

Interactive comment on “Measurement report: Fireworks impacts on air quality in Metro Manila, Philippines during the 2019 New Year revelry” by Genevieve Rose Lorenzo et al.

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Response: We thank the two reviewers for thoughtful suggestions and constructive criticism that have helped us improve our manuscript. Below we provide responses to reviewer concerns and suggestions in blue font. All changes to the manuscript can be identified in the version submitted using Track Changes.

Anonymous Referee #2 Received and published: 2 December 2020

Statement: This article investigates firework pollution during the 2019 New Year celebrations in Manila, Philippines. It takes a comprehensive approach of investigating

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the emissions and aftermath of the fireworks from a number of angles, including atmospheric composition, meteorological conditions, transport, and growth/decay of particles. It also investigates changes to atmospheric properties as a result of New Year celebrations. There are several measurements taken during this observation period that are unique to this study.

The authors provide an analysis of pollutants, including particulate matter, metals, and toxins. Further, the article includes particle mode analysis. Concentrations of many pollutants, metals and toxins increased dramatically during the celebrations. Some of these dispersed within a few minutes whereas others stayed longer. Some of the observed compounds decreased during the New Year, which is either attributed to interactions with firework emissions or is attributed to the decrease of normal-day human activity, such as traffic. The study also shows that the chemical behavior of the atmosphere, e.g. particle hygroscopicity, can be altered by firework emissions. Some of the content, especially in the Results and Discussion section, is rather choppy and needs to be restructured. There are numerous comparisons with other cities without much context explained. Some of the content in the Results and Discussion should be moved to the Introduction or Methods sections, noted in the specific comments below.

The results and conclusions of the article include a blend of scientific and detailed technical observations. Consequently, this feels like it is somewhere in between ACP and ACP Measurement Reports. I would suggest revisions to either make the paper more scientific in nature to submit to ACP, or focus on the new and unique measurements and keep it in ACP Measurement Reports. Should the authors decide to keep the article in ACP Measurement Reports with revisions, I would gladly re-review the article.

Response: Thank you for the thoughtful feedback. We have kept the paper as a Measurement Report and made the necessary revisions to address both reviewer comments, and hope this version is viewed as improved by this reviewer.

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Major comments: The article feels a bit choppy. It jumps from one subject or result to another without necessarily any coherent transition. A few examples are noted in “Specific comments” below. With some revisions to connect different points together, I think this article would flow much better.

The abstract states, “there have not been any comprehensive physicochemical and optical measurements of fireworks and their associated impacts in a Southeast Asia megacity.” A similar statement is made in the Introduction. This statement seems a bit bold and also vague and contradictory to the fact that several other studies of firework celebrations in China and India are cited. Perhaps the authors don’t consider China and India to be Southeast Asia, but regardless, this statement needs to be more clear. For example, which measurements have never been done before, and which are new in this study and not in the other cited studies? Is this the first study of its kind in the Philippines?

Response: Thank you for this comment. Yes, China (East Asia) and India (South Asia) are not part of South East Asia (Cambodia, Laos, Myanmar (Burma), Peninsular Malaysia, Thailand, Vietnam, Brunei, East Malaysia, East Timor, Indonesia, Philippines, Singapore, and small part of India). We add text to clarify studies in Southeast Asia (SEA) are limited (this is the first to our knowledge for the Philippines in the peer-reviewed literature) and that India and China are not considered part of SEA: “Studies on the properties of aerosols in general in South East Asia (Tsay et al., 2013) which is one of the rapidly developing regions in Asia are limited. This compounds the challenge to understand the interactions between aerosols and the complex hydro-meteorological and geological environment in South East Asia (Reid et al., 2013). Increased local and transported emissions (Hopke et al., 2008; Oanh et al., 2006) in South East Asia adds to the complexity and affects air quality in the region. Firework emissions are an example of extreme and regular local emissions in South East Asia. And even while several studies exist in the neighboring regions of East Asia and South Asia, there currently is no in-depth analysis of the chemical, physical, and optical properties of firework

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emissions in a South East Asian megacity where fireworks are culturally significant. Studies on the impacts on health and the general environment due to firework emissions in South East Asia are as scarce.” We also clarify what is unique about our study in terms of our technical approach. We specifically use a wide blend of datasets which are not commonly used altogether to study fireworks, including size-resolved aerosol measurements (e.g.. ionic/elemental composition, morphology), HSRL-2, PM2.5 and meteorology). The following text was added: “And even while several studies exist in the neighboring regions of East Asia and South Asia, there currently is no in-depth analysis of the chemical, physical, and optical properties of firework emissions in a South East Asian megacity where fireworks are culturally significant. This study is novel because it includes, for the first time aerosol data during fireworks, including size-resolved measurements (e.g. ionic/elemental composition, morphology), HSRL-2, PM2.5 and meteorology.”

There are many measurements and results here, and not all of them are linked or compared to each other. This contributes to the choppiness of the paper, and there could be more description of how the different observations and results relate to each other.

Response: We try to reduce the so-called choppiness by adding more transition statements between the different types of analyses we present. We also try to harmonize the results and observations better, especially in the conclusions. Here are examples of transition sentences we have now in the draft:

“We begin with hourly PM2.5 mass concentration results for the study period to provide context for the spatio-temporal characteristics of fine particulates due to fireworks, their interaction with meteorology, and effects on aerosol optical properties.”

“One factor impacting surface PM concentrations is the vertical structure of the lower troposphere, which is addressed in the next section based on HSRL data.”

“Building on the previous results describing the general environmental conditions dur-

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ing the study period, now we focus on the detailed size-resolved measurements. ”

“Here we more closely examine how much concentrations of species changed during the firework event. ”

The conclusion mostly reiterates the results in bullet point form. This needs to be more concise, with only key findings pointed out. Then the conclusion needs to include more relevance to the aerosol measurement science and/or the greater scientific community and public.

Response: We revised conclusions and it has fewer bullets. We tried to make it more concise with only the most important findings. We also tried to emphasize its relevance to broader themes.

This article was submitted to ACP Measurement Reports. In general, there is alignment with the aims of this journal in terms of measurements of various compounds in Manila, which is a new location for such study. This study also contributes new types of measurements. However, the questions in lines 149-155 are more broadly scientific in nature, and the results and conclusions package these results into a more scientific format, similar to other studies on the effects of firework pollution. At the same time, the scientific conclusions are minimal, and focus is very local and not focused on the bigger scientific aims of ACP. In its current form, the content and nature of this article feels somewhere in between ACP and ACP Measurement Reports and not focused on one or the other.

From the website of ACP Measurement Reports: Measurement reports present substantial new results from measurements of atmospheric properties and processes from field and laboratory experiments. Analysis of the measurements may include model results and conclusions of more limited scope than in research articles.

Although this study might be the first of its kind in the Philippines, the results are expected and not necessarily new with respect to the many existing publications related

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to air pollution from firework celebrations. The article needs more emphasis on the aspects of the study that can be considered as “substantial new results.”

Therefore, I would suggest the paper be revised as one of the following:

• Revise the overall nature of the paper to focus more on the scientific and societal contribution of the study, and then submit the paper to the main ACP journal. In particular, include more in-depth scientific answers to the scientific questions asked in lines 149-155.

Additionally, scientific results could, for example, include: How do the results of this study help scientists, policymakers and the general public in not just the Philippines but around the world, and how can these results be used to improve air quality during the New Year in the future?

• Revise to focus more on the aerosol technology, specifically the measurements that are new and unique. There also needs to be more elaboration to how this contributes to the aerosol measurement community. With such revision, this would better align with the aims of ACP Measurement Reports.

Response: We respond to the string of suggestions above all at once here because the string relates to the same theme of whether this paper is a Measurement Report or not. We originally intended for it to be a Measurement Report and still stand by this idea with the submitted draft. We break down each of the 2 sentences from the ACP website about what a Measurement Report is and we justify why our previous version and the revised version fit into this category:

“Measurement reports present substantial new results from measurements of atmospheric properties and processes from field and laboratory experiments.”: We indeed present new and valuable data and results about atmospheric properties from field measurements. There should be no question about this hopefully.

“Analysis of the measurements may include model results and conclusions of more lim-

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ited scope than in research articles.”: We analyze the measurement data and present results and conclusions. They may arguably be more limited in scope than research articles because they may be mostly specific to the Philippines region. But again, the limitation of this study having been done in one site is why we originally even considered that this would eventually be placed into a Measurement Report category. We don't feel (like the reviewer said) that we need especially high focus on “aerosol technology” as we aren't focused on a methods/instrument paper (otherwise that would be a AMT submission). If we put in too much discussion and comparisons with other regions, we do not feel that hurts the paper but instead makes it stronger, especially for a Measurement Report type of paper.

As an example of what could be revised, the article throws in comparisons with various other cities around the world in with the results/discussion. This shows promise for good scientific content. In its current form, however, these comparisons cause the article to feel choppy. What is the relevance of these comparisons? What do these comparisons to other cities contribute to either aerosol technology and/or to the general scientific community and public? These comparisons could be elaborated and made more scientific.

Response: We have addressed these by moving some of the comparisons to the Introduction for better flow and background information before getting into the results. Examples of the text now are as follows:

“In Nanning, China, SO₄²⁻ peaked at 0.62 μm during fireworks (Li et al., 2017). The mass diameter of K⁺ was 0.7 μm due to firework emissions after transport in Washington State (Perry, 1999).” This sentence was moved from the discussion of results and now appears in the introduction section in the paragraph on size distributions.

“Inorganic salts (K₂SO₄, KCl) dominated the aerosol hygroscopicity in Xi'an, China during fireworks (Wu et al., 2018). In the Netherlands, enhancements in salt mixtures containing SO₄²⁻, Cl⁻, Mg²⁺, and K⁺ were noted to enhance hygroscopicity (ten Brink

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et al., 2018).” This sentence was also removed from the discussion of the results and moved to the introduction section on composition.

One thing that really stood out to me is the toxins, especially lead. This brings to mind a hypothetical question: Could it be possible to use this study to make an argument to policymakers to forbid the use of these toxins or find alternatives to these toxins in fireworks? Although such recommendation might be outside the scope of this specific Measurement Report, elaboration on the seriousness of lead and other toxins in fireworks, which were clearly observed in Manila, could be emphasized more – this could make the paper into a stronger contribution to the scientific community and general public, and it could make the conclusions much stronger.

Response: Excellent suggestion, thank you. We have included a phrase on the hazardous effect of Pb to health in the conclusion. We also add mention to a very recently published paper on lead in the Metro Manila region (Gonzalez et al., 2021). Here is our added text:

“The presence of Pb in the firework emissions exacerbates the presence of submicrometer Pb in Metro Manila (Gonzalez et al., 2021).”

I would also suggest making a timeseries figure with these metals and toxins, not just a before/during/after figure.

Response: This is currently not possible because we only have three data points in time (accumulated sample of 2 days for before, during and after) for each metal and toxin. We hope we understood what you meant. Had we obtained more data at better than 2 day time resolution, this would have been an excellent addition.

Specific comments: Title: The plural of “Fireworks” plus the second noun “impacts” is not correct English. It should say any of the following: “Firework impacts” or “Impacts of fireworks” or possessive “Fireworks’ impacts”.

Response: Thank you, we removed the “s” tailing Firework. Now the title reads...

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“Firework impacts” . . .

Lines 54-59: Listing these specific numbers from cities around the world is not necessary, and giving these numbers does not add any significance to the article. The two sentences following this are sufficient for this paragraph.

Response: We removed the specific numbers from the text but kept the list of cities and then combined that with the following sentence:

“Total PM mass concentrations during local celebrations in different cities: Leipzig, Germany, (Wehner et al., 2000), Texas, United States [U.S.], (Karnaev, 2005), Montreal, Canada (Joly et al., 2010), and New Delhi, India, (Mönkkönen et al., 2004) exceeded the 24 h U.S. National Ambient Air Quality Standard (NAAQS) for PM₁₀ of 150 $\mu\text{g m}^{-3}$.”

Line 64: “India where” should be “India, and”

Response: We replaced to “India, and” . . .

Lines 161-163: This sentence doesn’t make sense, and it is irrelevant to the article. This topic is not discussed anywhere in the article.

Response: Ok, we deleted that sentence.

Lines 207-214: The sentence beginning with “Although” through the sentence ending with “study” do not belong in this paragraph. This is introductory material, not methods.

Response: We needed to include that sentence because locally there is also firework activity on December 24 which is included in the date of the background sample (before) used for the New Year firework sampling (December 31 to January 2). We included the dates for the before, after, and during samples in the sentence before for context.

Line 211: The sentence, “There was limited firework after midnight” needs to be more specific and clear – what does “limited” mean, and with respect to what, specifically?

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Response: We changed the preceding sentence:

“Firework activity around the sampling site began around ~19:00 on December 31, 2018, peaked at 00:00 of 1 January 2019, and dropped drastically after. Based on PM_{2.5} data there was no evidence of sustained firework activity past midnight.”

Section 2.7 “Back Trajectories” should be moved to after section 2.2 “Meteorological Data” for better flow of related content and to be consistent with the order in which results are presented.

Response: Thank you for this note, we reordered the section and moved Back Trajectories to section 2.3 and reordered the sections that came after. We also edited in-line text that may have been affected by this reordering.

Line 293-295: This first sentence should be in the introduction or methods section, not results.

Response: Thank you for this, we deleted this first sentence in the results and added the following to the first sentence of the Methods section “the evolution of and the”:

“Hourly PM_{2.5} mass concentrations were obtained to assess the evolution of and the temporal characteristics of fine particulates due to fireworks and their relation to meteorology and aerosol optical properties.”

Lines 325-329: The last two sentences in this paragraph jump back to talking about fireworks in other countries, which was already stated in the introduction and are now redundant. These two sentences could be deleted. Alternatively, if the intention is to make a scientific comparison of Manila in 2019 to other cities, then this needs to be elaborated, and the comparison needs to be done in more scientific detail.

Response: The last two sentences were revised. The first sentence was revised to emphasize that the results are comparable to past studies, and that greater increases (second sentence) have been observed where there were more firework activity in general (Chinese New Year, more intense and prolonged, lasting several days)). The

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edited two sentences follow:

“Two to three-fold increases in PM mass concentration due to fireworks has also been observed in previous work in other countries (Rao et al., 2012; Ravindra et al., 2003; Tsai et al., 2011; Shen et al., 2009). Greater increases (> 5 times) in particulate mass concentrations elsewhere were related to more intense and prolonged “(lasting several days)” firework activity (Tian et al., 2014)”

Lines 330-332: This first sentence was already stated in the methods sections and is redundant here.

Response: We removed this first sentence from the results and added the following to the methods section for context: “To ascertain the impact of fireworks on the surface particulate concentrations, . . .”

Lines 353-358: Again, this is jumping back to methods. Only the last three sentences in this paragraph are the results.

Response: We moved these sentences to the methods section and edited appropriately. Here is what it looks like in the methods section:

“To verify the height values based on the vertical profiles of aerosol backscatter, the “surface-attached aerosol layer” height is estimated using the maximum variance method more commonly used for daytime convective boundary layer detection (Hooper and Eloranta, 1986). The height detection method is limited by the complexity of the firework event case due, however, to pertinent rain signals. The “surface attached aerosol layer” is derived from a 15-min moving window average based on the 30-s values.”

Lines 364-367: These first two sentences are also describing methods of calculation as opposed to results.

Response: We moved these sentences to the methods section (2.5 Aerosol Composition and Morphology Measurements).

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Lines 393-394: Again, this jumps back-and-forth from showing results to comparing to another city. If this kind of comparison is desired, then another sentence or two describing the relevance and greater context of this should be added. This should be in a separate paragraph rather than squeezed in the middle of a paragraph reporting numerical results.

Response: We were doing the comparison in order to suggest possible mechanisms for the slightly larger sulfate particle size during fireworks. The Li article makes a suggestion that it is because sulfate is formed secondarily during the fireworks and that particle aging contributes also to growth. We moved the information about the size to the introduction. Then we moved the other sentences in the noted line numbers to another paragraph after the discussion of K+ results.

Lines 404-405: This is another comparison to a different city that doesn't quite fit in between reporting numerical results from Manila.

Response: We moved the size info of the different city to the introduction.

Lines 429-433: Here is another comparison to a different location, this time Taiwan. Here, though, the relevance is better explained, and it flows better than these comparisons in other places in the manuscript, but then the following sentence beginning with "The lack of increased sea salt" jumps back to results/discussion in Manila. I would suggest the comparison to Taiwan be moved to a separate paragraph.

Response: Thank you for this note, and for the appreciation. . . we moved the note on the Taiwan results to the introduction as there was only one sentence about this and would have been insufficient for another paragraph.

Lines 485-486: "Lead is highly toxic and thus regulated (Moreno et al., 2010) as its occurrence in fireworks is not ideal." – I would say it's more than just "not ideal;" it sounds like a serious health hazard to me.

Response: We have changed the wording to "serious health hazard"

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Lines 570-573: This is again a place where the text jumps into comparisons with specific other cities. The relevance and context needs to be elaborated a bit more. Figure 3: Why does this figure use UTC when the other figures use local time? Then there is unnecessary text in the middle of (a) stating that 16UTC is midnight local time. I would suggest using local time because the study is with respect to the New Year (centered around 00:00) and to be consistent with other figures.

Response: Thank you, we moved the note on the different countries to the introduction. We changed the time units to local time instead of UTC for Figure 3.

Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2020-1028>, 2020.

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