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Atmospheric Measurement Techniques Discussions



# *Interactive comment on* "The scientific basis for a satellite mission to retrieve CCN concentrations and their impacts on convective clouds" *by* D. Rosenfeld et al.

**Anonymous Referee #1**

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General remarks

Rosenfeld et al. propose a way to retrieve cloud condensation nuclei number concentrations for convective clouds consisting of liquid water from satellite observations – a very challenging and interesting objective. A plenty of assumptions are necessary to perform this retrieval.

This paper is intended as the scientific basis for a new satellite mission. It is thus expected that the retrieval methods laid out in this article will serve to produce the scientific data from the satellite should it be built and operated. This has two implications, namely (1) that it is likely a very important article, and highly relevant to AMT, but also

(2) that is has to be a study carried out very soundly. By this, I particularly expect a very thorough error analysis, which the study currently still is lacking.

In the Introduction section, the authors describe many postulated aerosol effects on clouds in a way that the uninformed reader could consider them as textbook knowledge. A more cautious language is necessary. It should also be clarified in the Introduction section that reliable measurements of CCN(S) are just one – albeit certainly very important – contribution to a better understanding of aerosol-cloud-interactions. One could characterize it as a necessary, but not sufficient condition to solve the aerosol-cloud uncertainty problem.

The manuscript is written in a very good English language, and the choice of Figures is appropriate.

Section 9 is superfluous, and controversial. It should be deleted from the manuscript.

Overall, I suggest the paper needs some substantial revisions before it can be published. Particularly, a thorough error assessment beyond the current "back-of-envelope"-type of assessment is necessary. This in particular concerns also the algorithmic parts of the retrieval, and the validity of the assumptions.

Specific questions for the error analysis An overall error assessment including the error propagation for each of the contributions to the overall retrieval error is necessary, and a special section on this is suggested. It has to consider the following points, in addition to what the study already provides:

(i) Does the geometry allow for a unique detection of cloud base for each convective clouds? Otherwise, how far apart do two clouds have to be in order to see the entire sides down to the cloud base? Is the retrieval biased by this?

(ii) The retrieval assumes that N_a does not change above cloud base anymore. However, there are studies showing that this is not the case in convective clouds (e.g. Pinsky and Khain, Quart. J. Royal Meteorol. Soc, 2002). How important is this for the



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retrieval? Or can such cases be clearly separated from the ones for which the retrieval is valid?

(iii) The retrieval relies on knowledge of the saturation water vapor mixing ratio, e.g., for the adiabatic liquid water mixing ratio in Eq. 1 (p 1328), for which the cloud-base value is necessary (and in addition the temperature profile within the cloud) and to correct for the homogeneous mixing. (a) how accurately is the temperature as a function of height retrieved? (b) what does this imply for the subsequent quantities?

(iv) Cloud-base vertical velocity retrievals rely on the identification and tracking over time of protuberances at cloud edges at cloud base plus the assumption that their vertical displacement is equal to the updraft speed relevant for aerosol activation at cloud base. The error assessment has to consider (a) the ability to identify such features by automated algorithms at the base of each convective cloud, (b) the ability to uniquely track these over the curse of 1 min, and (c) the link between the retrieved vertical displacement and the relevant updraft velocity for cloud-base activation.

(v) The retrieval of CCN as a function of size is dependent on the assumed $\kappa$ values. How accurate are these assumptions for an individual retrieval?

Specific remarks

p1318

l3: The statement, if kept in the revised version, needs to be clarified: For climate sensitivity, it is more the cloud feedback, not the cloud-mediated forcing, which is the uncertainty. However, if the total forcing was known quantitatively, one could infer the climate sensitivity from the observed warming record.

l4: It should be specified that these are some of the outstanding issues. To name a few others, more challenging ones, in this context: we should know about IN, anthropogenic fraction of the aerosol, . . .

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l10: This is just one of the reasons for the uncertainty, among others. The references Rosenfeld et al. (2012a) and Rosenfeld et al. (2012b) should be referred to in the opposite order.

l18: The role of ice nuclei has to be mentioned here, too.

l23: This is a simplification. Entrainment-mixing may also enhance N_d, by enhancing N_a above cloud base, in certain conditions (e.g. Fridlind et al., Science 2004)

p1320

l2: This is so far just a hypothesis, opposing effects have been postulated as well.

l4: Rain forms eventually only if the thermodynamic conditions are appropriate.

l5: Invigoration can occur only in certain situations. The hypothesis is formulated for clouds with liquid-water at the base, which reaches the freezing level.

l6: This statement is based on hypotheses and should be reformulated with more caution.

l15: The Rosenfeld and Bell (2011) study relies on statistics only and should not be taken as unequivocal evidence here.

l23: greenhouse in one word

p1321

l1: quantities

l6: Also simply because aerosols are currently usually not observed at all in cloudy skies (in some cases above the clouds, though).

l15: Unfortunately, not just random, but also systematic errors such as the swelling or cloud contamination problems.

p1323



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l5: velocities

l21: why extensive? Is a concentration not rather an intensive quantity?

p1325

l19: in the tropical atmosphere

p1326

l3: the study by Painemal and Zuidema (J. Geophys. Res. 2011) shows that the retrieval works well at least in some cases

l4: larger

l20: does

p1327

l17: on the other hand, retrievals at 3.7 $\mu$m will be representative really of the cloud sides, not cores

l1328

l1: the relative humidity necessary for the assessment is the RH really in the vicinity of the clouds. However, RH is highly variable spatially, and it is highly questionable to which accuracy it can be retrieved. An error analysis is necessary here in which the measurement error for the water vapor mixing ratio from the vertical change in precipitable water as function of height from the absorption, and the measurement error for the temperature and subsequently saturation water vapor mixing ratio are taken into account.

p1329

l8: however, temperature has to be known with extreme accuracy, since the saturation water vapor mixing ratio exponentially depends on temperature



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p1331

l3: The assumption that the rate of vertical displacement of a protuberance is equal to the updraft speed at cloud base is crucial for the retrieval and needs corroboration. (i) how reliable is the assumption that a protuberance moves at the in-cloud updraft speed? (ii) to which degree is the updraft speed at the cloud edge representative for the average updraft speed for the entire cloud base? (iii) how valid is the assumption that at each clouds' base a protuberance is identifiable by an automated algorithm, and (iv) how valid is the assumption that it maintains its unique shape over the time of 1 min?

p1333

l21: This is a quite misleading statement. Table 2 in the cited paper (Pringle et al., 2010) shows an agreement to within $\pm 0.05$ only in 4 cases, in another 6 cases, the model value is within the observed range or up to 0.05 outside this range. More importantly, these are monthly mean values, whereas the algorithm would need accuracy for individual cases.

p1334

l4: Period is missing.

p1354

Please write Kappa consistently as a Greek letter.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 1317, 2012.