Measurements of $H_2{}^{18}O$ and HDO Isotopologues in Condensed Water during the IMPACTS 2020 Campaign

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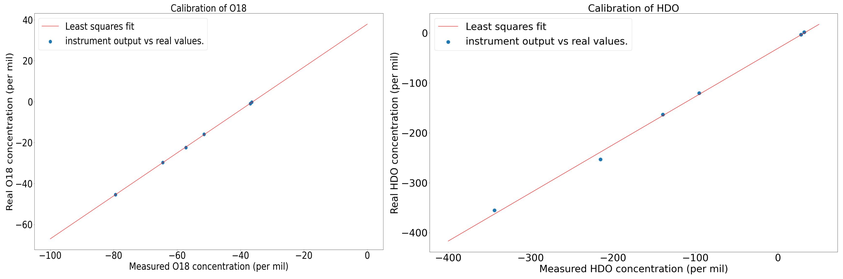
Abstract

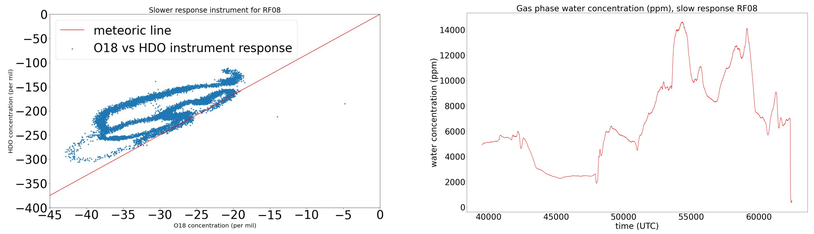
During summer 2021, calibrations of isotopologues H_2O^{18} and HDO were completed for all three cavity ringdown spectrometers (CRDS) flown with the WISPER system on the P-3 in 2020. One fast-response instrument measured condensed water contents and isotopologues on all research flights. Two slower instruments measured water vapor and isotopologues on different sets of flights. Laboratory calibrations were carried out with a Picarro vaporizer and exploited standard methods as recommended by Picarro. This is the first summary of isotopologue data in condensed water. Results are shown from all research flights to illustrate the consistency of the measurements over the duration of the campaign. The quality of the data are discussed by examining deviations from the expected meteoric line due to condensation on the inlet.

Example Calibration



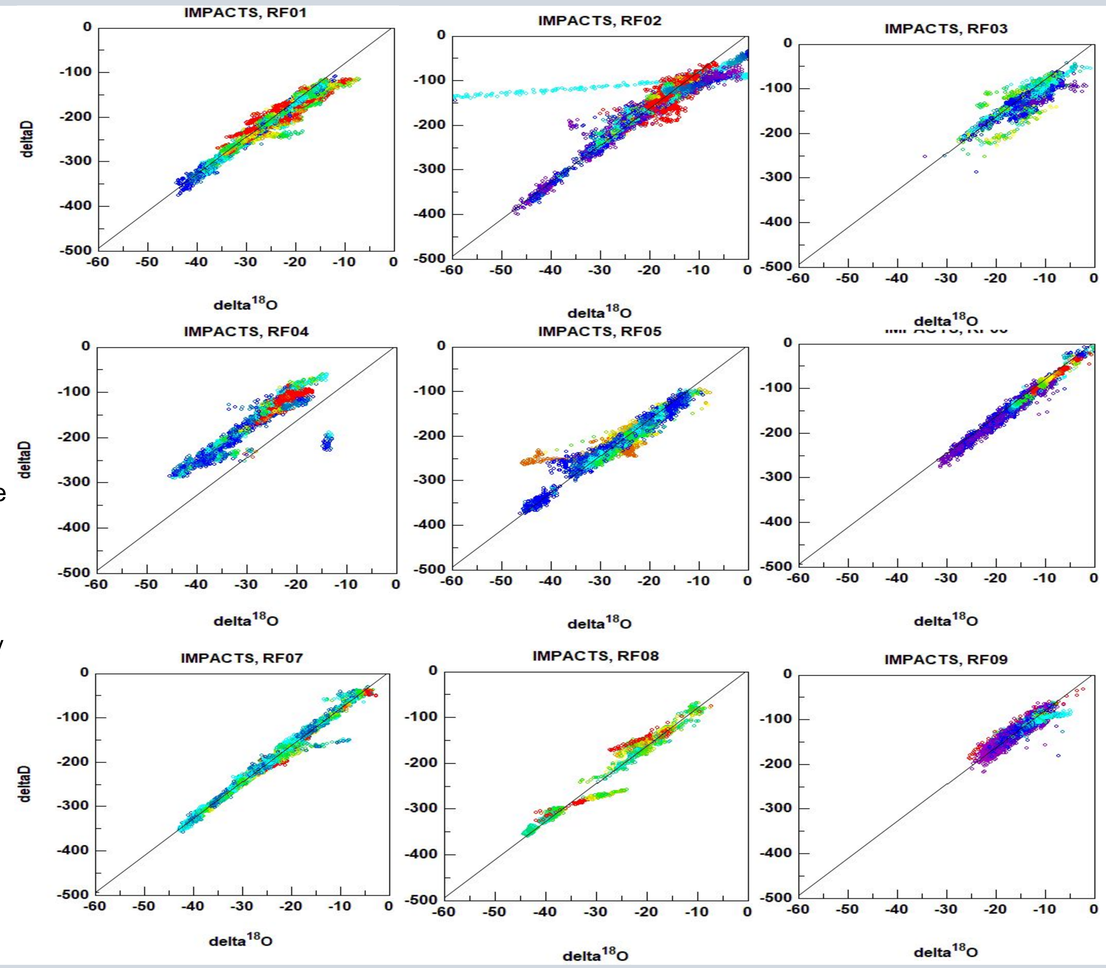
Picarro calibration has been carried out in July and August 2021 utilizing standard methods provided by Picarro. An instrument attachment known as a vaporizer and is used to inject samples of known values into instrument with a consistent concentration of 20,000 ppm of water to calibrate instrument response to HDO and H_2O^{18}. Instrument response is then plotted vs. the real values and a least squares linear fit is used to generate conversion functions to transform IMPACTS research isotpologue data into the real values.

Gas-Phase instruments have some issues

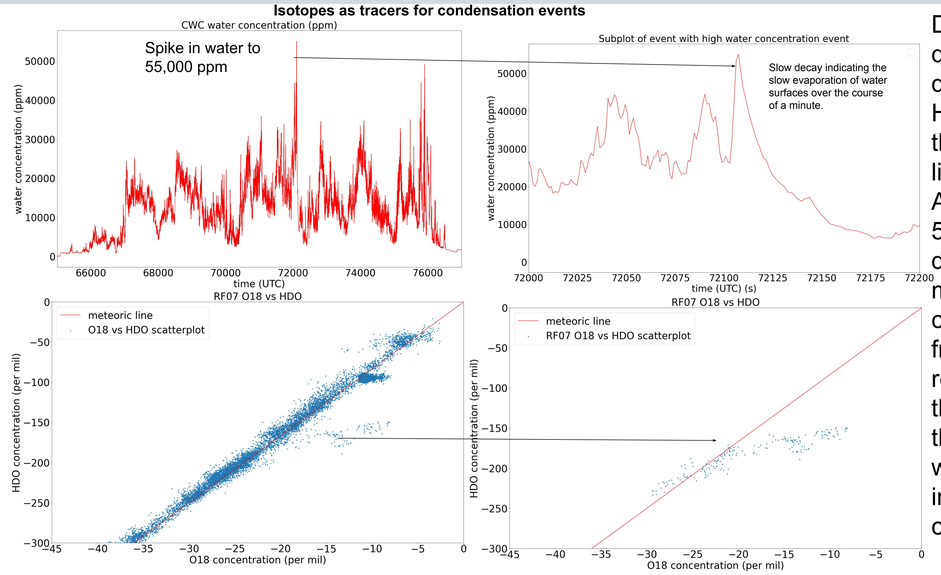


Large deviations from the meteoric line in the gas phase instrument illustrates two issues. 1) Lack of heating of instrument flow lines combined with 2) a slow flow rate makes concentration events much more of an issue for the gas phase instruments. These issues will be addressed in IMPACTS 2022 to make this data reliable.

Data from all flights is presented here displayed as O18 vs HDO concentration (per mil). Datasets are first sorted for low condensed water by omitting any points less than a threshold 5000 ppm. From here each dataset is then plotted as described. All flights presented are color coded for high water (red) and low water (blue). Most of the measurements are between 10,000 to 25,000 ppm and the vast, vast majority of measurements fall on the meteoric line. Events that do not fall on the meteoric line represent condensation events (see panel below). These events will be sorted from the final data utilizing the isotopologue data. Since these data represent small periods of time (~1 min or so) and are infrequent. These events represent a very small minority of data thus demonstrating that the CVI is operating well the vast majority of the time. RFO4 deviates heavily from the meteoric line and still needs processing to understand what went wrong. All flight data will go through multiple iterations of QA/QC to ensure quality of data for IMPACTS 2020.



Isotopes as tracers for condensation events



Data from each flight is assessed for general quality by evaluating when certain periods of data vary from the meteoric line. The plot of HDO vs H_2O^{18} shows this clearly whenever the slope is less than that of the meteoric line. An example of this is shown in the plots. A large spike in water mixing ratio up to 55,000 ppm in RF07 shows how this deviation manifests. Large spikes in water mixing ratio are associated with condensation and subsequent evaporation from surfaces in the instrument. The recovery of HDO to real values takes longer than H_2O^{18}. This manifests as a lower slope than the meteoric line and is a proxy to know when data can be omitted for lack of usability in evaluating relevant cloud physics due to condensation events. .