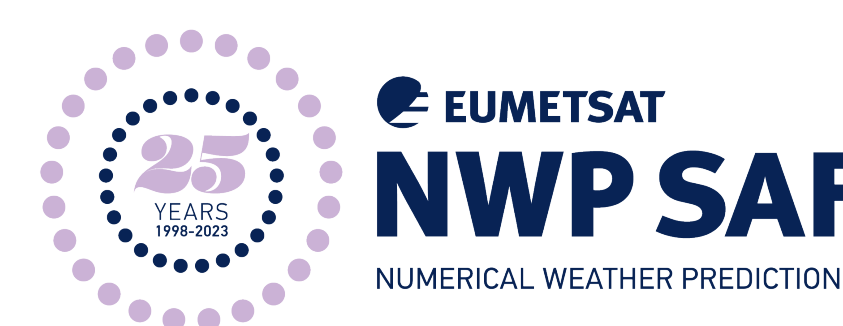




# Impact of Spectroscopy on IASI and FORUM Clear-Sky Simulations



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## PhD Objectives

- Analyze the impact of spectroscopy on fast RT simulations from RTTOV
- Comparison with other RT models to assess various spectroscopic databases (HITRAN & GEISA)
- Examine the modeling in RTTOV
  - Look into the parametrization of OD and coefficients generation process currently used in RTTOV
- Implications of spectroscopy in Data Assimilation
  - Inversion Algorithm 1D Var for Temperature and Water Vapor profiles
  - Test different sets of coefficients in Data Assimilation Experiments

## Radiative Transfer Models

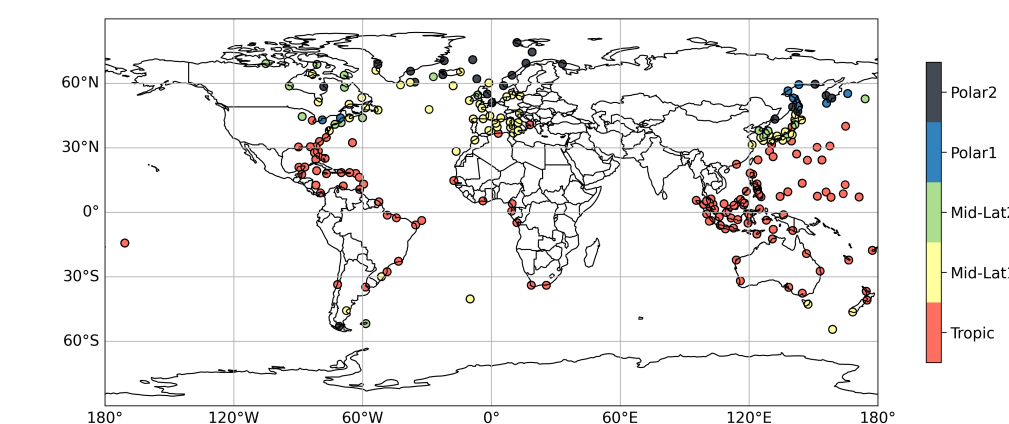
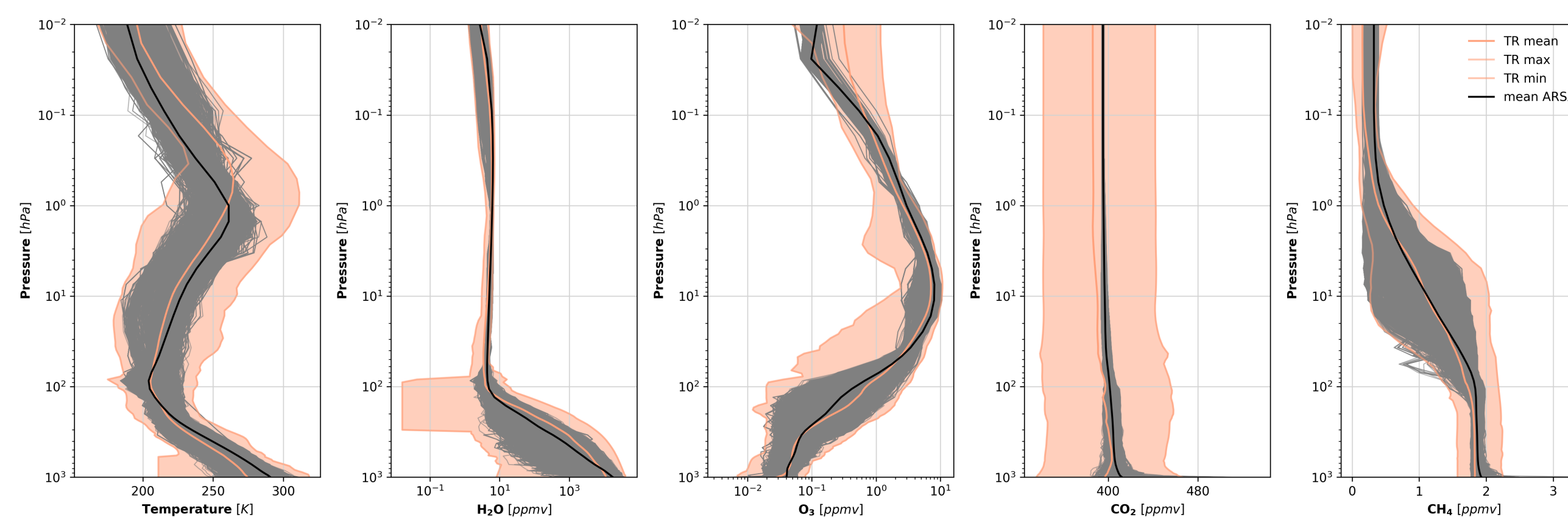
	RTTOV v13	4A/OP v1.7	KOPRA
<b>Model type</b>	Fast Band model <sup>†</sup>	Fast Line-By-Line <sup>††</sup>	Optimized Line-By-Line <sup>†††</sup>
<b>Spectral Range</b>	UV to Submillimeter	Infrared [100 – 14000] $cm^{-1}$	Infrared [100 – 14000] $cm^{-1}$
<b># Molecules</b>	28 (7 variables)	52	55
<b>Spectroscopic DB</b>	HITRAN 2012	GEISA 2016	HITRAN 2020
<b>Water Vapor</b>	MT CKD (3.2)	MT CKD (3.2)	MT CKD (2.5.2)
<b>Jacobians</b>	✓	✓	✓
<b>Main Purpose</b>	Data Assimilation in NWP	GHG Retrievals	Atmospheric Retrievals

<sup>†</sup> Parametric model of convoluted transmittances (#120 instruments)

<sup>††</sup> Atlases of monochromatic optical thicknesses

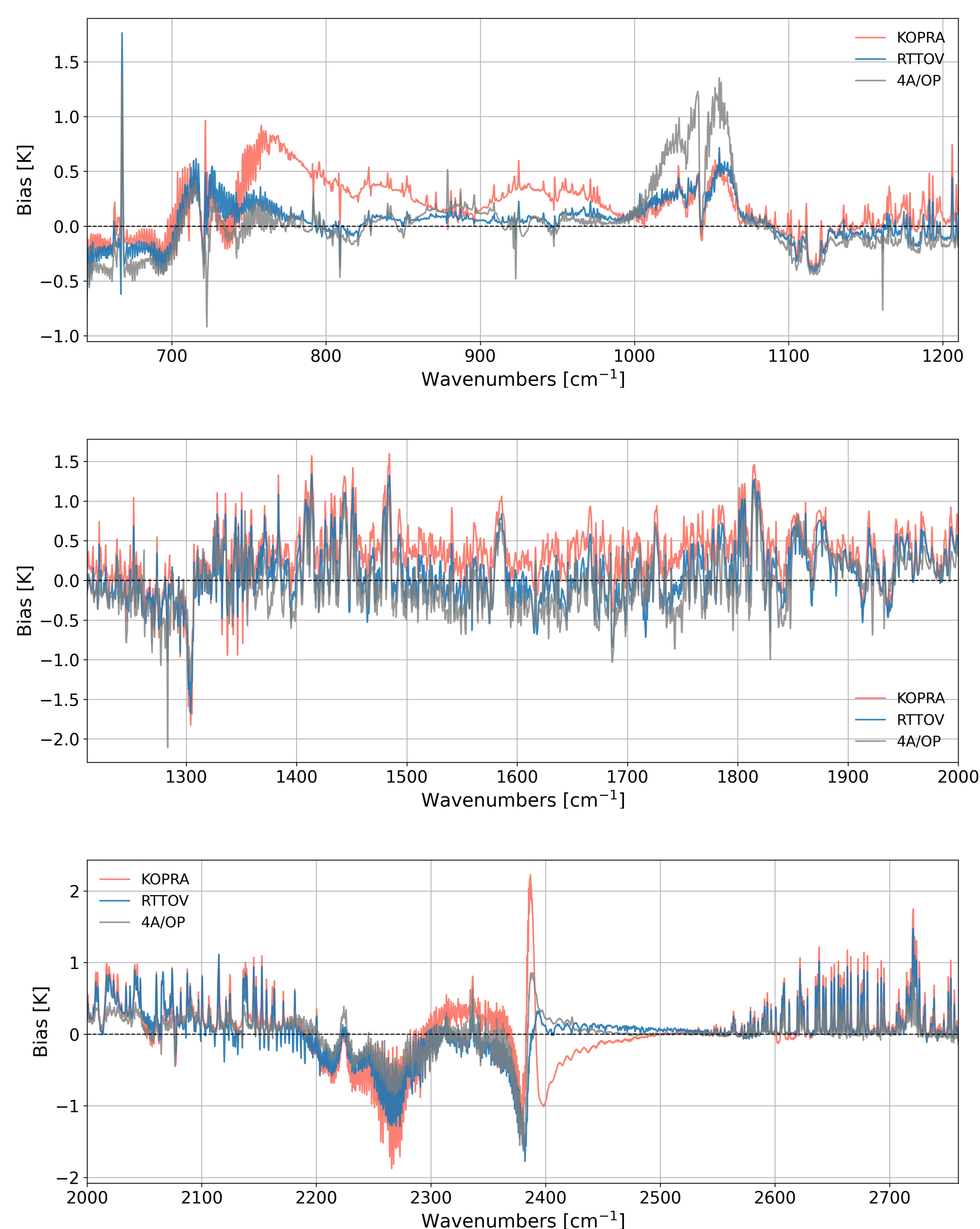
<sup>†††</sup> Calculation of absorption coefficients on an optimized wavenumber grid

## Database of atmospheric profiles colocated with IASI observations: ARSA v2



- Radiosounding:**  $P(z)$ ,  $T(z)$ ,  $H_2O(z)$  interpolated on ERA-5 grid
- ERA-5:**  $O_3(z)$ ,  $T_{surf}$
- CAMS:**  $CO_2(z)$ ,  $CH_4(z)$
- Conditions:** Night (avoid non-LTE effect) / Ocean / Clear-sky
- 19706 IASI** observations (Fourier Transform Spectrometer) colocated with 43 levels profiles
- Dataset spans all four seasons of **2017** and profiles are sorted per airmass class (TIGR2000 classification)

## Intercomparison RTTOV, 4A/OP, KOPRA vs IASI observations



The figures on the left show the differences between IASI observations and the spectra simulated by KOPRA, RTTOV and 4A/OP. Potential sources of bias may come from the spectroscopic database, numerical scheme of the RT model, transmittance parametrization (in case of RTTOV), or the atmospheric profiles.

### 1<sup>st</sup> band [645-1210 $cm^{-1}$ ]:

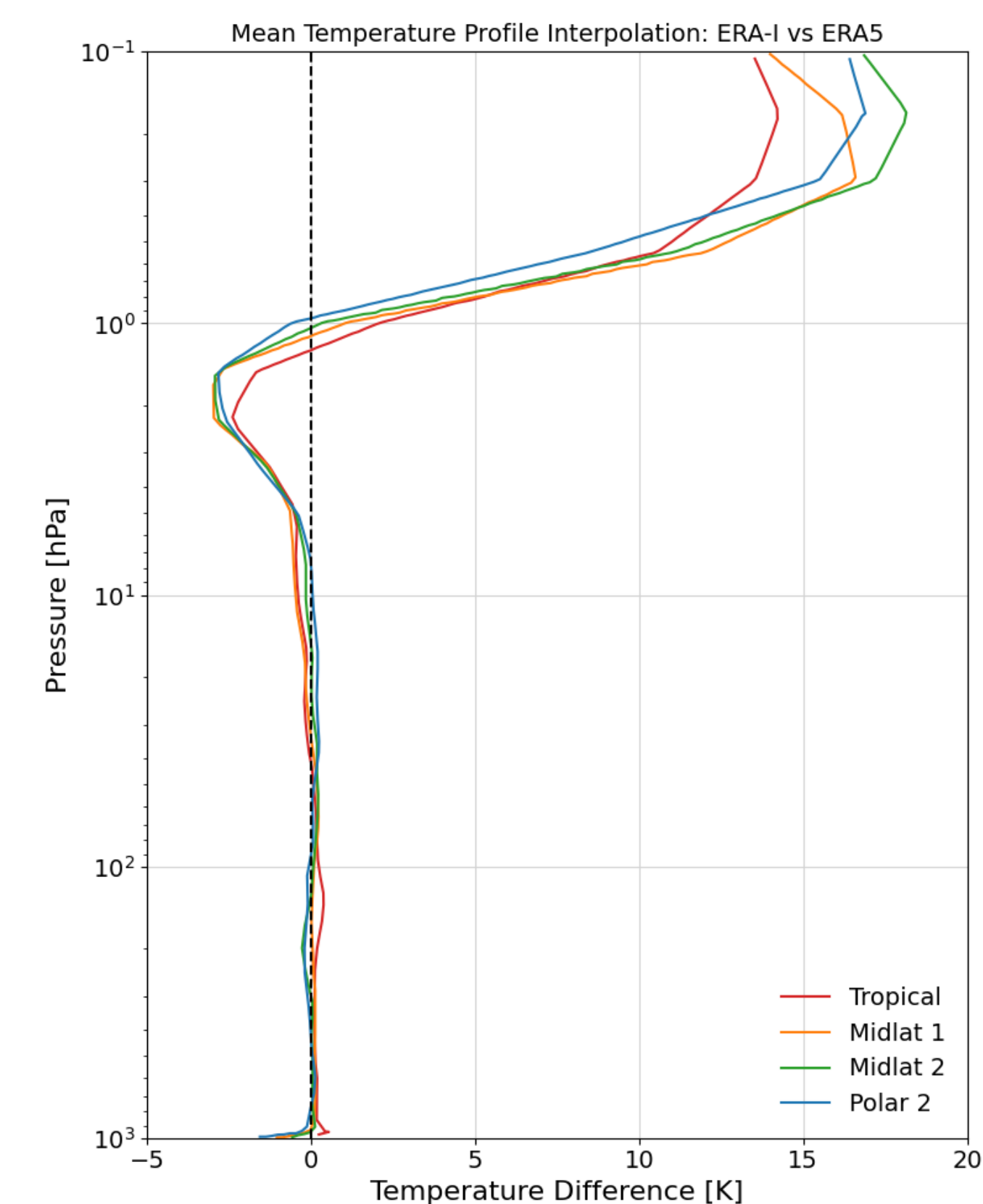
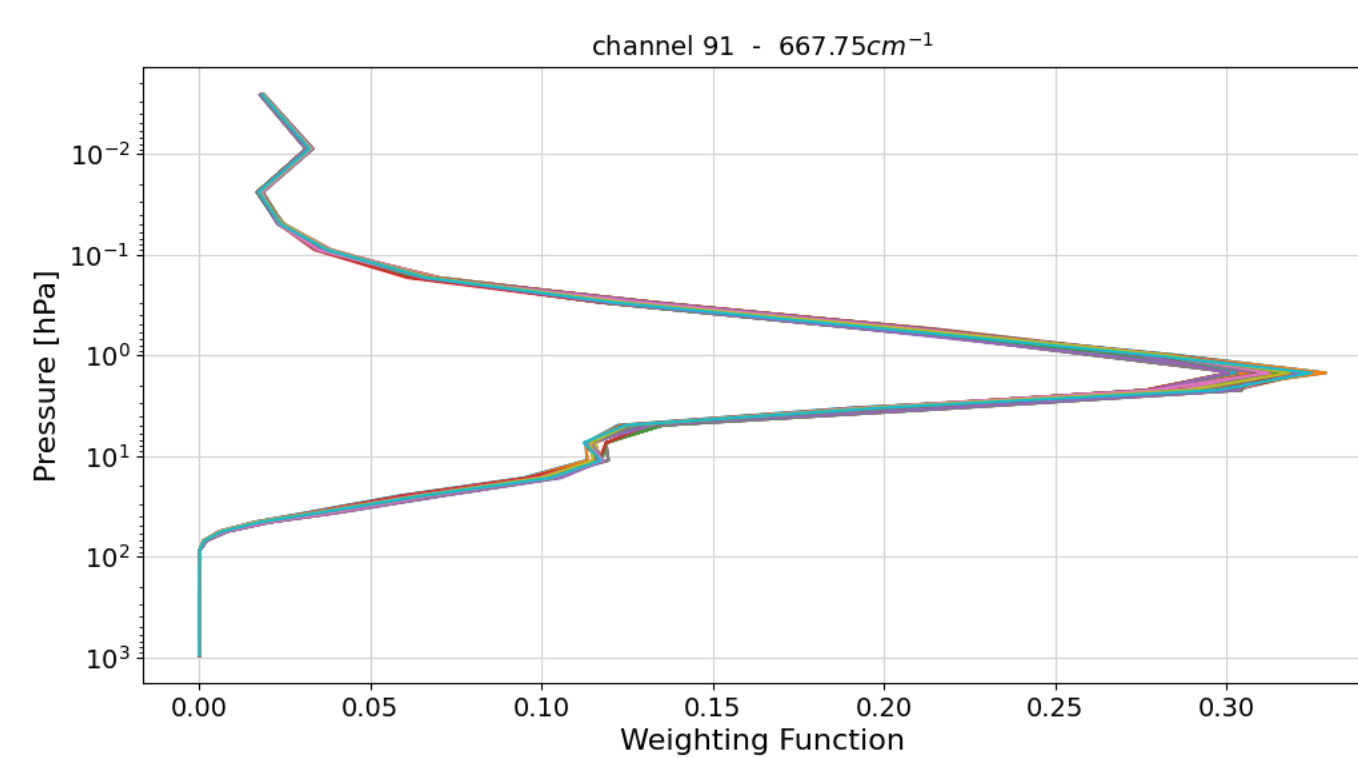
- ~ Bias in ERA-5 Temperature profiles impacting on the  $CO_2$  vibrational bending mode at  $667 cm^{-1}$  (the figure on the bottom right illustrates the warm bias of ARSA temperature profiles interpolated with ERA-5 between 1 and 2 hPa, corresponding to the peak of the weighting function)
- ~  $CO_2$  concentration profiles can be a possible cause of the bias at  $700-750 cm^{-1}$
- ~  $O_3$  spectroscopy and ERA-5 ozone profiles are the major contributors at  $1010-1080 cm^{-1}$  (4A/OP spectroscopy not updated for  $O_3$ )

### 2<sup>nd</sup> band [1210-2000 $cm^{-1}$ ]:

- ~  $H_2O$  continuum absorption comprises most of IASI band 2
- ~  $CH_4$  spectroscopy is linked to the bias at  $1305 cm^{-1}$
- ~ Small bias due to overestimation of water vapour content in ERA-5

### 3<sup>rd</sup> band [2000-2760 $cm^{-1}$ ]:

- ~  $CO$  spectroscopy and concentration profiles at  $2080-2200 cm^{-1}$
- ~  $CO_2$  and  $N_2O$  spectroscopy and concentration profiles affect the intervals  $2230-2390 cm^{-1}$  and  $2200 cm^{-1}$  respectively
- ~ HDO spectroscopy effects between  $2590-2760 cm^{-1}$



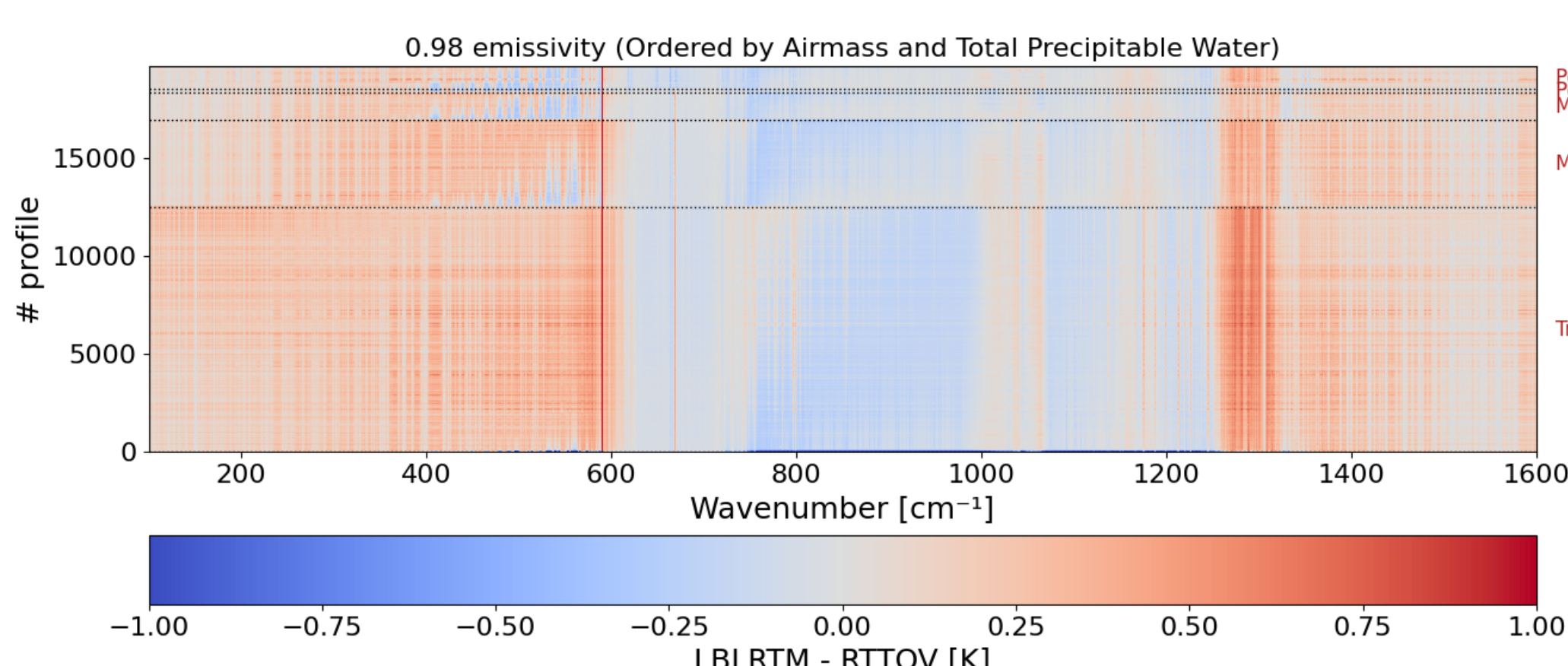
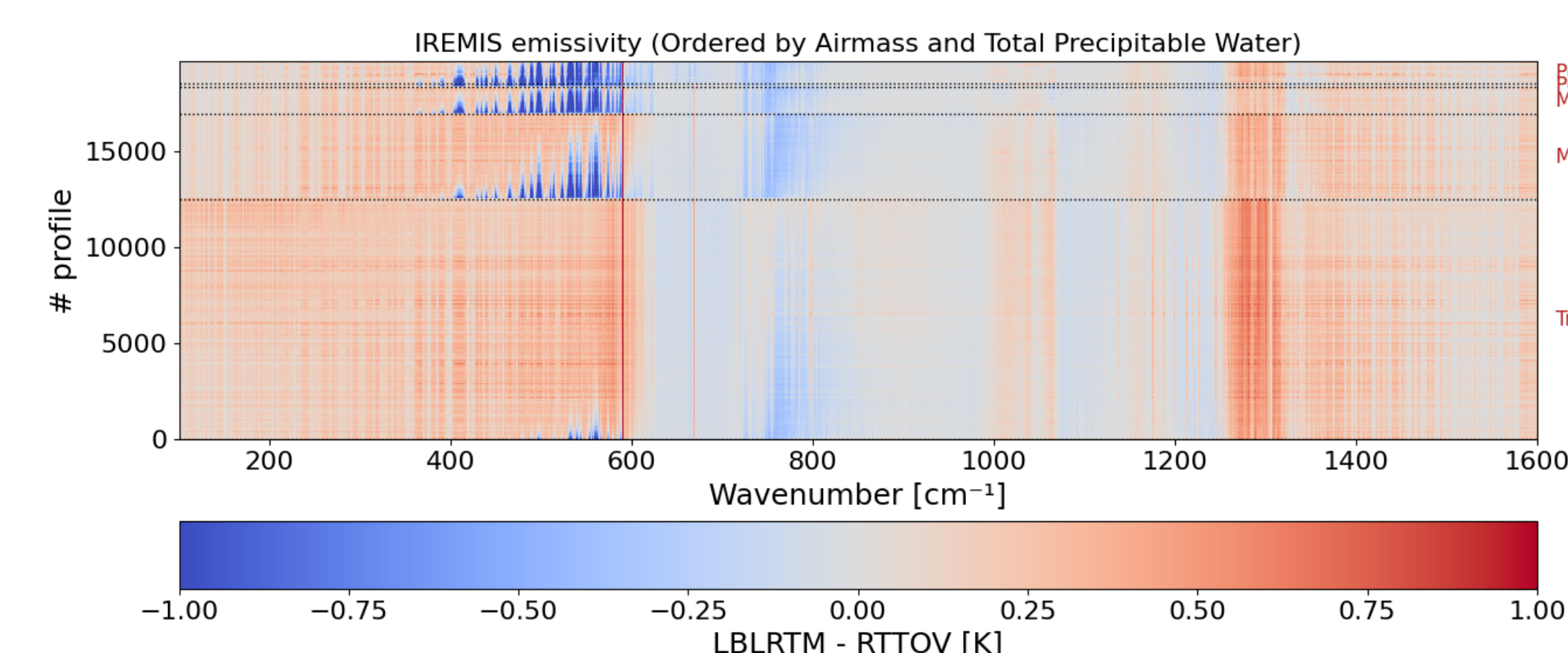
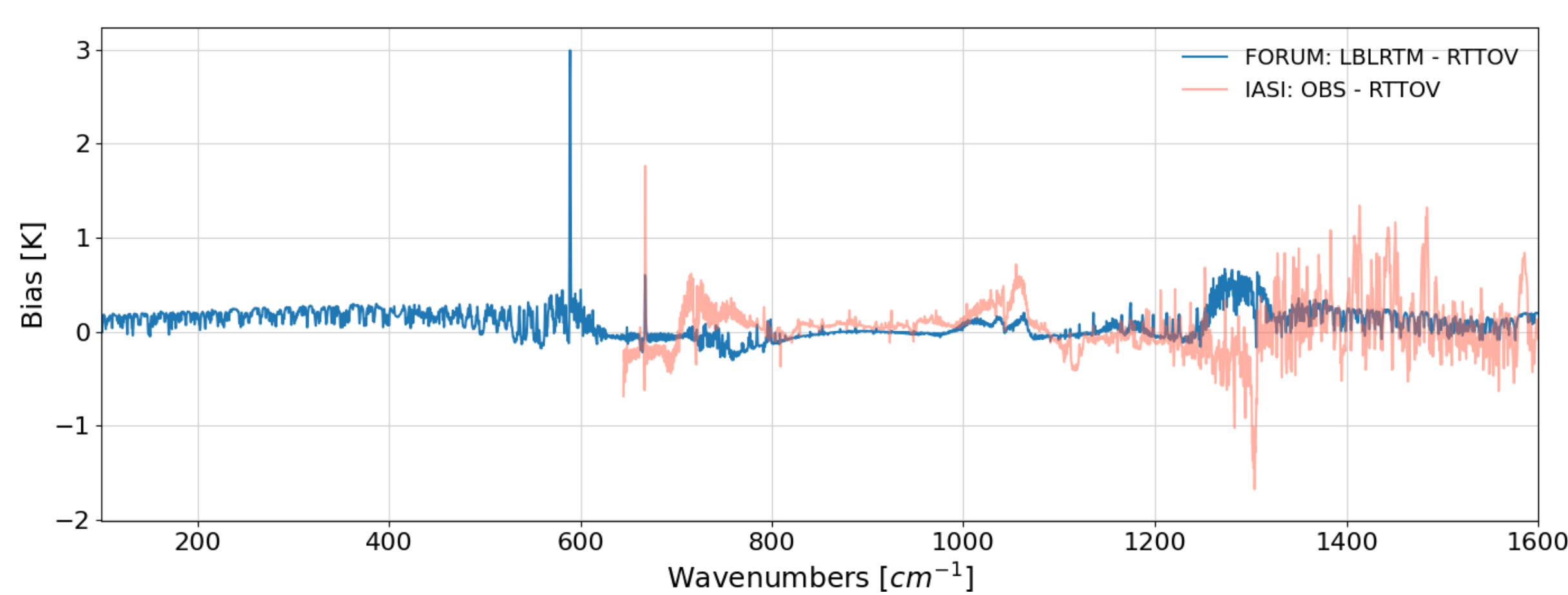
## Intercomparison RTTOV vs LBLRTM: FORUM

The figure at the bottom illustrates the bias between RTTOV and LBLRTM simulations for FORUM, compared to the previous results for IASI.

- ~ Can RTTOV **parametrization error** (LBLRTM-RTTOV) be seen and quantified in the comparison with observations (OBS-RTTOV)?
- ~ Can we isolate spectroscopic bias in the Mid-Infrared?

On the top-right the same bias is shown profile by profile (IREMIS emissivity model), while the bottom-right figure displays the values obtained using a constant emissivity of 0.98.

- ~ The bias around 3K at  $589 cm^{-1}$  is due to a technical error in the  $N_2O$  profiles ingested by LBLRTM (it will be corrected in the future run)
- ~ RTTOV seems to be colder in absorption bands and warmer in the windows, indicating an **overestimation of gas absorption**
- ~ When  $\epsilon = 0.98$  the RT model considers less atmospheric contribution ( $R = 1 - \epsilon$ )
  - ~ RTTOV BT are warmer in the atmospheric window ( $800-1000 cm^{-1}$ ) due to less absorption from water vapour
  - ~ The decrease of the bias the close FIR ( $400-600 cm^{-1}$ ) for profiles with low TPW suggests a smaller **RTTOV error for reflected radiation** ( $1 - \epsilon$ ).



## Next Steps and Outlook

- Analyze the biases in simulations to identify if they stem from spectroscopy, atmospheric profiles or instrumental noise
- Examine differences in Jacobians for few selected channels
- Compare RTTOV with 4A/OP and KOPRA to assess the effects of different spectroscopic databases also in the FIR
- Generate coefficients in RTTOV for updated spectroscopy

## Contact information

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