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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Measurements of electric charge separated during the formation of rime by the accretion of supercooled droplets" *by* R. A. Lighezzolo et al.

Anonymous Referee #2

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To add to the initial discussion on the Hallett-Mossop mechanism for ice multiplication.

Possible reasons for the high temperature cut-off at -3°C.

At high temperatures, the freezing time is long so the droplet has time to spread on the rimer before freezing and it does not produce a shell so does not fragment. Dong and Hallett point out that the spreading is particularly effective at temperatures above -3°C because the liquid like layer on the ice surface is thicker at higher temperatures.

Reasons for the low temperature cut-off at -8°C.

a) Griggs and Choularton (1983) say that at temperatures below -9°C several ice den-

drites cross the liquid droplet from the substrate side to the outside which initiates freezing at several points on the outer surface of the droplet so that the freezing front moves inwards, making the shell very strong, so it does not fragment.

b) Dong and Hallett (1989) suggest smaller and more concentrated air bubbles will be formed at lower temperatures because the solubility of air in water increases at lower temperatures (more air to come out on freezing). The air makes the ice more plastic and so less likely to fracture.

c) Mason (1996) points out that on freezing, the droplet expands (by the same amount at all temperatures). He suggests that at low temperatures the shell thickness is greater than the radial expansion so the shell is not ruptured. At temperatures above -8°C the shell thickness is less than the radial expansion so the expansion causes the shell to rupture.

{B. J. Mason The rapid glaciation of slightly supercooled cumulus clouds. Q. J. R. Meteorol. Soc. (1996), 122, pp. 357-365 }

The Bader et al 1974 paper on droplet splintering on accretion has not become the established work on the subject because they had a low impact velocity and used droplets > 15 um radius, which is larger than the droplets involved in splintering in natural clouds.

General comment Only 1% of ejected particles carry measurable charge – so the other 99% may carry charges that are below the detection threshold, but which may collectively add up to a significant larger charge than that detected. Extrapolating the measured charges to smaller values may provide a value to determine whether this is the case. For example, every undetected charged fragment could carry 0.5 fC while the average charge on 1% of fragments is 14 fC.

p23358 The charge on the fragments could be due to them stripping the negatively charged surface layers of the water droplets during the separation and breakup process.

p23358 line 25 50 fC min-1 and line 26 charging rate should be min-1 mm-2 ??

p23359 line 5 charges

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 23349, 2009.