Review: ACPD 10, C690-C691, 2010

Manuscript

Testing remote sensing on artificial observations: impact of drizzle and 3-D cloud structure on effective radius retrievals

By: T. Zinner, G. Wind, S. Platnick and A.S. Ackermann

Overall Recommendation

This paper tests the impact of drizzle and 3-D cloud structures on the retrieval of effective radius assuming plane-parallel homogeneous clouds. The authors quantify the impact of drizzle and 3-D cloud structures for stratiform and convective clouds, using a simulated clouds from a LES model.

The presented work is of great importance to those using cloud properties retrievals, as it hints on the applicability of these retrievals in case of precipitating water clouds. The authors test the effect of drizzle for stratiform and convective clouds cases, for which they conclude that partcile size retrievals are almost insenstive to drizzle. The importance of this conclusion depends on the occurence of these clouds occur in nature. To my opinion the number of presented cases is insufficient to draw conclusions on the impact of drizzle and 3-D cloud effects on particle size retrievals. The authors obviously have all the appropriate tools to evaluate the impacts of both drizzle and 3-D cloud structures. Therefore, the paper can be made stronger by using a more cases, and quantify the impact for different depths of the drizzle layer, different drizzle intensities and different cloud optical thicknesses.

Although the English writing of the paper is well, not all steps conducted in this research are presented clearly. To improve the readability the paper some clarifications and reorganization of the paper is needed. The manuscript needs some major revisions before it can be published. Below the major points of criticisms are indicated, then followed by a chronological list of minor points of criticisms.

MAJOR CRITICISMS

Point A

The description of the mehod for evaluating the results of drizzling clouds with respect to their effective radius needs more explaination. The effective radii of the drizzling clouds as presented in table 1 and 4 are calculated for a bimodal distribution. First, the “true” droplet distribution of the cumulus scenes seems different from the droplet distribution that is used in the retrievals (described in section 3). In order to match the “true”size distribion the reff value of the bimodal distribution is conserved by playing arround with

reff1 (cloud droplets) and reff2 (drizzle droplets). Therefore the reff1 value seems to be lowered as compared to the reff1 value of the "true" size distribution. Since the majority of the droplets comprise cloud droplets, small modification to reff1 will largly effect the retrieval results. Therefore the authors should aim for a parameterization that does not change the value of reff1 as compared to the "true" value of reff1. Second, effective radius is calculated as the ratio of the third over the second moment of the size distribution. This calculation is most meaningfull for clouds with monomodal droplet size distributions, and less suited to describe the particle size of the bimodal distributions of precipitating clouds. Third, assuming a vertical homogeneous droplet distribution is already unrealistic for no-drizzling water clouds, but even more unrealistic for drizzling water clouds. This should be explained clearly in the paper.

Point B

As written by anonymous Referee #1, there are several studies that find a relationship between drizzle and particle size retrievals. There seems to be disagreement between the findings of these papers. Some see an increase in effective radius, while others hardly find any influence. The impact of drizzle on the particle size retrievals often depends on the set up of the theoretical experiment. In order to verify the sensitivity to drizzle the authors present results of a theoretical study in Figure 7. This is an important Figure, which provides information on the assumptions made in this study. The authors present a droplet size parameterization for drizzling clouds assuming vertical homogeneity. This assumption is verified for 50 cases. However, to verify its applicability for different depth of the precipitating layer within the cloud profile more information is needed. First, the statistics of the 50 samples used (tau, reff_drizzle, reff_droplets) are missing. Second, error bars for the classical and fitted bimodal distributions. Third, an analysis relative to cloud optical thickness, or even better depth of the precipitation layer relative to the cloud top, would be meaningful. Please clarify these points in this section.

MINOR CRITICISMS

Organization of the manuscript

The research method conducted in this paper can be presented more clearly. One needs to read the paper several times before the study set-up becomes clear. Consider to present the research method in the following order:

- LES simulations (section 2)
- Satellite reflectance simulation (section 3)
- Satellite cloud properties retrieval (section 4.3)
- Evaluation method (scattered over several sections)

A schematic representation of the study set-up would be very helpful.

Introduction

- **Page 1224:** *" This is why some studies suspect …."* Can the authors shortly quantify the effects of drizzle on particle size retrievals as found in previous studies?
- **Page 1225 (line 26):** This important paragraph of the introduction misses references to the investigations mentioned in this paragraph. Moreover, in this paragraph the authors should present the objective of their paper, so as to emphasis the unique aspects of this paper relative to work done in the past.

Cloud model

- **Page 1228 (line 25):** Give for the trade cumulus simulations also the range of optical thicknesses that is considered.

Separation of clouds and drizzle modes

- In this section it is not clear what the authors assume with respect to the size distribution. To my observation the authors present a parameterization that relates the original vertical size distribution (of the LES model) to a size distribution the may be considered representative for drizzling clouds assuming vertical homogeneity. Please clarify this in this section.
- **Page 1231 (line 15):** How large are the differences in optical properties found by Minnis et al. (2004)? Please quantify.

Results

- This section needs some re-organization.
  Section 4.1: Results of theoretical study
  Section 4.2 and 4.3 (introductory part): present no results but rather descriptions of the operational retrieval method. As with the LES and parameterized droplet size distributions, these sub-sections may be introduced earlier.
  Section 4.3.1 and 4.3.2: results of the evaluation of stratocumulus and overcast stratocumulus cases.
- **Page 1233 (4.3 Particle size retrieval):** Consider renaming this section to *"Optical thickness and effective radius retrieval"*.
- **Page 1233 (line 15):** *" all operational retrievals ..* " can the authors give some more examples of state-of-art operational methods and the satellites they are applied on (MODIS, AVHRR, ATSR, GOES, SEVIRI, ..)
- **Page 1233 (line 23):** *"Instead of using the .."* In this paragraph it is not completely clear what settings the authors used for their RTM. Do they assume PP clouds? Do they assume vertical homogeneous clouds? Do they use the droplet spectra as parameterized after the cloud model analysis?
- **Table 2 and 4:** The authors find a small decrease in effective radius retrieval for precipitating clouds. This is opposite of the expected effect. This might be related to the parameterization of the droplet size distribution. Where the size of the water droplets is reduced so as to conserve the effective radius value. Is this realistic with what will happen in nature? In order to match the effective radius size, a large number of cloud droplets is reduced in size (e.g. from 12 to 8.5 micron) so as to conserve the

effective radius of the drizzling cloud. How would a precipitating layer affect an effective radius retrieval for a “traditional” PP retrieval as done by the MODIS team?

Discussion and outlook

- Discuss how the finings of this study are related to findings of earlier studies and explain reasons for the observed differences.
- In order to translate the findings of this study to users of cloud properties retrievals the authors are encouraged to spend some works on the frequency of occurrence of these clouds in nature.