

Interactive
Comment

***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 #2

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General comments:

The manuscript summarizes a cloud mission referred to as CHASER, which would consist of three cameras (VIS/NIR/SWIR/MWIR/IR) flying in a 1400 LT polar orbit and viewing off-nadir into the backscattered solar direction. The multiple cameras work like MISR to determine stereoscopic cloud height but at much higher spatial resolution (50m) as well as cloud effective radius and phase. The mission was “inspired” by the CLAIM-3D concept of Martins et al. (2007, 2011), Zinner et al. (2008), etc.

Apparently, a manuscript on the CHASER mission has also been submitted to BAMS (Renno et al., 2012, in review). Perhaps the authors have informed the editor as to how

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this AMT manuscript differs from the BAMS submission. If not, I recommend this be discussed.

The science goal of the mission is highly relevant and I commend the authors for taking on important science questions via this passive imager approach. The paper is generally well-written but I have several major concerns on the suitability of the presented material for a measurement/technique journal. Largely, these come down to: (a) the lack of detail provided on mission science and measurement requirements, coupled with (b) a lack of significantly new science technique descriptions and/or validation. While the manuscript probably does provide a “scientific basis” for the mission as stated in the title, the quantitative link between the science (algorithms) and mission are not strong. I consider the manuscript not acceptable in its current form.

Major comments/questions

1. What clouds?

From the introduction: “The uncertainty in aerosol cloud-mediated radiative forcing is composed of two large and highly uncertain opposite effects from shallow and deep clouds (Rosenfeld et al., 2012b). This underlines the importance of conducting global measurements of the aerosol effects on clouds.” But based on the title, the emphasis of the CHASER mission is on convective clouds, and from the microphysical retrieval discussion, it is about cloud tops/sides that are still in the liquid phase. Does the mission address “shallow” clouds? If so, what does shallow mean in the practical sense? The references to cloud sensitivity in the literature are largely concerned about shallow marine BL clouds. Does the mission address ice phase cloud properties or just the onset of the ice phase?

2. Mission Details

The authors don’t have to show us mission proposal-level details but further information is needed. The manuscript would be strengthened by a list of instrument requirements,

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and nominal data products with expected uncertainties and sampling (and supporting text). I leave it to the editor to provide guidance on expectations for AMT for this type of article. Suggestions follow:

2a. There are no instrument requirements other than Table 1 and brief text. Table 1 should include spatial resolution (abstract says 100m for re but Sect. 2, paragraph 2 only seems to mention 50 m). Is that pixel resolution for the center camera only or do the other cameras have higher spatial uncertainty to give identical FOV at cloud level? Where did the spatial resolution come from for re retrieval requirements, i.e., reference for 1327, L7 (w.r.t. 1329, L24 – there is no Rosenfeld et al. 2004 in the reference list)? What are the cloud temperature retrieval requirements for the unspecified 3.7 um re retrieval accuracy and RH requirements? Table 1 could also include delta time requirements. Can the S/N or NEdT requirements realistically (cost) be achieved at the required spatial resolution? What are the radiometric/spectral calibration accuracy requirements and how can they be achieved? These requirements ultimately come from the data product retrieval requirements.

2b. Data products: includes phase and re (Table 1), stereo heights are implied elsewhere and of course derived quantities. Anything else?

2c. Uncertainties include the propagation of derived Na from re (re retrieval errors including 3D biases, entrainment/mixing assumptions, the re to rv relationship, etc.), uncertainty in phase determination, derived updraft errors (presumably a function of updraft speed, temperature->height errors, along-track wind component), etc.

2d. Sampling issues as a function of lat/long include the narrow swath (~100 km) coupled with cloud fraction and the frequency of higher clouds obscuring the lower developing convective clouds of interest. How does sampling inform how long the operational phase of the mission should be to achieve science objectives?

2e. Given the science objectives, I'm curious why next generation active measurements (cloud radar, lidar) are not a core part of the mission concept? Is it just a ques-

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tion of cost? Technology? Please elaborate.

2f. What aircraft validation work do the authors feel should be done to support the mission, or be done before the mission moves to the development phase? Please discuss. I'm skeptical as to how such a mission would proceed without an aircraft simulator and intensive validation campaigns.

3. With respect to comment 3, the larger question then remains as to whether the mission objectives have been achieved (“disentangling the effects of aerosol and [thermo/dynamics]”, “a new concept to overcome these two challenges”, “feasibility of what has been considered impossible until now”, “significant advancement”, etc.). It is not clear how these lofty objectives can be met with the mission. Given the fact that retrieval uncertainty requirements are not provided or mapped to science questions, there isn't much to go on with which to evaluate the likelihood of achieving mission success.

4. Much of the science of the manuscript reads as a review paper for the works of the authors. While the authors have made important contributions to cloud-aerosol interactions, surely there are more groups active in the field than references in some sections of the text would suggest. This is prevalent in certain parts (not all) of the manuscript and I don't think it requires elaboration. However one example that caught my attention was on p. 1320, L4, Rosenfeld et al. (2006) w.r.t. Sc cloud lifetime. This reference, put alongside the well-known Albrecht reference, refers to a “hypothesis” whereas there have been a number of detailed quantitative LES modeling and observational studies that have demonstrated the various sensitivities/complexities of Sc cloud-top entrainment for cloud evolution and lifetime.

Other comments:

5. Abstract refers to “the proposed satellite mission”. For context, has the mission in fact been formally proposed to an agency?

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6. 1321, L17: I see the point, but rather simplistic. Depends on length of time record relative to prescribed noise. Aerosol and cloud retrieval errors are not likely to be random as a function of cloud fraction. L21: or might also be explained by hidden (non-retrieved) parameters.

7. 1322, L8: According to Table 1, MAI has more than “visible” cameras.

8. 1324, L5. The statement that “clouds mix nearly inhomogeneously” based on the 1989 reference is a key assumption in the use of re measurements near cloud boundaries as being representative for a Na derivation (the other assumption is the relationship between r_v and r_e). The authors then go on to show examples in Fig. 2-4 without providing a reference in the text. Perhaps the data are from Freud and Rosenfeld (2012) which is somewhat ambiguously cited in Fig. 2. Once again, the authors only cite their own work. As an alternate example, Burnet and Brenguier (JAS, 2007) looked at both convective and Sc clouds and, by my read, concluded that the entrainment situation is more complicated: “In summary, the three case studies presented here confirm that droplet spectra sampled in diluted cloud volumes show features intermediate between the two extreme scenarios [homogeneous vs. inhomogeneous]. This study also suggests that part of the inhomogeneous-like features observed in real clouds with single particle counters may be due to an artifact of the measurement technique, which also implies that the spatial heterogeneities of the droplet distribution in most of the mixed cloud volumes have scales smaller than 10 m . . . the examination of the buoyancy of the mixed parcels reveals that dynamical sorting could also play a role in the selection of the mixing scenarios.”

9. Section 4: Thermo/dynamic environment doesn't also control the onset of warm rain?

10. 1326, L17: A strong and important statement. References (or do they come later)?

11. 1327, L16: Inherently? Perhaps, but have the authors done a thorough error analysis that includes cloud temperature retrieval accuracy, round-trip atmospheric path

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absorption correction to the cloud element (at 3.7 and in IR channels), solar spectral irradiance at 3.7 μm , ...? L25: Column water vapor from a ~ 1130 nm channel is said to give RH near the cloud edge assuming enough measurements in the “cluster”. Doesn’t internal cloud scattering in that vapor band cause issues (refer to text regarding 1.6 and 2.1 μm)? This is what solar reflectance based A-band and water vapor retrievals of path absorption/cloud height have to deal with.

12. 1330, L23: Don’t understand how reducing spatial resolution to 50m reduces MISR-like derived height errors by an equivalent factor of 5. There are other MISR error sources besides FOV. What about the along-track wind component?

13. 1331, L3: Is this assumption validated in the literature?

14. 1332, L13: “Current” (this statement is new)? Certainly the k factor includes the molecular information that goes back to Kohler theory (van’t Hoff factor, molecular weights, etc.).

15. Section 9: I understand this text is trying to get at some of the important science questions of particular interest to the authors that might be answered in part with CHASER observations. But the review text doesn’t make it obvious to me how well CHASER can resolve the issues, especially w.r.t. ice cloud and lightening since MAI imagery can’t see through cirrus and ice cloud layers to allow correlations with water cloud Na, wb. Presumably, statistical studies can peel back some layers of the entanglement, but the 1400 LT orbit will sample land and ocean at different parts of the diurnal evolution.

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

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