

CONTINUOUS WATER SAMPLING CAVITY RING-DOWN SPECTROSCOPY (CWS-CRDS)



FOR REAL-TIME MEASUREMENTS OF WATER ISOTOPES

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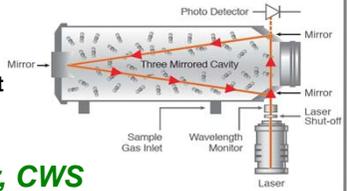
Introduction

- Stable isotopes of water, $\delta^{18}\text{O}$ and $\delta^2\text{H}$, are unique tracers for studying hydrological and associated processes.
- CWS-CRDS System produces high spatial and temporal resolution measurements of water isotopes to follow the dynamics in rapidly changing systems and to map out the spatial heterogeneity of water circulation and mixing.

CRDS Analyzer, L2130-i

Cavity Ring-Down Spectroscopy (CRDS) Technology:

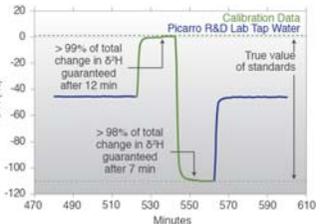
- Laser-based technique to measure the stable isotopes of water, $\delta^{18}\text{O}$ and $\delta^2\text{H}$
- Robust, compact and field-deployable
- Capable of continuous measurement of stable isotopes (1Hz).
- Highest precision and lowest drift



Continuous Water Sampler, CWS

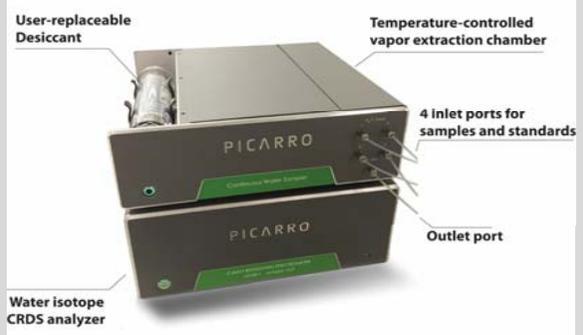
- Water vapor extracted through a micro-porous ePTFE membrane.
- The vapor is then carried by a carrier gas to the L2130-i /L2140-i for high precision measurements of $\delta^{18}\text{O}$ and $\delta^2\text{H}$.
- Active feedback control of the factors that affect kinetic fractionation across membrane (e.g., temperature and flow rate). The magnitude of water isotope fractionation across the membrane is thus stable and readily-calibrated.

Continuous Water Sampler Typical Performance	
Precision	0.1 / 0.2 ‰ for $\delta^{18}\text{O}$ / $\delta^2\text{H}$ (1 σ of 5-minute average measurement)
Reproducibility	0.4 / 1.0 for $\delta^{18}\text{O}$ / $\delta^2\text{H}$ (1 σ of the mean of 5-minute measurements over 12 hours when switching between two water sources; applicable to clean waters in a laboratory setting)
Memory (sample-to-sample)	Better than 99% / 98% ($\delta^{18}\text{O}$ / $\delta^2\text{H}$) of the true difference between two standards after 7 minutes



Switching between Calibration Waters

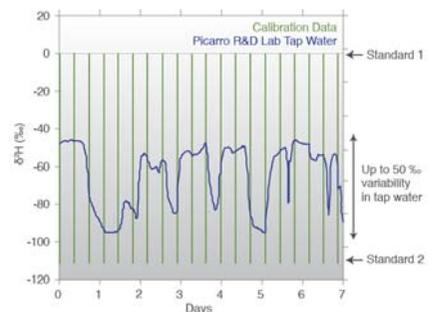
CWS Operation and Maintenance



- 4 inlet ports can be programmed using Picarro software to cycle through the samples and calibration water standards.
- 20-minute calibration per water isotope standard (20 ml).
- The desiccant (Drierite) is user-replaceable and lasts for one month of continuous operation.
- ePTFE membrane is also user-replaceable.
- For waters with high TDS, Picarro recommends placing a 2 μm water filter upstream of the CWS to protect the inlet sample selector and enhance membrane lifetime.

App Case I: Where does your tap water come from?

- CWS-CRDS system in continuous operation for 7 days with automatic switching between two water standards and local Santa Clara tap water.
- Variations in isotopic signature indicate variation in water source [1].
- Hetch Hetchy water [2]: $\delta^{18}\text{O} = -12$ to -14 ‰, $\delta^2\text{H} = -90$ to -95 ‰

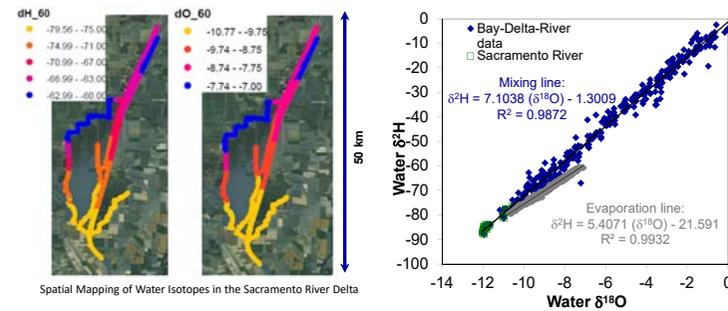


Santa Clara County
by the numbers

- 30% local water
 - 15% natural groundwater
 - 10% from reservoirs to groundwater
 - 5% from reservoirs to drinking water treatment plants
- 55% imported water
 - 15% thru Delta to replenish groundwater
 - 25% thru Delta to drinking water treatment plants
 - 15% from Hetch Hetchy system
- 5% recycled water
 - 10% savings needed
 - 100%

App Case II: California Drought and the Sacramento River Delta

- Collaboration with USGS on isotopic mapping of the Sacramento River Delta in Fall of 2014 and 2015.
- Real-time measurement of the spatial variations of the isotopes throughout the Delta area over approximately 5 hours.
- The Sacramento River Delta is a two-member mixing system, in which one of the end members was observed to exhibit significant evaporation with respect to the historical data. Sacramento River data is from [3], Bay-Delta-River data is from [4].



Spatial Mapping of Water Isotopes in the Sacramento River Delta

Acknowledgements

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References

- [1] <http://www.valleywater.org/services/wheredoesyourwatercomefrom.aspx>; [2] Yates et al. (1999) USGS Water Resources Investigations Report 90-4080; [3] Kendall and Coplet (2001), Hydrological Processes, 15, 1363-1393; [4] Unpublished USGS data (provided by Carol Kendall) from monthly RV Polaris cruises (2006-2008).

Interested in learning more?

- Contact Chris Zwanenburg (czwanenburg@picarro.com)
- Visit www.picarro.com