Reviewer #2: This is not a full review of this paper, but a request for clarification about the sampling of clouds by AIRS. I hope that the authors can reply to these questions promptly and at least before the end of the discussion period, so that I can adjust the full review accordingly. More information about the sampling is essential for interpreting the results and comparisons to earlier work.

Response: We thank the reviewer for prompting the authors for clarification. Please see below for our responses.

Reviewer #2: It is not clear to me which clouds are included in the sample. The authors state that "AIRS sensitivity is maximized for optically thinner cirrus with tau < 5". Given that the ice cloud properties are derived from infrared measurements, I interpret this as meaning that there is no information on optical depth or effective radius in these measurements for clouds with an optical thickness larger than 5. Yet, parts of the paper focus on convective clouds, of which larger parts would have optical thicknesses much larger than 5. For example, figure 10 suggests that the properties of a cirrus above deep convection is retrieved. However, only the parts over thick outflow of that system would have column optical thickness lower than 5. If I am correct, AIRS would only sample the thick anvils of such clouds. Is this indeed the case?

Response: The AIRS instrument is sensitive to tau <= 5 or so, but we want to clarify that this value is with respect to that defined in the infrared (about 11 microns). We report AIRS retrievals of tau with respect to 0.55 microns in the operational retrieval for easier comparison to the MODIS instrument. Please see Kahn et al., 2015, J. Geophys. Res. definitions and the comparisons to MODIS. We are able to extrapolate from 11 microns to 0.55 microns because we use Bryan Baum's bulk scattering models that are consistent across the wavelengths. In that case AIRS is sensitive to about tau <= 8 or so, with a few outliers that approach 10 (see Kahn et al., 2014, Atmos. Chem Phys., Figure 10 upper row).

As far as the sampling, we observe all clouds above some nominal tau > 0.1 or so, including convective clouds, but we are geometrically-speaking only sensing the upper tau <=5 (with respect to 11 microns). The same applies to the cloud effective radius (CER): it is retrieved for opaque/thick clouds only from the spectral signature in the upper 5 optical depths of the cloud. The rest of the cloud that is physically located below this upper layer is not retrieved since AIRS has no sensitivity to it.

So, bottom line, AIRS detects almost all ice clouds but the values of tau and CER are only obtained for the upper 5 optical depths.

In the revised manuscript, we will be clearer about the <u>sensitivity</u> of the AIRS instrument versus the <u>sampling</u> of the population of clouds.

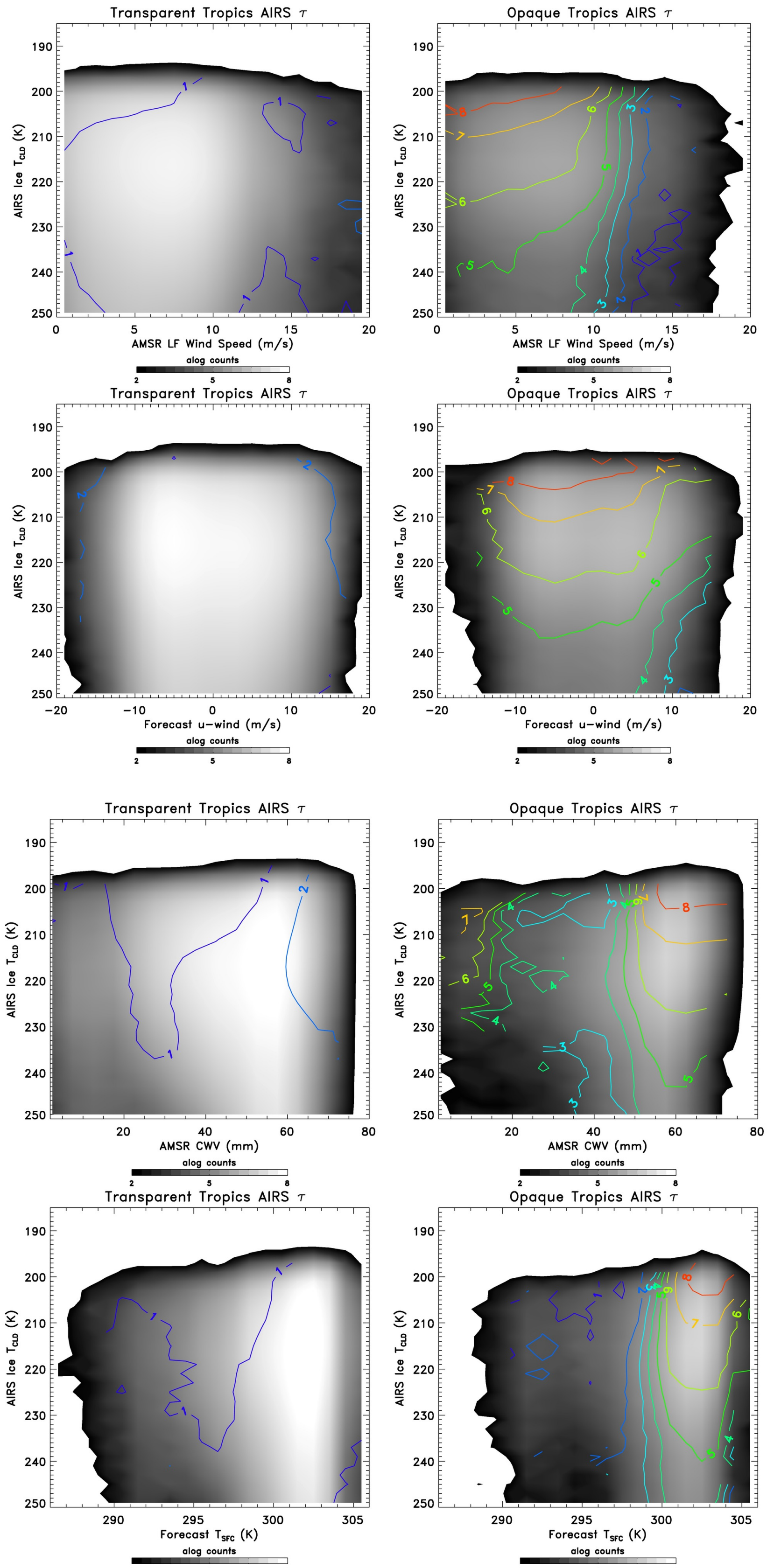
Reviewer #2: I might be wrong though. Another interpretation is that there is no sensitivity to optical thickness for clouds with an optical thickness larger than 5, but there is still sensitivity to effective radius for these clouds in the AIRS wavelength range. In this case the sample would include essentially all clouds. The optical thickness would be 5 for any cloud thicker than that. Is this maybe the case?

Response: The reviewer is correct that for very thick clouds the optical depth plateaus around 5-8. We include all cloud samples but the sensitivity limits us to the upper tau <=5 of the cloud. Furthermore, all CER retrievals are for the same portions of the cloud in which AIRS can sense tau.

Reviewer #2: Related to that, I am confused what sample of clouds are included in the 'opaque' cloud selection. Opaque is defined related to the effective cloud fraction, but it is unclear which optical thickness that would correspond to. If cloud with optical thicknesses larger than 5 are included in the sample, my guess is that these are opaque. If only clouds with optical thicknesses lower than 5 are included, what optical thickness range would correspond to 'opaque' clouds then?

Response: This is a great question. We did not report that in the submitted version of the manuscript, so we have included figures in this response for clarification. (We could add these figures, or similar ones, in the revision if the reviewer so chooses.) Below are figures 8 and 9 with ice cloud tau as a function of the AMSR variables and AIRS derived ice cloud top temperature, broken into opaque and transparent.

In general the opaque categories have several times larger values of tau than transparent. However, there is some structure in tau for some of the AMSR variables. Especially where the counts are lowest, tau can be below 5 for opaque clouds. This is not entirely surprising as lower layer clouds may exist and this drives the effective cloud fraction to near 1.0 even though some of the upper level ice cloud may in fact be transparent. The strong relationships of opaque tau with SST and column water vapor are very encouraging, and the dependence on ice cloud top temperature is also expected. The strong drop-off in tau with AMSR low frequency wind speed is quite interesting, but we note that the counts of those values are very low (the gray scale is on a log scale for counts). The asymmetry in tau with u-wind direction suggests larger tau for weak easterly winds. This is consistent with the arguments made, and cited literature to support the arguments made, in the manuscript about weak easterlies as more convectively active with somewhat larger cloud top CER values.


Transparent Tropics AIRS τ
Opaque Tropics AIRS τ
AIRS Ice T_CLD (K)
AMSR LF Wind Speed (m/s)
Forecast u-wind (m/s)
AMSR CWV (mm)
Forecast T_SFC (K)
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