

Reviewer1:

Review of: Development of a fast radiative transfer model for ground-based microwave radiometers (ARMS-gb v1.0): Validation and Comparison to RTTOV-gb

This article presents the development and extensive validation of a new fast radiative transfer model for ground-based microwave radiometers. It is compared versus a line-by-line model and the well-established RTTOV-gb forward model. The topic is of high relevance, the model and its development are described adequately, and the corresponding validation is carried out carefully and described properly. I recommend the publication of this manuscript subject to some (minor) corrections.

Abstract: In my opinion the abstract should be easy to understand for people who have not yet read the article, and who might not be that familiar with the overall topic. Several terms like “Optical Depth in Pressure Space Scheme”, “UMBC48”, “MonoRTM” are used without saying at least very roughly what it is. It is not really clear that with bias drops and different Jacobians you mean the two biases and Jacobians of the two different vertical interpolation modes.

Answer: We rewrite the abstract following the reviewer’s suggestion. In the new abstract, we delete words like “MonoRTM” and use “a statistical regression scheme” to replace “Optical Depth in Pressure Space Scheme”. We also give the full name of ECMWF (the European Centre for Medium-Range Weather Forecasts) and UMBC (the University of Maryland at Baltimore County).

Sentences includes “bias drops” and “different Jacobians” are changed to “Additionally, an advanced water vapor vertical interpolation method is incorporated, offering improved accuracy compared to the interpolation method used in RTTOV-gb. The standard deviation is reduced by 0.15 K in channels with strong water vapor absorption. Jacobian calculated by these two interpolation modes are also different. ”

See Lines 1-21 in diff.pdf.

Line 10-11 and line 66-67: From my opinion it is difficult to say that GMR observations are the true reference here. It is reasonable to do “obs minus background” comparisons, but as you are using ERA5- profiles as input to the radiative transfer codes, and not real observations of temperature and humidity, I would not name it “true reference value”, as with simulated input profiles having certain errors it is not expected to obtain the observation as output.

Answer: Following the reviewer’s suggestions, we use “The Observation Minus Background analyses” to replace “true reference value” in the abstract as well as Introduction. See Lines 17-18 and Line 80 in diff.pdf.

In section 4, the sentence is changed to “Three GMRs are selected: two are used to provide benchmark values for comparing the accuracy of ARMS-gb and RTTOV-gb, while the third is utilized to demonstrate the ability of ARMS-gb to monitor observational quality.”. See Lines 289-291 in diff.pdf.

Line 12-14: Also this last sentence is only understandable having read the paper before.

Answer: The sentence is changed to “Furthermore, the ability of ARMS-gb to monitor GMRs’ observational quality is demonstrated.”. See Lines 19-21 in diff.pdf.

Line 63: typo, must be “each component”

Answer: Corrected. See Line 74 in diff.pdf.

Line 102: shouldn’t it be “transmittance in spectral channel V”?

Answer: We use “transmittance across the channel bandwidth V” to replace “transmittance in spectral channel V”. See Line 124 in diff.pdf.

Section 3.2: For me here the description is somewhat confusing and not really exact (especially Line 138 and line 150). The tangent linear and the adjoint model are two different things needed for four-dimensional variational data assimilation, although they are closely related. The tangent linear model linearizes the forward model to

compute how small changes in the state affect the future model state. The adjoint model is the "backward" version of this process. It allows the calculation of the sensitivity of the cost function with respect to the state at previous times. Thus, in four-dimensional variational data assimilation, they work together to update the model state based on observational data, by first using the tangent linear model to compute how perturbations in the state evolve and then using the adjoint model to find how these perturbations should be adjusted to minimize the difference between the model output and the actual observations. I suggest to correct this chapter.

Answer: In the revised version, we keep the description of K matrix as it is used in 1D-Var systems and delete the description of the finite difference method. We rewrite the description of the tangent linear and adjoint module following the reviewer's suggestions. See Lines 155-185 in diff.pdf.

Line 208: Say more exactly what you mean with "bias drops"

Answer: The sentence is changed to "In channel 4, AVG and STD of mode 2 are 0.19 K and 0.15 K lower, respectively, compared to mode 1.". See Lines 262-263 in diff.pdf.

Line 210: Grammar mistake, rewrite to: "The slight reduction of STD..."

Answer: The sentence is changed to "STDs in these channels also show slight reductions when mode 2 replaces mode 1". See Lines 264-266 in diff.pdf.

Line 216: Please rewrite to: "The Jacobians calculated by the two interpolation modes...."

Answer: Corrected. See Line 273 in diff.pdf.

Line 254: I would rewrite the heading to "Comparison to RTTOV-gb"

Answer: Corrected. See Line 314 in diff.pdf.

Line 349: also here the term “bias drops” is not clear enough. It would be better to describe which bias is lower compared to what.

Answer: The sentence is changed to “For example, in channel 4, AVG and STD using mode 2 are 0.19 K and 0.15 K lower, respectively, compared to mode 1.”. See Lines 444-446 in diff.pdf.

Line 366: I would recommend to start a new line after “2.59%.”

Answer: Corrected. See Line 477 in diff.pdf.

Line 386: better: “... obtained by taking the mean over the...”

Answer: Corrected. See Line 506 in diff.pdf.

We appreciate the Reviewer 1 very much for the favorable assessment of our work and the constructive comments.