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Interactive comment on "Evaluating the diurnal cycle in cloud top temperature from SEVIRI" *by* Sarah Taylor et al.

Anonymous Referee #2

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This study attempts to evaluate retrieval biases in the CLAAS-2 Cloud Top Temperature (CTT) dataset derived from SEVIRI via a comparison with co-located CALIOP retrievals. The novelty of the study involves the separation of the evaluation into daytime and nighttime components, in order to establish whether the quality of the retrievals is consistent through the day. This is important given one of the key benefits of SEVIRI based retrievals should be their ability to capture the diurnal cycle in the geophysical quantity of interest. Having qualified the retrieval quality the authors then investigate the diurnal variability seen within the CLAAS dataset and discuss the implications of their evaluation for the robustness of the CTT signals contained within it.

Overall I think that the concept of the study is a good one – as noted about, the key benefit of CLAAS above what is possible from instruments in polar orbit should be an accurate representation of the diurnal cycle in cloud parameters. Hence making

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potential users aware of deficiencies in this representation is useful. The paper is generally well written and the methodology clearly presented.

However, I do have some major and minor comments which I list below. Subject to these being satisfactorily addressed, in my opinion, the paper will be suitable for publication.

Major Comments

1. Nowhere is the accuracy of the 'truth' dataset, CTT from CALIOP, actually quantitatively defined. There is also no mention of whether there is any difference in CALIOP retrieval quality from day to night which I suspect there might be. I also wonder whether the CALIOP inferred heights and optical depths are equally accurate for all cloud types since I would expect the sensitivity to be higher for clouds comprised of smaller ice particles and droplets than for those comprised of larger droplets. Quantitative information concerning accuracy must be in the paper rather than phrases like 'very accurate'.

2. In a similar vein, the transition of height or pressure to CTT using model fields is mentioned as a possible reason for discrepancies between the CALIOP and SEVIRI retrievals, particularly in the SE Atlantic stratus region. However, detail on how the transition is done is rather lacking. It would be useful to know how, for example, timing discrepancies between the background meteorological fields and the satellite overpasses are dealt with. Ideally, in order to isolate the impact of differences in the background model fields one would want to be able to do the analysis using the same set but I appreciate this is beyond the scope of this study. Can any literature be used to give some idea of how well the different meteorological models represent the background state under different regimes as this will affect the CTT comparison?

3. The introduction focuses almost exclusively on convective cloud yet much of the paper discusses regions of stratiform and potentially mixed cloud. Hence the introduction needs some broadening to reflect this.

4. It was unclear to me whether pixels were only considered if they were fully cloud covered or if broken cloud scenes were also considered. I thought the former, but there seemed to be a significant amount of discussion on the effects of surface emission. For the majority of deep convective cases, for fully covered pixels this wouldn't actually have an effect. Since the authors limit the cases studied to greater than an optical depth (where spectrally?) of > 1.0 even outside of those regions the surface impact would be limited.

5. Given much of the manuscript is spent showing deficiencies in the CLAAS retrieval algorithm outputs I feel a short summary of the algorithm is necessary. If this seems too demanding I think at the very least there should be some description of what changes from day to night. I assume that visible channels are used in the daytime (in addition to IR) which may go some way towards explaining why the biases, relative to CALIOP, are improved during the day.

Minor Comments

Page 2 line 32: Consider also adding papers by Pearson et al., 2010 (JGR), 2014 (QJRMS)

Page 3 line 14: It's a little bit of a stretch to say that SEVIRI 'covers' the Middle East as implied here. It certainly sees it but perhaps not all of it. Similar comments apply to the Atlantic Ocean.

Page 3 line 17: Perhaps a little pedantic but SEVIRI does not observe the radiometric height of the cloud, it observes radiances (or, if we want to be completely technically accurate, digital counts). These can then be inverted to estimate the radiometric height. On a similar theme, the manuscript is written as if CALIOP observes cloud top height, which is not technically true, rather it observes backscatter, and, as with any satellite instrument, the required geophysical variable is inferred in some way.

Page 3, line 34: quantify what you mean by optically thin, and give the wavelength that

you are defining the opacity at.

Page 4, line 14: this makes it sound as if you are using data from one instrument flying on one satellite through the whole period considered here which is not true. Neither is it true that throughout this record the operational SEVIRI instrument was at 0 degrees longitude.

Page 4, line 31: more detail on how this CTP retrieval works is required. For example, the wording 'the data available', is extremely vague.

Page 5, line 10: as noted in the major comments, more detail on how this is done is required.

Figure 1: I find this figure, although useful, somewhat misleading as it implies that clouds are ubiquitous. I would suggest another figure or set of panels indicating frequency of cloud occurrence would be beneficial. Similar information is shown later on in the paper but I think it would be good to have it upfront.

Page 6, line 12: while I agree that the diurnal cycle could well be largest here I don't think it necessarily follows from the reasoning given. It could be that the cold clouds are there throughout the day. Figure 1 tells you nothing about this on its own.

Page 6, line 18: Figure 1 implies a spatial and seasonal pattern in cloud type but it doesn't explicitly show it. Since you state that the cloud retrieval you are using gives cloud type it would be interesting to see if that maps to what you see in Figure 1.

Page 6, line 20: I don't think section 2 really gives a quantitative idea of the implications of cloud type and land surface emissivity for the accuracy of CLAAS CTT. There was more of a general discussion in the introduction to be honest.

Page 6, line 25: When the authors say 'data was processed' are they referring simply to the collocation process? It might be good to state this explicitly.

Page 6, line 30: 'very accurate' is not very scientific.

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Page 7, line 17: define COD as Cloud Optical Depth (and give wavelength).

Page 7, line 25: I assume the temporal collation window is centred on the CALIOP observation. Is the variation in the timing of SEVIRI scan lines accounted for? What is the spatial match up criterion?

Page 7, line 28: Actually figure 2 suggests that the tightening from 0.3 to 1 does result in a reduced bias while above 1 there is not much change. The authors say this themselves in the next paragraph.

Page 7, line 30: How is a cloud layer defined? i.e. are the thresholds simply applied to the topmost layer with a COD as diagnosed by the CALIOP product? Is there any change in vertical resolution in this product? I'm not sure whether it would have an impact but if for example the vertical resolution reduces with height above a certain point, the same COD would actually indicate a more diffuse extinction profile within the layer.

Page 8, line 13: what is the 'relatively coarse' resolution in numbers? How does this compare to the CALIOP vertical resolution? How well do both of the meteorological models actually capture low level temperature inversions? Do they persist throughout the night and day?

Page 9, line 7: do the deviations show a Gaussian distribution?

Figure 5: I would weight these differences by occurrence or at the very least discuss them in the context of Figure 4. Otherwise the eye is drawn to the very strong positive daytime bias over the Sahara when really there are few clouds there. Why are there negative differences over the east of Africa during the daytime (Sudan/Ethiopia)?

Page 9, line 28: it may be the colour scale but I would say that while the majority of the ocean shows small biases, there are regions where differences look relatively large. One of these regions is discussed in the next paragraph so perhaps merge these two parts together.

Page 10, line 20: I understand that the authors have used three month means in order to obtain sufficient data to see a coherent cycle at the pixel scale but do they perhaps worry that by doing this you are losing information about how the phase of any diurnal cycle in CTT might vary through the year? The discussion about producing 'smooth cycles' is rather vague.

Figure 6: Can the authors provide some idea of the range of values that comprise each hourly mean please, perhaps using quartiles or SDs if the distribution is Gaussian?

Page 10, line 33 (and in other sections focused on the Sahara): I am a bit bemused about the emphasis on the Sahara in the latter part of the paper. As is shown, there is very little cloud being detected there (as one might anticipate) and I am not sure that I would expect too much of what is there to be deep convective in nature (at least north of the inter-tropical front). Hence why should we expect a marked diurnal cycle? Moreover, when what is happening there is analysed the statistics will be poor.

Page 12, line 33: I agree that vegetated Central Africa will typically have a lower surface albedo than the Sahara but I don't see why this would cause the Sahara to heat up more quickly after sunrise (I would actually expect the opposite based on albedo alone) or how this would produce lower, warmer clouds. Please explain.

Page 13, line 22: 'Additional biases. . .' – this sentence is very vague. What retrieval errors are being referred to?

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