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Aging affects the ice-nucleating properties of volcanic ash aerosol

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The effectiveness of volcanic ash as ice nuclei (IN) has been debated in the past. While some reported enhanced IN concentrations in volcanic plumes, others found no evidence for that. Here we show that "aged" volcanic particles sampled from the atmosphere in central Germany when the ash cloud of the 2010 Eyjafjallajökull eruption was present are very effective IN, as compared to particles of aerosolized "fresh" volcanic sediment that had been collected close to the eruption site in Iceland.
The number concentration of atmospheric IN was measured with the same method both at the Taunus Observatory in central Germany and at Tel Aviv University, Israel, as well as in laboratory-generated aerosol of volcanic ash. Aerosol was sampled by electrostatic precipitation of particles onto silicon substrates and was subsequently analyzed at - 8° to -18°C (deposition and condensation nucleation modes) in the isothermal static vapor diffusion chamber FRIDGE. The composition of individual atmospheric IN was analyzed by environmental scanning electron microscopy (ESEM) with EDX.
Our daily measurements show a significant enhancement of atmospheric IN when the dispersed ash cloud reached central Europe in April 2010 and the eastern Mediterranean in May 2010. Pure volcanic ash accounts for at least 53-68% of the 239 individual ice nucleating particles that were analyzed by ESEM-EDX in aerosol samples collected at Taunus Observatory during the volcanic peak of April 2010.
Volcanic ash samples that had been collected close to the eruption site were aerosolized in the laboratory and measured by FRIDGE. Our analysis confirms the relatively poor ice nucleating efficiency (at -18°C and 119% ice-saturation) of such "fresh" volcanic ash, as it had recently been found by other workers. We find that both the fraction of the aerosol that is active as ice nuclei as well as the density of ice-active sites on the aerosol surface are three orders of magnitude larger in the samples collected from ambient air during the volcanic peaks than in the aerosolized samples from the ash collected close to the eruption site. From this we conclude that the ice-nucleating properties of volcanic ash may be altered substantially by aging and processing during long-range transport in the atmosphere, and that global volcanism deserves further attention as a potential source of atmospheric ice nuclei.