Geophysical Research Abstracts,
Vol. 11, EGU2009-3310-1, 2009
EGU General Assembly 2009

Continuous measurements of water vapor isotopic compositions using an integrated cavity output spectrometer: calibrations and applications

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The ^{18}O and ^{2}H of water vapor can be used to investigate couplings between biological processes (e.g., photosynthesis or transpiration) and hydrologic processes (e.g., evaporation) and therefore serve as powerful tracers in hydrological cycles. A typical method for determining $\delta^{18}O$ and $\delta^{2}H$ fluxes in landscapes is a "Keeling Plot" approach, which uses field-collected vapor samples coupled with a traditional isotope ratio mass spectrometer to infer the isotopic composition of evapotranspiration. However, fractionation accompanying inefficient vapor trapping can lead to large measurement uncertainty and the intensive laboring involved in cold-trap make it almost impossible for continuous measurements. Over the last 3-4 years a few groups have developed continuous approaches for measuring $\delta^{18}O$ and $\delta^{2}H$ that use laser absorption spectroscopy (LAS) to achieve accuracy levels similar to lab-based mass spectrometry methods. Unfortunately, most LAS systems need cryogenic cooling, constant calibration to a reference gas, and substantial power requirements, which make them unsuitable for long-term field deployment at remote field sites. In this research, we tested out a new LAS–based water vapor isotope analyzer (WVIA, Los Gatos Research, Inc, Mountain View, CA) based on Integrated Cavity Output Spectroscopy (ICOS) and coupled this instrument with a flux gradient system. The WVIA was calibrated bi-weekly using a dew point generator and water with known $\delta^{18}O$ and $\delta^{2}H$ signatures. The field work was performed at Morgan-Monroe State Forest Ameriflux tower site (central Indiana) between August 8 and August 27, 2008. The combination method was able to produce hourly $\delta^{18}O$ and $\delta^{2}H$ fluxes data with reproducibility similar to lab-based mass spectrometry methods. Such high temporal resolution data were also able to capture signatures of canopy and bare soil evaporation to individual rainfall events. The use of the ICOS water vapor analyzer within a gradient system has the potential to greatly expand the use of continuous $\delta^{18}O$ and $\delta^{2}H$ fluxes measurements to address a wide range of ecohydrological research topics.