Comparison study between RTTOV-13 and 4A/OPv1.7 to simulate IASI in clear-sky over oceans

Jean-Marie Lalande[1], Raymond Armante[2], Jerome Vidot[1], Virginie Capelle[2], Pascale Roquet[1]

[1]Centre National de Recherches Météorologiques, Météo France, CNRS
[2]Laboratoire de Météorologie Dynamique, École Polytechnique, CNRS

Objectives

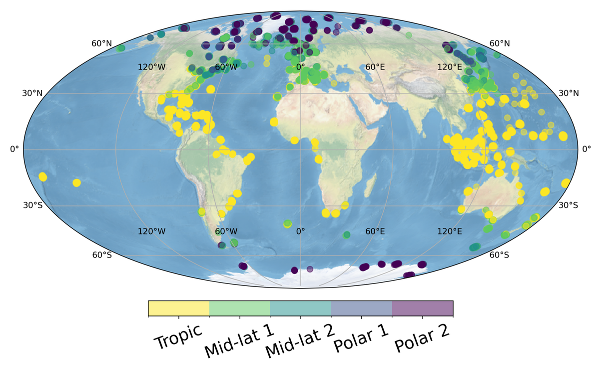
- Follow recommendations from the ITSC and Trattoria on radiative transfer codes intercomparisons
- Validation of new developments in Radiative Transfer codes
- Identify potential systematic errors:
  - spectroscopic databases
  - numerical integration, parametrization
  - atmospheric models

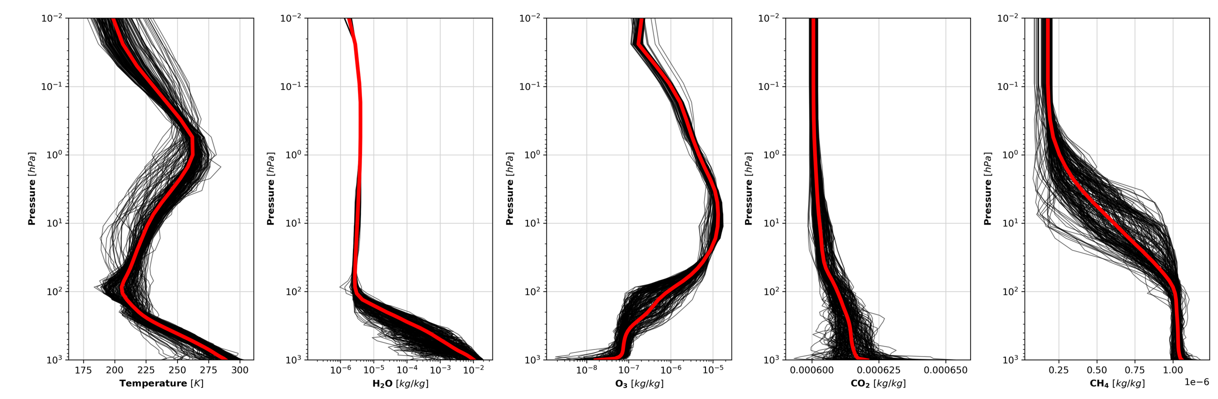
Radiative Transfer Models

	RTTOV v13[1]	**4A/OP v1.7**[2]
Model type	Fast Band model†	Fast Line-By-Line††
Spectral Range	UV to Submillimeter	Infrared $[100 - 14000]$ cm^{-1}
# Molecules	28 (7 variables)	52
Spectroscopic DB	HITRAN 2012	GEISA 2016
Water Vapor	MT CKD (3.2)	MT CKD (3.2)
Jacobians	✓	✓
Main Purpose	Data assimilation in NWPs	Greenhouse Gases Retrievals

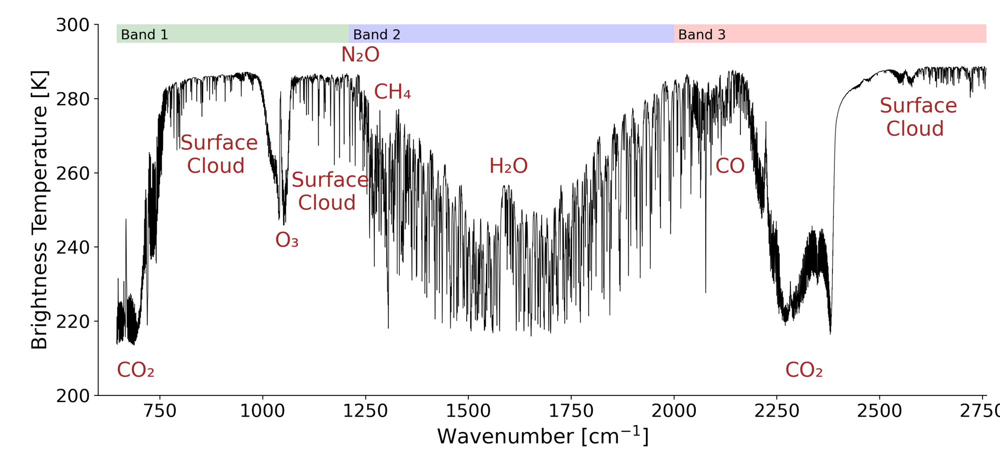
† Parametric model of convoluted transmittances (#120 instruments)[3]
†† Atlases of monochromatic optical thicknesses

Database of atmospheric profiles colocated with IASI observations

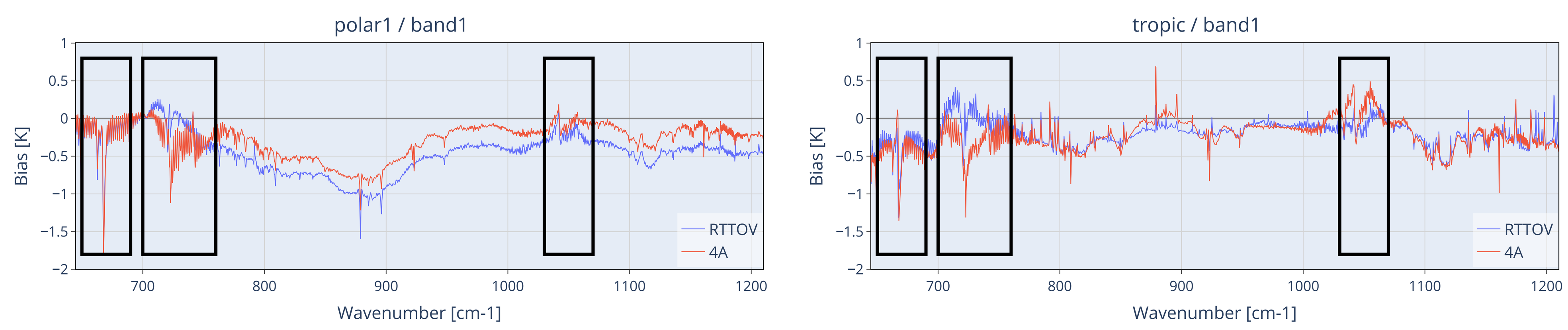




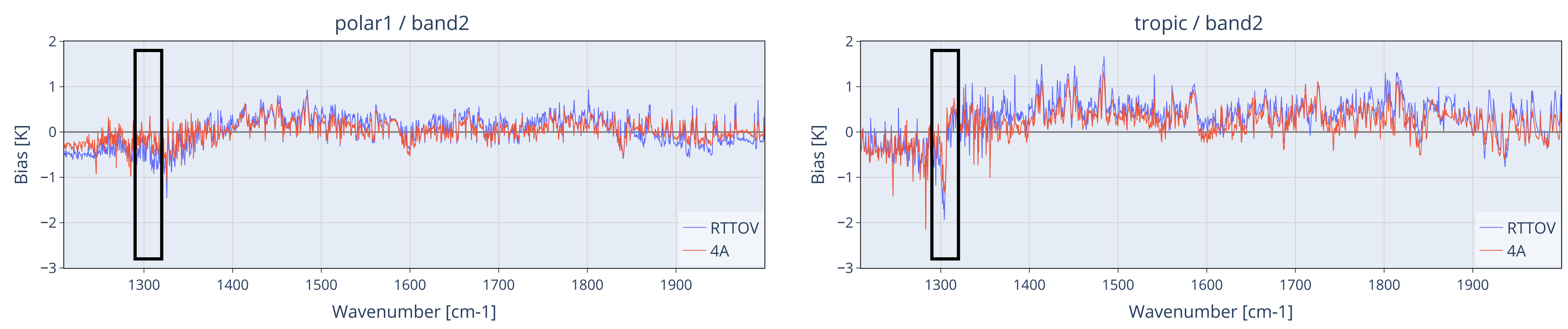
- **Radiosounding:** $P(z)$, $T(z)$, $H_2O(z)$
- **ERA-interim:** $O_3(z)$, T_{surf}
- **CAMS:** $CO_2(z)$, $CH_4(z)$
- **Conditions:** Night (avoid non-LTE effect) / Ocean / Clear-sky
- **15310 IASI** observations (Fourier Transform Spectrometer) colocated with 43 levels profiles
- Dataset spans all four seasons of **2017** and profiles are sorted per airmass class



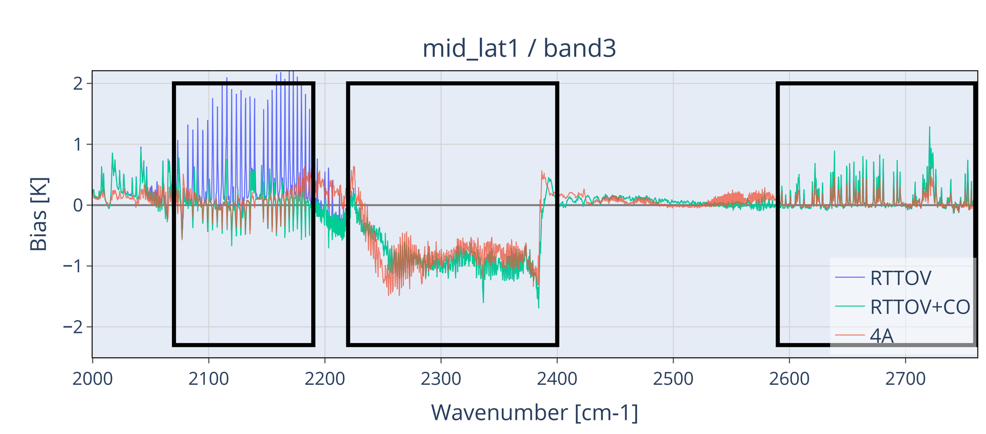
Spectrum comparisons

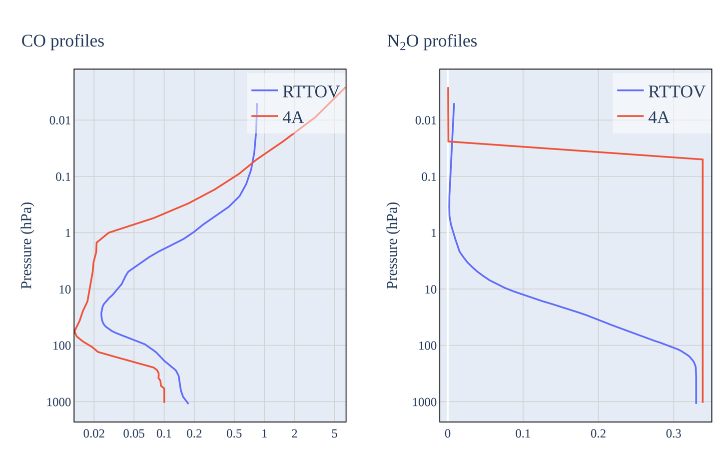


- At 667 cm^{-1}: ARSA temperature profiles extrapolated with ERA-interim reanalysis which is known to have a cold bias ⇝ Comparisons with ERA-5 ongoing
- Between $[700 - 750]$ cm^{-1}: More analysis on CO_2 concentration profiles
- Between $[1010 - 1080]$ cm^{-1}: O_3 spectroscopy is biased, ERA-interim O_3 profiles also biased ⇝ Study has began with new ozone spectroscopy in GEISA-2020 and ERA-5 ozone profile
- Slight offset between RTTOV and 4AOP in window channels ⇝ Due to sea-ice emissivity ([4] in 4A) / Improved in the tropic

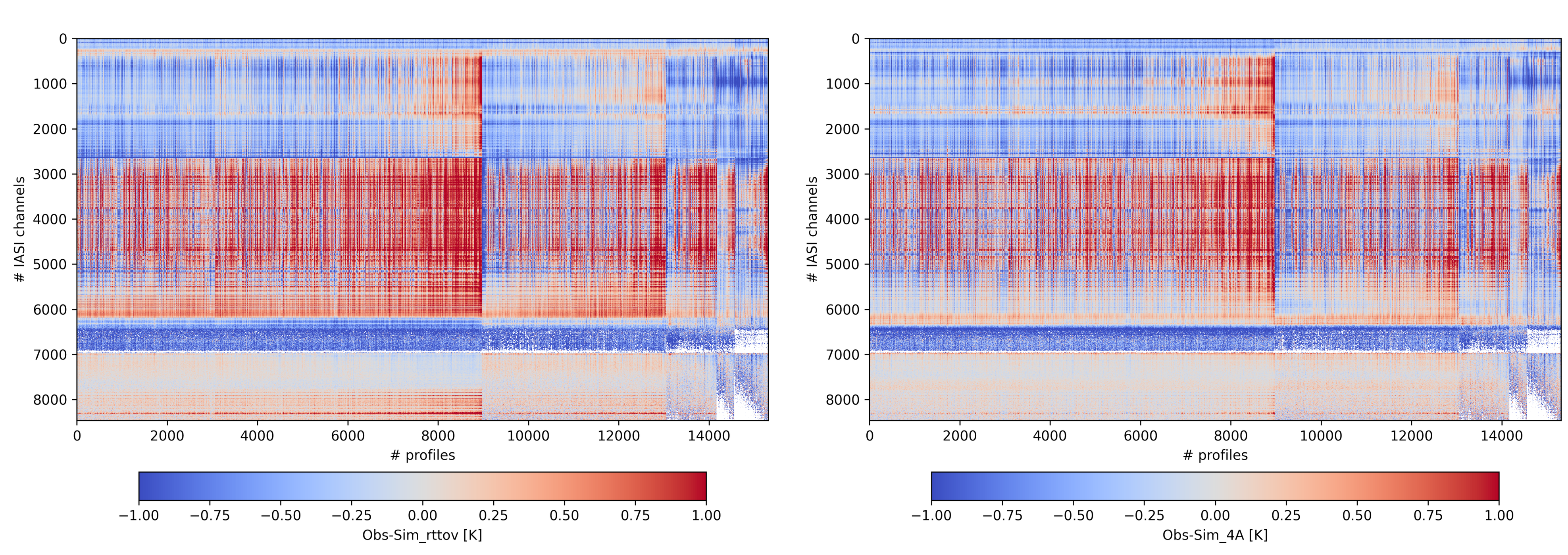


- IASI band #2 comprises mostly H_2O continuum absorption ⇝ RTTOV and 4AOP show very similar trends
- At 1305 cm^{-1}: bias linked to CH_4 ⇝ line-mixing, concentration profiles
- Increased bias in tropical zone linked to water vapor content overestimated in ERA-interim ⇝ Study differences between ERA-5 and ERA-interim



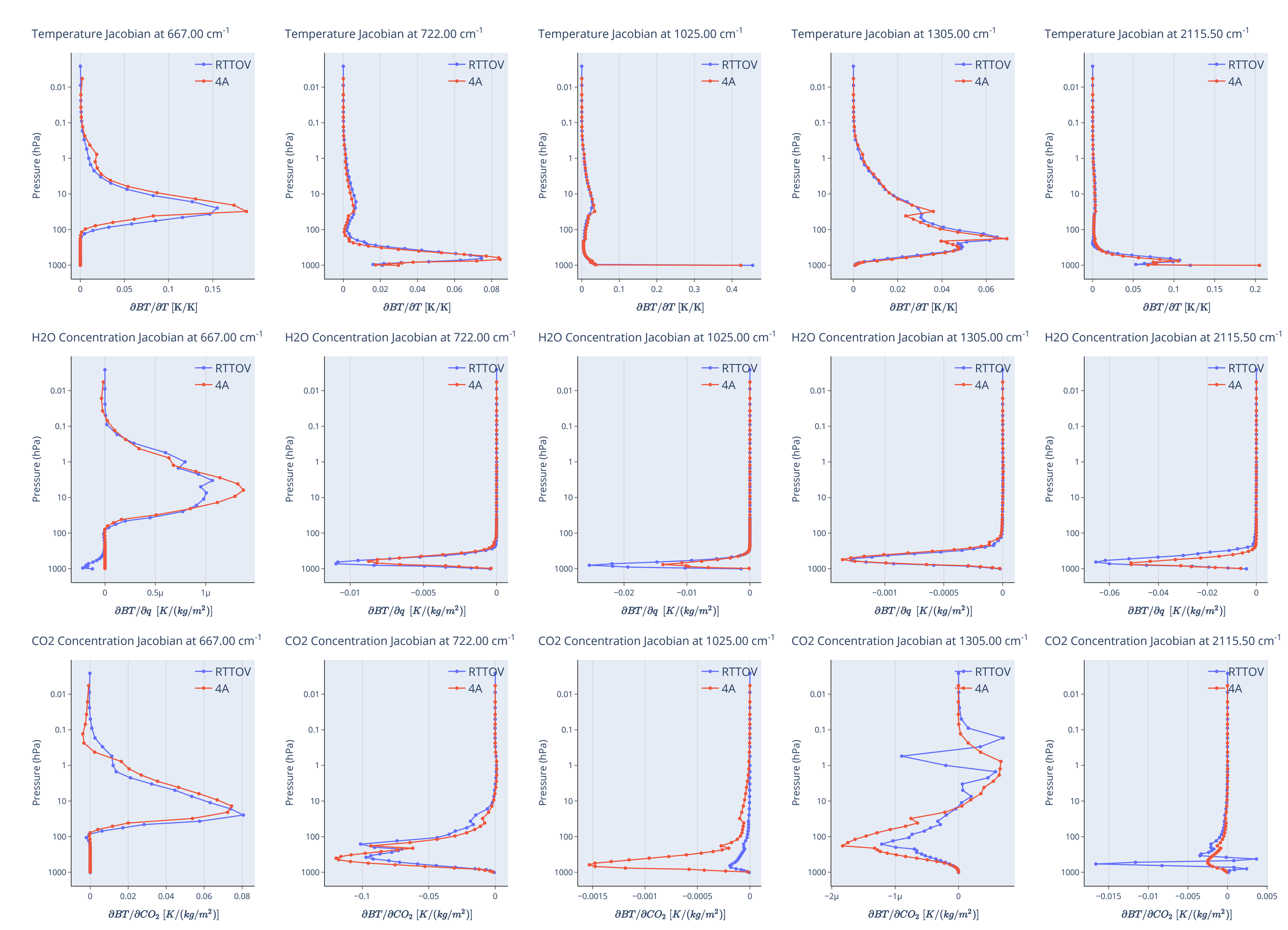


- Bias in the P and R branches from CO absorption in RTTOV ⇝ Improved by changing the fixed CO concentration profile
- Spectroscopy of CO_2 in $[2230 - 2390]$ cm^{-1} + temperature biased
- At 2380 cm^{-1}: line mixing artefact ⇝ can be corrected by adding a small CO_2 continuum
- Between $[2590 - 2760]$ cm^{-1}: H_2O vs HDO distinction in 4AOP ⇝ The profile of HDO is parameterized from the H_2O concentration profile
- At ~ 2200 cm^{-1}: bias linked to N_2O concentration profile



- Spectrum differences grouped by airmass class (tropical, mid-lat1, mid-lat2, polar1, polar2) and sorted in ascending order of Integrated Water Vapor
- Differences are clipped between $[-1, 1]$ Kelvins
- Overally **4A** model shows slightly better performances than **RTTOV**

Jacobian comparisons



- Temperature jacobians are in good agreement
- Some differences appear in concentration jacobians ⇝ Likely related to the parameterization of low optical depth values

Conclusions

- Intercomparisons are fundamental for validating spectroscopic databases and new development in codes
- We confronted RTTOV & 4AOP newest versions to IASI observations
- We use a dense set of radiosounds/reanalysed profiles in order to mitigate atmospheric uncertainties
- The results show similar features between RTTOV and 4A/OP biases albeit slight differences within instrumental noise
  ⇝ Recommendation: update RTTOV spectroscopic database
- *Not shown here:* standard deviations for RTTOV and 4A are very similar

Outlook

- New version of the ARSA database available soon with ERA-5 reanalysis
- Introduce realistic concentration profiles for CO and N_2O
- Investigate Jacobians differences (Optical Depth Parameterization)
- Use of a reference for Radiative Transfer (*i.e.*, LBLRTM)
- Couple with inversion procedure to estimate model related bias

References

[1] R. Saunders, J. Hocking, E. Turner, P. Rayer, D. Rundle, P. Brunel, J. Vidot, P. Roquet, M. Matricardi, A. Geer, N. Bormann, and C. Lupu.
An update on the rttov fast radiative transfer model (currently at version 12).
Geoscientific Model Development, 11(7):2717–2737, 2018.

[2] N. A. Scott and A. Chedin.
A fast line-by-line method for atmospheric absorption computations: The automatized atmospheric absorption atlas.
Journal of Applied Meteorology (1962-1982), 20(7):802–812, 1981.

[3] J. Hocking, J. Vidot, P. Brunel, P. Roquet, B. Silveira, E. Turner, and C. Lupu.
A new gas absorption optical depth parameterisation for rttov version 13.
Geoscientific Model Development, 14(5):2899–2915, 2021.

[4] W. C. Snyder, Z. Wan, Y. Zhang, and Y.-Z. Feng.
Classification-based emissivity for land surface temperature measurement from space.
International Journal of Remote Sensing, 19(14):2753–2774, 1998.

Contact information

jean-marie.lalande@meteo.fr