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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observation of new particle formation in subtropical urban environment" *by* H. C. Cheung et al.

Anonymous Referee #2

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1. General Comments This article analyzes a data set of particle size distribution measured in an urban environment in Brisbane (Australia). The article seems to be focused on studying the origin of ultrafine particle and the new particle formation processes. I have two major criticisms:

A. DATA DISCUSSION. Along the manuscript size distribution data are interpreted only in terms of emission sources, whereas attention is not paid to microphysical processes. In my opinion this may lead to wrong data interpretation. Some examples:

Example-1. Section 3.4.2, page 22635: "the plume was not directly emitted from the local vehicle emissions or ship emission from the Port of Brisbane, since the particles

from vehicle and ship emissions are in the range 20–130nm (Morawska et al., 2008) and 60–120nm (Sinha et al., 2003), respectively. However, the emissions of SO2 and VOCs from the industrial sources located at the coast could be possible precursors to the formation of new particles by nucleation process".

Comment: In my opinion, these observations to not allow discarding the role of ship emissions. Primary particles emitted by ships are 60–120nm size, however, the plume of ships are enriched in sulphur dioxide and it may result in new particle formation (photo-chemically induced nucleation) several kilometres downwind of ships. Thus, in my opinion both ships and industrial emissions in the shore may contribute to the new particle formation observed at QUT site during inland sea breeze blowing periods. In their description, authors have interpreted size distribution data by comparing with size distribution of primary particles in the source emissions. However, microphysical processes have not been taken into account.

Example-2. Section 3.1, page 22630: "During the period of UFP morning peak, Aitken mode particles also peaked, which implies that the particles measured during this period were emitted by diesel 10 and petrol engine emissions, which produce particles in the size range of about 20–130nm and 20–60 nm, respectively (Morawska et al., 2008)"

Comment: Solid particles emitted by diesel and petrol exhaust may occur within the range 20-130nm and 20-60nm. However, these emissions also result in the formation of new particles < 20 nm. This occurs during the dilution and cooling of the vehicle exhaust due to condensation of sulphur and organic vapours onto sulphur clusters. The formation of these particles < 20 nm is significantly influenced by the ambient air and dilution conditions (temperature, relative humidity and wind speed). In many most of cases these nucleation particles in the vehicle exhaust may dominate the UFP concentration (Charron and Harrison, 2003, Atmospheric Environment, 37, 4109–4119; Casati et al., 2007, Atmos. Environ., 41, 2125–2135; Burtscher, 2005; Journal of Aerosol Science, 36, 896–932; De Filippo and Maricq, 2008; Environ. Sci. Technol., 42, 7957–

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7962).

Example-3. Section 3.2.2, page 22631. Authors discuss how the concentration of Aitken particles changes with wind direction: “.....while the Aitken mode particles were emitted from both industrial and vehicle emission sources.....”.

Comment: Aitken particles show high concentrations under NE wind and under S-SW wind conditions. As said by author, NE direction is clearly linked to transport from shore by inland sea breeze. For S-SW direction, authors simply said they that are associated with industrial and vehicle emissions. In my opinion, Aitken particles coming from S-SW may be representative of the aerosol background, and would be a mixing of particles emitted by specific sources (vehicle exhaust and industry) and aged aerosol (smaller particles that have grown by coagulation and condensation processes). The correlation between aitken particles and relative humidity observed in Figure 5B suggests that atmospheric microphysical processes are involved in the formation of the aerosol background in the S-SW direction.

Example-4. Abstract says: “i) the nucleation burst with particle growth which was associated with the particle precursor emitted from local vehicle emission, ii) the nucleation burst without particle growth which was due to the transport of industrial emissions from the coast to Brisbane city, and iii) interplay between the above two cases which demonstrated the impact of the vehicle and industrial emissions on the variation of particle number concentration and its size distribution during the same day.”

In my opinion, the results of this study do not allow to get such conclusions. Did authors performed measurement of primary trace gases (NOx, SO2 and CO) for differentiating these sources?, they do not show such data in the article. Aerosol precursors are emitted by several sources (with different CO/SO2 and NOx/SO2 ratios), if particle growth occur or not (during or after the burst) depends on a number of environmental factors, e.g. type of species emitted, emission or formation rate of the gas phase precursor, temperature, etc..(not all them well understood nowadays; e.g. see Kulmala and Kermi-

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nen, 2008, Atmos. Res., 90, 132–150). If authors see that new particle formation typically occur in a given direction (e.g. NE) is probably because, in addition to gas phase emissions, environmental conditions favouring gas-to-particle conversion occur under the meteorological scenario resulting in such wind direction (e.g. high solar radiation conditions under the inland sea breeze blowing). Again, take into account atmospheric microphysical processes, not only the features of the particles directly emiited by the sources (see in Kulmala and Kerminen, 2008 how environmental conditions influence on nucleation and growth)

In summary, microphysical processes occurring in the ambient air after the emission should be taken into account when interpreting size distribution data (these are very well described by Raes et al., 2000; Atmos Env 34, 4215–4240). Currently, the size distribution of primary particles emitted by the source is being taken into account in the manuscript. I think this should be corrected in the manuscript.

B. CONCLUSIONS. What is the general conclusion of this study?. When reading the conclusions section it is not clear what are the new findings of the study. In my opinion, there are some interesting results here, but they are not properly highlighted. The results obtained in this study should be compared with those obtained in other cities located close to the shore (e.g. Fernandez-Camacho et al., 2010, included in the reference list, and references therein). In my opinion, the key finding of this and of the previous studies performed in cities located close to the shore is this:

"in coastal areas where aerosol precursors are emitted, new particle formation processes (photo-chemically induced nucleation) is favoured in the inland sea breeze"

I recommend to the authors to read carefully the paper of Fernandez-Camacho et al. (2010). That study was performed in Huelva city, in a context very similar to that of Brisbane (a refinery in the shore, ship emissions, river location, and transport of pollutants by sea breeze). The overall result comparison (including other papers cited therein) will allow getting a conceptual model for new particle formation in coastal areas

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where aerosol precursors are emitted.

2. Specific Comments

2.1 I suggest to change the term “traffic emissions or vehicle emission” by “vehicle exhaust emissions”

2.2 section 2.1. When authors describe the breeze blowing they do not cite the river. In general, inland breezes tend to be channelled along rivers. This is very important in the pollutants transport in the small and medium scale. The role of the river as a prompter of the NE wind inland blowing should be cited. It favours the transport of the aerosol precursors emitted in the shore (industrial + harbour + airport) to the QUT measurements site.

2.4 data processing. Authors say they use temperature (instead if radiation) as an indicator of the nucleation and photochemical activity. Temperature tends to increase under the sunny weather conditions that usually favour photochemical activity. In my opinion this has a drawback. Increases in temperature may hinder the transfer of matter from the gas phase to the aerosol phase (e.g. the condensation processes that result in the particle growth shown in Figure 8). An example, in Rodriguez et al. (Atmos Environ, 2005, 6734–6746) observed that nucleation events occurred during events of high solar radiation, low relative humidity and decreases in temperature.

2.5 Section 3.2.1. I suggest to add the daily evolution of wind speed (mean values for each hour) and wind direction (mode values for each hour) in the top of Figure 3. This will help to discuss the daily evolution of particles in Figure 3 and to illustrate the influence of breeze blowing in the daily evolution of UFP, i.e. emissions in the morning and new particle formation during the inland breeze blowing period.

2.6. Section 3.4. Some parts of the subsection may be shortened.

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