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Interactive comment on "Technical Note: The horizontal scale-dependence of the cloud overlap parameter alpha" *by* I. Astin and L. Di Girolamo

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Response to reviewer#2

The reviewer became lost in the algebra and assumptions discussed used around Eqns. 12 and 13, and onwards, which made following the rest of the paper very challenging.

(1) In the revised manuscript more mathematical steps will be given to show how the equations after Eq.12 are derived. These are given in the pdf file attached to the response to reviewer#1

Some further discussion on the wealth of available data and how it can be used to

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address these issues should be discussed.

(2) This will be done in the revised manuscript, which will include 'CloudSat and CALIPSO for vertical profiling of multiple cloud layers and deriving vertical correlations, and imagers such as MODIS' etc.

The abstract starts off clearly enough, but after line 13 it gets detailed and it is unclear as to how these details should be considered take-home messages. Keep the abstract clear and to the point because this is as far as most readers will get.

(3) The abstract will be revised.

Line 13: clouds are deeper

(4) Will fix this typo.

Section 2. It is difficult to tell apart the uppercase and lowercase 'c' for cloud fraction. Furthermore, the 'rand' and 'max' subscripts are lowercase and uppercase depending on the case of 'c', but this is not true for the subscripts 'a' and 'b' (e.g., eqn. 5). Would it help if 'a' and 'b' changed to uppercase if 'C' was uppercase? 'C_T' and 'c_t' follow this convention.

(5) This can be done and would make reading easier, though a and b are the two fixed altitudes and don't change with scale.

Section 3, lines 19-23: Regarding the question of averaging two adjacent grid boxes, the idealized nature of this study is appreciated and well taken. But, if that grid box is averaged in the zonal or meridional direction, could there be anisotropies in certain cloud regimes that would lead to a breakdown of this approach in a practical setting, or may blur out the signal shown in this paper in real data?

(6) Anisotropies would make R directionally dependent and, so, alpha_2 would be different both zonally and meridionally. This wouldn't affect the mathematics in our technical note, but could 'blur the signal when applied to real data' if all pairs of adjacent

grid boxes are used when finding alpha_2.

One way around this would be to give a direction to j with grid box j+1 being zonally or meridionally adjacent to grid box j, giving rise to a R(meridional) and R(zonal). Though, mathematically there is no reason for the two grid boxes to even be adjacent.

Furthermore, can there be 'scale breaks' in particular cloud regimes that could cause different values of R depending on whether the grid box was averaged over a scale in which a scale break in power density or variance is observed? For instance, see Wood and Hartmann, 2006, J. Climate for low cloud examples (there are non overlapping examples). I could not find an obvious reference for this issue relating to overlapping clouds.

(7) Mathematically, the results given depend on R, so any variations in R will again affect alpha_2. This would be handled by the mathematics. Perhaps more important is any resultant change in mean cloud fraction between adjacent grid boxes. We will discuss this in the revised manuscript.

p. 9805, line 15: With regard to the time averaging, over what time scales are we talking about here? A day? Week? Month? Season? Since this is an idealized study, at what time scale would the averaging need to occur at for this study's results to hold?

(8) For the idealized case this is not that important. However, we do need the mean and variance in the cloud cover to be stable and similar at both heights. We will discuss the averaging period in the revised manuscript, though most published work on overlap is based on monthly or seasonal averages.

Line 16: in the parentheses, should it say 'and the altitude between a and b'?

(9) Will fix this.

p. 9806, line 6: not sure if this is an error or the mixed notation wasn't defined. A lowercase 'c' is mixed with an uppercase subscript 'MAX'.

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(10) This will also be fixed.

Before line 12, I was able to follow the algebra and assumptions after multiple readings. After line 12, it was impossible to figure out all of the details and steps. How does eqn.12 follow from eqn. 2? I don't see it. Same for eqn.13. Through eqns 17, it appears the authors are deriving forms of the algebraic relationships that will be functions of R so that relationships between alpha_1, alpha_2, and R (i.e., Fig. 1) can be calculated. Some discussion and clear description of what the authors are doing in simple words will be very helpful here.

(11) Will give more description in the revised manuscript and include more mathematical steps in line with that given in response to reviewer#1 and (1) above.

p. 9807, lines 9 to 11: Can't this depend on the cloud regime of interest?

(12) Yes, this would mostly likely be associated with vertically deep convective clouds.

From lines 20 and onwards, now the authors are rewriting the algebraic relationships in terms of rho to gather additional insight on the vertical correlation issue. Again, a few additional and simple words on what is being done will benefit the reader.

(13) Again, this will be done.

p. 9808, eqns 19 and 20, where did they come from? How do you get these from two triangularly distributed random variables?

(14) This will be explained in the revised manuscript and is explained in the pdf attachment in response to reviewer#1.

Conclusions, lines 7-10: R and rho can be obtained from real data. How does this study shine light on the use of remote sensing data for the cloud overlap problem and its relation to horizontal scale dependence?

(15) If R, rho, mu and sigma are found from real data then this publication allows the value of alpha_2 to be calculated from alpha_1 directly. Mu, sigma and R are

all horizontal cloud properties and can be found from the passive or active remote sensing of clouds. However, rho would require knowledge of cloud vertical structure which could come from active remote sensing (e.g. from CloudSat, Calipso, AEOLUS etc.)

Line 13, which published results? Please describe.

(16) This refers to figures, such as Figure 1 in Oreopoulos and Norris (2011)*, where alpha_1 and alpha_2 are plotted together on the same graph versus height separation, rather than versus one another. This could have been better explained in the text.

Lines 17-20: again, can test with real data. Also, same comment for lines 21-25. How do the authors conclude R must be small? Can't they say something more quantitative and definitive based on real data?

(17) The generally observed increase in alpha with scale (in the publications referenced) implies, from out note, that R must be positive and less than 1. Based on published data on alpha, or direct cloud data, it would possible to determine R, provided there is enough data to determine rho, mu and sigma.

As an illustration, in Figure 1 of Oreopoulos and Norris (2011)* alpha_1≈0 (@75km scale) and alpha_2≈0.04 (@150km) for an altitude separation of 10km when averaged over June, July and August. Based on our note, this would indicate that if rho=1 then R would have a maximum value of 0.8 (our figure 1). However, R could equal zero, provided that rho exceeds 0.2 (our figure 2). As rho is likely to be close in value to alpha_1 this would seem to imply that R is closer to 0 than 0.8. Hence, our conclusion that R is small.

*referenced

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