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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The effects of mineral dust particles, aerosol regeneration and ice nucleation parameterizations on clouds and precipitation" *by* A. Teller et al.

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We would like to thank referee #3 for his review of our paper and for giving us the opportunity to improve our paper. The comments that were raised in the review are answered in this document and some of them were also clarified in the final revised version. Below please find our response to the specific comments and questions that were addressed by the reviewer.

1. We modified the text to be more specific – on p. 8226, l. 7 we changed to: "We used a new detailed numerical cloud microphysics scheme that has been implemented in the Weather Research and Forecast (WRF) model in order to study aerosol-cloud

interaction in 3D configuration based on 1°×1° resolution reanalysis meteorological data."

2. In general the reviewer recommendation to use the latest and most updated version of WRF is reasonable and the authors fully agree with this concept that apparently has to be applied in any other software research tool. However, it should be taken into consideration that the development, testing and research with a new sophisticated tool such as WRF take a long time, sometimes more than one year. The adjustment of the bin microphysics scheme from WRF3 to WRF3.2 took two of the authors (AT and LX) almost a year due to the many changes that were made in the software Registry file, new ARW dynamic scheme and the need to carry out verification tests. We are currently working to couple the bin scheme in WRFV3.4. Furthermore, this matter was already referred by Warner, BAMS, Dec. 2011, who stated "Using the new model (in a new research) would involve the risk that a significant bug would be uncovered during a project and the work would need to be redone. Let others rush to use the new model and uncover the bugs"

3. First author of this study, AT, is a co-author in paper Smoydzin et al., ACPD, 2011 which is about to published in ACP. In this reference the study focused on the impact of dust on clouds and precipitation using the WRF-chem. The reviewer should be noted that the bin microphysics scheme used in our study requires more than 400 additional variables in the simulation. This heavy computational loading limits us in coupling the explicit (bin) microphysics scheme in WRF-chem, however parallel runs in which one scheme (for example the WRF-chem) output is used as an input to the other scheme has been already considered as a future direction by AT and Dr. Smoydzin.

4. The reasonable products of the new bin-microphysics cloud scheme can be inferred from the many examples in the text showing that sensitivities of the results to aerosol characteristics are in agreement with the cloud physics theory. It should be noted that the analyzed case has been recorded back in 2003 where some of the current satellite observation were still not available (e.g. CALIPSO). In the manuscript we showed that

both MODIS and TRMM retrievals are mostly in agreement to our simulation with regard to the location and accumulated precipitation. The reviewer is referred to p. 8238 for a discussion about the agreements and differences between the satellite observations and the WRF simulation results.

5. The titles were changed accordingly.

6. The reviewer is referred to Fig. 13 where the average aerosol concentrations are shown for the cases with and without GCCN. We find that many of the aerosols in the intermediate diameter range 0.5–1 micrometer serve as Cloud Condensation Nuclei and were activated at the beginning of the cloud formation. The reviewer is also referred to Levin et al. (2005) for a detailed discussion on the measurements of 28 January 2003 and the high presence of dust particles at this size range. Kohler activation at the intermediate size range is efficient at low supersaturation, therefore the differences between the GCCN and NGCCN cases were rather low. GCCN concentration in our study is in the order of 10 cm-3 for particles with diameter larger than 1 micrometer.

7. We added the following statement in the text (p. 8,245, l. 10) – "Similar results to those shown in Fig. 10 are found by analyzing the cloud particles' concentrations as function of time and height (not shown here). The concentrations of ice crystals are reduced when applying the DeMott et al. (2010) scheme, however the impact on precipitation is low as the cloud is already saturated with sufficient amount of ice crystals that are converted to snow and graupel particles through riming and aggregation. Teller and Levin (2006) showed that the effect of ice crystal number concentration on precipitation is evident in clean environments with aerosol concentration < 300 cm-3. In this study the aerosol concentration used for the sensitivity study of ice nucleation scheme was 950 cm-3, thus the effect on precipitation is minor." Following the reviewer comment, we also clarified the last sentence (p. 8,245, l. 15) – "More strictly speaking, it can be concluded that ice crystal formation is affected by the presence of mineral dust particles but the entire impact on precipitation was not found to be significant" The

impact of the dust storm dynamics (mentioned in the original manuscript, elimianted in the current one) referred to the spatial variations of the dust concentration in the domain causing the precipitation to be shifted in its location with only a minor change in the entire rainfall.

8. The reviewer is referred to the papers Xue et al., 2010, JAS and Xue et al., 2012, JAS for a more idealized analysis of the regeneration scheme in a 2D configuration. These manuscripts demonstrate the usefulness of the regeneration scheme when studying aerosol-cloud interaction processes in warm and mixed phase clouds. It is the authors' perspective that this study made a further step in understanding the impact of regeneration on clouds in a realized case. As stated above, the utilization of the scheme in WRF-Chem should be the next step in this effort

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