Atmospheric
Chemistry
and Physics
Discussions

Open Access

ACPD

Interactive
comment

Interactive comment on "Seasonal and diurnal variability in air pollutants and short-lived climate forcers measured at the Rwanda Climate Observatory" *by* H. Langley DeWitt et al.

Anonymous Referee #1

Received and published: 2 March 2018

This manuscript reports on the new Rwanda Climate Observatory, an atmospheric trace gas station as part of the established AGAGE network. The station was funded by a collaboration between MIT and the government of Rwanda. The data presented in this report represent the first year and a half of the operation of the atmospheric station and focuses on BC, CO and O3. Season and diurnal plots along with air mass back trajectories are presented. This data set is valuable for the air quality community, however the data in this study is simply reported and lacks a synthesized approach to validate publication in ACP. In addition, there are erroneous claims on ozone production. At the moment, this manuscript does not represent a significant advancement in the science of air quality. I would have to recommend rejection, although I would be

happy to review a new submission. I have suggestions to help improve the usefulness of this publication and I outline below my major comments and identify minor issues.

Reviewer general comments:

The goal of the publication is unclear. What are the others hoping to achieve with this study? The title suggests the discussion of pollutants AND short-lived climate forcers, but climate implication of BC, CO or O3 are not addressed in the paper. The introduction suggests the resolution of the air quality problem in Africa, but the study focuses solely on Rwanda. The BC time series suggest local episodic experiences, but no case studies of highly polluted days are presented. The ozone diurnal at a remote site is drastically different than at urban sites, but the mechanisms for these differences are not explained. In addition, it is difficult for a mountain site to inform on the air quality in Kigali and even more so on mitigation efforts within Rwanda.

The authors conclude that local reduction in emissions would improve air quality in Rwanda, yet their measurements suggests that the majority of high BC and CO concentrations observed at RCO are regionally impacted. Therefore, the mitigation strategies proposed by the authors wouldn't be so effective in my opinion. Can recommendations for air quality improvement on a regional scale be made based on the presented data?

Can the authors show a high pollution period with high frequency data to further support the importance and relevance of high-frequency measurements? A case study with the presented data would be valuable. From what I can see from Figure 9 - an interestingly high BC episode in Aug-Sept 2016 would be worth investigating.

Why don't the authors show CH4 and N2O data? Will it be part of a follow-up publication?

Correlation plots are missing to investigate co-transported pollutants at RCO. When and how often is RCO within the boundary layer compared to in the free troposphere?

C2

An interesting study could involve measuring pollutants in Kigali and correlating them to air mass age once they reach RCO. Similar case study work has been done by (Gao et al., 2017; Zhang et al., 2015) of which, Zhang et al 2015 the authors already cite (line 433).

Higher ozone precursors do not necessarily lead to higher ozone. (erroneous conclusion lines 615-624). Ozone production is not linear. Please familiarize yourselves with ozone chemistry. (examples of review references: Baier et al., 2015; Geddes et al., 2009; Monks et al., 2015)

Finally, to further improve the manuscript, I recommend that the authors thoroughly revise their manuscript to present the information more precisely and concisely. In particular, the authors should focus on revising the syntax of their sentences. A rule of thumb I can recommend: if the sentence does not add new information, delete it. I address these issues further in my specific comments.

Reviewer specific comments:

Title:

Much of the manuscript focuses on back trajectories and I think it might be valuable to include that aspect in the title. I would also encourage the authors to specify which "air pollutants and short-lived climate forcers" they studied. Why not simply write O3 and BC? Also, there is no discussion on climatic impacts in the study.

Abstract:

Line 15: The statement "air pollution is largely understudied in sub-Saharan Africa" should be supported. Why is it understudied? Because there is a lack of knowledge and expertise? A lack of funds? A lack of interest? Be specific.

Line 23: 20% of what? Of the population?

Lines 26-27: unclear that Rwanda has 4 seasons in one year (or that the two seasons

represent the time since the beginning of the measurements).

Line 37: name examples of major East African capital cities

It is unclear within the abstract what are the major findings of the study. The authors should include quantitative data in their abstract.

Introduction:

In general, the introduction is ineffective. It is too long and too broad. The introduction could be more effective by focusing on Rwanda's air quality rather than on Africa's air quality. The introduction begins on page 3, and the first time Rwanda is mentioned is on page 6. I recommend that the authors revise those three pages on African air quality into one short paragraph of 5-6 sentences. Furthermore, I recommend introducing the AGAGE network much sooner in the introduction and mention the network in the abstract since it is the first network station in Africa!

Line 50: I would disagree that little scientific research has been performed on air quality in Africa, unless it is in comparison with the Europe and North America (which would need to be specified). I would argue that important work on air quality in Africa has been done since the 80s. (See (Stevens, 1987) as an example) Perhaps it would be more effective for the authors to identify gaps in knowledge, rather than downplaying the existing research.

Lines 55-56: more recent references can also be included here.

Line 72: the authors say "past studies" but only reference one single study.

Lines 83-85: add SAFARI campaigns (Otter et al., 2002; Swap et al., 2002b, 2002a) and Cape Point GAW station (Brunke and Scheel, 1998)

Lines 98-101: the authors argue that long-term high-frequency measurements are important and needed, but this study focuses on monthly averages. Did the authors consider showing a case study with high frequency episodes?

Lines 112-114: do the authors mean in comparison to Nairobi?

Lines 120-121: add reference

Lines 127-131: add reference

Lines 134-137: unclear. What is meant here?

Lines 144-146: missing reference

Line 161: is the goal of the study really to understand air pollution in all of Africa? I recommend revising for a Rwandan context.

Methods:

Section 2.1: As a reader, I would be interested in knowing at the beginning of this section why RCO was chosen as the location for the AGAGE network. Was the intention to capture regional air pollution (as mentioned in the last sentence)? To sample free tropospheric air masses?

Line 190: what checks are in place at the station to ensure the diesel generator exhaust fumes are not sampled?

Table 1: additional columns could include minimum and maximum concentrations observed by each instrument, calibration frequencies, LODs, etc.

I recommend that the authors add a data processing section in their methods. How did they quality control the data?

Results and Discussion:

Figure 2: why is temperature constant at the beginning of the measurement period? Appears that data quality control is incomplete for temperature and CO trace (dotted lines between gaps in data). Are the lighter colour traces averages, running averages, extrapolations? Specify.

Figure 3: Why did the authors choose to use normalized values. Wouldn't absolute

values be more meaningful to highlight and air quality problem? The authors must be consistent in their graphing - each graph has different types of error representations. Choose one and use throughout each panel.

Figure 4: include a graph for RCO to effectively compare the three sites. Explain why data is incomplete for Uganda. Elaborate on the significant different in BC concentrations in DJF between Kampala, Addis and RCO. Nonetheless, comparing two urban sites with RCO is not so meaningful since they are affected by local sources to highly different extents.

Line 268: the authors could add the WHO's lines to their plots as a graphic reference point.

Lines 278-282: I believe the authors are suggesting that local air pollution is more problematic than regional air pollution? However, their data for RCO suggests the opposite, that in fact regional air pollution elevates the background level to such high concentrations that addition cooking fires do not make a significant contribution to concentrations measured at RCO. This result might be difficult and problematic for mitigating air pollution in Rwanda.

Figure 5: MODIS data should not be presented in the rainbow color scale. I recommend using a two colour bar so that it is clearer whether the FRP is low or high (like the blue-red color bar). The excellent match between FRP and BC concentrations is highly significant and should be further discussed in the paper. This comparison is striking! In the caption - do not use short/long to describe the different seasons. They are all of the same length - 3 months.

Figure 6: I have issues with the meaning of this figure. The comparison is problematic. Rwanda's bar is from RCO, a regional site whereas the comparison to other countries is an average of a number of sites throughout countries. This figure is unfortunately meaningless. BC data could be compared to other background and mountain sites - not between countries. Furthermore, if the authors want to highlight a pollution prob-

lem, then a better approach could include highlighting maximum daily pollutant levels (and/or exceedances) instead of averages.

Figure 7: be consistent with panel readings (top to bottom) when Figure 2 is bottom up.

Figure 8: Diurnal profiles are clearly not influenced by local emissions. Traffic peaks are not observed in the morning, nor in the evening. A discussion on boundary layer breakup is missing from the discussion. Also, I have never heard of a nocturnal boundary layer collapsing in the evening (lines 430-432); this explanation is wrong.

Figure 9: Why are running averages shown? What additional information to they provide? Discuss.

Lines 476-482: show graphically, like in a pie chart. However, how important is this Rwandan information if pollution at RCO is regional?

Lines 489-491: same issue as above - RCO measures regional air and so source apportionment would need to include surrounding countries' contributions.

Lines 569-578: show graphically

Line 588: rainout is hypothesized as having an impact on the BC:CO ratio. The authors show precipitation data in Figure 9. They therefore have the information to investigate this effect accurately.

Reviewer technical corrections:

There are important changes that the authors can make to improve the quality of the writing and thus the efficiency of their communication. I would like to point out the following grammar and syntax recurring issues in the manuscript:

1. The word "this" should be followed by a noun. "Despite this," and "This is" is incorrect syntax (ex. Line 50, line 111, line 278 and more).

2. When enumerating a list, all listed items must be the same type of word. Either all nouns, all verbs, etc.

a. ex line 59: "are known to increase aerosol and O3 conc and to transport aerosol…"

b. lines 105-106: "to increase…. And to improve.

c. Lines 127-129 rewrite the listed items so they can be correctly enumerated

d. Lines 175-179: revise syntax

3. Sentences longer than 2-3 lines of text need to be revised for syntax and conciseness.

Specifically: Line 54: replace "certain" with "dry"

Lines 56-61: syntax error - split into two sentences. (see point #2)

Line 59: rephrase because aerosol fire tracers are molecular

Lines 68-72: syntax error - rephrase

Lines 158-159: unnecessary sentence; this message is continually repeated.

Line 223: specify "regular"

Lines 232-236: Move whole paragraph to the caption of the figures.

Line 238: delete "it has been known for some time that"

Additional references:

Baier, B. C., Brune, W. H., Lefer, B. L., Miller, D. O. and Martins, D. K.: Direct ozone production rate measurements and their use in assessing ozone source and receptor regions for Houston in 2013, Atmos. Environ., 114(Journal Article), 83-91, doi:10.1016/j.atmosenv.2015.05.033, 2015.

Brunke, E.-G. and Scheel, H. E.: Surface Ozone Measurements at Cape Point, in At-

mospheric Ozone: Proceedings of the XVIII Quadrennial Ozone Symposium L'Aquila, Italy, 12-21 September 1996, edited by R. D. Bojkov and G. Visconti, p. 7, Parco Scientifico e Tecnologici d'Abruzzo., 1998.

Gao, J., Zhu, B., Xiao, H., Kang, H., Hou, X., Yin, Y., Zhang, L. and Miao, Q.: Diurnal variations and source apportionment of ozone at the summit of Mount Huang, a rural site in Eastern China, Environ. Pollut., 222, 513-522, doi:10.1016/j.envpol.2016.11.031, 2017.

Geddes, J. A., Murphy, J. G. and Wang, D. K.: Long term changes in nitrogen oxides and volatile organic compounds in Toronto and the challenges facing local ozone control, Atmos. Environ., 43(21), 3407-3415, doi:10.1016/j.atmosenv.2009.03.053, 2009.

Monks, P. S., Archibald, A. T., Colette, A., Cooper, O., Coyle, M., Derwent, R., Fowler, D., Granier, C., Law, K. S., Mills, G. E., Stevenson, D. S., Tarasova, O., Thouret, V., von Schneidemesser, E., Sommariva, R., Wild, O. and Williams, M. L.: Tropospheric ozone and its precursors from the urban to the global scale from air quality to short-lived climate forcer, Atmos Chem Phys, 15(15), 8889-8973, doi:10.5194/acp-15-8889-2015, 2015.

Otter, L. B., Scholes, R. J., Dowty, P., Privette, J., Caylor, K., Ringrose, S., Mukelabai, M., Frost, P., Hanan, N., Totolo, O. and Veenendaal, E. M.: The Southern African Regional Science Initiative (SAFARI 2000)âĂŕ: wet season campaigns, South Afr. J. Sci., 98(3-4), 131-137, 2002.

Stevens, C. S.: Ozone formation in the greater Johannesburg region, Atmospheric Environ. 1967, 21(3), 523-530, doi:10.1016/0004-6981(87)90035-7, 1987.

Swap, R. J., Annegarn, H. J. and Otter, L.: Southern African Regional Science Initiative (SAFARI 2000)âĂŕ: summary of science plan, South Afr. J. Sci., 98(3-4), 119-124, 2002a.

Swap, R. J., Annegarn, H. J., Suttles, J. T., Haywood, J., Helmlinger, M. C., Hely, C.,

Hobbs, P. V., Holben, B. N., Ji, J., King, M. D., Landmann, T., Maenhaut, W., Otter, L., Pak, B., Piketh, S. J., Platnick, S., Privette, J., Roy, D., Thompson, A. M., Ward, D. and Yokelson, R.: The Southern African Regional Science Initiative (SAFARI 2000)âĂŕ: overview of the dry season field campaign, South Afr. J. Sci., 98(3-4), 125-130, 2002b.

Zhang, L., Jin, L., Zhao, T., Yin, Y., Zhu, B., Shan, Y., Guo, X., Tan, C., Gao, J. and Wang, H.: Diurnal variation of surface ozone in mountainous areas: Case study of Mt. Huang, East China, Sci. Total Environ., 538, 583-590, doi:10.1016/j.scitotenv.2015.08.096, 2015.

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2018-100, 2018.