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Atmospheric Measurement Techniques Discussions

Interactive comment on "Megha-Tropiques/SAPHIR measurements of humidity profiles: validation with AIRS and global radiosonde network" *by* K. V. Subrahmanyam and K. K. Kumar

Anonymous Referee #2

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The manuscript describes comparisons of layer average relative humidity (LARH) retrievals from SAPHIR (a 183 GHz microwave sounder on the Megha-Tropiques satellite) with humidity profiles from AIRS (a thermal infrared sounder) and radiosondes.

The paper represents validation of a new dataset. As the authors point out, the highly inclined orbit of Megha-Tropiques allows SAPHIR to provide a unique perspective on atmospheric water vapour in the tropics, with sampling at multiple times of day. The NASA Tropical Rainfall Measuring Mission (TRMM) satellite also flies in a similar orbit,

but the TRMM payload does not include the 183 GHz channels that provide information on upper tropospheric humidity. A humidity product from SAPHIR is therefore of broad interest, and the validation of such a product is a necessary step before it can be utilized for scientific investigations. However, there are some important areas where the analysis and discussion are lacking. In particular, there is a distinct lack of information on the vertical sensitivity of the SAPHIR and AIRS measurements/retrievals (and on what the retrievals will revert to in the absence of information). This information is important for meaningful interpretation of the comparison results. In addition, the introduction lacks clarity and is missing references to a range of other extremely relevant satellite measurements. (Specific suggestions can be found below.) I recommend that the paper be reconsidered after major revisions.

General comments:

The introduction is lacking in clarity and is missing key references to other satellite measurements of upper tropospheric humidity. There are various conflicting statements. I'm not sure one can make the argument that "most of our understanding of the water vapor distribution so far" comes from radiosondes, when "space-based water vapor observations have been available for more than 4 decades"! The authors also use the term "lower atmosphere", which to me would imply boundary layer or lower troposphere, when the benefit of the SAPHIR retrievals described in this paper lies in new information about the upper tropospheric humidity.

A large fraction of the introduction is devoted to some references to previous satellite measurements. This reads like a random collection of information about selected measurements, but does not address what the advantages or disadvantages of these measurements are compared to the SAPHIR measurements. More importantly, the authors completely fail to mention a large number of other highly relevant satellite datasets. In particular, the authors make no mention here of the large number of existing polar-orbiting 183 GHz sensors, or of other hyperspectral infrared instruments. The important points here should be what the various broad categories of satellite

measurements can offer in terms of information on upper tropospheric humidity (spatial coverage, temporal coverage, vertical sensitivity, vertical resolution, etc.) Details of footprint sizes of individual instruments, the exact altitudes of the satellite orbits etc are largely just a distraction in this context. In my mind, the important categories of relevant measurements are: 1. Geostationary infrared measurements 2. Polar-orbiting microwave radiometers (e.g. SSMIS, AMSU-B, MHS, ATMS) 3. Polar-orbiting thermal infrared hyperspectral sounders (not only Aqua-AIRS, but also IASI on MetOp-A and MetOp-B, CrIS on Suomi-NPP) 4. GPS-RO

In the discussion of the SAPHIR instrument and retrievals, there is no real discussion of the vertical sensitivity of the SAPHIR measurements. To say that the six channels provide humidity information in six distinct pressure layers between the surface and 12 km is overly simplistic. In fact, for tropical atmospheres, the SAPHIR channels show almost no sensitivity in the 1000-850 hPa range. The paper would benefit from a figure showing the weighting functions of the SAPHIR channels. Such figures have been shown in other places – for example, see Figure 2 in Brogniez et al., 2011 – but the sensitivity of the instrument is key to the work presented here, so it would be worth showing something like this again here.

Reference: Brogniez, H., Kirstetter, P-E and Eymard, L.: Expected improvements in the atmospheric humidity profile sing the Megha-Tropiques microwave payload, Quarterly Journal of the Royal Meteorological Society, doi: 10.1002/qj.1869 (2011)

The authors state that channel 6 has sensitivity deep into the atmosphere as evident from the large bandwidth. The large bandwidth of this channel is not the reason why the channel is sensitive deeper into the atmosphere. The reason why the channel is sensitive deeper into the atmosphere is due to the distance of this channel from the center of the 183 GHz line. Channel 6 is furthest from line center, making it more transparent, which is why this channel "sees" deeper into the atmosphere.

On page 11411, the authors discuss the algorithm used for the retrieval of layer aver-

age humidities, citing the work of Gohil et al. Looking at the Gohil et al. reference, I see that the algorithm was developed based on NCEP model fields. This should be stated in the paper. It could be highly relevant for interpretation of the comparisons between SAPHIR/AIRS and SAPHIR/radiosondes. (NCEP is far better constrained by radiosonde observations over land than it is over ocean.) SAPHIR is not sensitive close to the surface. What happens to the humidity retrieval when the SAPHIR observations are not sensitive to the atmosphere? (From figure 5, it looks like the SAPHIR observations revert to some constant humidity value? Perhaps the initial guess?) The manuscript does not provide sufficient information about the algorithm for proper interpretation of the comparison results.

The paper is arranged such that the comparisons with AIRS are shown first, followed by the comparisons with the radiosonde profiles. It would seem to make most sense to show the radiosonde comparisons first. SAPHIR is not sensitive close to the surface. AIRS (and other thermal-IR humidity retrievals) only show near-surface sensitivity under particular conditions. It is likely that the AIRS retrievals are not sensitive close to the surface either. The radiosonde comparisons are more of a reliable reference than the AIRS comparisons. Therefore, these should be shown first, and the AIRS comparisons should come afterwards, since those are secondary information.

In the "Methodology" section, there needs to be some up-front discussion of the quality control that was applied to the SAPHIR and AIRS observations. The authors ought to state somewhere what the numbers of coincidences (during the three month time period of interest) were in each case, and how many of these were flagged as "good" quality.

The discussion of reasons for differences between SAPHIR and AIRS are extremely vague and hand-waving.

The authors state that "Infrared measurements are limited to cloud-free regions". In fact, the AIRS retrievals use a cloud-clearing algorithm (discussed in one of the

Susskind references) that enable retrievals in moderately cloudy conditions. The retrievals are performed from "cloud-cleared" radiances and numerous quality indicators are supplied with the AIRS retrieved products. Did the authors utilize any of these quality indicators?

What should we take from the fact that the SAPHIR retrievals over ocean in the 1000-850 hPa layer are confined to the 70-100% humidity range? The SAPHIR measurements don't really have information at this altitude. Does the 70-100 % come from some kind of initial guess information? AIRS observations are also not terribly sensitive in this range, in general, but the AIRS initial guess information might show a greater range than the SAPHIR.

The authors state "Further analysis with respect to scanning angle may be required to comment on this". Further analysis with respect to scanning angle ought to be performed before this paper moves beyond the discussion phase.

Figure 6 shows good correlation between AIRS and SAPHIR over land at all levels. My suspicion would be that both the AIRS and SAPHIR products are somehow heavily influenced by numerical weather prediction fields at the near-surface altitudes and that the NWP fields are better constrained by observations over land, hence the good agreement. However, the manuscript does not contain the information that would be necessary to draw definite conclusions on this.

Overall, the paper would benefit from a careful review of the grammar. The manuscript is littered with places where the English is not quite right. This was by no means severe enough to present a problem in understanding the paper, but ought to be addressed before the manuscript moves beyond the discussion phase and into the print journal.

Specific comments:

"SAPHIR" is mis-spelled in several places.

Page 11410, lines 17-18: How was the in-flight sensitivity measured? Is there a refer-

ence for this?

Page 11414, line 13: "...where retrieval could not be done." Why not? Because the retrievals were flagged as cloudy?

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 11405, 2013.