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Atmospheric Measurement Techniques
Discussions

Interactive comment on "Retrieval of Total Water Vapour in the Arctic Using Microwave Humidity Sounders" *by* Raul Cristian Scarlat et al.

Raul Cristian Scarlat et al.

rauls@iup.physik.uni-bremen.de

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General comments

We want to thank the anonymous referee for a very thorough and detailed review. If not especially addressed in our reply, we will implement these comments as is because we agree with the referee and we believe this is the simplest way to address those parts of the manuscript which were lacking in clarity.

In the following we try to address some specific comments and detail how we will modify the revised manuscript to satisfy the referee's concerns.

1) - "A table of all the algorithms would be immensely helpful."

This issue has been brought up in other discussions as well. The suggestion for a table to clarify the methods being used and their characteristic parameters is welcome and we will implement it in the revised manuscript.

Specific comments

2.6 - "My interpretation of Fig. 3 is that C(τj, τk) is only important for low values of TWV. But for those low values you're using an equation without C(τj, τk), so is it ever important? If not, why even bother with the term?"

This function has the largest variability in the low-TWV range of values where the retrieval equation does not include it. In the mid and extended range modules however this function is integrated in the retrieval equation and while it is not constant it varies slowly with increasing TWV. We show this behaviour in Figure 3 in order to support our assumption of using one constant value for the function. This constant value is different for the mid and extended range TWV retrieval modules. This clearly needs to be better explained and we will do so in the revised version.

2.9 - "It would be helpful to mention that these algorithms only work over open ocean. It would also be helpful to give some basic information on the RSS and NN algorithms. What range of TWV can they retrieve? Do they cover the entire Arctic? Do they work over sea or land ice (nope!)?"

Indeed this is one of the strongest points of our retrieval method and it needs to be better emphasized. Even though the RSS and NN algorithms show reliable results over open water, they are not suited for an Arctic wide retrieval which is the very motivation for our project.

3.1 - "It would be valuable to compare the "original" algorithm and the "new" algorithm to ECMWF for only the pixels where they're both retrieving TWV. That way you could confirm that the poor correlations in June and September are primarily from the "new" algorithm retrieving over sea ice and open water in regions of high TWV. I also think it would be helpful to see a plot of the "new" retrieved TWV error as a function of the retrieved TWV. That is, quantify how the errors increase as you approach the saturation limit (∼15 kg/m20)."

Comparing the New and Original versions only over common coverage areas was done internally and we have decided that the differences are very small and a plot would not bring sufficient new information to justify including it in the manuscript. This however seems to be an issue which touches on other unclear sections of the manuscript and including this plot might help bring the point across better. The areas covered by the Original algorithm are also covered by the New version using only slightly modified equations with the changes being detailed in Section 2.8. The main benefit of the New version when compared to the Original lies in the treatment of open water emissivities for the extended range which represents areas where the Original method simply couldn't retrieve anything.

- "Figure 6 just shows correlation, not necessarily a bias."

This part ("the highest bias is again seen. . .") is referring to Figure 7 which shows bias values between ECMWF and the two AMSU-B retrieval methods, and not Figure 6 which indeed shows correlation.

- "This is only because you averaged them. The "Bias New" for all 3 Decembers is closer to zero than "Bias Original" but by averaging you came to the opposite conclusion"

Regarding the interpretation of Figure 7 and the differences in bias between the two AMSU-B methods and the ECMWF benchmark, the errors you mention will be corrected. Indeed, using the 3 year average for the monthly bias values resulted in the wrong conclusions.

Considering that over the dry sea ice areas the two AMSU-B versions are almost identical the difference in bias vs ECMWF can only come from the new regions of open

water where the extended range TWV (6-14 kg/mˆ2) can be retrieved with the New algorithm. For the summer months (June and September), both the ratio of open water to sea ice cover is larger and the atmospheric water vapor load is higher than in winter. Both of these events will favor the use of the additional open water modules in the New algorithm. Looking at the comparison with RSS and NN methods that is done only over open water, this negative bias versus the ECMWF benchmark values is a particularity of the AMSU-B New algorithm. TWV values above the saturation limit will result in a negative brightness temperature difference ratio ηc and no numerical values can be retrieved in this case. As such only the retrieved values below the saturation threshold can be kept.

3.2 - "Do you mean the latter? AMSU-B?"

No, we mean the AMSR-E NN method which consistently shows the lowest magnitude bias throughout the time series.

- "Is the correct interpretation here that your new AMSU-B algorithm is frequently observing scenes with TWV values of >15 kg/m2 but still attempts a retrieval and gets values lower than 15 kg/m2 , resulting in a negative bias? Does this suggest that you need a better method than the one described in section 2 to prevent the algorithm from running on scenes that surpass the saturation value of TWV¿'

The 14-15 kg/mˆ2 is the upper limit above which numerical values cannot be returned from the retrieval equation. From an attempted retrieval in a scene with a ground truth TWV value ∼15 kg/m2, the method will retrieve the true value +- the retrieval error. From this retrieved value, only the underestimated values will be kept because values above this threshold cause Not a Number results from the retrieval equation. We are using this retrieval scheme up to the point where the retrieval equation fails and this inevitably means that there will be a negative bias close to this limit.

Fig. 3. - "What do the dashed horizontal lines represent?"

The dashed lines represent the range of variability for the C(τj, τk) function for the corresponding TWV range. In the panel on the left this means the dashed lines cover the mid-range TWV domain (>2 kg/m2) while on the right panel they represent the extended range TWV domain (> 6kg/m2). We will add this explanation in the text.

Fig. 6 - “Dec. 2008 has a much better correlation than the other two Decembers for the “Original” algorithm. Any idea why?”

We are not sure why. Except for a small increase in the retrieval coverage for the Original method probably correlated to the larger sea ice extent for the winter season of 2008 there doesn't seem to be anything special about that year. We will check again for any mistakes in the correlation values.

Fig. 9 - “Is the bottom panel open ocean and sea ice? Or open ocean, sea ice, and land ice, as stated in the manuscript?”

It represents open ocean, sea ice and all land surfaces regardless of ice cover where the TWV value is low enough for the method to retrieve numerical values. The ice cover is relevant because it usually correlates with a drier atmosphere.

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