

Interactive comment on “Evaluation and optimization of ICOS atmospheric station data as part of the labeling process” by Camille Yver-Kwok et al.

Anonymous Referee #1

Received and published: 21 August 2020

This paper represents a substantial contribution to scientific progress in atmospheric measurement techniques of greenhouse gases. It describes in detail the labelling process that atmospheric greenhouse gas measurement sites have to go through to receive approval to join ICOS, as well as the quality controls used to assure high quality and precise scientific data. To date, there are few papers outlining the steps taken to harmonise trace gas measurements from large networks with multiple stakeholders. This paper bridges this gap, gives good lessons learnt during the process and provides great clarity on the ICOS atmospheric station labelling procedure that can sometimes be a little opaque to those outside of ICOS.

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The paper is well written, with very good English and the scientific methods used are appropriate. The figures and tables are on the whole well-presented and add to the understanding of the manuscript. I thoroughly enjoyed reading and reviewing the manuscript.

Specific comments: There are a few inconsistencies within the manuscript that need to be addressed, including the mixing of units (e.g. ppm and $\mu\text{mol}\cdot\text{mol}^{-1}$) and whether species are written with subscripts or not (i.e. CO₂ or CO2) within both the manuscript, tables and figures. Furthermore, there are a number of times where the authors have used atmospheric or atmosphere interchangeably to describe ICOS stations where atmospheric GHGs are measured (c.f. P3 L23 and P15 L20).

In addition, the use of abbreviations and their introduction into the manuscript aren't always consistent. For example, the abbreviation of greenhouse gas to GHG is used within the abstract whilst no abbreviation is used within the remaining sections of the manuscript. In contrast, station acronyms based on GAWSIS IDs for stations have been used within the manuscript but no full name has been given the first time that the station has been introduced in the text. For clarity, please include the full name, followed by an acronym, the first time it is used in the manuscript.

Furthermore, there are some formatting issues with some of the tables and figures that need attending to, such as the inconsistencies of table presentation and the borders of column titles. Some figure captions are lacking in basic information (e.g. what abbreviations mean within the figure, keys for schematics, etc.) and mean that if a reader were to come and look at the figure only, it is difficult to comprehend (see technical corrections for specific figure comments). Additionally, some colour combinations are hard for people with colour-blindness to decipher. Please consider altering some combinations, e.g. not having red and green together.

Technical corrections: P1 L8: text does not read well, try – “... calibration gases are measured twice a month”. P1 L8: change “controlled” to “verified”. P2 L3: text does not

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read well, try – “... in a calibration sequence is possible, saving gas and extending the calibration gas lifespan”. P2 L10: text does not flow well, try – “Continuous, precise, greenhouse gas monitoring began in 1957 at the South Pole and in ...”. P2 L21: remove “i.e.” before “harmonized and high precision...”. P3 L1: seeing as the location of the ATC is stated in P3 L6, this should also be done for the Flask and Calibration Laboratory and the Central Radiocarbon Laboratory. P3 L6-8: the location of the ATC is ambiguous, would be better to state outright that it is in France, i.e. “The Atmospheric Thematic Center (ATC, <https://icos-atc.lsce.ipsl.fr/>) is divided into three components; the metrology laboratory (MLab) responsible for instrument evaluation, protocol definition and PI support (located in France), the data centre (located in France) responsible for data processing, code development and graphical tools for PIs, ...”. P3 L10: add “the” before ATC. P3 L15: it might be good to give an example of what elaborated products are available as those reading the manuscript who are not familiar with ICOS may not know what is offered. P3 L28-29: text does not read well, try - “... adhering to the WMO guidelines (WMO, 2018) for greenhouse gas observations but are elaborated on more in ATC and Laurent (2017) and presented in section 2.4. P4 L15: What is the frequency of routine data evaluation sessions? P4 L26-27: It is not clear here what it meant by the list of Class 1 parameters that aren't necessary for a station to be labelled. Is it that out of the three parameters (boundary layer height, GHGs and ¹⁴C values from flasks), two do not need to yet be in place for a site to be labelled; or should the sentence read three parameters? Additionally, could more clarity be given on what is meant by GHGs, seeing as in situ CO₂ and CH₄ measurements are mandatory and are GHGs. P5 L1: Please provide a reference for the specification document if publicly available. In addition, is the list of accepted analysers publicly available? P5 L15-18: the relative pronoun “whose” on L16, in the parentheses, should be replaced with “for which”. P5 L25: Try to avoid double parentheses. P6 L6: What mixing ratios do you suggest for the long-term target to ensure that it is representative for more than 10 years? P6 L7-8: For clarity, change to “It is recommended to send the long-term target, as well as the calibration set, for recalibration approximately every 3 years to

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the CAL-FCL to investigate and take into account any possible composition changes in the gases, especially for CO. P6 L10: To make the manuscript more accessible for colour-blind readers, change the end of the line to “The instrument calibration dates are included at the bottom of the plot by the open orange circles.”. P6 L15: replace “depending” with “dependant”. P6 L19: Include definite articles (the) in front of long-term and short-term target. P6 L22: replace “are going” with “go”. P6 L23: To remove potential misunderstandings with the meaning of the word “control” in relation to station PI's reviewing data, replace “control” with “verify” or “review”. P6 L28: Please state which server you are referring to at the beginning of the line. P6 L28: Where are the ATC data products located that station PIs check? Are they the plots shown on the ATC website (e.g. <https://icos-atc.lsce.ipsl.fr/SAC>)? If so, please state that these are publicly available for stations that have been labelled and give the link to the website. P6 L30: Please outline what is used as the flagging scheme. Is this already published in Hazan et al. (2016)? P6 L31: As for P6 L23, change “controlled” to “verified” or “reviewed” to remove misunderstandings. P7 L22-25: Establishing if your sample intake line has a leak or not is an important consideration. What is done at sites to establish if there are leaks if the mast cannot be climbed easily due to reasons outside of the control of the PIs and there is no infrastructure installed to alter intake configurations remotely? P8 L1-2: More information is needed for this test to be replicated by someone reading this paper and is not part of ICOS. It is not clear to me if a humidification loop is used, as in Stavert et al. (2019; <https://doi.org/10.5194/amt-12-4495-2019>) to conduct this test or is another method used within ICOS? In addition, what mixing ratios within the cylinder are suggested by ICOS for the test? P8 L9: Please provide a hyperlink for the automatically generated plots on the ATC website. P8 L14: Please alter “bi-monthly” to “twice-monthly” or “every 15 days” to remove ambiguity. P8 L30: Please include three letter identifier after Lindenberg to aid the reader in finding the example in Figure 4. P9 L8-9: Please include a space between numbers and units. P9 L18: Calibration drift is misleading as a title, as it suggests the drift of mole fractions within the calibration cylinders. This may be the case for some species and over longer periods of time

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than 2 weeks; however, the authors are discussing the assessment of instrumental drift in this section. I would suggest changing the sub-heading to “Instrumental drift and calibration optimization”. P9 L20: Is instrumental drift ever estimated over shorter timescales than 2 weeks? In my personal experience with optical instruments, some can drift quite significantly over periods of time less than 1 day. This is especially the case in environments where there is poor thermal stability (e.g. no air conditioning or too large thermal switches on air conditioning units). P9 L30: Are there specific types of analysers that are worse than others for temperature dependence, e.g. instruments with larger cavities? P10 L9-10: Please state what the meteorological sensors need to be complaint against? ATC specifications document? Also, are the meteorological data submitted to the same database as the GHG data? P11 L16: Replace “Belgium and France” with “Belgian and French”. P11 L28-30: This sentence isn’t clear and I cannot decipher what the authors mean. Please rephrase to give clarity. P11 L32-33: Has a study ever been done by ICOS on the representativeness of using buffer volumes? As I understand it, one of the main advantages of using optical instruments is the added information that can be gained from the short-term variability in mole fractions. Would it be better to not use buffer volumes to futureproof the data at these sites for when numerical models can ingest high frequency data and simply smooth data based on statistical filters, as used at other sites and networks? P13 L11-13: What were the sources of leaks for GAT and STE? It is not often that papers include lessons learned information, which is often very useful to other stations in diagnosing problems of their own. P13 L19: As American English has been used throughout the manuscript, please remove the th from after 15 (both occasions) as this is only included in British English. P14 L30: As far as I am aware, there are two methods for a Nafion counter purge: using a dry gas, such as zero air or N2, or the Welp et al. (2013; 10.5194/amt-6-1217-2013) method of reflux mode (i.e. taking a small portion of dried air post-Nafion and using it as the counter purge gas but ensuring it is at a lower partial pressure than the sample gas). Which method is currently recommended by ICOS when using a Nafion to dry samples? P15 L4: Full name used for Jungfraujoch instead of a trigram. Please

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replace with JFJ to be consistent. P15 L20: Grammatical error, please change to – “In this paper we have presented the process used to label ICOS atmospheric stations.”. P15 L28: Replace “oftentimes” with “often”.

Table 1: Please include a reference to the ICOS atmospheric station specification document in the caption. In the table, it is not clear that the column “Gases, periodical” relates to flask measurements. Please add in more information in the column caption or in the table caption to clarify this. In addition, was atmospheric pressure at the highest inlet height ever discussed as a useful parameter for modellers to see the pressure differences between the top and bottom inlets of towers?

Table 2: I am assuming that the thresholds cited in this table are specific to a certain type of instrument, i.e. CRDS seeing as these instruments are mostly used within the network for CO₂ and CH₄ analysis. In addition, please could you include the H₂O threshold used for calibration gases, as referred to on P5 L25-26.

Table 3: Please can you ensure that the writing of magl is consistent with figures (often written as m agl). This also applied to masl.

Table 4: The ambient air percentage for KRE looks erroneous (5069 %).

All figures: Please include lists of full site names, with acronyms in parentheses, of any site included in the figure. In addition, if any instrument number is included or a cylinder D number, please give an explanation. If species are mentioned, ensure that any numbers are subscripted, e.g. CO₂, not CO₂.

Figure 1 caption: Suggest changing to = “ One month of target gas injections for CO₂ (ppm), shown as the difference of calculated vs. assigned mixing ratios. Short term target data is plotted in green, whilst long term data is in brown. The calibration dates are shown by the light orange open circles. Cylinder number (D*****), mean values (\pm X), point-to-point variability (Ptp) and difference to the assigned value (Diff) are displayed above the figure.”

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Figure 2 caption: Notwithstanding that the figure is there to show locations to connect a cylinder to run the leak tests outlined in section 2.3.3., a key for the different parts shown in the figure would be useful for reader comprehension.

Figure 3 caption: Please indicate what the values in the 2nd and 3rd columns represent.

Figure 4 caption: Please indicate why there are duplications of LIN (as explained in the manuscript text).

Figure 6 caption: please indicate how the deviation of measurement from assigned values is calculated.

Figure 12 caption: The MHD Marine Smooth Curve isn't explained, please include a brief description of the methods used to derive the curve.

Figure 13: To make the insert clearer, consider adding a black border around to isolate it from the main figure. In addition, add in a list of the sites, with the acronyms in parentheses, as well as giving the years for the colours of when sites were first labelled.

Figure 15: It is currently hard to read the site acronyms and instrument numbers, please reduce the text size slightly so that there are some gaps between each site, like in Figure 16.

Figure 17: There is no bottom tine to the top plot.

Figure 20: What is the difference between ATC MetroLab HB 2016-05 and ATC MLab Droplet?

Interactive comment on *Atmos. Meas. Tech. Discuss.*, doi:10.5194/amt-2020-213, 2020.