Annually-resolved water isotope measurements in a shallow ice core (DFS10) for 60 meters depth

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Stable water isotopic composition (δD and $\delta^{18}O$) of ice cores are well correlated with the surface air temperature at precipitation site. The temperature reconstruction constitutes $\delta^{18}O$, whereas both δD and $\delta^{18}O$ are defined in d-excess (d), a second order isotopic parameter which correlates with the physical conditions (humidity, air temperature, and sea surface temperature) of the oceanic source area of Antarctic precipitation. It also reflects the conditions during the interaction or mixing or air masses travelling to the precipitation site. Due to its complexity, there has been extensive work on simulations and modelling.

The d-excess of annually-resolved shallow ice core samples drilled at the point of 10 km south of Dome Fuji station, East Antarctica, in 2010 (DFS10) were determined. An interpretation of the data is to be attempted and presented in this work. Our measurement has been done with temporal resolution of less than 1 year from 2 to 60 meters in depth (~1456 Samples in total).

δD and $\delta^{18}O$ is defined as:

$$\delta D \text{ or } \delta^{18}O\ (‰) = \frac{(R_{processed} - R_{VSMOW})}{R_{VSMOW}} \times 1000 \qquad (1)$$

and d-excess is defined as

$$d\ (‰) = \delta D - 8 \times \delta^{18}O \qquad (2)$$

Table 1. Isotope ratios of working standard solutions

Name	$\delta^{18}O$ [‰]	δD [‰]
DOME10	-52.585	-406.605
DF Snow	-48.894	-375.88
SLAP2 (IAEA)	-55.5	-427.5

$R_{processed}$ is isotope ratio (D/H or $^{18}O/^{16}O$) calibrated by linear regression and R_{VSMOW} is isotope ratio (D/H or $^{18}O/^{16}O$) of Vienna Standard Mean Ocean Water. Liquid Water Isotope Analyzer (Los Gatos Research, Inc.) based on the off-axis integrated cavity output spectroscopy is utilized for the isotope measurements. A precision of 0.2 ‰ for $\delta^{18}O$ and 0.6 ‰ for δD (equivalent of 1σ for measurement error) was maintained. We defined our original rule for evaluation, considering stability of the device and standard deviations of measured values. When a measurement did not meet our criterion, we conducted re-measurements as necessary.

Calibration was done by inter-/extrapolating a linear relationship between two working standards, DOME10 and DF Snow, in Table.1. The working standards are snow melt water collected around Dome Fuji station. The reproducibility of this calibration method was confirmed by measuring SLAP2, a primary standard solution (supplied by IAEA). Strictly following the protocols set in our laboratory, the measurements are sufficiently precise and reproducible.

Although, snow melt ice around Dome Fuji has been used as working standards, there are serious difficulties in employing them as working standards. It would be interesting to explore the use of synthetically, accurate water standards to be used as working standards. This led us to prepare inhouse working standards using water deuterium depleted (≤ 1 ppm, Deuterium oxide, Sigma-Aldrich) and Water-^{16}O (≥ 99.99 % ^{16}O, Sigma-Aldrich) in various proportions to attain required δD and $\delta^{18}O$ values, this could lead to accurate working standards to be used on a daily basis. The prepared working standards are calibrated against IAEA standards (GISP and SLAP2) to confirm the precision and accuracy. Further, the possibility of these working standards is being prepared for the determination of δD and $\delta^{18}O$ in future ice core samples.

References

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