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Atmospheric Chemistry and Physics Discussions

Interactive comment on "New particle formation, growth and shrinkage at a rural background site in western Saudi Arabia" *by* Simo Hakala et al.

Anonymous Referee #1

Received and published: 16 March 2019

Summary: This paper presents long-term measurements (Nov. 2012 – Feb. 2015) of particle number-size distributions (PNSDs) from a rural background site in western Saudi Arabia. Authors used a twin DMPS to measure PNSDs in the size range from 7 to 850 nm and Vaisala WXT sensors to measure meteorological parameters relevant to new particle formation (NPF). Atmospheric NPF, growth, and shrinkage are not new findings and have been reported by several other investigators around the globe (e.g. Young et al. Yao et al., and so on. . .). Authors have discussed almost all these studies. But, this paper offers an important addition to the global aerosol dataset from a site, which has not been studied in the past and therefore, such long-term studies of aerosol measurements should be encouraged. I recommend this paper for publication in ACP only after authors have satisfactorily addressed both major and minor concerns below.

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General comments: Page 3 and 11: Authors discuss by and large two mechanisms for aerosol shrinkage. First, the evaporation of semi-volatile organic vapours under favourable environmental condition. Second, transported smaller size particles to the measurement site. But authors fail to demonstrate either of the mechanism and said that "cause of the decreasing mode diameter (DMD) events observed in Hada Al Sham is further investigated in a future study". Authors came up with the new term "decreasing mode diameter" to explain aerosol shrinkage but did not reveal the cause. I strongly suggest NOT floating new terms in the literature without clearly demonstrating it. In fact, authors could look at coagulation sink, if the smaller particles are really being transported to measurement site (obviously not too far away from the site, is there any primary source of these small particles in the vicinity of the site?). If the smaller particles are being advected to the site during shrinkage then I would probably expect high coagulation sink during shrinkage than growth. The simple ratio of Aitken to accumulation particles during growth and shrinkage event may be useful to demonstrate it. Further Authors could also calculate shrinkage rate, similar to growth rate, this would help future investigators for comparison.

Page 7, Line 26: Authors state that "undefined days showed some features representative of NPF events but these features were not clear enough for the days to be classified as NPF days". I suggest referring to Buenrostro Mazon, S., et al., (2009) for classifying undefined events and classify undefined days according to Buenrostro Mazon, S., et al. approach.

DMD events are more frequent during the summer, possibly suggests the contribution of evaporation of semi-volatile compounds to the diameter shrinkage, but it needs to be investigated. E.g. Page 11, line 1-5.

Other comments: Page 1, Line 27: You meant to say "large number concentration of primary particles" not "large size primary particles". Remove "large".

Page 1, Line 29: Authors state that "the NPF events in Hada Al Sham are exceptionally

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frequent and strong" but authors did not quantify how strong NPF events are? You may want to refer to Stanier et al., 2004 for classifying NPF events into strong, moderate and weak events based on the net increase of N25 during the first few hours of the event.

Page 2, Line 9: Please give the range for

Page 2, Line 10: Several studies highlight the importance of NPF in heavily polluted megacities around the world, especially developing nations. Authors should consider citing them here. A few of them are; Stanier et al., 2004, Kanawade et al., 2014, Yue et al., 2009, Xiao et a., 2015, Iida et al., 2008, Yu et al., 2017 and so on. . .

Page 2, Line 30: Please could you specifically state the importance of long-term measurements.. e.g. to reduce uncertainties in aerosol nucleation rates which are currently a few orders of magnitude in global models, CCN estimation from NPF in the boundary layer or troposphere which also show large range.

Page 3 Line 29-30: How far each emission source and in which direction from the measurement site? What is the elevation of the site above mean sea level?

I would suggest replacing "NPF start" by "NPF event start" everywhere so that "NPF end" refers to the time when aerosol nucleation process ceases and not the entire NPF event. In that case, figure 2 legend should be "NPF+DMD", "NPF event", "Undefined event" and "Non-event" and elsewhere in the text and figures (fig. 6 and so on).

Are aerosol number-size distributions measurements are corrected for diffusional losses in the sampling line or diffusion dryer? What are the dimensions of the diffusion dryer? I assume the smaller particle losses are not more than 5-10

Figure 1: As a reader, I find difficult to follow this figure. Why do you cite Hussein et al., 2005 in the figure caption? If you have used GR calculation methodology based on Hussein et al., 2005 then please discuss it in the methods section (which you have!). What are "three" different black dots, one obviously mode diameter, the bottom one,

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what is middle and the top which is very sparse? It would also help the reader if you could use nanometer for y-axis. Figure legend says black dots as mode fit, I think, its mode diameter; the black line is the mode fit. I also suggest describing vertical lines in the figure caption than showing in legend. I can not figure out “NPF event” end time visually, though can see “NPF” end time. It would help if you could over-plot let’s say N<25nm (there is hardly any primary source of particles less than this size unless we measure next to the source e.g. vehicle exhaust). Page 7, Line 29: Authors state that “no clear seasonal pattern is observed in NPF frequency”- could it be that 5 months data is available only for one year whereas the remaining months data is available for 2 or more years (e.g. Feb. 70 days versus June 26 days). This can be ensured by selecting a year during which all months data is available. I would be interested to see figure 2 for the year during which all months data available.

Figure 4: Since authors sub-divided NPF event days into DMD and non-DMD events, I suggest to include air mass distribution maps for DMD and non-DMD events?

Authors report growth rates in the diameter range of 7 to 12 nm (7.4 nm h-1). How many bins do you have in this size range? From the figure, I can see that the fit line reaching upto 40 nm or may be more so that the reported GR are not actually GR of particles in the size range from 7-12 nm? Please clarify or correct.

I would suggest over-plotting particle mode diameter (thin black line) in Figure A1. There are some data gaps as you mentioned in the text which is not visible on this figure.

I have not checked the paper for linguistic/typo errors so I suggest authors to take off those carefully if any.

References Buenrostro Mazon, S., et al., 2009. Classifying previously undefined days from eleven years of aerosol-particle-size distribution data from the SMEAR II station, Hyytiala, Finland. Atmos. Chem. Phys. 9, 667-676.

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Yue, D. et al., 2009. Characteristics of aerosol size distributions and new particle formation in the summer in Beijing. J. Geophys. Res. 114, D00G12.

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Iida K et al., Estimating nanoparticle growth rates from size-dependent charged fractions: analysis of new particle formation events in Mexico City J. Geophys. Res. 113D05207

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