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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aerosol-cloud interaction determined by both in situ and satellite data over a northern high-latitude site" *by* H. Lihavainen et al.

Anonymous Referee #3

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General comments

Lihavainen et al. investigate aerosol-cloud interactions based on in-situ observations, a combination of in-situ and satellite cloud observations and just only satellite retrievals of cloud microphysical/optical and aerosol optical properties. A major part of our poor understanding of the role aerosols has on global climate change is due to the large uncertainties that are associated with aerosols influences on clouds. Since satellite sensors, constructed for investigations of cloud and aerosol optical and microphysical properties, have produced data for nearly 10 years now there is a good opportunity to use the retrieved products in aerosol-cloud interaction studies. Thus, aerosol trend could be studied but more important for the present study the aerosols influence on clouds could be observed based on a large and robust data set. Even so, both the

aerosol and cloud products need to be validated. For aerosol optical thickness Levi et al. 2007 have shown that the MODIS Collection 5 product agrees well with AERONET sun-photometer measurements. Considering the cloud products no such observation global network is however available, which mean that the results from these retrievals may be associated with substantial uncertainties. On the other hand, by comparing the aerosol cloud interaction (ACI) by using the three different approaches in the study by Lihavainen et al gives an opportunity to actually compare the satellite retrievals with probably more reliable observations obtained from the ground. The results in Figure 3 are also very promising. The inconsistency in ACI, estimated based on three different approaches, is discussed in the present study, but the assumed reasons for the discrepancies should, however, be more clearly explained. It is important that the investigations of ACI, based on the three different approaches, uses same time periods and is nearly consistent concerning the spatial resolution and finally be close to the definition of ACI as well as. The latter means that the authors should more properly take the LWP into account when ACI is estimated (see comment 1 below). The consequence of the poor horizontal resolution in the data used for the satellite cloud and aerosol optical retrievals are used, compared to two other methods, to estimate ACI should be more properly discussed (see comment 2 below). The study by Lihavainen et al is relevant for ACP, although there are a number of points that have to be taken in consideration before the work can be accepted for publication in ACP.

1) In an attempt to obtain consistent conditions for the three different methods, used to estimate ACI, include also data set 4 in the comparisons between satellite and ground-based data. For the same reason extend the time period in the study, when only satellite aerosol and cloud retrievals are used to estimate ACI, so that it cover the years 2000 to 2007. This will increase the data set and give the opportunity to estimate ACI with a subdivided range of LWP values to exclude or reduce dynamical effects. In addition, the authors should plot the ACI values as a function of LWP (all retrieved values) both for COT and effective radius. The LPW should be subdivided into smaller range (for example with increments of 20 g m-2) and the variability around each mean

value of LWP should also be presented.

2) The present grid of 1° * 1° for the averaged aerosol and cloud properties imply an area approximately something like 40 km, thus, approximately 10 times larger than for the in-situ measurements. Additionally, to get probably enough of aerosol optical data in the present study a very large area (65° to 70°N, 20° to 30° E) is used as an investigation area in the present study. This area is also very close to Kola Peninsula, a region associated with high human activities. However, the local emissions from this area are not expected to influence the large investigation area homogeneously. Since the authors do not take the air mass transports in to consideration in the analyses of the investigation area it seems unfair to compare the result obtained only with the satellite retrievals with the two other approaches. Although the authors mention air updraft velocity as a possible factor for affecting the variability in ACI between the three different approaches, considering also that the present cloud in-situ observations have been performed at a high-altitude station (Sammaltunturi). This means that higher updraft is expected compared to the surrounding area, which indeed is not representative for the large area the satellite aerosol and cloud retrievals have been analyzed for.

3) Considering the requirements for the satellite cloud retrievals the authors should also remove a) multilayered clouds b) too thin clouds ($\sim$<100 m), since those cannot be accurately retrieved from space c) ice clouds.

Specific comments

Page 27467, lines 20-21; the heights of the two stations should be given.

Page 27469, line 20; “sets 1-4” should be “sets 1-3”

Page 27469, line 25; Collection 4 or 5?

Page 27469, lines 24-25; The spatial pixel resolution of MODIS AOT should be given. I suppose it is 10 km. Collection 4 or 5?

Page 27473, line 4; should be “. . ...(Fig. 1a).”

Page 27473, lines 3 -10: Probably also due to large variability in LWP. Keep in mind that COT is more sensitive to dynamic effects, which means that the effective radius should be more reliable to estimating ACI, compared to COT, when the LWP is not known. The author write “This demonstrate that when aerosol and cloud properties are not exactly co-located, determination of aerosol-cloud interactions becomes challenging.” The in-situ aerosol and cloud observations are as well not exactly co-located. The question arise, could higher updraft velocity at the in-situ cloud site, which then is probably not representative for a larger area (see comments 2 above), explain some of the deviations in the results of ACI, obtained with the approaches 1 and 2? and of course when method 3 is also taken in to consideration.

Page 27474, lin4; estimated correlation coefficients according to a linear fit or another one? Additionally, the coefficient of determination (R2) should be estimated instead of correlation coefficient (R), then consistent with the referred results and a correct statistical treatment of the problem. For the same reason also change Figures 1b and 2b so that R2 is presented instead of R.

Page 27474, lines 5-18; Emphasize that the high altitude in-situ station leads to updraft velocity that is probably high and not representative for the surrounding area (see also comment 2 above.

Page 27476, lines 12-14; should be “One influencing factor, probably also in the present study, is that aerosol and cloud properties are often not measured at the same place and time. . .. .”

Technical comments

Page 27481, Figures 1d and 2d; y-labels are missing.

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