

## ***Interactive comment on “Aerosol-induced changes of convective cloud anvils produce strong climate warming” by I. Koren et al.***

### **Anonymous Referee #2**

Received and published: 8 March 2010

Review:

The submitted manuscript examines aerosol-cloud interactions in tropical deep convective clouds using a satellite-based approach. Specifically, the work attempts to qualitatively analyze the net cloud radiative forcing due to possible aerosol-induced effects, e.g., convective invigoration, smaller mean cloud droplet size, etc. Using MODIS data, the authors show that an increase in the aerosol number concentration acts to reduce the mean ice optical depth. This is caused by an increase in the ice anvil area with increasing aerosol number concentration. The manuscript describes, in detail, the chain of events that link the increase in aerosol number to a decrease in ice (anvil) optical depth. In regard to climate, the effect of such a perturbation on

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the ambient environmental conditions is discussed. The authors note that the overall effect of the aerosol-induced anvil enlargement is to generate a positive cloud radiative forcing, or a warming at the surface.

#### Major Comments:

A) The study focuses on a region of the tropical Atlantic bounded to the south by the equator and to the north by 14°N during the months of June through July in 2007. The analysis for this region and time provide robust the results described above. However, it would be beneficial to the reader to have a discussion related to this choice of region and time before the beginning of section 2. Some of the points that may be addressed are: Would the results differ if one chose the Pacific Ocean over the Atlantic Ocean? Since the chosen period of time immediately followed an El Niño event, how might the results change if the data were selected for a different period of time?

B) The introduction proposes in lines 4 - 5 on page 1942 that the authors will "estimate the anvil enhancement consequences to the climate radiative balance". Then, at the end of section 2 it is concluded that the anvil enhancement causes a "significant warming". However, from figure 2d and the associated caption it appears that an attempt at quantifying the warming was made (blue and green circles in figure 2d). I believe that it is prudent to move the discussion regarding these circles from the caption to the main text and include it with the discussion related to figure 2d. This is an important result of the paper and, although there are likely large uncertainties in the estimates of the positive cloud forcing shown in figure 2d, it is somewhat hidden in the caption to figure 2. Moreover, the results shown in figures A1 and A2 could be combined into one figure and, along with the discussion in Appendix A, moved to the main text. The  $\tau$ - $Z$  space diagrams are important for the climate response to the anvil enhancement and so the elaboration in Appendix A should be included in the main text.

C) The authors use histograms to specify whether cloud data represents the anvil or



the tower of a deep convective cloud. The demarcation for the two cloud regimes is set at  $\tau = 10$ . How was this chosen? It is noted that this value was chosen after inspection but it would be beneficial to the reader to know what criteria were used in making this decision. Moreover, how sensitive are the results to changes in the demarcation value? More details on the statistical techniques used are needed.

D) Appendix B and figure B1 include very important information that needs to be included in the main body of text. The discussion surrounding cloud contamination as well as cause and effect in section 3 should be more detailed. Including the contents of Appendix B in section 3 would add the necessary details to the main text.

Minor Comments:

A) On line 4 of page 1941, "Rosenfeld" is misspelled.

B) The sentence on lines 14 - 16 of page 1942 should be reworded to either say ". . . towards the base of the stratosphere" or ". . . towards the tropopause". Also, the units hPa are given as hPs.

C) In line 8 of page 1946, the word "form" should read "from".

D) The  $y$ -axes in figures 1b, 1c, and 1d are different making comparisons difficult.

E) The green and blue circles in figure 2d are very hard to decipher. They should be enlarged and/or depicted with different colors (e.g., white and black).

F) The color bars on figures A1 and A2 are missing units.

G) The  $x$ -axis of figure B1 is missing units.

H) There are many acronyms used throughout the manuscript. The acronyms should be defined when they first appear.

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## Summary

A) The submitted manuscript provides a relation between an increase in aerosol number concentration and ice optical depth in anvil clouds. The net result of this effect is a positive cloud radiative forcing.

B) I recommend that this paper be accepted with the above revisions.

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Interactive comment on Atmos. Chem. Phys. Discuss., 10, 1939, 2010.

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