AN025

Real-Time, Field-Based Water Vapor Isotope Measurements with a Picarro Analyzer.

Using a Cavity Ring-Down Spectroscopy (CRDS) instrument to probe cropland evapotranspiration, literally in the field.

Keywords:

Material: Evapotranspiration, drought, irrigation, crop, water vapor
Process: Stable isotopes, $\delta^{18}O$, δD

Summary and Relevance:

While stable isotope techniques have been previously applied to partition evapotranspiration fluxes in crops[1], it has only recently become possible to take in situ, long-term, continuous (every 10 seconds) measurements of stable water vapor isotopologues. A Picarro water vapor isotope analyzer based on CRDS was recently deployed at China's National Experimental Station for Precision Agriculture during the FAO/IAEA 2nd Research Coordination Meeting on "Managing Irrigation Water to Enhance Crop Productivity under Water-Limiting Conditions using Nuclear Techniques."

Measurements were conducted continuously over several days, sampling from five different heights within and above the canopy of a corn (Zea mays) ecosystem.

The isotope analyses can allow the partitioning of evapotranspiration into its components: soil evaporation and leaf transpiration. Once daily, during the vapor measurements, liquid water isotope standards were measured by the Picarro analyzer using its included autosampler and subsequently used to calibrate the vapor-phase data.

Process:

Air was drawn with a pump from five heights within and above the crop canopy through ~8m of Bev-a-Line tubing at ~3Lpm to a manifold and rotary valve, controlled by the Picarro analyzer, so that vapor was continuously measured for ~5min at each height sequentially see Figure 1 below. At the beginning and end of the day, the Picarro analyzer ceased measuring vapor and measured liquid standards by using ambient air dried by a Drierite canister. This air was mixed with liquid standards, injected by the autosampler, and vaporized in the instrument's vaporizer module. Air from each height in the vertical profile was pumped through a second parallel set of Bev-a-Line tubing to an additional infrared gas analyzer for determination of water vapor mixing ratios and then into Pyrex glass collection tubes for cryogenic trapping of the water vapor for further study. The vapor traps were kept at -80ºC by immersion in an ethanol bath cooled with liquid nitrogen.

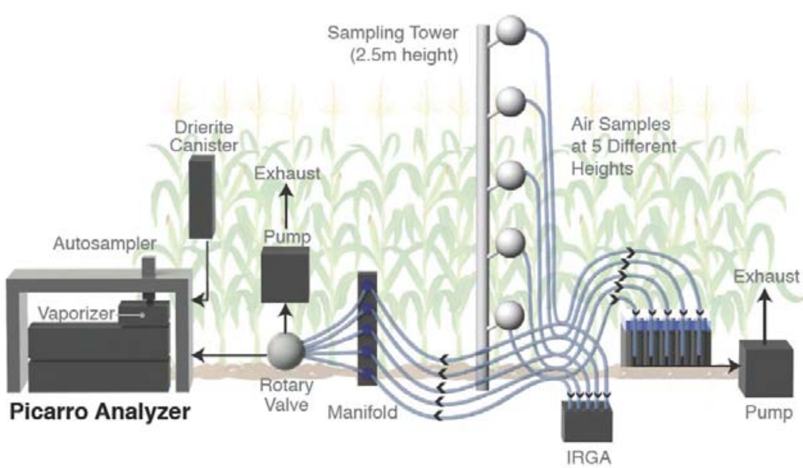

Figure 1. Experimental set-up for evapotranspiration studies

Results and Comments:

Full results have been submitted to a peer reviewed journal and will be available upon publication. However, the continuous water vapor isotope and mixing ratio data were recorded for several days and over wide temperature extremes (~19-42°C).

The Picarro analyzer was capable of monitoring rapid changes in δD and $\delta^{18}O$ ratios of water vapor in canopy air associated with irrigation over a 2.5m vertical profile. Together with information on the isotopic signature from different evaporation sources, the Picarro measurements will allow high-frequency estimates of the proportion of evaporation to transpiration water losses at the crop scale.

References:

1. Evapotranspiration components determined by stable isotope, sap flow and eddy covariance techniques, D.G. Williams et al, Agricultural and Forest Meteorology 125 (2004) 241–258