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Atmospheric Measurement Techniques Discussions

Interactive comment on "Synergy of stereo cloud top height and ORAC optimal estimation cloud retrieval: evaluation and application to AATSR" *by* D. Fisher et al.

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Firstly we would like to thank Referee 1 for their helpful and constructive comments. We address each of their specific comments in turn below.

Referee Comment 1: p. 5285, l15: Intergovernmental

Response: Thank you for spotting this. We will make the edit.

Referee Comment 2 : p. 5289, l2: . . .is built into. . .

Response: Thank you for the suggestion. We will make the change

Referee Comment 3: p. 5289, l14: awkward phrasing

Response: Thank you for the comment. We will attempt to improve the phrasing of this sentence.

Referee Comment 4: Section 3.2: There is a lot of technical jargon in this section. For instance, the first sentence along includes 'census stereo', 'bit vector', 'image pixel', 'pixel pattern', and 'pixel's local neighbourhood'

Response: We agree that some of the terminology used here may not have significant meaning to many readers. However, rephrasing the section in an attempt to reduce the usage of technical jargon may not improve its universal readability. We will consider your comments though and try to better explain the less intuitive technical terms.

Referee Comment 5: Section 3.3: How do the various retrieval approaches deal with the presence of aerosol features? Is this account for in the ORAC algorithm? Is any comparison done with the CALIPSO aerosol feature mask provided by the CALIPSO Science Team?

Response: This algorithm applies a cloud mask before the full retrieval is made. There is a separate ORAC aerosol algorithm (G. Thomas et al Thomas, G. E., Carboni, E., Sayer, A. M., Poulsen, C. A., Siddans, R. and Grainger, R. G.: Oxford-RAL Aerosol and Cloud (ORAC): aerosol retrievals from satellite radiometers. In Satellite aerosol remote sensing over land, Kokhanovsky, A. A. & de Leeuw, G. (eds.), Springer-Praxis, 193-225, 2009.), which is applied to aerosol scenes. This algorithm has not been validated against the CALIPSO feature mask but will be in the future.

Referee Comment 6: p5294, l26: the cited value of 20mK is really low. At what value of brightness temperature is this estimate? Won't the channel be noisier in colder scenes?

Response: The noise value is for the calibration blackbodies and is derived using the "blackbody cross-over test" (see p15 of the Smith et al., (2012) citation). We will clarify

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in the paper that this is not a direct verification of the radiometric error and that the noise for colder scenes may be greater than this.

Referee Comment 7: Section 4, p. 5295: The description of the a priori uncertainties for the STEREO CTH is nicely described and outlined. But how do the look-up tables with ERA-Interim work? Isn't each profile unique? Is this based on some average temperature lapse rate and surface temperature value?

Response: This terminology used here is incorrect. We do not use a lookup table but rather we interpolate between the two temporally closest ECMWF profiles grid cells which contains the AATSR observation. We will edit the paper to clearly state the process we apply.

Referee Comment 8: p. 5295, l19: assessments

Response: Thank you. We will make this correction.

Referee Comment 9: Section 5, first paragraph: This is where I started to get confused by the lack of detail and also the direction of the evaluation of optical depth, and effective radius. First, with regard to the STEREO first guess (but not used as a cloud mask), how does it work if stereo detects a cloud but ORAC does not, and vice-versa? How common are mismatches between them, either because of the pixel-scale mismatches and geometry of the observations themselves (as discussed in Sect. 3), or because of the relative sensitivity of cloud features? Furthermore, it is claimed that the optical depth and effective radius will be 'assessed ' in a similar manner as cloud top height (meaning spatial and temporal coincidences), but in fact, all that is done is the difference between ORAC and ORAC+STEREO is plotted in Figure 7 and Sayer et al (2011) is referred to for the other variables (even though these comparisons are based on gridded averages with MODIS).

Response: Regarding the use of stereo as a priori, it is only used if there is a stereo retrieved height for the AATSR image pixel being processed. If no stereo height is

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available, then the algorithm reverts to the default a priori value. As mentioned in response to comment 5 we use a cloud mask to determine which pixels to process using ORAC. We will clarify this in the paper.

It would be interesting to compare the performance of the cloud masks, but this is somewhat beyond the scope of the paper.

The further analysis required on the microphysical parameters is discussed in later responses.

Referee Comment 10: p 5299: with regard to the binning of single versus multi-layered ice or liquid, it appears the ice versus liquid is done with the height bins. It is unambiguous if a CALIOP cloud is ice because that feature is identified as ice in the cloud feature product – although there could be vertical stratification of phases and/or overlapping phase types, not to mention the spatial heterogeneity of phase over the AATSR pixel area – none of these details are discussed. How is cloud identified as liquid versus ice for AATSR – using the ORAC retrieved phase? Or is it assumed there is a perfect match between CALIOP and AATSR. If the latter, that implies there could be retrievals of cloud properties populated in the wrong phase bin. Are there any references and/or publications regarding the skill of AATSR cloud phase and how well it matches up with other well-characterised estimates from CALIPSO and MODIS. A simple table of occurrences of ice vs. ice, ice vs. liquid, liquid vs. ice, and liquid vs. liquid would be very helpful, and also clarification on whether the sample data set used is for liquid vs. liquid and ice vs. ice only.

Response: In the current analysis the phase binning and other cloud characteristics (height; number of layers) are determined only by the CALIOP. This decision was made, as STEREO only determines height and does not provide an estimate of phase. Furthermore, ORAC and ORAC+STEREO may have different performances in the retrieval of phase. These differences may have a confounding impact on the CTH analysis. Indeed, the aim was to make the conditions for analysis of the CTH retrieval as con-

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sistent as possible, using the CALIOP parameters to define the cloud characteristics is the best approach for achieving this consistency. However, we do agree that an assessment on the skill of ORAC (and ORAC+STEREO) in determining cloud phase, at least in comparison to the CALIOP retrievals, is required. We will extend the microphysical analysis to include this assessment for both ORAC and ORAC+STEREO, and will likely employ the suggested table of occurrences approach. Furthermore, we will provide justification in the text as to why the CALIOP parameters are used to define the features in the analysis.

Referee Comment 11: p. 5301: 'stereo matcher' is not clear

Response: We will change to 'STEREO'

Referee Comment 12: p. 5302, l5: isn't this an 'increase in the negative bias'

Response: Yes, it is. We will apply this correction.

Referee Comment 13: p. 5302, l10-25: The low cloud agreement (nearly zero bias) seems unusually good, even for the ORAC only version. So many other passive instruments have struggled with cloud height assignment of low clouds in the presence of inversions. If there is something unique in the ORAC algorithm that achieves this result, it needs to be discussed further.

Response: It is likely that the bias is not this good globally. This is due to the polar region where we performed the intercomparison analysis (which was required to find collocated AATSR-CALIOP observations with small time differences). In Polar Regions there are few strong boundary layer inversion, which is typically where the retrievals fail. Hence the reduced biases. We will state this in the paper.

Referee Comment 14: p. 5304, l15: median differences

Response: Thank you. We will make this correction

Referee Comment 15: p. 5305, l8-l9: But there is no way to assess this description in

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the results since no phase results from ORAC are presented. For l11-l14, the authors describe exactly reviewer's reasoning on why the same approach should be taken with additional variables as done with CALIPSO to evaluate cloud top height, but yet it is not done in the paper.

Response: We agree that the analysis of the cloud microphysics should be extended to include inter-comparisons against CALIOP. For the phase analysis we will apply the approach the referee suggested in comment 10. For the COT we will provide an analysis similar to that employed for CTH Figure 2, with a joint histogram of ORAC vs. ORAC+STEREO. We will also an inter-compare ORAC and ORAC+STEREO against CALIOP COT retrievals for optically thin clouds (where CALIOP is not saturated) and display the results in a table format (as suggested by referee 3). We will produce similar figures for effective radius.

Referee Comment 16: p. 5305, l22: scenarios that do

Response: Thank you. We will make this correction.

Referee Comment 17: p. 5306, l22: On the contrary, there is nothing clear at all about Figure 4. Why is a map of sea ice shown in a box, with empty space to the Tropics? Wouldn't it be more instructive to zoom in on the segment near Greenland? Also, the cross-section should use the full two-column width and stretched vertically. The font is small and it is impossible to see the different heights overlaid with the CALIPSO data.

Response: Yes we will improve the figure. The map is surplus to requirements here; we will show only the profile to improve the quality of the figure.

Referee Comment 18: p. 5309, l15: macrophysical retrievals.

Response: Thank you. We will make this correction.

Referee Comment 19: p. 5309, l15: multi-layer.

Response: Thank you. We will make this correction.

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Referee Comment 20: Figure 1 suggestions. First stretch the y-axis. Second, reduce the range of the y-axis from -10 to +5km. Third, place the red numbers (these are the means which are red circles?) on top of each panel so that some pace is created within the figure for the whiskers and boxes.

Response: Thank you for your suggestions. However, we are going to follow the suggestion of Referee 3 in this instance and replace Figure 1 with a table (with coloured cells) to ease interpretation.

Referee Comment 21: Figure 5: Is the first set of bars for the bin 0-500m? Why is it centred on 0m? Why does the figure go below the surface?

Response: Yes, the first set of bars is for 0-500m - we will change the x axis on figs. 4,5 and 6 to reflect the fact that they are bins. We will also correct the error bars so that they do not go below the surface.

Referee Comment 22: Figure 7 and 8 can use some similar treatment as Figure 1.

Response: We will also be replacing these figures with tables.

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 5283, 2015.