

# Authors Response Reviewer 2 - The Macquarie Island [LoFlo2G] high-precision continuous atmospheric carbon dioxide record

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We would like to thank the reviewer for their comments. Below we have provided a response to each comment along with any subsequent changes to the manuscript. The original review comments are in italics and our responses are in normal font.

*The authors report on high-precision continuous measurements of carbon dioxide (CO<sub>2</sub>) in the framework of the Commonwealth Scientific and Industrial Research Organisation (CSIRO). The measurements were performed at Macquarie Island in the Southern Ocean region using a LoFlo2 instrument based on non dispersive infrared (NDIR) method. A detailed discussion is given on protocols of measurements and calibration, analysis of measurement uncertainty sources and procedures for baseline determination.*

## General comments

*The manuscript is well structured and written, scientifically sound. It would be acceptable for publication in AMT after minor revision by addressing the comments and questions listed below.*

## Specific comments

- (1) *Page 14, section 5 "Defining a baseline record" : the authors discussed how to remove influences of local flux and Southern Hemisphere land flux to achieve a regional background CO<sub>2</sub> observation. Should be considered the ocean-atmosphere CO<sub>2</sub> exchange in this case? If yes, how to take into account such influence?*

To our knowledge there is no single definition of 'baseline' for atmospheric CO<sub>2</sub> measurements. In the description of the GLOBALVIEW-CO<sub>2</sub> data product ([https://www.esrl.noaa.gov/gmd/ccgg/globalview/co2/co2\\_comparability.html](https://www.esrl.noaa.gov/gmd/ccgg/globalview/co2/co2_comparability.html)), it is noted that baseline selection excludes samples influenced by local sources and sinks, is site-specific and is done

based on knowledge of local conditions. For coastal sites, it is conventional to define measurements from oceanic air to be baseline, as opposed to continental air which has larger anthropogenic and biospheric signals. This data may still be useful, but is not considered ‘clean’ or ‘background’ air. Since baseline definition is site-specific, it was important to explore this for the Macquarie Island record. Clearly samples that are influenced by sources or sinks on the island itself should be excluded for a baseline record. Given the remoteness of Macquarie Island, the need for any other selection (such as for Southern Hemisphere land influence) would depend on the application. After selection for oceanic data, the MQA record clearly still shows synoptic scale variability which would contain information about spatial or temporal variability in the ocean-atmosphere CO<sub>2</sub> exchange. Effectively extracting that information is a challenging research task.

We have added a sentence to the baseline section noting that for coastal sites it is usual to select for oceanic air.

(2) *Page 16, section 5.3 "Curve fitting" : a low-pass filter is used to fit the hourly CO<sub>2</sub> data to smooth the time-series results. Is the Kalman filtering method more suitable for such application? As an adaptive filtering technique, Kalman filter can efficiently remove the shot-to-shot variability related to the real-time noise in the measured data with minimal deformation of the physical quantity to be measured. Kalman filtering method has been successfully applied to perform fast and high-precision measurements of trace gas concentration [Appl. Phys. B 74 (2002) 85-93] and isotope ratio [Opt. Lett. 35 (2010) 634–636].*

We use curve-fitting for two purposes within the paper, one is to test the sensitivity to data selection methods and the other is to decompose the timeseries into trend and seasonal components. As noted by (Pickers and Manning, 2015), timeseries decomposition is a common motivation for fitting atmospheric composition timeseries, although the decomposition is not unique and depends on the choice of fitting procedure. A Kalman filtering method might be suitable for the data selection sensitivity testing but, as we understand it, would not be suitable for decomposing the timeseries. The Thoning fitting method (Thoning et al., 1989) used here is one of three methods compared by Pickers and Manning (2015) because of their common use within the atmospheric greenhouse gas measurement community. They found less sensitivity to method for atmospheric records with relatively small seasonal cycles (such as for our MQA data) but did not test the methods with high temporal frequency (e.g. hourly) data. For the purposes of this paper, the main requirement is to use consistent fitting procedures across the different tests, and when comparing the flask and LoFlo records. Hence our choice of the Thoning method is suitable. We have added as sentence near the start of section 5.3 to note the application of the fitting for decomposing the timeseries.

Addressing this comment prompted us to explore the sensitivity of the flask fit shown in Figure 10 to the fitting parameters which we briefly comment on in the relevant section.

## **Technical corrections**

*Page 6, line 8 and line 28 : "Fig. 2e" should be "Fig. 2f"?*

This has been corrected.

*Please make larger the following figures 2, 4, 6 and 7. 2*

Figures will be submitted as individual postscript files for the journal to size.

*Some sentences are too long. It would be better to rephrase them and to make them more understandable. For instance,*

*Page 2, lines 27-30 : "While the performance .... to reduced calibration requirements";*

The sentence has been divided into two and simplified.

*Page 5, lines 24-26 : "Macquarie Island .... sample measurements";*

Actually line 19-21: The sentence has been simplified. The information contained in the second half of the sentence has been moved to section 3.1.

*Page 8, lines 24-26 : "This is independent .... in a calibration run)";*

The sentence has been divided into two.

*Page 10, lines 2-4 : "The uncertainty .... 18 reference standards";*

The sentence has been divided into two and simplified.

*Page 15, lines 21-23 : "Radon is input .... and zero poleward of 70°";*

This sentence has been divided into four sentences.

*Page 15, lines 27-29 : "Radon selection .... for radon of 20 mBqSCM-1";*

This sentence has been simplified (as part of re-writing the section in response to a comment from reviewer 1).

*Page 17, lines 21-23 : "Tropical and northern .... Frederiksen, 2016)";*

This sentence has been simplified.

*Page 18, lines 7-9 : "The in-situ .... by multiple orders of magnitude";*

This sentence has been simplified.

## **References**

Pickers, P. A., and Manning, A. C.: Investigating bias in the application of curve fitting programs to atmospheric time series, Atmos. Meas. Tech., 8, 1469-1489, 10.5194/amt-8-1469-2015, 2015.

Thoning, K. W., Tans, P. P., and Komhyr, W. D.: Atmospheric carbon-dioxide at Mauna Loa observatory .2. Analysis of the NOAA GMCC data, 1974-1985, Journal of Geophysical Research-Atmospheres, 94, 8549-8565, 10.1029/JD094iD06p08549, 1989.