

INTRODUCTION

- Nitrous oxide (N₂O) is a powerful greenhouse gas that also affects the ozone layer. To better understand how N₂O is produced and consumed in soils, oceans, the atmosphere, and wastewater, scientists measure its isotopes—slightly different forms of the same molecule that reveal its sources and transformation processes. Until now, making these measurements has often been complex and slow.
- Picarro has developed a new instrument, the PI5131-i isotopic N₂O analyzer, that can measure multiple isotopic signatures of N₂O continuously with high precision. The analyzer uses advanced laser technology to deliver stable and reliable results. It can also be paired with Picarro's new Sage gas autosampler, which makes it possible to process many small gas samples automatically. Together, these tools provide scientists with an efficient way to study N₂O across a wide range of environments

Picarro PI5131-i: Isotopic N₂O

Specifications	N ₂ O (concentration)	δ ¹⁵ N, δ ¹⁵ N _α , δ ¹⁵ N _β	δ ¹⁸ O
Precision (1-σ, 10 min)	<0.05 ppb	<0.7‰	<0.7‰
Precision (1-σ, 300 sec)	<0.1 ppb	<1‰	<1‰
Max Drift (> 24 hrs, peak to peak, 1 hr average)	<0.2 ppb	<3‰	<3‰
Measurement Range (ppb N ₂ O in Air)	300–1500		
Measurement Interval	<10 sec		



Fig. 1: PI5131-i iso-N₂O analyzer

Highlights

- High-precision at atmospheric concentrations
- Excellent long-term stability and low drift
- δ¹⁸O, δ¹⁵N bulk and site-specific (δ¹⁵N_α, δ¹⁵N_β)
- Field station and laboratory deployable
- Cryogen-free, continuous operation

METHODS

Picarro-Sage System Set-Up

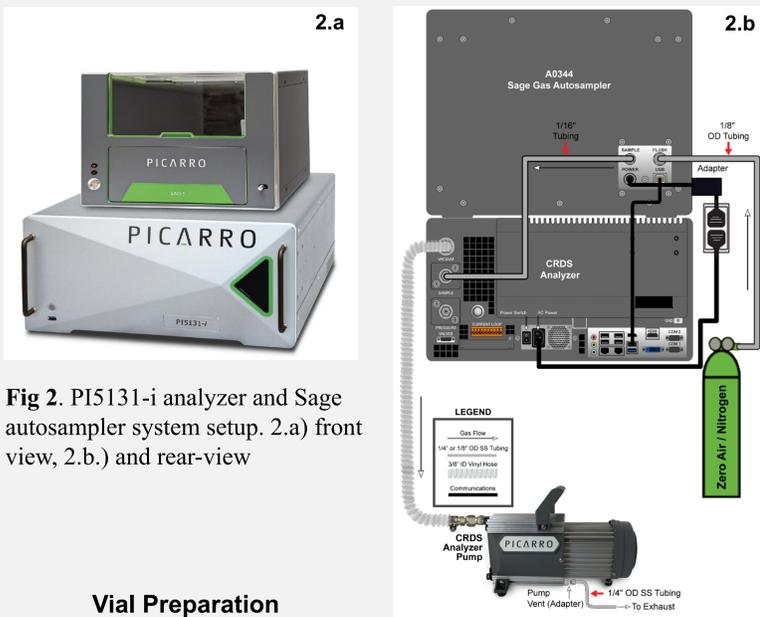


Fig 2. PI5131-i analyzer and Sage autosampler system setup. 2.a) front view, 2.b.) and rear-view

Vial Preparation

- The Sage autosampler requires well-evacuated vials for optimal performance.
- Users can choose to install the auto-evacuation method using the Sage Sample Preparation Kit A0346 (Fig. 3).
- The evacuation method can be run using Sage software on the analyzer and an additional pump.

Automated Vial Evacuation

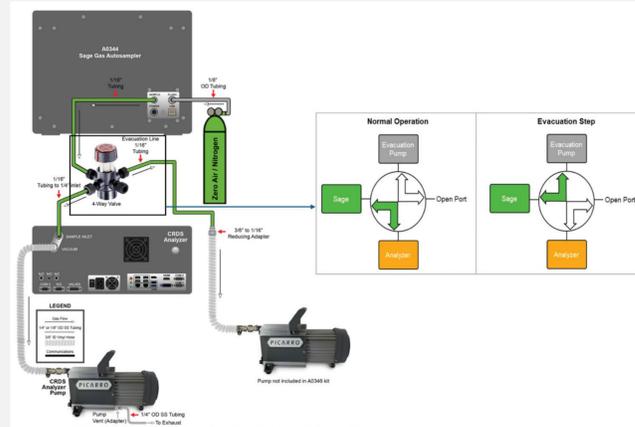


Fig. 3. Sage Gas Autosampler's automated vial evacuation set-up

Best Practices

- Evacuation of Vials: Properly evacuate to prevent contamination, recommended pressure in vial <8 Torr for well evacuated vials.
- Filling Up Vials: Fill at least 25 ml for leak-tight sample analyses; if filling from a pressurized gas tank, set regulator pressure to 9 psi and fill for 5-10 s.
- Storage of Samples: Store under appropriate conditions to maintain integrity, avoid T changes during storage; optimum performance when filled vials are analyzed as soon as possible.

Samples Filling Process



Fig. 4. Samples were stored in leak-tight bags and transferred into vials using a syringe

Samples Analysis

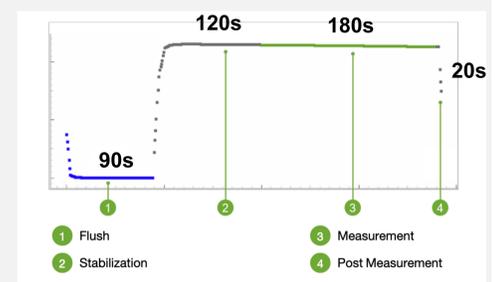


Fig. 5. Method for sample analysis.

5. CONCLUSION

Table 1: N₂O concentration and stable isotope precisions at different N₂O concentrations

Tank / Sample Description	N ₂ O concentration SD [ppb]	δ ¹⁵ N _α N ₂ O Standard Deviation [‰]	δ ¹⁵ N _β N ₂ O Standard Deviation [‰]	δ ¹⁵ N _{bulk} N ₂ O Standard Deviation [‰]	δ ¹⁸ O N ₂ O Standard Deviation [‰]
Tank 1 (330 ppb)	3.4	0.5	0.7	0.8	0.9
Tank 2 (693 ppb)	7.6	0.5	0.6	0.5	0.7
Tank 3 (1066 ppb)	8.6	0.3	0.4	0.4	0.5
Tank 4 (1437 ppb)	12.3	0.6	0.8	0.5	0.6

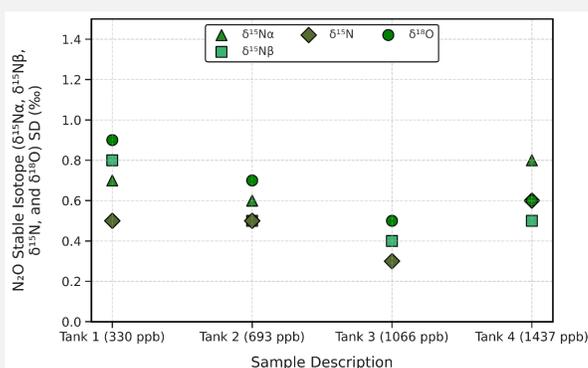


Fig. 6: N₂O stable isotope precisions: (1) The SD for all isotopic values was found to be within 1‰, (2) the highest precision with SD <0.5‰ for all isotopic parameters was achieved at 1000ppb.

NITROGEN POLLUTION AND NITRATE ISOTOPE ANALYSIS

- Global fertilizer use doubled between 1978 and 2014, while the nitrogen use efficiency (NUE) declined, indicating increased nitrogen losses to the environment.
- Approx. 80% of reactive nitrogen is lost to the environment, negatively impacting human health ("blue baby syndrome") and ecosystems (e.g., eutrophication and harmful algal blooms)
- Stable isotope analysis of nitrates is (δ¹⁵N, δ¹⁸O) is a powerful tool for identifying nitrate contamination sources, including agriculture, human sewage, stormwater runoff, aquaculture, and atmospheric deposition.
- Prior to isotopic analysis, nitrate (NO₃⁻) must be converted to N₂O using the following methods [1]:
 - Bacterial denitrifier method
 - Cadmium reduction method
 - Ti(III) reduction method
 - Ion-exchange-based method
- With an appropriate nitrate-to-N₂O conversion approach, the PI5131-i analyzer coupled to a Sage autosampler can be used to measure δ¹⁵N and δ¹⁸O of nitrate. McKay et al. [2] demonstrate the integration of the Ti(III) reduction method with the PI5131-i + Sage system for high-precision nitrate isotope analysis reaching a similar precision as in Table 1.

REFERENCES

- [1] Wassenaar, L. I., Douence, C., and Miller, J. (2023): Assessing the performance of international laboratories analysing the stable isotope composition (δ¹⁵N, δ¹⁸O, δ¹⁷O) of nitrate in environmental waters, Rapid Communications in Mass Spectrometry, 37, e9642.
- [2] McKay, J., Douence, C., Hofmann, M., Woźniak, J., and Bhattacharya, J. (2026): Analysis of nitrate stable isotopes by Cavity Ring-Down Spectroscopy, EGU General Assembly 2026, abstract

