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Comparison of effective diffusion rates in multiple ice cores

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To extract climatically relevant chemical signals from the deepest, oldest ice in the polar ice sheets, we must first understand the degree to which chemical ions diffuse within solid ice. Volcanic sulfate peaks are the ideal target for such an investigation because they have a uniform peak shape at deposition. Processes of chemical diffusion and ice sheet thinning modify sulfate peak shapes with depth/age in an ice core. Our previous work developed a forward model, which simulates sulfate peak evolution in the ice sheet, and identifies the optimum effective diffusion rate for individual peaks. Analysis of the EPICA Dome C (EDC) sulfate record over the last 450 kyr suggests that the rate of sulfate diffusion is initially relatively rapid ($2.4 \pm 1.7 \times 10^{-7} \text{ m}^2 \text{ yr}^{-1}$ median for Holocene ice) and slows down over time to rates on the order of $1 \times 10^{-8} \text{ m}^2 \text{ yr}^{-1}$ or less. We hypothesize this may result from a switch in the mechanism of diffusion resulting from the changing location of sulfate ions within the ice microstructure. Here we apply our forward model to three other ice cores: NGRIP (Greenland), EDML (East Antarctica) and WAIS Divide (West Antarctica) to determine sulfate diffusion rates and their evolution over depth/age. These ice cores are different to each other, and to EDC, in terms of their temperature profiles, ice grain size evolution and dust loading, all factors which may influence sulfate diffusion rates.