The manuscript by Scarlat et al. discusses an attempt to improve upon the total water vapor (TWV) retrieval described in Melsheimer and Heygster (2008). They extend the coverage of the retrieval to low ice cover and ice-free areas in the Arctic by using modeled emissivity values. They find that their new algorithm is able to retrieve TWV over more of the Arctic than the previous algorithm but with larger errors in the newly measured regions. This topic is of importance because in situ measurements of water vapor in the Arctic are sparse and satellite retrievals are still limited in a number of ways, which this paper attempts to address. The manuscript is well written and I recommend publication in AMT after considering my comments below.

General comments:

1) A table of all the algorithms would be immensely helpful. Include:
   - The channels used
   - The corresponding AMSU-B channel numbers
   - The expected TWV range measured
   - The surface types allowed

   You may want to also include the original Miao and Melsheimer and Heygster algorithms for comparison.

2) It would be helpful to have a plot of new AMSU-B TWV vs. ECMWF as a function of TWV to show how the errors get worse as you approach the saturation limit of 15 kg/m^2.

3) Many of the equations presented in this manuscript are directly in Melsheimer and Heygster (2008) and it may not be necessary to duplicate them here.

4) The authors refer to an "original" algorithm multiple times throughout the manuscript. It should be clarified that this is referring specifically to the Melsheimer and Heygster (2008) algorithm.

Specific comments:

Abstract:

- You don't mention what you found. How did the new algorithm perform and what are you general conclusions? This needs to be in the abstract.

Introduction:

- "*However this AMSU-B based method...*"
  Miao et al. (2001) uses SSM/T2. Regardless, please define acronyms the first time they are used.

- "*But the emerging errors were deemed acceptable as a trade-off for extending the retrieval range from 1.5-2 kg/m^2 (for only the three band channels) up to 7 kg/m^2 (for two band channels together with the 150 GHz channel).*"
  The use of "band channels" to refer to the 183 GHz channel specifically is confusing.

- "*Melsheimer and Heygster (2008) extends the TWV retrieval range over sea ice by including the 89 GHz channel into the retrieval."*
  Include a short sentence on why including the 89 GHz channel is physically useful (it doesn't saturate as quickly).

- Much of the paragraph starting at P4 L9 feels like it belongs in section 2.2. Too many technical details for the introduction.

- It may be useful to include a statement at the end of the introduction explaining what will be described in remaining sections (e.g. "Section 2.1 provides a discuss of the RT...").

Methods

2.1

- Need to make it clear early in the paper that you're primarily analyzing AMSU-B measurements in this study.

- "*A down-looking microwave radiometer*"
  You may want to note that this is the same type of instrument as a "humidity sounder".

2.2

- "*In the original paper (Miao, 1998)...*"
  If this is the original paper that this work is based on, it deserves discussion in the introduction.

- "*Because the Ts term is the same for both brightness temperatures, it has disappeared from Eq. (2) as a result of the subtraction.*"
  Technically T_s is still in the b_{ij} term and thus in Eq. (2).

- "*To find the relationship between the measured brightness temperature and the water vapour absorption we require the third brightness temperature measured in channel k.*"
  A brief physical explanation of why three channels are necessary would be appreciated for people unfamiliar with microwave TWV retrievals.

- "*Compared to the first two terms under the exponent, the quadratic term can be neglected...*"
  Why? State because it is comparatively small.

- "*for Arctic atmospheric profiles retrieved from radiosonde measurements.*"
  Please describe the source of these radiosondes measurements and give a few details.

- "*W threshold value after which $T_{b,j} \leq T_{b,k}$, or simply...*"
  A brief physical explanation of why this works would be helpful.

2.3

- "*The Melsheimer and Heygster (2008) algorithm extension is adapted only for sea ice surfaces.*"
  Now would be an appropriate time to explain why they didn't apply it over ocean.

- "*From the data points over sea ice, the following regression relationship was found...*"
  Make it clear that this is from Melsheimer and Heygster (2008).

- "*The set of four parameters is determined through regression by using simulated brightness temperatures and atmospheric data from radiosonde profiles*"
  Some detail on how ARTS is used to do this would be helpful.

- "*for the L (low TWV), M (mid-TWV) and X (extended-TWV) cases. In the new algorithm, two extra sets of calibration parameters are required, for the M-ow (mid-TWV over open water) and X-ow (extended-TWV over open water) components.*"
  These nicknames (e.g. "X-ow") are created but not used in the rest of the manuscript. Either used the shortened names or get rid of them entirely.

2.5

- "*from radiosondes profiles and simulated brightness temperatures*."
  Like was done previously? Please clarify.

2.6

- "*lead to differences in the third significant digit of the C0 and C1 parameters, which is small compared to other error contributions."*
  My interpretation of Fig. 3 is that $C(\tau_j, \tau_k)$ is only important for low values of TWV. But for those low values you're using an equation without $C(\tau_j, \tau_k)$, so is

it ever important? If not, why even bother with the term?

2.8

- "*One of the critical points in the algorithm...*"
- "*to the conditions used in their retrieval...*"
- "*the classical mid-TWV retrieval...*"
  As there are many algorithms discussed in this manuscript, it's confusing when you use vague references. Please be clear which algorithm you're referring to at all times.

- "*SSMIS or AMSR-E data...*"
  Need to define and cite both.

2.9

- Perhaps consider naming this section "Comparison of results to Melsheimer and Heygster (2008)", as "previous method" is, again, somewhat vague.

- "*The second dataset is the TWV product from Remote Sensing Systems...*"
  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 Artic? Do they work over sea or land ice (nope!)?

Results and Discussion

3.1

- "*Comparing this with the results in Fig. 5 shows that in the months where the contribution of the improved algorithm is greater, the correlation drop is more significant. Most of this contribution represents pixels with large TWV values, close to the retrieval limit that have a higher uncertainty.*"
  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/m^2).

- "*the highest bias is again seen...*"
  Figure 6 just shows correlation, not necessarily a bias.

- "*For December there is an increase from −0.06 to −0.3 kg/m^2.*"
  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.

- "*Earlier the algorithm was underestimating in both months compared to ECMWF by −0.38...*"
  June 2007 and June 2008 overestimate and June 2009 underestimates but by averaging you concluded that the algorithm was underestimating for all Junes.

- "*Thus, the increase of bias becomes highest in June.*"
  1.86 – (-0.38) = 2.24 and 1.29 – (-1.94) = 3.23 so the increase in bias is actually highest in September.

  Presumably the high bias in the "new" algorithm is due to the addition of retrievals over sea ice and open water. It would be helpful to actually show this. Additionally, do you have a physical explanation for the bias patterns seen in Fig. 7?

3.2

- "*with the former showing the lowest bias...*"
  Do you mean the latter? AMSU-B?

- "*While the AMSU-B method shows much higher negative bias values in summer it is important to note that average TWV values for the ice-free ocean in the summer months frequently surpass the saturation value of 15 kg/m^2.*"
  Is the correct interpretation here that your new AMSU-B algorithm is frequently observing scenes with TWV values of >15 kg/m^2 but still attempts a retrieval and gets values lower than 15 kg/m^2, 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?

- "*Figure 9 top displays the average TWV...*"
  Might make more sense to show the top panel of Fig. 9 before Fig. 8.

- "*The average retrieved TWV for winter months matches better with the model while the overestimation for summer months, although still present is greatly diminished.*"
  Is an interpretation of Fig. 9 summer months that:
  - Over open ocean, often with high TWV, it does poorly (top panel)
  - The bottom panel shows that over all surfaces it does better
  - Thus, the bottom panel implies that over sea/land ice the algorithm must be doing very well compared to ECMWF?

If this is a logical interpretation, you should state as such and include a third panel in Fig. 9 of "New AMSU-B" plotted over ECMWF for only sea and land ice covered regions.

- "*This shows the difference between the average atmospheric water vapour load in the dry Central Arctic compared to the ice-free Arctic Ocean areas*."
  My understanding is that it technically shows the difference between the entire Arctic and the ice-free Artic Ocean.

- "*The previous method was able to retrieve TWV over all surface types for atmospheric water vapour loads up to 6 kg/m^2 and over sea ice for up to 15 kg/m^2.*"
  This will be nice to see in a table near the beginning of the paper.

Conclusions

- "*(Fig. 9, Fig. 4)*"
  Do you mean Fig. 5 and Fig. 4?

- "*This difference can be explained by the additional area covered with the new algorithm.*"
  You could prove this by plotting the original and new AMSU-B vs. ECMWF for matched pixels.

- "*This demonstrates the capabilities of the method to retrieve TWV simultaneously over all surface types in the dry atmospheric conditions of the Arctic.*"
  Well, in the "dry" months you only get ~20% more data with the new algorithm and about the same bias as in the original algorithm. I think the stronger conclusion of this work is that the new algorithm provides greater spatial coverage, primarily in the warmer months, but that the new measurements, often at higher TWV values, have somewhat larger errors.

Figures:

- You capitalize "New" and "Original" in many of the figure captions but not in the manuscript. Please be consistent.

Fig. 3.

- What do the dashed horizontal lines represent?

Fig. 4

- Here you refer to the "new" algorithm as the "improved" algorithm. Please be consistent in your figures and the manuscript.

- Please make all the text larger.
- Please either make the plots larger or the land/ocean/country border lines thicker.
- The color for missing data (grey) doesn't contrast well with the high TWV color (white). Maybe consider upping the contrast somehow?

Fig. 6

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

Fig. 9

- Make all the text larger.
- Is the bottom panel open ocean and sea ice? Or open ocean, sea ice, and land ice, as stated in the manuscript?

Technical corrections:

P2 L5: "above-mentioned"
P2 L16: "radiation, and is..."
P3 L27: "fulfill"
P4 L6: "Infrared"
P4 L10: "Miao et al. (2001)"
P9 L8: "called the focal point"
P9 L18: New paragraph after "...regression fit."
P12 L8: "ocean/ice/land"
P12 L13: Don't start a new paragraph, as you're still talking about SEPOR/POLEX.
P14 L19: "of the AMSU-B instrument, sea surface temperature, and sea surface roughness..."
P15 L6: "(top panel of Fig. 2)
P15 L7: "following linear relationship in the form of Eq. 19"
P17 L11: "specific"
P18 L24: "Heygster (2008)"
P21 L5: Please cite the ECMWF ERA-Interim.
P22 L9: "new method (Fig. 5)."
P22 L24: "spatial contribution"
P23 L27: "closely follow"
P25 L11: Please define RMS.
P25 L15: "174%"
P26 L2: "high spatial coverage"