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Atmospheric Measurement Techniques Discussions

Interactive comment on "Uncertainties of satellite-derived surface skin temperatures in the polar oceans: MODIS, AIRS/AMSU, and AIRS only" *by* H.-J. Kang et al.

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Comments for referee (Dr. C.-Y. Liu) We thank the reviewer very much for the valuable comments. Detailed responses to the comments are given below.

Q1) First, the terminology of "AIRS only" may not be a good choice throughout the manuscript. We understand that this term is adopted from AIRS Science Team. However, this "AIRS only" may lead the misunderstanding of this hyperspectral IR sensor. AIRS is an advanced IR sounder with approximately 13.5 km IFOV spatial resolution on the ground at nadir, while AMSU is 45 km spatial resolution. The "AIRS

only" in this manuscript eventually stands for the combined use of 3-by-3 AIRS single field-of-view (SFOV) radiances. Therefore, the retrieved variables, for example, atmospheric thermodynamic, cloud, and surface parameters (e.g., SST/IST) is the Level 2 (AIRS2RET) product based on AIRS 3-by-3 SFOVs (âĹij45 km spatial resolution) data. There are further post-processing and quality control to obtain Level 3 daily gridded product (AIRS3STD). The author should be aware of, cite the discussion in, and elaborate the results, some previous studies that use the real "AIRS only" observation (i.e., the AIRS SFOV data), although to a different end from what is addressed in this manuscript [e.g., (i) Liu et al. (2014), IEEE-TGRS, 52(11), pp. 6957-6963, doi:10.1109/TGRS.2014.2305992 ; (ii) Zheng et al. (2015), Adv. Atmos. Sci., 32(3), pp. 319–335, doi: 10.1007/s00376-014-3162-z ; (iii) Li et al. (2012), Weather Forecasting, 27(2), pp. 515-524, doi: 10.1175/WAF-D-10-05057.1]. A1) Referee #2 (Dr. Liu) pointed out that the terminology of "AIRS only" might not be proper based on the difference in FOV at nadir between AIRS sounder and AMSU. AIRS and AMSU have spatial resolution of about 13.5 km and 45 km, as mentioned by Referee #2. However, the main issue in this study is to compare AIRS only (i.e., AIRS without the microwave information of AMSU) with AIRS/AMSU under the possibly same condition. Further, the terminology of "AIRS only" has been defined and used by the AIRS Science Team (Susskind et al., 2014). In this study, the two Level 3 (L3) products of AIRS/AMSU (AIRX3STD) and AIRS only (AIRS3STD) have been analyzed under the same spatial resolution of a $1^\circ \times 1^\circ$ ($\sim$100 km $\times$ 100 km) grid. These two L3 products are from two Level 2 (L2) datasets of AIRS/AMSU (AIRX2RET) and AIRS only (AIRS2RET), and both are with the same spatial resolution. Therefore, the products of AIRS/AMSU and AIRS only have been compared under the same spatial resolution (i.e., 45 km at L2, and 100 km at L3), regardless of the different level data. The L3 data have been produced for the users who are interested in the studies of the long-term temperature change and climate, etc. In the viewpoint, we think that the use of the L3 products in this study can be reasonable for the primary purpose of our analysis. However, the background information of the L2 and L3 products, as mentioned by Referee #2, could

be helpful for us to understand the spatial difference between them as well as the hyperspectral function of AIRS. Thus, the text has been revised to include the L2 and L3 information, based on three references as follows: i) Liu et al. (2014), ii) Zheng et al. (2015), and iii) Li et al. (2012) (New Version; Lines 73-76, 174-179, 601-603, 608-610, and 662-664).

Q2) Second, the manuscript starts with the processing of NASA/Aqua MODIS Tskin. From Fig. 1(a) and 1(b), the dataset doesn't cover lower latitudes but only the latitudes close to the South Pole. Although author mentioned the process from its original 4km by 4km to 1 degree by 1 degree, the comparisons among the other two data sets is not in an equal level. The ice coverage won't be that symmetrically close to the South Pole. Since the studied temporal window is only 9-day per year per hemisphere (data amount should be manageable), the use of daily Level 2 is strongly recommended but not Level 3.

A2) Referee #2 mentioned that in Fig. 1a and 1b, the data of MODIS IST did not cover lower latitudes but only the latitudes close to the South Pole. However, the MODIS IST data are actually available for the region poleward from 40 S in the southern hemisphere (Fig. S1a-b). We think that the MODIS IST is useful for the potentially frozen ocean from $\sim$50 S to the Antarctic, while the use of MODIS sea surface temperature is good for the ocean from the equator to $\sim$50 S (Lee et al., 2013, AMT, 6, 445-455). Referee #2 also pointed out that the comparisons of MODIS IST with SSTs of either AIRS/AMSU or AIRS only were not in an equal level despite the IST data reconstructed in spatial resolution from 4 km $\times$ 4 km to 1° $\times$ 1°. We partially agree with Referee #2's comment because the regridded process could result in $\sim$0.5 K uncertainty in the comparison of zonal averaged values of Tskin(MODIS), as shown in Fig. 7 in the manuscript. In order to investigate the effect in the difference of spatial resolution between L2 and L3 products, the 9-day composite data from the L2 products of Tskin (MODIS), Tskin (AA_V6), Tskin (AO_V6) and have been compared with each other over the southern hemispheric ocean during September 15-23, 2003 (Fig. S1). The L2

MODIS IST in non-grid is aggregated to the grid data in 45 km $\times$ 45 km for matching either the L2 'AIRS/AMSU' or 'AIRS only' SST products (Fig. S1a-b). The L2 datasets of 'AIRS only' and 'AIRS/AMSU' SST are also analyzed and compared in their colocation in the 45 km resolution (Fig. S1c). Figure S1d presents zonal averaged values of Tskin (MODIS) minus Tskin (AA_V6), Tskin (MODIS) minus Tskin (AO_V6), and Tskin (AO_V6) minus Tskin (AA_V6) utilizing L2 datasets. The spatial distribution in the difference between the L2 products of Tskin (AA_V6) and Tskin (AO_V6) over the region southward of 35 S in Fig. S1c is similar to that between the L3 products showing the negative value pattern (i.e., Tskin(AO_V6) < Tskin(AA_V6)) of encircling the Antarctica (Fig. 6a in the manuscript). In the L2 datasets, Tskin (AA_V6) is systematically higher than Tskin(AO_V6) near the sea ice/water boundaries, consistent with the L3 cases. Meanwhile, the difference in the L2 between Tskin(MODIS) and Tskin(AA_V6) in Fig. S1a is somewhat different from that in the L3 (Fig. 5a in the manuscript), probably due to various reasons (e.g., different spatial resolution, re-gridding method, data screening, quality control, and processing, etc.). The difference in the L2 or L3 between Tskin(AO_V6) and Tskin(AA_V6) is relatively small, mainly due to the same spatial resolution and the channels except for AMSU (Fig. S1c). The peaks in the zonal average differences between the L2 products occur near the seasonally varying sea ice/water boundaries, similarly to the previous L3 cases (Fig. S1d and in the manuscript Fig. 8). In other words, the negative values ($\sim$ -1.0 K) in Tskin(AO_V6) minus Tskin(AA_V6) commonly occur in the L2 and L3 datasets near 60 S. The L2 peak is also shown as a reduced negative value near the latitude. However, the L3 peak in Tskin (MODIS) minus Tskin(AA_V6) has been given in the positive value in Fig. 8a of the manuscript. This disagreement is probably due to aforementioned reasons. Overall the uncertainties among the three L2 datasets are similar to those of the L3, but the magnitude of Tskin(MODIS) minus Tskin(AA_V6) for L2 is somewhat different from that of for the L3 (Fig. S1d). Although the detailed analysis of L2 is beyond the scope of this study, further studies are warranted. The text has been revised to including the L2 results for a sample year of 2003 (New Version; Lines 483-499).

Q3) Lastly, when I look over the manuscript, it discussed surface skin temperatures which has two categories: IST and SST. The authors should make sub-title (IST vs SST), such as Section 3 and 4, in the content. This will help reader to follow the analysis and discussion logics.

A3) The text has been revised to clarify the difference between MODIS IST and AIRS/AMSU (or AIRS only) SST (New Version; Lines 190 and 358).

References Li, J., Liu, C. Y., Zhang, P., and Schmit, T. J.: Applications of full spatial resolution space-based advanced infrared soundings in the preconvection environment, Wea. Forecasting, 27, 515-524, doi: 10.1175/WAF-D-10-05057.1, 2012.

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Zheng, J., Li, J., Schmit, T., Li, J., and Liu, Z.: The impact of AIRS atmospheric temperature and moisture profiles on hurricane forecasts: Ike (2008) and Irene (2011), Adv. Atmos. Sci., 32, 319-335, doi: 10.1007/s00376-014-3162-z, 2015.

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/8/C1920/2015/amtd-8-C1920-2015-supplement.pdf

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Interactive comment on Atmos. Meas. Tech. Discuss., 8, 4451, 2015.

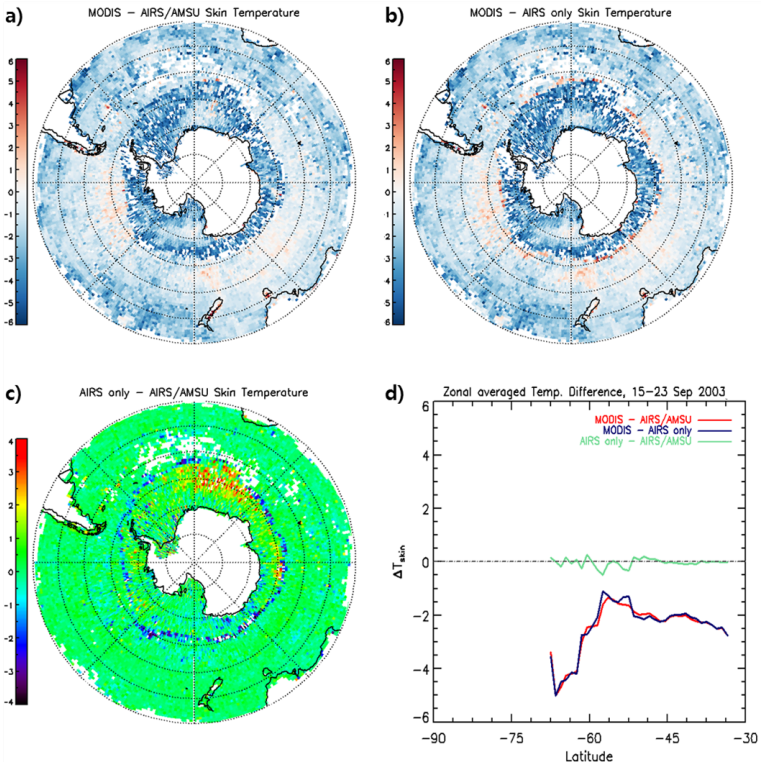

Fig. 1. Spatial distributions in L2 datasets of the a) Tskin (MODIS) minus Tskin (AA_V6), b) Tskin (MODIS) minus Tskin (AO_V6), and c) Tskin (AO_V6) minus Tskin (AA_V6). d) Zonal averaged values of the Tskin