Non-spherical microparticle shape in Antarctica during the last glacial period affects dust volume-related metrics

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Abstract. Knowledge of microparticle geometry is essential for accurate calculation of ice core volume-related dust metrics (mass, flux, and particle size distributions) and subsequent paleoclimate interpretations, yet particle shape data remain sparse in Antarctica. Here we present 41 discrete particle shape measurements, volume calculations, and calibrated continuous particle timeseries spanning 50 – 10 ka from the South Pole Ice Core (SPC14) to assess particle shape characteristics and variability. We used FlowCAM, a dynamic particle imaging instrument, to measure aspect ratios (width divided by length) of microparticles. We then compared those results to Coulter Counter measurements on the same set of samples as well as high-resolution laser-based (Abakus) data collected from the SPC14 core during continuous flow analysis. The 41 discrete samples (~490 years per sample in the Last Glacial Maximum; LGM) were collected during three periods of rapid global climate reorganization: Heinrich Stadial 1 (18 – 16 ka, n = 6), the LGM (27 – 18 ka, n = 19), and during Heinrich Stadial 4 (42 - 36 ka) and Heinrich Stadial 5 (50 – 46 ka, n = 16). Using FlowCAM measurements, we calculated different particle size distributions (PSDs) for spherical and ellipsoidal volume estimates. Our calculated volumes were then compared to published Abakus calibration techniques. We found that Abakus-derived PSDs calculated assuming ellipsoidal, rather than spherical, particle shapes provide a more accurate representation of PSDs measured by Coulter Counter, reducing Abakus-to-Coulter Counter flux and mass ratios from 1.82 (spherical assumption) to 0.79 and 1.20 (ellipsoidal assumptions; 1 being a perfect match). Coarser particles (>5.0 µm diameter) show greater variation in measured aspect ratios than finer particles (<5.0 µm). While fine particle volumes can be accurately estimated using the spherical assumption, applying the same assumption to coarse particles has a large effect on inferred particle volumes. Temporally, coarse and fine particle aspect ratios do not significantly change within or among the three time periods (p-value > 0.05), suggesting that long range transport of dust is likely dominated by clay minerals and other elongated minerals.