ACP Review

General comments (overall quality): This study analyzes how calcium-containing dust particles from Asian deserts react with water, finding that a majority of particles lose soluble components when exposed to moisture. Particle size, mineral composition, and surface coatings determine the dissolution rate of calcium. These findings are important for modeling how mineral dust neutralizes atmospheric acidity and mitigates ocean acidification.

The impact of mineral dust on the climate system depends on its size-resolved mineral composition and mixing state. The authors identify saltation bombardment as a key mechanism for enhancing dust emissions and enriching soluble calcium. Using laboratory dust abrasion, water dialysis, and electron microscopy, this study tracks the evolution of calcium-containing dust at the single-particle level, estimating particle emissions and mixing states, thereby providing highly valuable data.

By analyzing 4 soil samples collected from the Taklimakan and Gobi deserts, the authors report that 57–88% of calcium-containing particles released soluble calcium. Calcite often exists as nanometer-scale coatings on larger particles, which likely accelerates dissolution and increases dust hygroscopicity, which implys faster alkalinity release from Asian dust than previously thought.

I find the paper highly interesting and generally well written. The combination of techniques for analyzing calcium-containing particles, both pre- and post-dialysis, at the individual particle level is impressive. The experiments are well executed, carefully examined and analyzed.

I do have a few suggestions to improve the presentation of the results. I would aks the authors to keep in mind in their presentation how their data can be more directly used for modeling purposes. Additionally, I hope to see more explanations of how laboratory-based results relate to natural processes would be valuable.

Specific comments (scientific questions/issues):

I realize that dust aerosols were generated from the samples using a resuspension chamber that simulates saltation bombardment. Are there comparisons of size distribution and chemical composition with field or wind-tunnel experiments, say equivalent to friction velocity of 0.54 m s^{-1}? If data exist, it would be interesting to provide such a comparison. Otherwise, some discussions of chamber limitation would help.

I understand that dust samples were analyzed using X-ray spectroscopy for size, morphology, and elemental composition individually. The same sample was subjected to water dialysis to remove soluble components. The identical particle set was reanalyzed post-dialysis for comparison with pre-dialysis. This enables estimates of water-soluble calcium-containing particles and soluble calcium mass. I can see how these values can be used to calculate emission fluxes of soluble calcium particles, but cannot relate these values to what happens in nature.

Equations (3) and (4) should be written better, e.g., Eq. (4) can be simplied to

$F_m = m_{ca}\, F_n$

with m_{ca} being the average Ca mass per particle. Actually, I think it is better to estimate first dust-mass flux and then a Ca-mass flux, which is Ca mixing ratio times dust-mass flux. It would be much clearer and easy to use for future studies.

Figure 1 and 2: again, I would be very interested to see the mixing ratio, because this is the quantity one would use for global dust/Ca modelling.

Technical corrections (technical corrections, typing errors, etc.):

Line 31: „Global dust emissions are estimated at 2000 ± 400 Tg yr–1 (Kok et al., 2020), with Asia contributing approximately 25–30 % of this total (Kok et al., 2021).” Note the debate on the estimates and uncertainty involved.

Line 43: “below the direct entrainment threshold”. May be you mean below the direct entrainment threshold of fine dust particles.

Citation of papers from Chinese scientists. I find it is overall confusing in citing papers of Chinese scientists, e.g., Wang Z and Wang Y, but sometimes with no abbreviation of first name, e.g., Zhao. It may be time to think a way how to standardize the citations. Taking the first name does seem to make sense. This should be discussed with the publisher.