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Reconstructing Antarctic snow accumulation using nitrogen isotopes of nitrate

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Precise Antarctic snow accumulation estimates are needed to understand past and future changes in global sea levels, but standard reconstructions using water isotopes suffer from competing isotopic effects external to accumulation. We present here an alternative accumulation proxy based on the post-depositional photolytic fractionation of nitrogen isotopes ($d^{15}N$) in nitrate. On the high plateau of East Antarctica, sunlight penetrating the uppermost snow layers converts snow-borne nitrate into nitrogen oxide gas that can be lost to the atmosphere. This nitrate loss favors $^{14}NO_3^-$ over $^{15}NO_3^-$, and thus the $d^{15}N$ of nitrate remaining in the snow will steadily increase until the nitrate is eventually buried beneath the reach of light. Because the duration of time until burial is dependent upon the rate of net snow accumulation, sites with lower accumulation rates have a longer burial wait and thus higher $d^{15}N$ values. A linear relationship (r^2 = 0.86) between $d^{15}N$ and net accumulation^{-1} is calculated from over 120 samples representing 105 sites spanning East Antarctica. These sites largely encompass the full range of snow accumulation rates observed in East Antarctica, from 25 kg m^{-2} yr^{-1} at deep interior sites to >400 kg m^{-2} yr^{-1} at near coastal sites. We apply this relationship as a transfer function to an Aurora Basin ice core to produce a 700-year record of accumulation changes. Our nitrate-based estimate compares very well with a parallel reconstruction for Aurora Basin that uses volcanic horizons and ice-penetrating radar. Continued improvements to our database may enable precise independent estimates of millennial-scale accumulation changes using deep ice cores such as EPICA Dome C and Beyond EPICA-Oldest Ice.