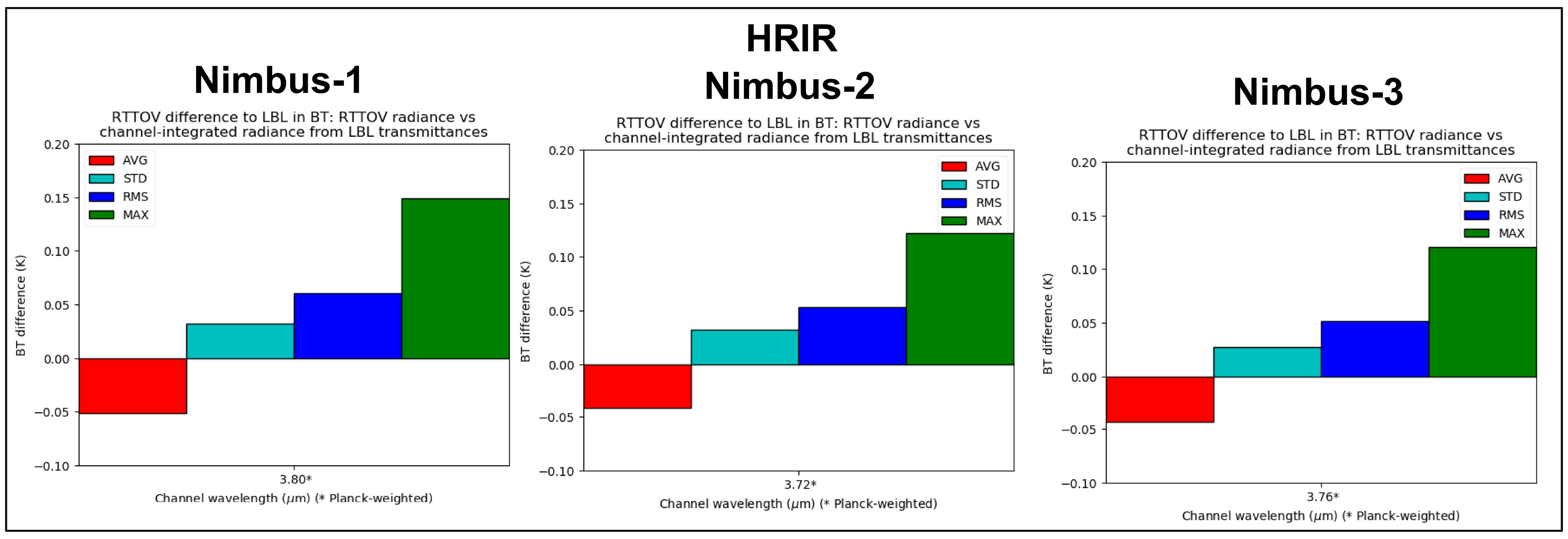
Figure 1. (Left) 83 training profiles at 54 levels for temperature, water vapor and ozone with the mean in red. (Right): Subset of 5000 profiles of the NWPSAF diverse profiles at 137 levels interpolated at 54 levels with the mean in blue.

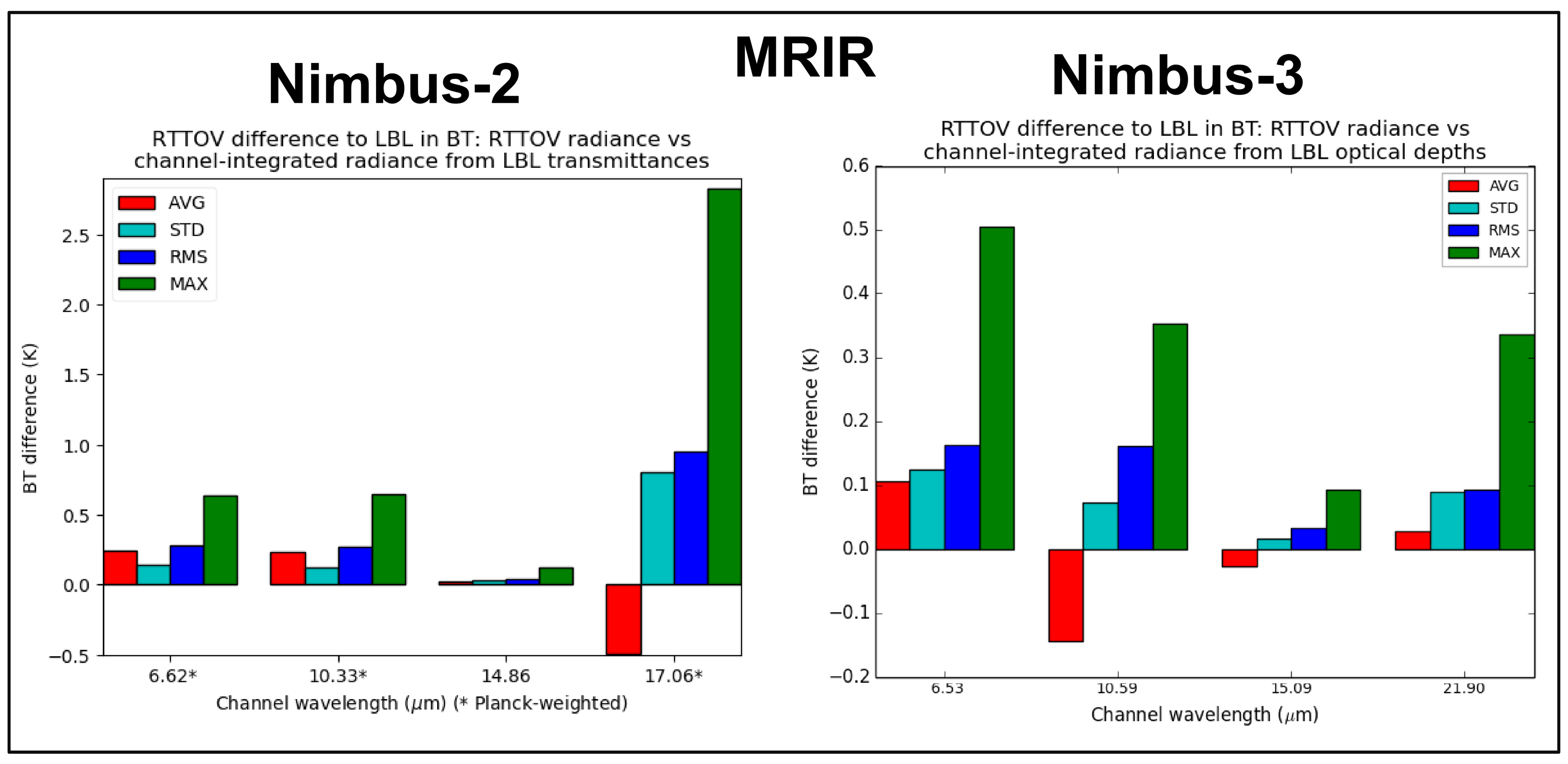


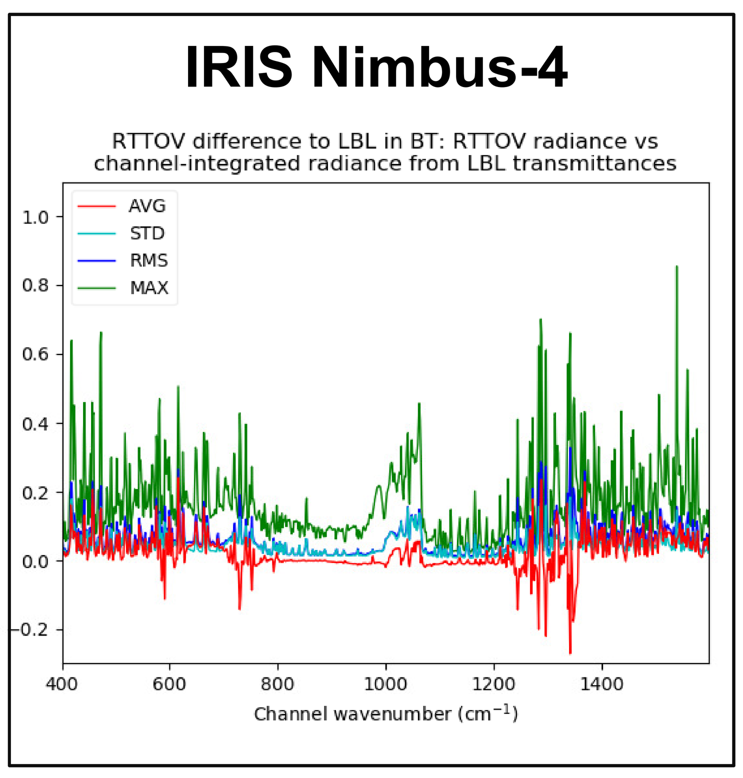
Preliminary results

■ The Figure 1 show preliminary results of the RTTOV coefficients validation when using the 83 training profiles (in red)) and a subset of 5000 profiles of the NWPSAF diverse profiles (in blue) for SSM/T-2 (top) and SMMR (bottom). The preliminary results indicates that the errors are robust no matter the size of profile set. The biases are interesting around the water vapour lines, close to the line centre (183+1 GHz) they increase a lot, a little further away (21 GHz / 183+7 GHz) they become negative and smaller.

■ The plots below show the classical RTTOV validation plots with the 83 training profiles for IR instruments: HRIR with 1 channel on Nimbus-1, -2 and -3, MRIR with 4 channels on Nimbus-2 and -3 and IRIS (hyperspectral sounders) on Nimbus-4.







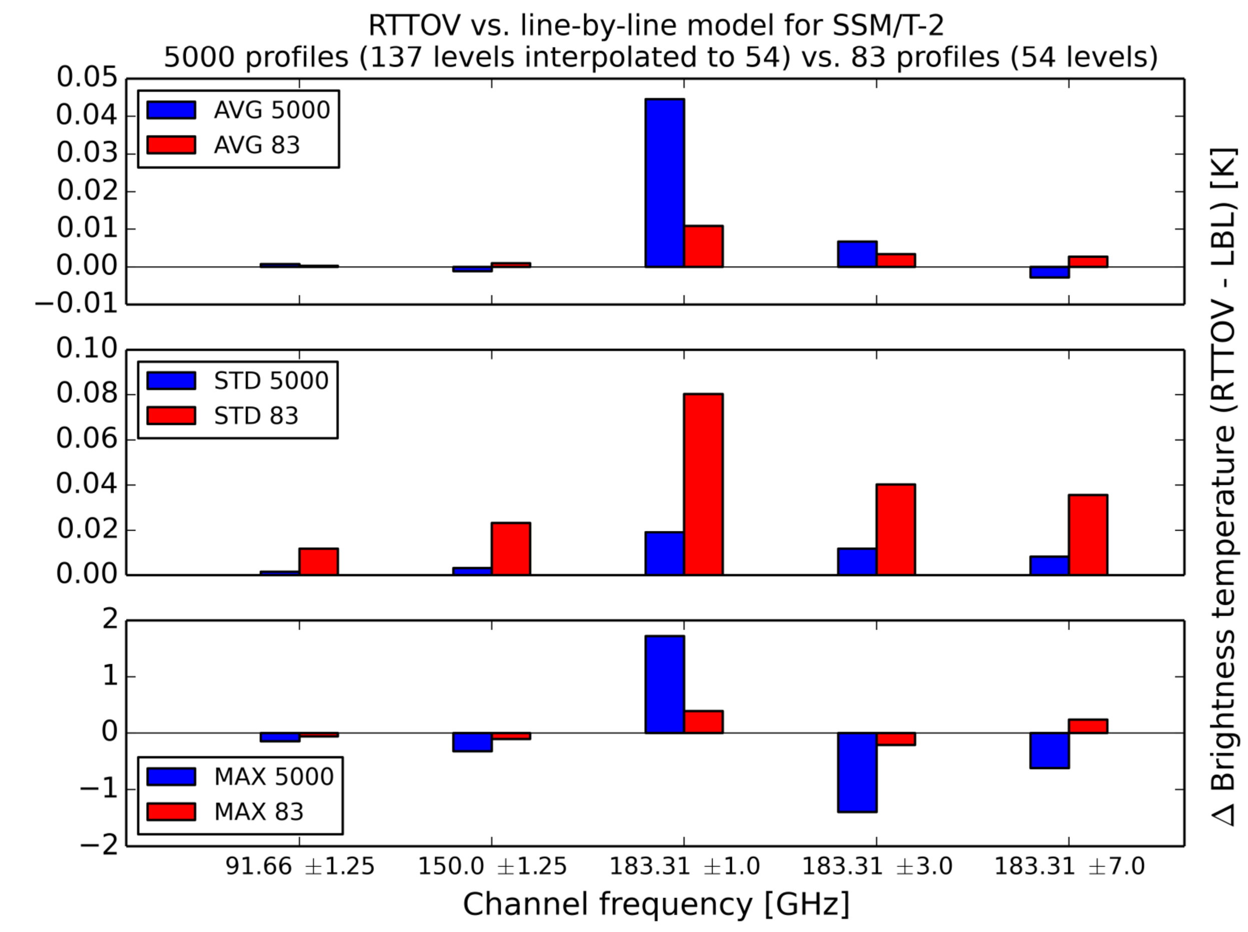
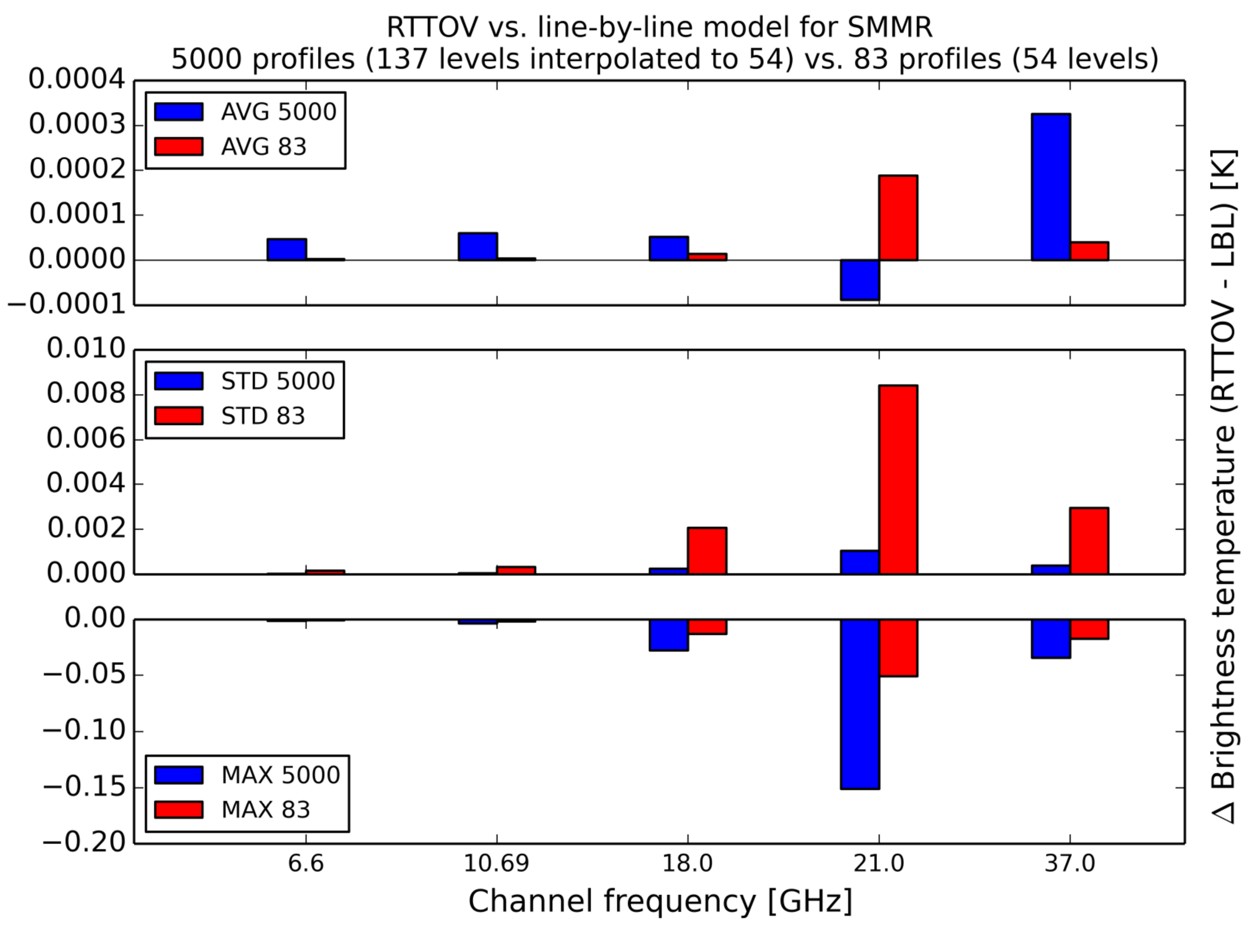


Figure 2. Statistical difference (average, standard deviation and maximum) of the RTTOV coefficient validation against LBL when using the 83 training profiles (red) and a subset of 5000 profiles of the NWPSAF diverse profiles (in blue) for SSM/T-2 (top) and SMMR (bottom).



References:
Saunders, R., Hocking, J., Turner, E., Rayer, 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/