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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A critical look at spatial scale choices in satellite-based aerosol indirect effect studies" *by* B. S. Grandey and P. Stier

Anonymous Referee #2

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General comment:

In this article, the authors try to answer the following questions: What are sensible choices of spatial scale for aerosol-cloud interaction studies? What effect may spatial scale choices have on global estimates of radiative forcing due to the cloud albedo effect?

To answer those important questions, the authors used 10 years of Terra MODIS satellite product (cloud products and aerosol optical depth) to study the global cloud albedo effect. The authors calculated the cloud albedo effect for each season and using 2 different averaging methods within regions of different size to highlight the impact of the spatial scale. Maps of annually averaged cloud albedo effects for different spatial scales are shown in the paper. Variations of the methodological error due to spatial

scale against the size of regions are also shown. Notably, the authors found that for regions larger than 4x4 degrees, methodological errors due to spatial scale become significant. For a region with a spatial scale of 60x60 degrees, the uncertainty is about 80%.

While the effect of the spatial scale is clearly convincing, the results are only valid for satellite-based aerosol-cloud interaction studies without any constrain on cloud type, meteorology or aerosol vertical distribution. Without constraining the data, the annually average cloud albedo effect found in the paper is quite uncertain. The applicability of the results to assess the methodological uncertainties from previous studies is therefore limited. I recommend this paper for publication after addressing the comments below:

Specific comments:

In the introduction, the authors cited the results of previous studies on cloud-aerosol interactions and notably the size of the regions used. As mentioned by reviewer #1, the cited papers studied aerosol-cloud interactions on large regions but they reduced the uncertainty in those regions by selecting specific meteorological situations or specific type of clouds (shallow clouds, constant LWP). In this paper, the only constrain that I see, if I am right, is liquid water clouds. McComiskey et al. (2009) have shown that aerosol-cloud interactions is dependent on the spatial scale when inhomogeneous clouds are involved. The spatial scale dependence is reduced if the clouds are more homogeneous (by constraining the LWP for instance). So basically, all the results on the methodological uncertainty found in this paper are potentially incorrect for constrained data.

A second problem that has not been discussed in the introduction is the vertical distribution of aerosols. Within the same grid cell, an absorbing aerosol layer can have a different effect on a cloud if the layer is located far above, right above or mixed with a cloud. Depending on the vertical distribution, the cloud albedo effect can be negligible,

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positive or negative (respectively). Costantino and Breon (GRL 2010) showed that by restricting a statistical analysis to aerosol-cloud mixed cases, the cloud albedo effect is increased. Again, constraining the dataset affects the statistics.

The unconstrained method used in the paper makes the cloud albedo effect found in 1x1 degree regions (the reference scale in the paper) doubtful, as a given AOD value will be related to different vertical distributions and meteorological situations. It can potentially cause spurious relationships as aerosol (concentration and vertical distribution) and meteorology (transport pattern for instance) are potentially correlated, and cloud/meteorology are correlated. As the authors said (page 15426 line 10-13), aerosol types and cloud properties are known to vary spatially within large regions and variations may have a significant impact on observed aerosol indirect effects. I would like to add that in a 1x1 degree region (a small region), cloud properties and aerosol type/distribution vary throughout a season (the time scale used in the paper). So basically the uncertainty of the values within 1x1 degree regions could be very large. The authors should at least emphasize that the results in the paper are valid for unconstrained data only, and that constraining aerosol-cloud interaction statistics to a specific cloud type, meteorology or aerosol distribution would reduce the methodological uncertainty due to the spatial scale of the regions. Furthermore, the following sentence "For regions on the scale of 60x60 degrees, these methodological errors may lead to an overestimate in global cloud albedo effect radiative forcing of order 80%" is correct relatively to a 1x1 degree region only. We don't know the uncertainty in the 1x1 degree region itself. Please, be more specific in the abstract and the paper.

I suggest that the authors check if the relationship found between methodological uncertainty and region scale is robust by constraining, for instance, the LWP, cloud height, or some meteorological parameters within each region. The paper and its impact would benefit of it. The authors should at least constrain their data the same way as Quaas et al. (2008) (by excluding data with LWP<20gm-2 and multilayered clouds) before inferring any methodological uncertainty in Quaas et al. (2008).

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Interactive Comment