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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Wet scavenging limits the detection of aerosol–cloud–precipitation interactions" *by* E. Gryspeerdt et al.

Anonymous Referee #1

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Review of Wet scavenging limits the detection of aerosol-cloud-precipitation interactions Authors: Gryspeerdt, Stier, White and Kipling

This manuscript addresses the important problem of what can be implied from the observed relationship between aerosols and cloud properties from spaceborne sensors. Most studies have, either explicitly or implicitly, assumed that positive correlations between aerosol optical depth (AOD) and cloud cover imply a causal relationship whereby the cloud changes are a response to the differing aerosol state. But we know that aerosols are themselves affected by clouds, most importantly through their removal by precipitation (here termed "wet scavenging"). This study uses a combination of observations and numerical modeling to show that aerosol properties are significantly impacted by wet scavenging, but that much of the impact of clouds on aerosols

is confined to the region below the clouds themselves, which would not be detectable from space because these rely on clear-sky conditions. This is a generally well-written manuscript, with a few exceptions, describing a strong piece of work. This is one of a handful of recent papers that are undertaking the noble task of trying to better understand what processes are driving the AOD-cloud correlations seen in spaceborne data. I support its publication in Atmospheric Chemistry and Physics subject to some revision.

MAIN POINTS:

1. For the modeling study, the obvious omission to me is a case without wet scavenging, or at least one where is it significantly perturbed. For example, the low aerosol extinction values below cloud in Fig. 5 could simply be caused by penetrative downdrafts bringing clean air from aloft. Such downdrafts are quite common in deep convection. In addition, the conceptual model of Houze (1989) has downward moving air passing toward the storm center from the rear, and this too would be bringing air from aloft down to lower levels. How do the authors know that the low extinction values below the center of the precipitating cloud system are caused by wet scavenging? This is a fundamental tenet of the study and no evidence is provided to support it.

2. The authors point out important differences in the "all-sky" aerosol assessments (e.g. from MACC) with the "clear sky" aerosol from MODIS, but the study really would benefit from a simulation with a high enough resolution that it could be used to directly compare AOD-cloud relationships for all-sky with clear-sky aerosol.

3. The shift from the modeling study (section 3.1) to observations (3.2) is too abrupt. The observations are not even from the same region as the modeling study, but seem to include the entire tropics, most of which is over the ocean rather than the land in the observational study. I find this switch to be quite confusing. I couldn't really follow the arguments about wet scavenging in section 3.2. The text in this section appears to fall into the "causality trap" that the authors are trying to warn against. Maybe I missed

some key point, but I found this part very confusing as to what the authors are trying to say.

4. The post-storm "wake" of low AOD seen in Fig. 5 seems to warrant more mention. How much further behind the storm does it extend (it reaches the edge of the composite domain and so would be expected to extend further). Surely, these wet-scavenged clear sky AOD values would be observable from space. For example, P6870, line 6-8. The authors appear to be arguing that using clear sky AOD is better for inferring aerosol impacts on precipitation. But don't such clear sky measurements include the storm wake, where scavenging has played an important role? The authors need to back up their assertion that clear sky AOD is more useful with model simulations that demonstrate it. It seems far too speculative to me. Why is meteorological covariation not an issue?

5. P6871, line 17. What on earth is an "invigoration-like effect"? Is there a "wet scavenging-like effect" to parallel this? What would it be?

OTHER ISSUES:

1. P6853, line 27. Chand et al. (2012) concludes the same as the Quaas and Grandey papers.

2. P6847, line 8-10. Why is the indirect effect of aerosols on clouds expected to be much weaker than the wet scavenging effects? I thought that the whole idea is that understanding the wet scavenging effects is needed to help understand the indirect effects. If the latter are negligible then what is the purpose of this study?

3. P6849, line 14. "data are"

4. Figure A2. I would have expected more water than dry aerosol mass. Radius growth factors of 2 are not uncommon, which implies almost an order of magnitude more water in the aerosol than other material.

5. P6864, line 15. What "regimes" are being discussed here?

6. P6865, line 22: How exactly is wet scavenging "observed" here? Also, P6866 line 25 talks of "observation of wet scavenging", but I don't know what observation they are referring to.

7. P6866, line 3-4. How is the invigoration effect "observed" here? Are the authors concluding the opposite of their title statement? I was losing steam by this point and was a little confused about whether the authors are arguing for an invigoration effect in shallow cumulus which probably don't even contain ice (and therefore how can there be an invigoration effect as outlined by Rosenfeld?).

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