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Comment on acp-2020-1307

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Referee comment on "Opinion: Gigacity – a source of problems or the new way to sustainable development" by Markku Kulmala et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-1307-RC1, 2021

Kulmala and co-authors provide a fascinating insight into the consequences of the huge concentration of population living in eastern China. The demographic statistics are remarkable: 10% of the world's population living in a 1Mkm^2 area of eastern China, and more than 50% of global population concentrated in an area of South-east Asia covering only a small proportion of the global landmass. The paper makes a strong case that the "gigacity" in eastern China greatly affects local weather patterns and may influence global climate through the Asian monsoon. Such influences appear inevitable, and a strong case is made for further research.

In formulating such a research programme many factors need to be considered. While urban Beijing is clearly very densely populated, travelling only a few kilometres beyond the boundaries of the city reveals open countryside with evidently low population density. The extent to which this rural hinterland moderates the impact of the built-up areas upon the weather and climate is a key question, as is the consequence of further development of this rural space, which will surely fill gradually if population expands further.

The paper shows the impact of haze pollution on mixing heights and explains how this serves to exacerbate ground-level pollution by reducing vertical mixing. It appears to imply that the haze is an inevitable consequence of the gigacity, a point on which my opinion would differ. An analysis of urban/rural gradients in pollutant concentrations in Beijing (Harrison et al., 2021) demonstrates that for many pollutants, the high concentrations are a regional phenomenon and little influenced by emissions within Beijing itself. However, this is not the case for all pollutants, and most notably for nitrogen dioxide which shows marked urban and roadside increments above the rural concentrations. This demonstrates that local measures can improve air quality for some pollutants. Additionally, a careful analysis of air quality trends in Beijing which corrects for the influences of changing weather (Vu et al., 2019) shows the success of the 2013-2017 five-year pollution control plan in reducing all measured pollutants except ozone. This was achieved largely by enhanced controls on road traffic and domestic combustion, but much can still be done to reduce emissions from rural biomass burning (Wu et al., 2020) and from industry, thereby reducing concentrations of long-lived primary pollutants such as carbon monoxide, and secondary particles formed from

emissions of SO_2, NO_x and VOC. Such measures, by reducing the haze phenomenon, will increase mixing depths and have huge benefits for air quality. The haze is not unique to China (consider Delhi which has a worse haze problem than Beijing), and nor is it an inevitable consequence of the gigacity, although such extensive urbanisation and industrialisation makes the control challenge inevitably greater.

Another point to consider is the point at which population size and density creates an entity which has properties similar to those of Eastern China. Although the population is far lower, the north-eastern United States (referred to as the BosWash megalopolis, with a population of over 50M), and western Europe (197M population) show a degree of connectivity in which air pollution phenomena cannot be solved by one municipality, or in Europe, one country acting alone. There is inevitably a continuum of urbanised land masses ranging from individual major megacities to the Chinese gigacity, and research

needs to study the impacts of population size and density, and geographic extent upon weather, climate and air quality in the wider context of impacts upon human health and ecosystems.

References

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