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Stable Isotope Laser Spectrometer Comparative Study through Vapor Concentration Manipulation

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Introduction

Stable isotope analysis allows us to trace elements through meteorological, geological, and vegetation systems. The increased study of laser absorption analyzers, over previously used accelerator mass spectrometers, is making highly precise, near real-time, monitoring of natural systems feasible. An important requirement for the interpretation of data from automated long-term field measurements is a detailed knowledge of instrument characteristics and the ability to properly calibrate the instruments. Here, we performed a comparative study between two types of laser spectrometers using a new low-cost, high-flow calibration system.

Theory and/or Method

The instruments included a tunable diode quantum cascade laser spectrometer and an off-axis integrated cavity output spectrometer. The calibration system was tested for its ability to provide a stable, but adjustable, delivery of vapor from liquid samples of varied standard sources. Water vapor from the system was simultaneously ran through both spectrometers for a real-time comparison of the lasers' δD (deuterium) and δ18O values. Variability was created by changing the vapor moisture content though adjustments of the system's sample flow rate. The collected data was analyzed to compare the lasers' measurement stability, precision, and vapor concentration dependency.

Examples

The performered experiment is influenced by F. Aemisegger's, *Measuring variations of δ18O and δ2H in atmospheric water vapour using two commercial laser-based spectrometers: an instrument characterisation study*, published in 2012. While Aemisegger's primary focus was on the difference in performance of the two spectrometers, this experiment was used to test a new method that could improve the performance of all similar spectrometers. Aemisegger briefly described the advantages and disadvantages of conventional calibrations systems, one being that liquid analyzer calibration adds a notable delay making uninterrupted sampling impossible. The designed system seeks to provide an accurate, uninterrupted delivery to multiple spectrometers simultaneously.

N. Kurita's *Evaluation of continuous water vapor δD and δ18O measurements by off-axis integrated cavity output spectroscopy* and P. Werle's *The limits of signal averaging in atmospheric trace-gas monitoring by tunable diode-laser absorption spectroscopy (TDLAS)* provided information on the efficient testing of the spectrometers used, and also assisted in the spectrometer selection.

Conclusions

The calibration system successfully delivered equal amounts of water to both spectrometers with high precision in controlled increasing intervals. The system's vapor delivery is also largely non-discriminatory, allowing researches to used it with a wide variety of spectrometer models. Collected data shows that both spectrometers will drift after a short amount of time, but can be adjusted to provide essentially perfect reading. Readings of isotopic weights tend to favor higher values when exposed to low concentrations of water, however become more accurate at higher vapor concentration levels. These results show that the tested laser spectrometers and calibration system set up has promising reliability and stability, which can open up experiments to a wider range of researchers who require a less expensive and/or continuous high-flow method of isotopic vapor analysis.

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