

Spatial variability of stable isotope ratios in snow: How representative are ice cores?

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Isotopic records from ice cores are used as a proxy for temperature history. However, to what extent annual average (or sub-annual) isotopic values derived from an isotopic record are representative of a larger area is not well known. Prior work has addressed this issue through replicate coring and has shown that the 'deposition noise' (i.e. the uncorrelated variance of two adjacent time series) in isotope records are inversely related to local accumulation rate. These studies have used ice cores separated by a few kilometers (Dome C) or tens to hundreds of kilometers (ITASE). Time series separated by these distances may record different climatic conditions and should not necessarily show a large correlation coefficient.

In this study, we examine the meter-scale spatial variability of stable isotope ratios in snow by collecting several snow samples from a single stratigraphic layer. Samples were collected from snow pits in Antarctica with a range of accumulation rates from 5 to 50 cm a⁻¹. Results confirm that the small-scale lateral variability in high accumulation rate areas is much smaller than the seasonal variability. However, the lateral variability can become as large as (or larger than) the seasonal variability as accumulation rate decreases, and a clear relationship between small-scale variability and accumulation rate is not apparent.

These results suggest that: (1) The large isotopic variation of precipitation and atmospheric vapor on short time scales (e.g. daily variation measured at Summit, Greenland) may be preserved due to the episodic nature of snow accumulation. However, some of the lateral variation in near-surface snow may be due to post-depositional changes, particularly in low-accumulation rate areas. Further measurements should be able to separate these two effects. (2) Caution is required when using annual average isotopic values derived from a single isotope record due to potentially large meter-scale spatial variability. (3) Since the lateral isotopic variability can be as large or larger than the vertical variability, isotopic diffusion may be considered to act in three dimensions (rather than only vertically) when reconstructing seasonal climate parameters from isotopic records.