Referee Comment 1 (RC1) by Anonymous Referee #1

The paper presents a review of current formulations of the microwave absorption parameters between 20 and 60 GHz examining in detail the uncertainties associated with each parameter. It then identifies the spectroscopic parameters that most affect microwave brightness temperature measurements at commonly used channels and it estimates the resulting covariances due to the atmospheric model.
The manuscript is well written and organized and it provides an important contribution for users of microwave data to retrieve atmospheric parameters.

We thank the reviewer for the positive feedback.

My only concern is related to how these uncertainties affect the measurements and retrievals. I would expect most of the forward model uncertainties to be systematic (biases) and therefore difficult to characterize in terms of covariances? Can the authors comment on this aspect of the uncertainties.

We agree with the reviewer that forward model uncertainties are generally systematic, though they depend on atmospheric conditions (e.g. temperature, pressure, humidity). The presented approach aims at evaluating the total uncertainty of simulated T_B. In fact, spectroscopic parameters are affected by both systematic and random uncertainties. Contributions to the systematic component include theoretical assumptions and systematic experimental errors. Contributions to the random component include spread of laboratory data and experimental noise. Our analysis takes into account the total (i.e. systematic and random) uncertainty of spectroscopic parameters, which combine to result in the total uncertainty of simulated T_B. If parameter values are determined with methods that introduce correlation between them, their total uncertainty will also be correlated. The consideration of the parameter covariances allows to estimate more rigorously the magnitude of the total uncertainty affecting T_B.
We now emphasize this concept at the beginning of Section 3.

A second question is about Fig. 11. The uncertainty in Q seems very high for Arctic atmosphere as Arctic specific humidity can be as low as 0.5 g/kg which would make the spectroscopy uncertainty about 50%. If Fig. 11 represents the uncertainty only due to the spectroscopy, to which all the other uncertainties, such as radiometric noise, etc. are added, does this make the whole microwave retrievals useless in dry conditions?

We agree with the reviewer: Figure 11 shows high Q uncertainty for Arctic atmosphere. However, as stated in the manuscript (last paragraph of Section 5.2), these uncertainty profiles are to be considered just as indicative, as they depend upon the vertical grid spacing and the choice of $\mathbf{Cov}(\epsilon)$ and $\mathbf{Cov}(x_a)$. The last two terms represent the radiometric noise and the a priori uncertainty; thus $\mathbf{Cov_p}$ (whose diagonal terms are displayed in Figure 11) represents the model parameter uncertainty covariance matrix, given the choice of $\mathbf{Cov}(\epsilon)$ and $\mathbf{Cov}(x_a)$.
To present general results, we used $\mathbf{Cov}(\epsilon)$ and $\mathbf{Cov}(x_a)$ resembling typical matrices adopted in ground-based microwave profiling. The assumed a priori uncertainty for Q (σ_Q=3.2 g/kg at surface) is definitely high for Arctic conditions, and thus it dominates the gain matrix.
We have added the following sentence to Section 5.2 to make this point clear:

"Values are particularly high for relative drier climatology (e.g. Arctic); this is simply a consequence of the assumed *a priori* σ_Q, which is typical of mid-latitude climatology. Reducing σ_Q by a factor of 10 (to be closer to values for dry climatology), the uncertainty profile would reduce roughly by the same factor."