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Development and Deployment of a Portable Water Isotope Analyzer for Accurate, Continuous and High-Frequency Oxygen and Hydrogen Isotope Measurements in Water Vapor and Liquid Water

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Stable isotopes of water in liquid and vapor samples are powerful tracers to investigate the hydrological cycle and ecological processes. Therefore, continuous, in-situ and accurate measurements of del_18O and del_2H are critical to advance the understanding of water cycle dynamics around the globe. Furthermore, the combination of meteorological techniques and high-frequency isotopic water measurements can provide detailed time-resolved information on the eco-physiological performance of plants and enable improved understanding of water fluxes at ecosystem scales. In this work, we present recent laboratory development and field deployment of a novel Water Vapor Isotope Analyzer (WVIA), based on cavity enhanced laser absorption spectroscopy, capable of simultaneous in-situ measurements of del_18O and del_2H and water mixing ratio with high precision and high frequency (up to 10 Hz measurement rate). In addition, to ensure the accuracy of the water vapor isotope measurements, a novel Water Vapor Isotope Standard Source (WVISS), based on the instantaneous evaporation of micro-droplets of liquid water (with known isotope composition), has been developed to provide the reference water vapor with widely adjustable mixing ratio (500-30,000 ppmv) for real-time calibration of the WVIA. The comprehensive system that includes the WVIA and WVISS has been validated in extensive laboratory and field studies to be insensitive to ambient temperature changes (5-40 C) and to changes in water mixing ratio over a wide range of mixing ratios. In addition, by operating in the dual inlet mode, measurement drift has essentially been eliminated. The system (WVIA+WVISS) has also been deployed for long-term unattended continuous measurements in the field. In addition to water vapor isotope measurements, the new Water Vapor Isotopic Standard Source (WVISS) may be combined with the WVIA to provide continuous isotopic measurements of liquid water samples at rapid data rate. The availability of these new field instruments provides new opportunities for detailed continuous measurements of the hydrological cycle and ecological systems.