Chemical aging of atmospheric mineral dust during transatlantic transport

Reply to Anonymous Referee #1 (doi:10.5194/acp-2016-470-RC1)

by Mohamed Abdelkader and Swen Metzger, et al.,

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We thank the anonymous referee for the comments on this manuscript. The comments and questions raised are addressed below by our point-by-point reply (black) and the revised MS.

The authors used EMAC (The ECHAM5/MESSy2 atmospheric chemistry General Circulation Model) to evaluate transport and loadings of mineral dust particles during transatlantic transport. The study carefully considered aging mineral dust in the model and compared the results with non-aging mineral dust particles. They found some interesting results such as the removable efficiency and optical properties. These results will be potential useful for the future study on the ground base. On the other hand, the study carefully used the satellite data (AOD and CALIPSO) to calibrate the modeling results. They obtained the consistent results. The developed method is significant to improve the current model.

We thank the referee for this general comment.

The mineral dust particles are important for climate change, biogeochemical cycle, and heterogeneous atmospheric chemistry in global. Many studies found how the mineral dust changes in air. However, the modeling work is rare. The modeling work is useful to evaluate effects of mineral dust in the air. Although the modeling parameters are not based on measurements, the results and comparison is interesting.

We also appreciate this comment.

I would like to recommend accepting this paper after one minor revision. In the introduction section, the authors should add some findings in field campaigns which have revealed the nitrate coatings on alkaline mineral dust particles in the worlds. For example, Tobo, Li, Sullivan et al., found mineral dust aging process in the air. Although the authors consider the mineral dust particles absorbing acidic gases transformed from SO2, NOx, or HCl. However, these field study all pointed out the nitrate coating determine particle hygroscopic properties ("Asian dust particles converted into aqueous droplets under remote marine atmospheric conditions." P Natl Acad Sci USA 107(42): 17905-17910./ "Observation of nitrate coatings on atmospheric mineral dust particles." Atmos. Chem. Phys. 9(6): 1863-1871/"Direct observations of the atmospheric processing of Asian mineral dust." Atmos. Chem. Phys. 7: 1213-1236.).

We do agree that nitrate coating can determine hygroscopicity of mineral dust particles, which

is especially the case in an polluted atmosphere (Bauer et al., 2007). Moreover, our EMAC set-up accounts for this effect, since the nitric acid (e.g., as oxidation end product of combustion NO_x) may react in our set-up with the calcium fraction of the mineral dust particles to form calcium nitrate, which takes up water vapour from the atmosphere at ambient conditions where the humidity is just about 50% (the RHD of $Ca(NO_3)_2$ is 48% at T=298 K). In strong contrast, dust coating by sulphuric acid does not lead to hygroscopic particles since the RHD of $CaSO_4$ is close to 100% (at any T).

The authors should mention the aged mineral dust particles become hydrophilic and can act as CCN during the transport (Mixing state and hygroscopicity of dust and haze particles before leaving Asian continent. J. Geophys. Res. 119 (2), 1044-1059.)

This sentence and the reference has been added to the introduction of the revised MS.

Page 1 line 16 miss blank after comma.

We have added this blank in the revised MS.

Figure 3 should be marked where is the Cribbean.

We have marked the Caribbean in Figure 3 of the revised MS.

Why did not the authors consider the mineral dust as ice nucleation? It could be one removable pathway for mineral dust in air.

We agree that the consideration of mineral dust can be regionally important for ice nucleation. However, the effect will be less pronounced for our global modeling. The main reason is simply that the cloud micro-physical processes needs to be parameterized for the still relatively coarse model grid box (here approx 110 km). On these (model grid) scales many (partly unknown) micro-physical processes are implicitly parameterized, if the model results more or less agree with e.g., AOD observations. Changes in the micro-physical assumptions will therefore not alter the overall picture much. We have learned that from several additional sensitivity studies. Thus, for the current scope of this paper, we omit a more explicit aerosol-cloud coupling that includes feedback of mineral dust particles on ice nucleation. Aerosol-cloud coupling of dust is implicitly accounted for by changes in solubility of the aged dust particles due water uptake, which feeds back with scavenging, cloud water content, remaining aerosol loadings and radiation. A more detailed analysis of the current assumptions on aerosol-cloud coupling will be presented elsewhere.

I recommend revising the current title. Because the study focused on the evaluation of mineral dust during transatlantic transport using model and other methods, it didn?t study chemical aging of mineral dust. The current title seems that the study understand the chemical aging mechanism of mineral dust in the air.

We have revised the title to:
"Sensitivity of transatlantic dust transport to chemical aging and related atmospheric processes".

References

Bauer, S. E., Mishchenko, M. I., Lacis, A. A., Zhang, S., Perlwitz, J., and Metzger, S. M.: Do sulfate and nitrate coatings on mineral dust have important effects on radiative properties and climate modeling?, Journal of Geophysical Research: Atmospheres, 112, D06 307, doi: 10.1029/2005JD006977, URL `http://dx.doi.org/10.1029/2005JD006977`, 2007.