

I have reviewed the article “Organic matter matters for ice nuclei of agricultural soil origin” by the authors Tobo et al., which is under review for *Atmospheric Chemistry and Physics*. This article explores the importance of agricultural soil dust for ice nucleation in the water saturated regime at temperatures above -36 °C. These conditions mimic the environment in mixed phase clouds. In order to explore the role of organic matter in these soils, the ice nucleation behavior was measured with and without treatment with heat or H₂O₂, which removes the organic material. Results are compared to China Loess (a “typical” desert dust sample) and kaolinite.

Ice nucleation is a popular topic in the atmospheric chemistry literature. While mineral dust and biological particles are known to be good ice nuclei, recent papers have pointed out unexpected systems that may play an important role in ice nucleation in the atmosphere (e. g. feldspars). This manuscript suggests another important type of species, soil organic matter, which the authors suggest may be a large global source of ice nuclei. The paper is therefore timely and important to the evolving discussion on ice nucleation. It would be of great interest to the readership of *Atmospheric Chemistry and Physics* and should be accepted pending minor revisions.

Specific Comments:

Materials and methods:

How long were samples boiled in H₂O₂? How was it determined that all the organic material was removed? Why were these two treatments (heat and H₂O₂) chosen?

Please point out early in the paper that China Loess is used for comparison purposes as a desert dust rather than an agricultural soil.

Results and Discussion:

Are the images in Fig. 4 examples of 600 nm particles even though the scale bar is 300 nm?

Do you expect all organic compounds of interest to contain both N and S? Aren't there lots of organic compounds that just contain C, H, O? Were all the CHO particles just soot? Is there a reason why organic compounds in agricultural soils would contain N and S rather than N or S or just CHO? You may be obtaining an underestimate of the number of organic compounds.

Pg 9710 line 25: My understanding is that a sample of the soil was aerosolized and imaged. Other samples of soil were run through the CFDC or treated and run through the CFDC. The particles that nucleated ice were then collected after the CFDC for imaging. This should be stated in the Materials and Methods Section.

Pg. 9710 line 27: The DMA size selection only produces monodisperse particles if the particles are spherical. It is unlikely that you have imaged enough particles to plot a size distribution, though it would be helpful if it could be provided. The distribution of particles studied can be referred to by their 600 nm mobility diameter, but cannot be called monodisperse.

Pg 9711 line 7: A few more sentences could be added to this paragraph to clarify Fig. 5b.

Kaolinite is unlikely to be affected by 300 °C temperatures or H₂O₂. What are the other common minerals in the soil? How do these differ from the common minerals in China Loess? Could any of these minerals be altered by heat or H₂O₂? If minerals are also deactivated, Fig. 5b may over estimate the amount of organic.

Pg 9712 line 5: The structure of this paragraph is confusing. Please start with the main point (the last sentence) and then compare to literature. Is soil from England and Wyoming very different in composition?

Pg 9712 line 23: It is hard to tell whether the impact on the ice nucleating ability of China Loess is small because of the log scale. Please give numbers rather than referring to changes as “small” or “large”.

Fig. 4 legend: Please specify that the particles are also Au-coated.

Figs. 4&5: EDX is not generally used as a quantitative technique, and it is challenging to make it quantitative. When imaging the particles, the background is also imaged, and the peaks due to the background should be reduced in intensity. The amount these peaks come through the particles of the sizes given in Fig. 4 could be estimated using a SEM simulator like Casino. How far into the particle does the EDX beam penetrate? Why is there so little variation in the intensities of the carbon peaks? What is being normalized? The minerals have additional carbon; I suspect they are coated with CHO compounds. Why are so many particles pure organic or pure mineral and so few internally mixed? Is this typical of soils? Why does this separation between organic particles and mineral particles occur in soils?