Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC2
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Comment on amt-2022-187

Anonymous Referee #2

Referee comment on "Performance of AIRS ozone retrieval over the central Himalayas: use of ozonesonde and other satellite datasets" by Prajjwal Rawat et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-187-RC2, 2022

Overall Comments:

The authors have access to some 250 ozonesonde profiles from the central Himalayas. They were launched from a high altitude location just north of many heavily populated cities in the Indo-Gangetic Plain. Their objective is to use this valuable and unique dataset to evaluate the quality of ozone data from several satellite sensors, particularly the AIRS sensor on NASA's Aqua satellite. Though their objective is commendable, the paper suffers from several problems that include flaws in the analysis methodology, poor quality of the figures and captions, and lack of careful editing.

The authors rely very heavily on the use of the so-called "smoothing" formula (Equation 1) proposed by Rodgers and Connor (2003) published in JGR (vol 108, D3). Unfortunately, this formula is often misused. Equation 1 actually creates a hybrid of a high res profile and a priori (AP) profile. Its purpose is to asses if a remote sensing instrument has been properly calibrated and its retrieval algorithm has been correctly implemented. In such cases the retrieved and the hybrid profiles should agree. However, the formula does not provide a method of assessing the science value of the profiles independently provided by the low vertical resolution sensor. To asses it one needs to apply more traditional smoothing methods, such as Gaussian smoothing or computation of layer columns.

To understand the difference let us consider two simple examples. Let us say that a satellite sensor provides no information in a given atmospheric layer. In such cases the AK of the satellite sensor in that layer will be zero and eqn. 1 will yield the a priori (AP) value in that layer irrespective of what the ozonesonde measures. This is not what one means by "smoothing". A more relevant case is when a satellite sensor contains just the total ozone information with no useful profile information. In such cases it can be shown that eqn 1 will transform two high res profiles with very different shapes but containing the same total ozone amount to exactly the same profile that will look like the AP profile but scaled to provide the correct total ozone. Again, this is not what one means by "smoothing". In such cases it is best to compare total ozone values from different sensors directly.

Given this background I find only Fig 10 of the paper useful. Unfortunately, the figure is marred by several flaws. Firstly, computation of layer amounts by itself amounts to smoothing, so equation 1 should not be applied to the ozonesonde profiles. Secondly, the figure seems to show ozone variability as error bars. It is far better to plot the standard error of the mean, which is the proper method of assigning errors bars to mean values. These two changes will make the figure less cluttered and easier to evaluate.

Unfortunately, my assessment of the results presented is that the correct smoothing of the ozonesonde profiles by applying a Gaussian filter or by comparing the layer amounts (without applying eqn 1) would not confirm the key conclusion of this paper that AIRS does well in the troposphere and the stratosphere but not in the UTLS. Still, given the uniqueness of the location, the results are worth publishing.

Detailed Comments:

1) Short Summary: I have not seen any compelling evidence that AIRS does "well in the lower troposphere and stratosphere" at their site.

2) Abstract: Worth mentioning the total number of sondes. These sondes, combined with sondes from other sites in India constitute a unique resource not only to evaluate satellite data but to understand the transport of ozone over north India. As I have noted above, I do not agree with the statement that "AIRS can provide quality data of ozone in the lower and middle troposphere and stratosphere" at their site. The statement "similar to AIRS, Infrared Atmospheric Sounding Interferometer (IASI) and Cross-track Infrared Sounder (CrIS) are also able to produce ozone peaks and gradients successfully" may be true at other locations, but no compelling evidence has been presented to show that it is true at their site. The statement "the monthly variations of columnar ozone (total, UTLS, and tropospheric) are captured well by AIRS, except the total columnar ozone" is confusing. It should say that monthly variation of column ozone at their site is not captured well by AIRS. The evidence that AIRS measures UTLS and tropospheric layer ozone well needs stronger justification.

3) Table 1: The caption needs to indicate what is mean by the numbers following ± sign. I assume they are standard deviations, not standard error of the mean. In that case the standard error would be much smaller and even small differences would become statistically significant. As discussed above, the agreement in the lower layers does not necessarily imply that AIRS is doing a good job. It may only imply that AIRS AP is consistent with ozonesonde. Large differences near 100 hPa is a concern, since it implies some sort of problem with the AIRS retrieval algorithm.

4) Table 2: If these values were derived after applying AK to the ozonesonde data, then it would be very useful to provide the values with and without applying AK, since the latter values are what a user of AIRS data would actually care about. It makes no sense to me to average the MR in the 10-100 hPa layer. Since the MR drops by nearly two orders of magnitude between 10 and 100 hPa, the average would essentially be the value near 10 hPa. It is much better to compare the ozone column in this layer (without applying AK).

5) Table 3: In comparing columns one should not apply AK.

6) Figure 2c: This figure very clearly shows the problem one has in interpreting AIRS ozone profile data. Since the AKs peak near the ozone density peak, the primary information contained in AIRS measurement is the column ozone amount. The profile information is extremely limited. However, if the variability of (log of) ozone near the peak is small, the secondary peak at 200 hPa may help capture some of the variability near that level. While the short-term variability of O3 near the density peak is probably quite small (this needs to be checked using sonde data), it is important to note that QBO in O3 occurs near the ozone density peak. So, the peak in the AK near the peak may introduce QBO like signals at the lower levels.

7) Figure 5: The caption should clarify what do the error bars mean. They should show standard error of the mean not standard deviation. It appears that AIRS provides just the AP value in the troposphere, as one expects from the AKs.

8) Figure 6: Delete the top panel. (See comment no 4.) The results plotted in the second and 3rd panels are hard to see. To make it clearer remove the error bars (they are not errors anyhow) and the dashed vertical Iines. It is not clear why the data are doubly averaged. If one wants to shows the mean MR in a layer, show just the mean MR without applying AK to the sonde data. This is what a user cares. But if the purpose is to evaluate the AIRS algorithm and calibration, show the MR at a single pressure level after applying AK. (See overall comments.)

9) Figure 7: It would be useful to plot the mean difference between sondes and MLS on the left panel. This will tell us if the sondes agree with a much higher vertical resolution satellite instrument. If not this will either imply problems with sonde data or more likely the complexity of doing satellite retrievals near their site. Recommend deleting the middle panel. In the right panel show the std devs desperately from sondes, sonde AK and AIRS to see if AIRS is at least capturing the variability irrespective of the bias. A figure showing r2 would also be useful.

10) Figure 8: Same comment as for Figure 6.

11) Figure 9: same comment as for Figure 7.

12) Figure 10: This is arguably the most important figure of the paper. Please try to improve the figure so it is easier to evaluate. See discussion in overall comments.

13) The figure captions should be self-explanatory. One shouldn’t be required to hunt in the text to understand the figures.

14) The paper requires careful editing. I see citations with no references and references with no citations.