

Interactive comment on “Comparison of nitrous oxide (N₂O) analyzers for high-precision measurements of atmospheric mole fractions” by B. Lebeque et al.

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A good and timely paper which appears to be the first to report a comprehensive comparison between new and established techniques for the high precision, in situ measurement of atmospheric N₂O. This is an important step for global networks to develop the capability for greater precision and inter-comparability to enable greater understanding of the global N₂O biogeochemical cycle. It introduces the background and need for such a study very well.

We would like to thank Mr Vanderschoot for having reviewed this paper and formulated helpful comments. We answer each of them hereafter and add when needed the modifications in the revised version.

It does appear to be a little too focussed on providing recommendations to the European ICOS community specifically. It does read a little too much like an expanded internal ICOS document.

We will clarify this in the reviewed manuscript:

P10941 L29 While the tests have been carried out in the frame of ICOS, the results are valid for all groups and networks doing high precision atmospheric N₂O measurements.

Some of the sections could be trimmed down. Perhaps some more thought about co-authors who are also instrument vendors in the study as it may appear to some as a conflict of interest, especially as not all vendors in the study appear to be listed as co-authors. This is more relevant as the paper makes instrument recommendations to the reader.

The two co-authors who are also instrument vendors have decided to withdraw from the co-author list as their contribution, apart from lending us their instrument, was minimal. The acknowledgment will be rewritten in order to acknowledge all the contributions from the various instrument providers:

This work has been funded by the InGOS EU project (284274). We acknowledge the financial support given by CEA, CNRS and UVSQ for ICOS France. Special thanks to David Griffith for his help during the installation of the FTIR (2011-2012) and for the help during later updates. We would like to thank Picarro Inc, especially Eric Crosson and Chris Rella for providing us the prototype of the N₂O G5101-i analyzer. We also want to thank Hj Jost and Thermo Fischer Scientific for providing us their N₂O IRIS 4600 analyzer. We are grateful to Macel Vanderschoot and three anonymous referees for their detailed and constructive reviews.

It is difficult at times to compare instrument techniques where not all is equal eg the impact of sample size/cell volume and averaging time have on reported instrument precisions; sample drying or not, and different research applications may have different needs.

We fully agree with this comment, but this limitation is inherent to the comparison of different technics. We would also have preferred to have all instruments available at the same time for the comparison but this was unfortunately not possible.

Some comment should be made about N₂O isotopes, and the difference between techniques regarding this. GC techniques are not sensitive to these, however optical techniques are. There are also isotopologue specific analyzers available by at least two of the instrument vendors mentioned in this study.

We understand the interest for studying N₂O isotopes or other isotopologues and species measured by the various instruments. The focus of this paper is however to compare different analyzers measuring the same species. The isotopes of N₂O are only measured by one instrument, which makes the study of the isotope influence not possible here.

The abstract could be reworded to remove the sentence starting in line 19 (WMO comparability goals) should be omitted from abstract as that reference should be introduced in the introduction as it is a research community specific term. This concept would be better explained by reference to the small spatial gradients of N₂O and the need for greater instrument precision and comparability.

We will remove WMO comparability goals from the abstract.

P10939 l4 This technique however becomes very challenging when trying to detect the small variations of N₂O as the detectors are highly non-linear...

Line 22 remove 'robust' as it is used twice in the same sentence and without context a technique that has been used for a "... a few decades.." sounds quite "robust".

We will change "robust" to "new".

If this study is the first to report these comparisons then it is a good leading statement as well, or at least include it in the abstract.

We will modify the abstract.

P10939 L11 In this study, we present the most complete comparison of N₂O analyzers, with seven analyzers that were developed and commercialized from five different companies.

"ICOS" is defined for defined for two different things, although they are not related it would be better to make the distinction clearer for those outside the community.

We will use in the text, for the measurement technique Off-Axis Integrated Cavity Output Spectroscopes, the abbreviation OA-ICOS.

Pg 2, line 15 in the introduction could be moved to the end of the paragraph.

It will be done.

Pg 2. The sentence starting in line16 should include the mention of the CSIRO GASLAB network in that global network list as a very significant network, particularly for the SH. Especially since Cape Grim station is specifically mentioned (a suitable reference could be Francey et al. 1996). This should include more long term N₂O growth rates determined from CSIRO GASLAB integrated ice-core, firm air and the Cape Grim Air Archive. Growth rates

given in the paper only refer to the last 5 years. “AGAGE” should probably be replaced with “ALE/GAGE/AGAGE”.

We will include CSIRO GASLAB network but we will keep the focus of the last 5 years keeping AGAGE as written on their webpage.

Pg 2, line 32 “..expert group..” should be specific to WMO/GAW GGMT meeting.

The line will be modified

P10940 L23 At the 17th WMO/IAEA Meeting, 10-13 June 2013, in Beijing, an expert group on CO₂ and other GHGs from the World Meteorological Organization Global Atmosphere Watch (WMO/GAW) recommended an N₂O inter-laboratory comparability goal of ± 0.1 ppb

Pg 3, line 9 sentence better worded as “Since 1995 methods incorporating this technique have achieved a typical short term repeatability of 0.1 to 0.3 ppb N₂O..”

We will change the line according to comment.

Pg 3, sentence beginning Line 27 could be removed.

We think this sentence is important to explain why the tests were not exactly identical for all instruments.

Pg 4. Title 1 suggestion “Instrument specifications”

Thank you for the suggestion but we feel “Instrument descriptions” is more accurate as we are describing the setup for each instrument, and we have not chosen to put the manufacturers’ specifications in this paper.

Pg 4. Subheading suggestion “Gas Chromatograph with Electron Capture Detector (GC-ECD)”
We will change the heading to Gas Chromatograph with Electron Capture Detector, Agilent (GC)

Pg 4. Sentence starting line 17 could be confusing for those outside community w.r.t to leading comment in abstract the GC-ECD’s are “highly non-linear”.

We will modify the sentence to:

P10942 L18 For the small range of N₂O mole fractions in ambient air (324-334 ppb), the ECD can be corrected for non-linearity, applying a two-point calibration strategy with two working standards (322 and 338 ppb).

Pg4. Sub heading 1.2 should be titled “Fourier Transform Infra-Red (FTIR)” and exclude the vendor name. “Agilent” is not included in sub-heading 1.1. Or include commercial name in parenthesis. Also this section seems overly long and could perhaps be trimmed down or referenced to another document. Also sub headings 1.3, 1.4, 1.5 and 1.6 should all be consistent with 1.1 and 1.2 as specified above. Pg 4. Line 29 “FTIR” has already been defined on pg 3.

Sub-headings will be modified to include vendors name and to be consistent. FTIR section will be a little trimmed down according to comment.

Pg 8. Title 2 suggestion. “Calibration Protocol” and move much of section 2.1 into this. Much of laboratory description may not be required for this paper. A table of the different sets of calibration gases and mixing ratios may be useful.

We will shorten a bit this paragraph and add the range of the different sets of calibration into Table 1.

Pg 12. Line 22 “dispersion”? used several times in the document.

All occurrences of “dispersion” will be either removed or changed to “standard deviation”.

Pg 14. Line 14 “constructors” should be “vendors” or “manufacturers”

We will change it to “manufacturers”.

Pg 17. Suggested subheading 2.9 “Ambient air measurement comparisons”.

The subheading 2.9 will be changed to suggested subheading.

Pg 21. Line 11. clarify “..and the room temperature should be monitored to correct for dependency”.

This sentence will be clarified:

P10963 L11 ...the room temperature should be monitored to assess its evolution and the validity of the measurements.