

Interactive comment on “Recent six-year atmospheric CO₂ concentration at the summit of Mt. Fuji observed by a battery-powered CO₂ measurement system” by Shohei Nomura et al.

Anonymous Referee #2

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Title: Recent six-year atmospheric CO₂ concentration at the summit of Mt. Fuji observed by a battery-powered CO₂ measurement system

Authors: Shohei Nomura et al.

General comments:

The manuscript presents a technical description of a CO₂ monitoring system operated for 6 years at the high altitude site Mt. Fuji, Japan, and associated data analysis. The description of the measurement setup is rather short for a publication in Atmospheric Measurement Techniques and should be extended (see specific comments below). On the other hand, the data discussion could be shortened as it is not the main scope of

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a paper in AMT. This would be easily possible as the current manuscript extensively compares the Mt. Fuji data with data from Mauna Loa, Hawaii (differences of daily averages (Fig. 10), differences of daily averages for summer and winter (Fig. 12), trends and growth rates for Mt. Fuji and Mauna Loa (Fig. 13), Mt. Fuji and Mauna Loa time series (Fig. 14), trends of monthly Mt. Fuji-Mauna Loa differences (Fig. 15)). Alternatively, the authors can also envisage to elaborate the data interpretation section, e.g. by also incorporating observations from other (high altitude and/or background) monitoring stations, and can consider submitting the manuscript to Atmospheric Chemistry and Physics. Thus, I recommend the publication of the manuscript in AMT after strengthening the experimental section and concisely abridging the data interpretation. A revision of the manuscript with a stronger focus on the data analysis and a submission to ACP seems to be a suitable alternative, too.

The manuscript contains quite a lot of tables and figures, some of them are to my mind not really needed or can be merged. The authors may consider reducing the number of tables and figures, see also my comments below.

I strongly suggest revising the conclusions which are currently only a summary of what was said before. Please add the lessons-learned (especially on the instrumental side) – e.g. what would you do differently when you could start from scratch again – and provide an outlook, e.g. are the measurements ongoing? If so, are there any changes/improvements on the measurement setup planned? Did the authors modify the measurement setup during the 6 years of operation, i.e. did they improve their system based on the experience gained in the earlier years?

Even if it is common to use expressions such as “the CO₂ concentration was 400 ppm” colloquially, it is an incorrect statement and not suitable to be used in the scientific literature. Quantities given in ppm refer to mole fractions or mixing ratios and cannot be called concentrations. Please use the correct terminology throughout the manuscript.

Specific comments:

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Title:

I suggest changing the title to “Six-years of atmospheric CO₂ observations at Mt. Fuji recorded with a battery-powered measurement system”

Abstract:

Lines 15-18: “The difference in monthly average CO₂ concentration between Mt. Fuji and MLO appeared to increase from 2009 to 2015. Interannual variability and growth rate of CO₂ concentration were similar both at Mt. Fuji and MLO, 13 ppm increase from 2009 to 2015, but the annual average concentration at Mt. Fuji was about 1 ppm higher than at MLO.” It sounds like a contradiction (the difference increases but the average was 1 ppm higher), or is at least not understandable without having seen Fig. 15 and the related discussion, respectively. I suggest to delete the first sentence and to add another sentence after the second sentence, like “However, differences in Mt. Fuji and MLO observations show divergent trends depending on seasons.”

Line 18-19: delete “Monthly averaged ... in April 2013.” Not relevant here.

Lines 21 – 22: change “... indicating that Mt. Fuji was a representative site ... in the mid-latitude Asian region” to “... indicating that Mt. Fuji is a representative site to monitor CO₂ concentrations in the mid-latitude region.”

Introduction:

Page 3, lines 8-9: “... without electricity supply ...”, better say “... without gridded electricity supply ...”

Page 3, lines 8-9: reword sentence: “... even under the harsh conditions ...”

Page 3, lines 8-9: “... harsh conditions found at the summit of Mt. Fuji, where the atmospheric pressure is low ...” Why is low pressure a harsh condition?

Page 3, line 16: add latitude, longitude and altitude for Mauna Loa

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Page 3, line 17: “To evaluate the regional representativeness and precision of the measurements obtained by our system, the data are compared with aircraft observations.” Don’t you evaluate the accuracy rather than the precision when comparing with other data?

Methods:

This should be the main part of the paper and thus, needs elaboration.

Page 3, lines 20-25: add Mount Fuji altitude. How can you access the station? Is access only possible in July and August, or also during the rest of the year (in exceptional cases, e.g. for trouble-shooting).

Page 4, line 6: add number of pumps (4, according to Fig. 3). Why do you need four pumps? Can you redesign the setup using less pumps reducing the power consumption?

Page 4, line 7: write “... using a Nafion membrane ...”. What is the dew point that you achieve with the setup? Does the drying efficiency change (decrease) with time? Is a 2 litre cartridge of Silica gel sufficient for the Nafion counterflow for 10 months.

Page 4, first paragraph: did you apply any modifications to the measurement setup, in particular to the CO₂ analyzer? E.g. disconnecting the display or reducing the flow through the NDIR to reduce power consumption.

Page 4, line 17: “... a small internal heater was planned to activate ...” was it only planned or was it also in place? If the latter is true, write “... a small internal heater was implemented to activate ...”

Page 4, lines 20-24: did you use any inlet filter? If so, how often was it changed?

Paragraph 2.3 Electrical power system:

It remains unclear why gridded power is only available in summer. What does exactly change in early July and late August? Is the station permanently staffed in summer?

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Did you ever try off-grid generated power with wind turbines or solar panels?

Paragraph 2.4 Measurement sequence:

How is the measurement system controlled? Which software is used? Elaborate on the instrument maintenance. Can you remotely access the measurement setup, i.e. can you access the computer when the satellite communication is running? E.g. to modify the measurement sequence. Did you ever face any serious instrumental failures? There seems to be a longer data gap in 2012 (according to Fig. 10)? What happened? What is the overall data coverage based on your daily averages?

What is the yearly consumption of reference gas? How long do the reference cylinders last?

Page 5, lines 15-18: “However, we subsequently changed the operational time to 21:00–00:28 JST, to avoid local daytime influences from transportation of the air mass around Mt. Fuji that might affect the CO₂ concentration over the summit of Mt. Fuji, which is similar to how observations are obtained at MLO.” To my knowledge, CO₂ measurements at MLO are continuous and a filter to extract background conditions is applied afterwards. However, most background data are identified at Mauna Loa in the late afternoon, see http://www.esrl.noaa.gov/gmd/ccgg/about/co2_measurements.html for more details.

Page 5, line 22: did you use an inlet filter when measuring room air?

Page 5, line 22: “. . . to stabilize the flow line.” What does that mean?

Page 5, lines 23-24: Why do you need to push the air into the analyzer when another pump sits behind?

Page 5, line 27: why does it need one hour to send the data? How large are the data files? Which time resolution do you store the CO₂ data?

Page 5, lines 28-29: “The derived concentration was based on the average of the data

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from the second, third, and fourth cycles . . .”, in other words, the daily average is based on 3 x 8 min = 24 minutes of observations. In fact, it will be even less since you have to discard some data to account for flushing and signal stabilization after switching from room air to outside air. Add the information how many minutes of data were discarded after switching. Please mention explicitly that the daily averages used below only rely on a very short measurement period.

Paragraph 2.5 Continuous measurements in summer:

Does the continuous system use the same inlet? Did you use the same reference gases? Does the default system operated all year long also only measure for 3.5 hours a day in summer? The summer system has no dryer. Did you test and quantify the CO₂ losses in the Nafion dryer?

Paragraph 2.6 Weather data:

How does the power supply for the meteorological measurements look like?

Page 7, lines 14-19: again, didn't you experience any other interruptions, in particular during the 10 months of unattended operation?

Paragraph 3.2 and onwards:

Use data other than Mauna Loa for comparison and interpretation. E.g. Lulin (Taiwan), Niwot Ridge (USA), Mt. Waliguan (China) etc.; use the marine boundary layer reference (available at <http://www.esrl.noaa.gov/gmd/ccgg/mbl/>) for comparison which is also available for the Mt. Fuji latitude. How does the difference in latitude (Mt. Fuji – Mauna Loa) influence your comparison?

Page 7, line 29: add altitudes for Niwot Ridge and Hakkouda

Page 8, lines 4 – 8: move this paragraph up to paragraph 2.1

Page 8, line 13: say “18 ppm larger”, add altitudes for Mt. Fuji and MLO.

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Page 8, line 16: Table 1 is not needed, in particular if data are available in a publicly accessible data repository. Did you submit the data to the World Data Centre for Greenhouse Gases?

Page 8, lines 22 – 23: “Conversely, the CO₂ concentration from December to March at Mt. Fuji was generally higher than at MLO.” February and March are the months with most intense biomass burning on the Indochinese Peninsula. Do these fires affect the observations at Mt. Fuji?

Page 9, line 5: add reference to Fig. 1

Page 9, lines 12-13: this statement is based on the Fourier-transformed (i.e. deseasonalized) data, correct?

Page 9, lines 20- 21: “. . .the increased rate of growth of CO₂ concentration because of accelerated plant respiration over land and weakened photosynthesis activity”. Add reference. Next to vegetation effects, it is also due to more intense biomass burning, see e.g. Betts et al., Nature Climate Change, September 2016).

Page 9, lines 24-26: “For example, the negative values of Δ CO₂ concentration have enlarged gradually over the six-year period of 2009–2014, as shown in Fig. 10. Chen et al. (2014) reported that growth of Asian vegetation increased recently.” I doubt that such an effect can be seen in a 6-year time series. Moreover, Chen et al. refer to changes over the last three decades.

Page 9, lines 26-28: “In particular, remote sensing observations over eastern Siberia have revealed a notable increase in vegetation during recent decades. Correspondingly, the negative values of Δ CO₂ concentration have enhanced gradually.” Is there any proof confirming this statement. How about CO₂ observations at other Asian sites? Can't it also be an emission effect with decreasing emissions in summer?

Page 9, lines 28-29 and page 10, lines 6-7: “This phenomenon might be related to the increase of anthropogenic CO₂ emissions in China during recent decades” and

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“. . .the positive trend in winter was not so significant, which might be attributable to the slowing of the growth rate of CO₂ emissions in China during 2011–2014.” Sounds like a contradiction.

Page 9, lines 20-32: “Such event-based phenomena should be evaluated by numerical simulation, but we expected that such signals from regional emissions or absorption changes would be included in the data at Mt. Fuji.” If you expected it, why didn't you look closer at it?

Conclusions:

As mentioned above, revise the conclusions and add lessons-learnt and an outlook.

Tables and Figures:

Table 1: not needed, a release of the data in a public data repository is strongly encouraged.

Table 2: not needed, some numbers could be incorporated in Fig. 15.

Fig. 1: add areas of air mass origin (Fig. 11) to Fig. 1 and delete Fig. 11.

Fig. 5: what is the nominal value of the standard gas?

Fig. 6, caption: Write “Monthly averages of ambient temperatures outside . . .”

Fig. 11: merge with Fig. 1 and delete

Fig. 14: does it show daily averages? Monthly averages? The figure repeats Fig. 9, the long-term evolution is not of real interest here. I suggest to delete it.

Fig. 15: only a few trend lines are plotted: for which months? Use open symbols for the months without trend line?

Fig. 16: add information to Fig. 1 and delete Fig. 16

Minor comments:

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Page 2, line 11: start with lowercase letter after semicolon.

Page 5, line 12: typo “Phenobaboad”

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