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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Longwave indirect effect of mineral dusts on ice clouds" *by* Q. Min and R. Li

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We appreciate the reviewer's constructive suggestions on our paper of "Longwave indirect effect of mineral dust on ice clouds". Here is the point-by-point response to the questions:

1. Page 764 Line 2 (P74-2), it is not clear what is the cloud top distribution. Please modify it. Answer: We changed it to "cloud top temperatures".

2. P764-26, could the authors provides a very simple description why the dusts can lower the threshold temperature and relative humidity, which helps the readers to understand the physics without reading a lot of reference. Answer: Heterogeneous nucleation forms at preferential sites such as phase boundaries or impurities like dust and requires less energy than homogeneous nucleation. At such preferential sites, the effective surface energy is lower, thus diminished the free energy barrier and facilitating

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nucleation. Thus, the main effect of efficient IN is to lower the threshold temperature and relative humidity for ice cloud formation.

3. P766-6, please double check that the resolution is 20km. Can the micro-physics properties be detected well with such resolution? Answer: The CERES SSF data is at 20km resolution. However, cloud properties within the SSF footprint are retrieved from MODIS with 1.0 km resolution.

4. P766-11, should it be called blackbody temperature? The cloud emissivity is generally lower than one especially for high cloud. Answer: It is equivalent to blackbody temperature. Most high clouds are optically thin, hence the cloud emissivity is less than one.

5. P767-16, and Fig. 2b, the authors showed that there is a trend that CET decrease with increase of AOD. However, most of ice clouds appear in the very low AOD region (<0.5). The authors might need to emphasize that kind of trend still exists in the small AOD region. Using a logarithm scale might demonstrate the problem more clearly for the result of small AOD.

Answer: The trend of decreasing CET with AOD does exist in small AOD region, as shown in the attached figure 1 "CET vs small AOD (<1)".

6. P767-24-27, I hope the authors will rephrase this sentence. 'IWP is an indicator of dynamic and thermodynamic conditions', why this suggests that the tendency of CET with AOD is not attributed to dynamics and thermodynamics. I can not follow this. Also the authors need to discuss the results of Fig.2c.

Answer: First, the words "to some extension" in P767-24 should be "to some extent". We corrected it in the revision.

Because thick ice cloud (large IWP) generally formed in stronger updraft velocity with larger amount of water vapor, IWP, to some extent, is an indicator of dynamics and thermodynamics conditions. As shown in Figure2a, there is a negative correlation

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between IWP and CET, indicating that the CET is firstly controlled by dynamics and thermodynamics. Then, as shown in Figure2b, there is a statistically significant negative correlation between AOD and CET. There are two possible reasons for this: 1) dust aerosols influence CET independently; or 2) dust aerosols are strongly and positively correlated with IWP, then consequently impact CET. As shown in Figure2c, there is almost no correlation between AOD and IWP, which excluding the second reason. Hence, we stated that "it suggests that the observed tendency of CET with AOD can not attribute simply to changes in cloud dynamic and thermodynamic conditions." Also, we added a brief explanation into the manuscript to make this point clearer.

7. P768, second paragraph, to my knowledge nobody had mentioned that aerosol can invigorate the convection. Aerosol can slightly change the cloud heating rate, but that is negligible in comparison with the convective heating. I believe there is some physics behind the correlation between dust and convection. For example, stronger boundary turbulence, stronger surface wind, etc. might be benefit to both of the dust loading and convection strength.

Answer: Changes in latent heat due to aerosols may invigorate the convection. It has been proposed and demonstrated by model simulations [Rosenfeld et al, 2008; van den Heever et al, 2006; Gong et al 2010]. We already added those references into the manuscript.

Rosenfeld D., U. Lohmann, G.B. Raga, C.D. O'Dowd, M. Kulmala, S. Fuzzi, A. Reissell, M.O. Andreae, 2008: Flood or Drought: How Do Aerosols Affect Precipitation? Science, 321, 1309-1313.

van den Heever, S.C., G.G. Carrió, W.R. Cotton, P.J. DeMott, and A.J. Prenni (2006), Impacts of Nucleating Aerosol on Florida Storms. Part I: Mesoscale Simulations, J. Atmos. Sci., 63(7), 1752-1775

Gong, W., Min, Q., Li, R., Teller, A., Joseph, E., and Morris, V. 2010: Detailed cloud resolving model simulations of the impacts of Saharan air layer dust on tropical deep

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convection – Part 1: Dust acts as ice nuclei, Atmos. Chem. Phys. Discuss., 10, 12907-12952, doi:10.5194/acpd-10-12907-2010.

8. P769 first paragraph and Fig.3, the authors had investigated various possible impacts of large scale dynamics on clouds. However, there is not enough discussions for related physics. I don't see any trend from the figures. For example, let us look the relation between CET and SST. Most cloud cases have CET from -30K to -50K, this seems true for the whole range of SST. I hope the authors can provide more detailed discussions. In addition, how about the results between the chosen physical quantities and IWP? I guess CAPE and IWP should have correlation.

Answer: We stated in the conclusion that "Without in-situ measurements, it is hard to exclude completely all possible dynamic impacts." Those selected parameters and others (not shown here) are considered most likely dynamical factors that may impact the cloud development. Figure 3 shows the CET difference between dust-laden and dust-free conditions. They show no significant trend for any given value of a particular parameter, suggesting what we observed is independent of those dynamical factors. We changed the figure caption to make it clearer.

As we discussed, IWP is an indicator of dynamic and thermodynamic conditions. There are some correlation between IWP and some of those parameters.

9. P770 and Fig.4, the first column of Fig.4 seems be the same as that of Fig.2(a), both plot the CET against IWP. However, the IWP is about two order larger in Fig.4. I don't understand. Please check.

Answer: The figure 2a is in logarithm scale.

10. Fig.5, Fu-Liou model (at least its early version) is not accurate in comparison with some other models, like the radiation mode created by AER.

Answer: Yes, we agree with you. The Fu-Liou model is just used for a sensitivity study.

11. P772 last paragraph and Fig.6, in comparison with the model calculations and

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observations, how can the authors be sure there is no low liquid cloud existing in the observation cases. Brief discussion is needed.

Answer: We have already done the sensitivity study for a possible underlying liquid cloud (i.e. P772, lines6-14, figure5 g,h,i)

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 763, 2010.

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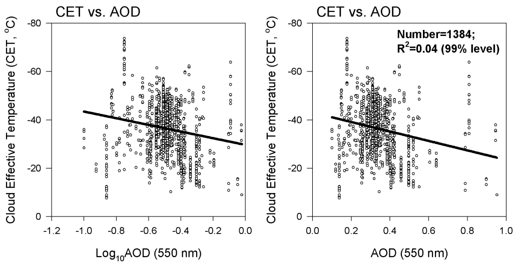

Fig. 1. CET vs small AOD (<1)

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