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Measuring the Isotopic Composition of Evapotranspiration Using the Eddy Covariance Technique

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Measurements of the isotopic composition of water vapor provided valuable insights into the hydrological cycle and eddy covariance measurements are widely used to quantify biosphere-atmosphere exchange processes. Yet, the direct combination of water isotope approaches and the eddy covariance method remains challenging. Here, we present eddy covariance (EC) measurements of the isotopic composition of evapotranspiration (ET) for a forest ecosystem in Central Germany. Our isotope EC setup is based on 2 Hz measurements of the concentration and isotopic composition of water vapor (δD and δ18O) in 44 m height. We used a high flow and high frequency-customized version of a commercially available water vapor isotope analyzer (Los Gatos Research Inc.). We present the instrument characteristics and calibration strategy as well as the feasibility of our setup to perform EC measurements of the isotopic composition of ET. The measured spectra and cospectra and the evaluation of setup-specific limitations of our measurements (e.g. the measurement frequency of 2 Hz) suggest that direct EC measurements of the isotopic composition of ET are feasible for both, δ18O and δD. The seasonal variability was -15 to -7‰ for δ18O and -120 to -60‰ for δD of ET. For most of the seasons, the mean diurnal cycles showed a progressive enrichment of the isotopic composition of ET throughout the day with an amplitude of approximately 3‰ for δ18O and approximately 20‰ for δD, indicating non-steady state conditions. We propose that EC measurements of the isotopic composition of ET could further be used to partition ET and thus improve our understanding of the hydrological cycle, in particular when flux gradient methods show limited applicability.