Improved Precision of $\Delta^{17}$O Measurements by Laser Spectroscopy

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$\Delta^{17}$O and dxs reflect kinetic fractionation

$\Delta^{17}$O and dxs are calculated from corresponding measurements of $\delta^{17}$O and $\delta^{18}$O or $\delta^D$ and $\delta^T$ respectively. Both $\Delta^{17}$O and dxs record the difference from equilibrium fractionation behavior. Kinetic fractionation records from ice cores can inform past hydrologic cycle conditions.

$\Delta^{17}$O should provide new hydrologic cycle information

$\Delta^{17}$O should reflect different climatic conditions than dxs:
- $\Delta^{17}$O is less sensitive to temperature than dxs
- $\Delta^{17}$O observations are strongly correlated to humidity at low latitudes
- Improved spatial and temporal resolution of corresponding $\Delta^{17}$O and dxs records are needed to better understand the implications of $\Delta^{17}$O for paleoclimate.

Our goal: improve precision for $\Delta^{17}$O, maintain high resolution

- $\Delta^{17}$O measurement precision at South Pole is as good as 6 per meg, but consistently only <12 per meg
- Duplicate core measurements suggest some high-frequency signals are reproducible, but signal-to-noise ratio could be improved (see inset, above)

References


New CFA system was designed to optimize $\Delta^{17}$O measurement

- Custom vaporizer uses low-volume flash vaporizer tee (Gkinis et al., 2010) to minimize memory effects and ensure instantaneous sample evaporation
- Bubbles and particulate (>0.2μm) are removed, then sample is metered into vaporizer by peristaltic pump

Improved $\Delta^{17}$O measurement precision

- Consistently achieves <6 per meg precision for $\Delta^{17}$O with 4000s integration time
- Currently using new CFA system to test reproducibility of measured $\Delta^{17}$O from ice cores

Data from the South Pole ice core shows great potential for high-resolution $\Delta^{17}$O measurements:
- $\Delta^{17}$O shift during glacial-interglacial transition generally agrees with modeled expectations
- Duplicate ice core measurements generally agree within 12 per meg (1σ)

CFA-CRDS improves $\Delta^{17}$O measurement efficiency & measurement resolution

- $\Delta^{17}$O measurements:
  - $\Delta^{17}$O shift during glacial-interglacial transition generally agrees with modeled expectations
  - Duplicate ice core measurements generally agree within 12 per meg (1σ)

Improved spatial and temporal resolution of corresponding $\Delta^{17}$O and dxs records are needed to better understand the implications of $\Delta^{17}$O for paleoclimate.