Review “The impact of atmospheric dynamics on vertical cloud overlap over the Tibetan Plateau” by J. Li et al

The study uses 4-years of CloudSat-CALIPSO cloud profiles and a reanalysis to explore cloud overlap over the Tibetan Plateau, and its sensitivity to atmospheric instability and wind shear. With this analysis, they propose a parameterization of cloud overlap for GCMs that takes into account this sensitivity.

I appreciate the authors’ diligence in taking into account my reservations and their willingness to redo their analysis with the radar-corrected profiles.
There are issues with the study though, mostly with the presentation of the results, and the organization of the paper, as well as some remaining issues with the language usage.

1. As early as the abstract, quantities used to characterize the degree of overlap of cloud layers are introduced but never explained. These are the parameter α and the decorrelation length L. The authors need to explain what these parameters physically mean. This is to say that the cloud overlap characterization and parameterizations need to be explained at the beginning of the paper. The sooner the jargon is introduced and explained the easier it is to follow the paper. The authors have to realize that not a lot of people are familiar with this formalism, and a reminder is necessary. So, the third paragraph of the introduction should be rewritten and include: 1) what is meant by overlap and the three different types, with reference to papers that actually describe parameterizations; 2) explain the formalism introduced by Hogan and Illingworth (2000) and the two quantities that are used to characterize the overlap and 3) the efforts that have been made to characterize the overlap using observations (e.g. Mace and Benson-Troth 2002) and to improve model representation (e.g. the Di Giuseppe and Tompkins 2015 paper, Shonk et al 2010, etc). Then Explain the distinction between continuous and discontinuous cloud layers (I thought that the exact term was contiguous, and non-contiguous) and that there is a consensus on the fact that discontinuous cloud layers are always randomly overlapping. This way you can focus on only contiguous cloud layers later on.
2. The focus of the paper is not very clear: it starts off as an observational study of overlap over the Tibetan Plateau, but navigates through the best way to analyze the data and then moves on to proposing a new parameterization. I think that the interesting point of the study is to test whether existing overlap parameterizations (e.g. the Di Giuseppe and Tompkins 2015 parameterization) are valid over the Tibetan Plateau, demonstrate that it is having difficulty because the relation between cloud overlap and wind shear is not the same as that used in the DGT15 study, and moreover that by also taking into account instability you actually improve the overlap parameterization there. Actually, I think that it is an interesting result that the Shonk et al 2010 scheme is giving fairly decent results too, when it is only latitude dependent. It would have been interesting though if you could demonstrate that your scheme also works in other parts of the

world, in particular over the tropical oceans. In any case these conclusions should be made more prominent, in both the abstract and the conclusions section.

3. It seems to me that the overall method is very much identical to the method used by Di Giuseppe and Tompkins (2015), in particular the choice of horizontal scale, the choice of threshold for the lidar information and the use of the reanalysis to obtain the large scale atmospheric conditions. Therefore most of section 2 could be significantly simplified by summarizing the Di Giuseppe and Tompkins method and choices.
4. It would be great to see the results of the impact of vertical velocities in the paper rather than in supplementary materials. First there are only 7 figures for now, so more could be added, second Figures 3 and 4 could be put together. Mace et al. (2009) found some connection between the occurrence of maximum overlap and strong ascent over the Tropics. Also, according to Naud et al 2008 there is an impact at a continental site in the US, so I am intrigued as to why this is no longer true over the TP. I also wonder what would happen to the total cloud cover if the overlap was parameterized with instability, wind shear and vertical motion: would this make the difference between parameterized and real cloud cover closer to zero? This would be a more convincing test to decide whether vertical velocity has any impact on cloud overlap, other the Tibetan Plateau and elsewhere.

Detailed comments:

Abstract:

1. Line 35: you mention an "overlap parameter" but you have not explain what this is. You might want to add a sentence prior to this one explaining that there is such a parameter to characterize the transition from maximum to random overlap with increasing layer separation. "sensitivity" should be "sensitive"
2. Line 37: what is α? See above.
3. Line 39: similar comment to above: what is this decorrelation length?
4. Line 42: "above 1 km" is confusing: since these are layer separations, use "greater than 1 km" instead.

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5. Line 85-90: the phrase in brackets (L85) is incorrect, please explain here what these three assumptions are and how they relate to the "cloud overlap parameterizations" more explicitly. You have two sentences after that explaining what they do, but only explain what maximum overlap is, not the other two.
6. Line 93: isn't the whole point of the overlap parameterization to help make the radiative budget calculation. Here you write "will also", maybe remove "also"?
7. Line 104: remove "other" before "passive measurements", otherwise it sounds as if radar observations are passive and not active measurements.
8. Line 107-108: add "Mace et al. 2009" in your list of references as they also explore overlap using CloudSat-CALIPSO.
9. Line 130: add "Mace and Zhang 2014" for reference to the GEOPROF-LIDAR product.

Section 2:

10. Section 2.3: The first sentence of the section is mentioning an overlap parameter that has still not been defined. So you need to reorder the section such that the equations come first, then the overlap parameter and decorrelation length are introduced and then you can discuss the importance of horizontal scale. In fact this is discussed in section 2.4, so why not wait until then. My preference would be to have most of this material on the formalism of cloud overlap as early as the introduction (see above).
11. Section 2.4: this is a rather long and confusing section, is this necessary when it seems you are in the end using a similar horizontal scale as in Di Giuseppe and Tompkins 2015? Part of the confusion comes from a lack of distinction between the *horizontal* scale, that is the length of the segment of CloudSat orbit you choose to calculate the cloud cover, and your vertical scale as you mention the larger distance here for Figure 2d. As mentioned above, do you need to discuss "discontinuous" layers when you are only interested in continuous layers?
12. Line 293: what does "is resolvable to approximately 2%" mean?

Section 3:

Section 3.1:

13. Line 333-335: I do not understand this sentence, in particular the phrase "cloud-pair related pentad-averaged the degree of conditional instability…"
14. Line 339: do you really mean May *and* September" or instead "May *to* September"?
15. Line 343: "is" should be "are". Here it might be the case that vertical velocities might be large because of extratropical cyclones or other baroclinic instability which could explain maximum overlap. "the increasing of layer distance" should be "the layer separation increases" (check entire text as this phrase is used a few time).
16. Lines 349-352: here it is also quite possible that other large scale forcings might influence the overlap, this should be considered.
17. Line 360: "cloud layer with large distance" should be "cloud layers with large separations". How large? Greater than 2 km, more?
18. Line 375: this is not exactly true, Naud et al (2008) say that vertical velocities in the tropics are not well captured in reanalysis when convection occurs, however they use them in the midlatitudes.
19. Line 375-384: as mentioned previously, the monthly and zonal variation plots are not sufficient proof that vertical velocity is not impacting the overlap. It was found to be the case in the midlatitude winter over land. At least these figures should be included in the manuscript.
20. Line 381: sensitivity to what? "relative" should be "relatively"

Section 3.2:

21. Line 407: the use of "stable" is not clear, do you mean "uniform"? I would write instead that the "relationship display some variability, in particular spatially and seasonally." Or something like that.
22. Line 454: what does "small cloud cover bias" mean?
23. Line 468: "are still difficult" should be "still have difficulties"

24. Line 470: replace “rare” with “scarcity”. I do not understand this statement. Why would overlap representation have anything to do with radiosoundings. I think that you refer to the Di Giuseppe and Tompkins (2015) statement about reanalysis being less reliable in places where assimilation of radiosoundings is scarce. This is because in this case, within the fine scale information from the radiosounding missing, the reanalysis is driven mostly by its model (IFS in the case of ECMWF) and the model has a resolution that is too coarse for small separations. Please elaborate. What is the minimum separation in your study, 250 m?
25. Line 475: the sentence “The biases…distinguishable” does not make sense. Please rewrite.
26. Line 476: “close cloud layers”: how close, please specify.
27. Line 477-478: replace “are still cause slightly overestimation” with something like “overestimate total cloud cover slightly”. This sentence is unclear.
28. Lines 475-484: this whole paragraph is very hard to follow, please try and clarify.

Conclusions:

29. Line 500: please specify “over the Tibetan Plateau” after “data”
30. Line 506: “greater α values”: please explain what this means physically.
31. Line 508: again explain what the decorrelation length is physically
32. Line 536: here I am not sure I understand the logic of these last few lines. Surely, cloud trends over the Plateau were obtained with observations and not models? Or do you mean to say that these trends are in fact obtained from GCMs prediction runs? Please specify. Cloud trends from observations have little to do with overlap.

33. Acknowledgments: please specify the locations of the datasets so readers can find them.

Typos/language issues:

Abstract:

- Line 34: “overlapped” should be “overlap”. Here and every else in the manuscript, the “increasing of layer distance” is incorrect, it should read “increasing layer separation”.
- Line 38: “well agreement” is incorrect, replace with “in good agreement”. Add “a” before “multiple linear regression method”.

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- Lines 66-67: this sentence is confusing, “increasing” should be “increase”, “became” should be “has” and the last statement is unclear, has the “variation” also weakened?
- Line 72: “such as” is not appropriate here, maybe you mean “For example”?
- Section 2.1, line 160: replace “other radar information” with “the radar information”

Section 3:

- Line 327: replace “occurs” with “during”
- Line 340: “instability” should be “unstable”
- Line 348: replace “of” with “between”
- Line 354: replace “to the south part” with “in the southern part”
- Line 355: replace “instability” with “a relatively more unstable”
- Line 356: add “that” before “enhances”

- Line 359: add “the” before “southern part”
- Line 364: replace “contributed” with “attributed”
- Line 366: add “the” before “accelerated”
- Line 370-371: replace “are still difficult to capture” with “still have difficulties to represent”
- Line 371: “those cloud layer” is plural, i.e. “cloud layers”
- Line 400: replace “relative” with “relatively”
- Line 408: remove “shortly”

Conclusions:

- Line 497: replace “and related to” with “and it impact on”
- Line 503: again rewrite “the increasing of layer distance”, not correct phrase.
- Line 506: again, “well agreement” should be “in good agreement”
- Line 507: again, add “a” before “multiple”
- Line 511: again, replace “above” with “greater than”