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Continuous online field deployable high precision and high resolution water isotope analysis from ice cores

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One of the most important features of ice cores as climate and atmospheric paleoarchives is their potential for high temporal resolution. The measurement of chemical impurities in ice cores that fully exploits this high resolution has become standard with the advent of Continuous Flow Analysis (CFA) from continuously melted ice core segments, often performed in the field. Meanwhile, the measurement of water stable isotopic composition (deuterium and oxygen-18) continues, for the most part, to be performed offline via discrete sampling with traditional mass spectroscopy. These offline procedures are time consuming, expensive, and do not fully exploit the temporal resolution available in the ice core. Here we describe a new method and the first results for the determination of water isotopic content measured from a continuous melted rod with a commercially available near-infrared cavity ring down spectrometer (CRDS; http://www.picarro.com/) coupled to a CFA system both in the field on the Greenland ice sheet and in the laboratory. For the measurement of water isotopes a carefully controlled fraction of the CFA melt stream is evaporated directly into the laser cavity for simultaneous analysis of both deuterium and oxygen-18 content. The details of the system have been tested with a deployment to the North Greenland Eemian Ice Drilling (NEEM) coupled to the University of Bern CFA system and in the laboratory with NGRIP ice coupled to the University of Copenhagen CFA system. The results show that the system already produces the highest interpretable resolution records that are comparable or somewhat less precise than traditional mass spectroscopy discrete sample methods. The enormous potential of the system is being realized in the density and resolution of the produced records in connection with other highly resolved series (e.g. chemical impurities), and also in the efficiency by which the records can be produced. Among other things, time series from this type of analysis will benefit ice core dating via layer counting of deconvoluted isotopic series. High resolution paleo-temperature reconstructions based on the calculation of the differential diffusion rates of the two heavy isotopologues of water vapor in firn, via the study of their spectral properties, can also benefit from the enhanced resolution of the measured time series.