Researchers measure atmospheric water vapor using open-air spectroscopy

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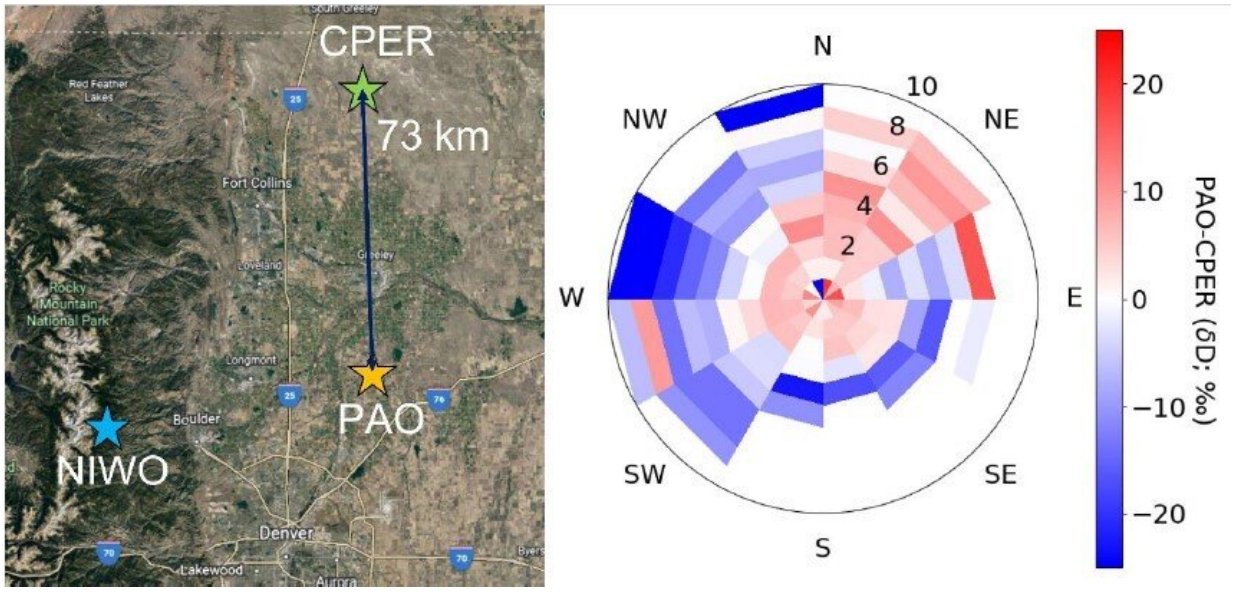

Left: Satellite image of northern Colorado Front Range with stars indicating locations of NEON CPER, NEON NIWO and PAO measurement sites. Image: Google Earth. Right: Difference between PAO and CPER δD binned as a function of PAO wind speed (in m/s) and direction. Generally, δD at PAO is greater than CPER for winds from the northeast and lower than CPER for high westerly winds. Credit: Optica

Researchers have shown that a new mid-infrared spectrometer can precisely measure the ratios of different forms of water—known as isotopologues—in atmospheric water vapor through open air in a little

over 15 minutes. Isotopologue ratios, which can be affected by land-based water evaporation and plant transpiration, are used to develop models of climate change and to understand how water is transported globally in the atmosphere.

"Open-path sensing using dual frequency combs may make atmospheric water vapor isotopologue sensing simpler and easier to apply in remote environments. A broader network of isotopologue measurements will contribute to improved numerical weather modeling. The long beam paths achievable using the dual-comb technique will enable spatially resolved studies of water vapor transport over natural ecosystems as well as human-engineered ones (e.g. farms)," explained researcher Daniel Herman, National Institute of Standards and Technology (NIST). "Future vertical column measurements using combs might also improve calibration procedures for isotopologue measurement using satellites. In addition, sensing of water vapor with dual combs can also compliment other emerging air quality applications of broadband mid-infrared spectroscopy."

Daniel Herman from NIST will present the new findings at the *Optica* Imaging and Applied Optics Congress, 11-15 July 2022. Herman's talk is scheduled for 11 July 2022, at 11:45 AM PDT.

Today, scientists rely on networks of point sensors to analyze isotopologues in atmospheric water vapor. Although these networks are expanding, they require careful calibration to maintain accuracy over time and between sites. Detecting water vapor in an open-air path may eliminate the need for calibration and make it easier to capture large-scale evaporation above reservoirs or over entire watersheds.

However, accurately detecting multiple water vapor isotopologues in the air requires a mid-infrared spectrometer with high spectral resolution, high accuracy and fast measurement rates. To accomplish this, Herman

and colleagues developed a new open-path mid-infrared dual-comb spectrometer (DCS) that uses near-infrared femtosecond laser pulses and specially designed waveguides to create broadband mid-infrared pulses in a compact package.

The researchers tested the new instrument by using it to take measurements over a 760-meter path at the Platteville Atmospheric Observatory in Colorado. They found that the instrument could operate in the field for weeks at a time without requiring intervention. This allowed them to acquire several months of data during a variety of weather conditions and temperatures.

The measurements obtained using the DCS correlated well with those acquired using a point sensor network, showing the potential for open-path DCS in characterizing atmospheric water vapor.

Herman adds that "in order to expand isotopologue measurement networks, we are working to improve the accuracy of our technique by analyzing systematics in the detection setup. The sensitivity of the technique can be improved by using higher power combs to enable longer paths. Also, balanced detection technology will be implemented in the future to decrease technical noise."

More information: Conference: www.optica.org/en-us/events/co … ied_optics_congress/

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