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Geographic variability of nitrate deposition and preservation over the Greenland Ice Sheet

JF Burkhart (1,2), RC Bales (2), JR McConnell (3), MA Hutterli (1), MM Frey (1,2)

(1) Norwegian Institute of Air Research, Atmospheric and Climate Research, Kjeller, Norway (jfb@nilu.no), (2) School of Engineering, University of California, Merced, USA, (3) Division of Hydrologic Science, Desert Research Institute, Reno, NV, USA, (4) British Antarctic Survey, Natural Environment Research Council, Cambridge, United Kingdom

‘An analysis of 96 snow-pit and ice cores distributed over the Greenland ice sheet is used to determine the main drivers of variability in the preserved records of nitrate concentration. The dataset provides samples from spatially distributed locations allowing us to investigate the effect of snow accumulation rate, temperature, and sublimation on nitrate concentration. The mean ice sheet concentration in the dry snow zone (2000 $\geq$masl) is 132 ng g-1 ranging between 47 and 265 ng g-1 with a standard deviation of $\pm$37 ng g-1. Nitrate flux varies between 1.1 and 14.7 microg cm-2 a-1 with a mean of 4 $\pm$ 2 microg cm-2 a-1. Large scale spatial variability exists as a result of accumulation gradients, with concentration 5% greater in the northern plateau, yet flux over the northern plateau is 30% lower than the dry snow zone as a whole. While spatially, flux appears to be more dependent on accumulation, preservation of flux shows increasing dependence on concentration with increasing accumulation. The relationship between concentration and accumulation is non-linear, showing less dependence in the low accumulation regions versus high accumulation regions. Accumulation alone is insufficient to account for the observed variability in nitrate flux in the low accumulation regions, and evidence supports the need for additional components to a transfer function model for nitrate that includes photochemistry, temperature, and sublimation. Spatial variability across the ice sheet is non-uniform, and changes in nitrate concentration have occurred in some regions at a greater rate than others. While, the data supports that overall the ice sheet acts as an archive of paleo-atmospheric concentration despite the effects of post-depositional processing, one needs to consider spatial variables to properly account for trends and variability in the records. This is tested by evaluating past spatial relationships, and yields the result that the significant geographic shifts with respect to reactive N concentrations have occurred over the ice sheet in the past century.