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In situ measurements of the non-sulfate fraction of volcanic aerosol following the Pinatubo (1991) and Kelud (2014) eruptions

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In situ size resolved particle concentration observations, from instruments with ambient intakes and with heated intakes, following the eruptions of Pinatubo in 1991 and Kelud in 2014 are used to infer characteristics of the mixing state of the particles, of their gravitational sorting, and of the evolution of the non-volatile component. This approach was used for measurements from Laramie, Wyoming (41°N), 30-50 days following the eruption of Mt. Pinatubo (15°N) in June 1991, and for measurements from Darwin, Australia (11°S), 90 days following the eruption of Mt Kelud (8°S) in February 2014.

Following the Pinatubo eruption the particles appear to be internally mixed. Above 20 km the ash appears as 0.25 μm radius particles carried within a 0.5 μm radius particle, indicating the ash is $\sim$15% (20%) of the particle volume (mass). Following the Kelud eruption, the solid particles appear to have persisted just above the tropopause for at least three months. These measurements suggest the particles are externally mixed with almost exclusively sulfate particles, $<$ 0.15 μm, in the upper portion of the volcanic layer, 19-22 km. A second layer at 17-19 km contains particles $>$ 0.25 μm which are almost exclusively non-volatile. These sizes for the ash are similar to the non-volatile cores observed above 20 km following Pinatubo.

In both cases the observations show clear evidence of gravitational sorting of the particles. The lapse rate of the heated to ambient concentration ratio had a very characteristic decreasing ratio as altitude increases. Initially the slopes were quite steep and nearly the same for all particle sizes, suggesting rapid sorting by terminal velocity with the denser particles with non-volatile cores moving to the bottom of the layer. As the larger particles were lost the slopes became less steep and there was a separation between the slopes for the various particle sizes, with the smallest particles displaying the least differences between the top and bottom layers. At 9 months after the Pinatubo eruption the gravitational sorting induced by solid cores was complete. The slopes at all three sizes measured were nearly identical.