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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Ice nucleation properties of fine ash particles from the Eyjafjallajökull eruption in April 2010" *by* I. Steinke et al.

Anonymous Referee #2

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The manuscript introduces a laboratory study investigating immersion freezing and deposition nucleation behavior of polydisperse volcanic ash particles at the AIDA facility. The volcanic ash samples considered were collected in the vicinity of the Eyjafjallajökull during the eruption period in April 2010. In general, it was found that in deposition nucleation mode, volcanic ash particles nucleate ice more efficiently than Asian and Saharan dust, and less efficiently than ATD, while in immersion mode the volcanic ash particles show an IN ability similar to that of the other dusts particles. Determined ice nucleation abilities were parameterized as function of temperature for the immersion mode and as function of temperature and relative humidity over ice for the deposition mode, using the ice-active surface site densities derived from the experiments. The influence of volcanic ash particles (despite their usually sporadic occurrence in the atmosphere) on cloud microphysics and here specifically ice nucleation, is a highly relevant and up-to-date topic in atmospheric research. The paper is well structured and written, and contains interesting and original work. Therefore the manuscript is suitable for publication in ACP once a few major and minor points are addressed.

Major comments:

1) Larger ash particles sediment near the source region from which the sample was taken. Smaller ones are transported over longer distances and may have a larger impact on cloud microphysics. Therefore a discussion dealing with the atmospheric relevance of the investigated volcanic ash particles is necessary since the chemical and physical properties of the emitted volcanic ash particles, and hence their IN ability, may vary over the original size distribution.

2) The derived parameterizations are based on the concept of ice-active surface site density, i.e., the singular approach. Following the long term discussion whether the heterogeneous ice nucleation process has a stochastic or singular nature a discussion concerning the validity of the approach applied would be desirable.

Minor comments:

Page/line

17667/20-24: For completeness of atmospheric volcanic ash observations in connection with the eruption of the Eyjafjallajökull volcano in 2010, please cite the LIDAR observations performed by several European groups (e.g., Ansmann et al. (2010) and Mona et al. (2011)),

17668/14-15: Immersion freezing requires an insoluble or undissolved aerosol particle.

17671/1-10: The differentiation between droplets and ice crystals with the WELAS instrument is done by particle size whereas ice crystals are larger than droplets. Is there an overlay region between droplets and ice crystals where the droplet signal can not really be separated from the ice crystal signal? How large are the measurement uncertainties when deriving ice fractions? According to the size distribution measurements,

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you also have very large unprocessed aerosol particles inside the AIDA chamber, is it possible that these particles interfere with the droplet and ice measurements?

17673/8-10: Why did you choose different particle diameter thresholds to distinguish between aerosol particles/droplets and ice crystals for the immersion freezing and deposition nucleation experiments? Please add an explanation.

17677/1-4: What measure has been used for comparing the surface properties of the ash particles investigated in this study to those observed in the atmosphere?

17678/25-27: What is the physical concept underlying this statement? Please add something like: "... assuming that ice fraction is related to the available ice nucleus surface area ...".

17679/14: Why is the ice crystal number density used? According to DeMott (1995), Connolly et al. (2009) and Niedermeier et al. (2010) the ice active surface site density has the dimension # m-^{2}. Or is A the total aerosol surface density? Please clarify the units.

Technical comments:

17666/3: Delete “However,”.

17677/22&25: Fig. 5 instead of Fig. 4.

17678/10: Fig. 5 instead of Fig. 4.

17678/1-2 and Fig. 5: To illustrate the uncertainty of the relative humidity with respect to water and ice of the measurement the uncertainty range could be shaded in Fig. 5. So that shaded area of the immersion freezing results would lie on the water saturation line.

17680/5: Fig. 6 instead of Fig. 4.

17680/10: Fig. 3 instead of Fig. 4.

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17680/11: Fig. 6 instead of Fig. 4.

17681/1: Fig. 6 instead of Fig. 4.

17681/13,15,22,27: Fig. 7 instead of Fig. 4.

17682/13: Fig. 8 instead of Fig. 4.

17682/17,19: Fig. 7 instead of Fig. 4.

17684/7: Delete the brackets.

17690/Table 1: Would “aerosol surface area density” be more appropriate than “aerosol surface area”?

References:

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Connolly, P. J., Möhler, O., Field, P. R., Saathoff, H., Burgess, R., Choularton, T., and Gallagher, M.: Studies of heterogeneous freezing by three different desert dust samples, Atmos. Chem. Phys., 9, 2805-2824, doi:10.5194/acp-9-2805-2009, 2009.

DeMott, P. J.: Quantitative description of ice formation mechanisms of silver iodide-type aerosols, Atmso. Res., 38, 63-99, doi:10.1016/0169-8095(94)00088-U, 1995.

Mona, L., Amodeo, A., D’Amico, G., Giunta, A., Madonna, F. and Pappalardo, G.: Multi-wavelength Raman lidar observations of the Eyjafjallajökull volcanic cloud over Potenza, Southern Italy, Atmos. Chem. Phys. Discuss., 11, 12763-12803, doi:10.5194/acpd-11-12763-2011, 2011.

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Poulain, L., Reitz, P., Spindler, C., Clauss, T., Kiselev, A., Hallbauer, E., Wex, H., Mildenberger, K., Stratmann, F.: Heterogeneous freezing of droplets with immersed mineral dust particles - measurements and parameterization. Atmos. Chem. Phys., 10, 3601-3614, doi:10.5194/acp-10-3601-2010, 2010.

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