Geophysical Research Abstracts,
Vol. 11, EGU2009-7825-1, 2009
EGU General Assembly 2009

Water vapor δ^2H and δ^{18}O measurements using off-axis integrated cavity output spectroscopy

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The stable isotopes of water are powerful tracers for studies of the hydrological cycle and ecological processes. Recently developed spectroscopic techniques allow the simultaneous in-situ measurement of δ^2H and δ^{18}O in water vapor at high time resolution. We use a commercially available water vapor isotope analyzer (Los Gatos Research, Inc.), which is based on off-axis integrated cavity output spectroscopy. This instrument provides simultaneous measurements of $^1H^{16}O^1H$, $^1H^{18}O^1H$ and $^2H^{16}O^1H$ isotopologues at a sampling rate of 0.5 Hz. Additionally, a custom made calibration device based on ink jet technology was developed. Water with a known isotopic signature is injected into a dry air stream, immediately vaporized to prevent any fractionation and then admitted to the analyzer in order to calibrate the water vapor isotope measurements.

Here, we present an extensive quantitative assessment of the performance of the analyzer and its calibration system in terms of precision, accuracy, long-term stability, linearity and memory effects. The 2-sec standard deviation of δ^2H and δ^{18}O in ambient water vapor is about 1.0 ‰ and 0.3 ‰, respectively. The accuracy of the laser spectroscopic measurements is assessed by comparative measurements using isotope ratio mass spectrometry. Results of two recent campaigns both in the field and in the laboratory illustrate possible ecophysiological applications of our measurement system. On the ecosystem scale, vertical profile measurements of δ^{18}O and δ^2H in water vapor within and above a forest canopy have been performed in summer 2008 at the Lägeren site, Switzerland. The isotope ratios show large diurnal and day-to-day variability, but little vertical variation within the canopy indicating strong vertical mixing. On the leaf scale, chamber based measurements in the laboratory were used to study the isotopic signature of transpiration fluxes under drought conditions.