

Responses to Referee #1's Comments

Comment 1

I have found some missing references concerning new-particle formation in other urban areas located widespread in subtropical climate. For example, I have found that other (recent) studies reporting nucleation episodes in urban areas in coastal locations in Korea (see Lee et al., 2008), Beijing (Wu et al., 2008), near Shanghai (Gao et al., 2009), Spain (Pey et al., 2008 and 2009, Perez et al. 2010, even extracting specific photochemical PCA factors), in Los Angeles (Moore et al., 2007) etc. Thus I consider that the bibliographic research is not complete and it should be. The list of recent references included bellow may help you to discuss about the seasonal evolution of nucleation processes, the growth rates, the types of nucleation episodes observed in other urban areas and its origin, etc.

Response 1

The literature review concerning the urban studies has been revised and amended in the first paragraph of section 1.

Section 1, paragraph 1, lines 12-21

“These urban studies...on new particle formation” has been revised to “However, most of these studies focused on particle formation in rural settings and in colder climates, with very few studies conducted in urban environments, especially in the southern hemisphere (Kulmala et al., 2004). A limited number of studies were conducted in continental (e.g. Woo et al., 2001; Moore et al., 2007; Wu et al., 2008) and coastal (Rodríguez et al., 2008; Fernández-Camacho et al., 2010) urban areas. These studies examined the variation of particle number concentration in urban environments. The major influence on particle number concentration was vehicle exhaust emissions during the traffic peak hours (e.g. Pey et al., 2008; Pérez et al., 2010) and new particle formation by photochemical reactions (e.g. Pey et al., 2009), as well as the influence of power plant and industrial emissions from an area upwind from the urban site (Gao et al., 2009).”.

Comment 2

To study the formation of new particles in the atmosphere, in addition of the appropriate instrumentation for measuring the number and size distribution (it is adequate in this case), is necessary to have high-time resolution meteorological data, and preferably registered at the aerosol monitoring site. The authors use some meteorological parameters from a meteorological station located around 0.4 miles far from its site, but this meteorological station do not have solar radiation information. This lack of information conducts the authors to consider that the solar radiation and the temperature follow the same trend, which is true in some cases but not in many others. Nevertheless, it is known that photochemical nucleation

episodes are really dependent of the intensity of solar radiation (see for example Pey et al., 2008), and consequently it is necessary to monitor this parameter in addition to others such as wind direction and speed, temperature and relative humidity. I suppose that in Brisbane, a city with 2 million of inhabitants, there should be a number of meteorological stations even not belonging to the Queensland Bureau of Meteorology. See in this Figure the relation between solar radiation and temperature in a subtropical environment. It is clear that 35°C are reached under sunny and cloudy conditions. With a high probability, the photochemical activity was different in both cases.

Response 2

The solar radiation data has been updated with higher time resolution in the article. The corresponding discussions in relation to the solar radiation data have also been revised (sections 2.3, 2.4, 3.1, 3.2.1 and 3.3.2).

- i) Figure 3: solar radiation data has been added.

The caption of Figure 3 has been revised to “*Diurnal variation of (a) averaged solar radiation, (b) averaged wind direction/speed, (c) averaged temperature and RH, and (d) averaged UFP, nucleation mode and Aitken mode particle concentrations.*”.

- ii) Figures 10, 11 and 12: solar radiation data have been added.

The caption of figure 10 has been revised to “*The nucleation events observed on 28-29 April 2009. From bottom to top, the parameters are: i) Geometric median diameter (GMD); ii) Particle number concentration of nucleation and Aitken mode particles; iii) Particle number concentration of ultrafine particles (UFP); iv) Temperature and relative humidity; v) Solar radiation; and vi) wind direction and speed.*”.

The caption of figure 11 has been revised to “*The nucleation bursts measured on 11 November 2009. From bottom to top, the parameters are: i) Geometric median diameter (GMD); ii) Particle number concentration of nucleation and Aitken mode particles; iii) Particle number concentration of ultrafine particles (UFP); iv) Temperature and relative humidity; v) Solar radiation; and vi) wind direction and speed.*”.

The caption of figure 12 has been revised to “*Contour plot of particle size distribution observed on 15 March 2009. From bottom to top, the parameters are: i) Geometric median diameter (GMD) and contour plot of size distribution; ii) Particle number concentration of nucleation and Aitken mode particles; iii) Particle number concentration of ultrafine particles (UFP); iv) Temperature and relative humidity; v) Solar radiation; and vi) wind direction and speed.*”.

- iii) Section 2.3, paragraph 2, last sentence “It should be... (about 15km North-East of QUT).” has been revised to “*It should be noted that global solar radiation was measured at the Queensland Environmental Protection Agency site (Rocklea), about 10 km south of QUT.*”.
- iv) Section 2.4, paragraph 1, last sentence “For the temporal analysis... that of solar radiation (10 mins vs. daily).” has been deleted.
- v) Section 3.1, paragraph 4, last sentence “During the period...the number concentration of UFP.” has been revised to “*During the period of second UFP peak, a nucleation mode peak was also observed associated with highest level of solar radiation, which implies that new particles were produced during the early afternoon by photochemical reactions.*”.
- vi) Section 3.2.1, subtitle “Temperature and relative humidity” has been revised to “*Temperature, relative humidity and solar radiation*”.
- vii) Section 3.2.1, paragraph 2 has been added.

“In some cases, temperature data can not directly reflect the strength of photochemical activities. For example, the high temperatures observed during cloudy days in summer time. In addition, condensation vapour H₂SO₄ production was related to the solar radiation (Ristovski et al., 2010). Therefore, solar radiation was used to indicate the reactivity of photochemical reactions. The particle number concentration did not show a clear relationship with the ambient temperature. In contrast, a positive relationship between particle number concentration and solar radiation data was observed ($r = 0.92-0.98$; $p < 0.01$). This result showed that the N_{nuc} was related to the photochemical reactions.”
- viii) Solar radiation data applied in Figure 9 has been revised

The caption of figure 9 has been revised to “*Seasonal variation in (a) particle growth rates and solar radiation and (b) number of class I event and the percentage ratio of class I event to total sampling days.*”.
- ix) Section 3.3.2, paragraph 2, sentence 3 “($r = 0.83$, $p < 0.05$)” has been revised to “($r = 0.76$, $p < 0.05$)”.

Comment 3

As for the meteorological parameters, it should be highly recommendable to have the time variability of level of a number of gaseous pollutants. It is dangerous to assure on the origin of nucleation episodes as page 22635, Case II and page 22636, Case III without performing any kind of measurements of gaseous precursors. In my opinion all the mentioned sources are possible to cause the nucleation burst (ships, traffic, industries) but I seriously have doubts about the influences of the aircraft emissions on these nucleation processes. Did the authors though in the role of biogenic emissions? I didn't been in Brisbane but I have note that there are several green areas in the city and in the surroundings...With a high probability, the natural contributions are influencing more than the aircraft emissions the bursts of ultrafine particles. As far as I know, there is an Air Quality monitoring site at the Queensland Sciencentre, which is close to your monitoring site. At this station a number of parameters are being measured (carbon monoxide, ozone, nitrogen dioxide and sulphur dioxide, as well as benzene, toluene, xylene and formaldehyde) in addition to meteorology including solar radiation. Why did not use this information to support your interpretations? http://www.derm.qld.gov.au/environmental_management/air/air_quality_monitoring/air_moni

Response 3

Biogenic emissions did not seem to be a major contributor in our study since the particle concentrations achieved during nucleation events in Eucalypt forests are of the order of 10^3 p/cm³ (Suni et al., 2008), as compared to 10^4 p/cm³ in our study.

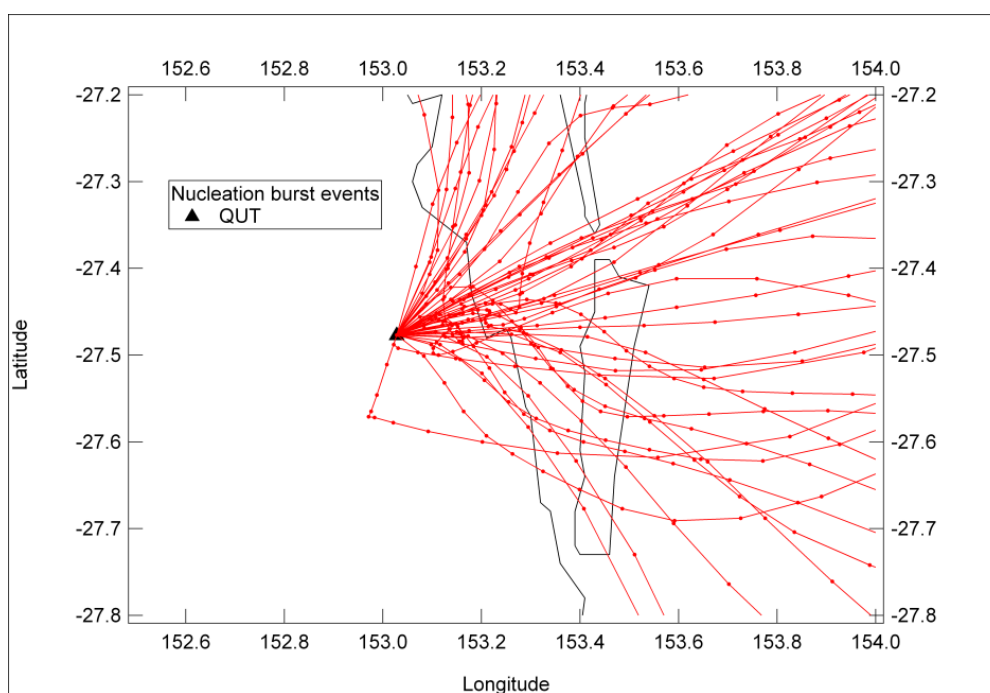
The following text has been added as a new section – 3.4.4 Source Identification – and the air masses trajectory figures have been added as supplementary material:

“Gaseous data measured at Pinkenba, which is located near the lower reaches of the Brisbane River (close to the airport, oil refinery and port of Brisbane) and South Brisbane (about 1km south to QUT) were used to conduct source analysis. These gaseous measurements were conducted by the Queensland Environmental Protection Agency. Also back-trajectories of the nucleation growth/ burst events were calculated using the HYSPLIT model (Hybrid Single Particle Lagrangian Integrated Trajectory, Version 4.9), in order to trace the origin of the air masses.

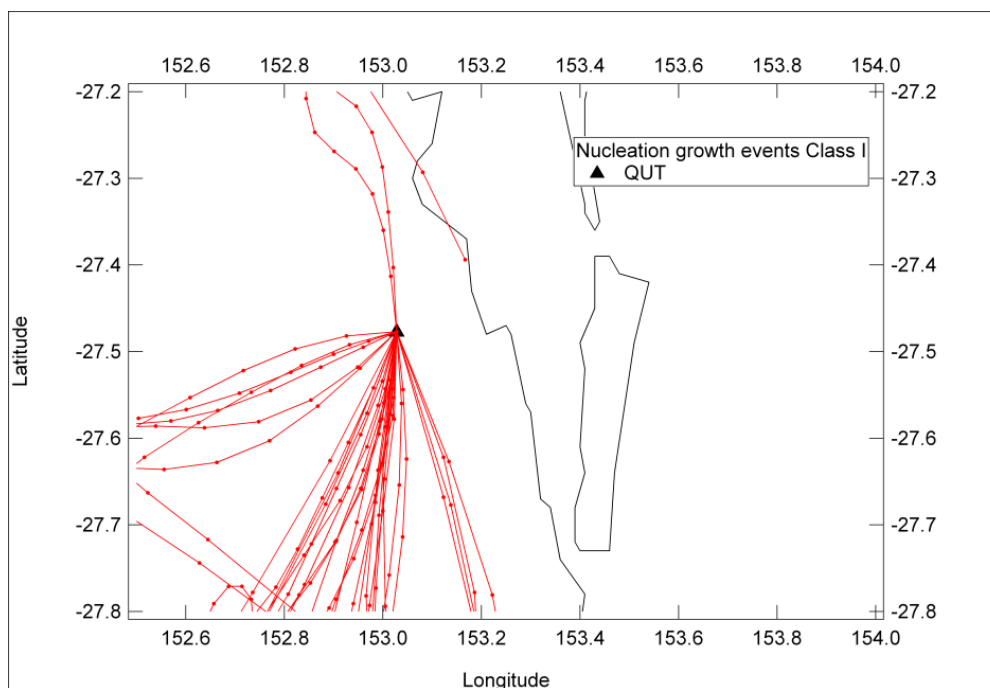
The gaseous data available for Pinkenba included CO, NO₂ and SO₂, while only CO and NO₂ data were available for South Brisbane. 48-h back trajectories were calculated for the first two sampling hours of each event (see supplementary figures S1 and S2) and the average CO/NO₂ and SO₂/NO₂ concentrations measured at Pinkenba during the event period were 89.7 and 0.57, respectively. Overall, the CO/NO₂ ratio exceeded the ratios reported in the 2008/2009 National Pollution Inventory (from www.npi.gov.au, accessed on 15 January 2011) for other sources, such as vehicles (9.7), oil refineries (6.4), ships (0.69) and wildfires (24.6). If the pollution plume was contributed by single source, it was possible to identify the emission source by comparing these emission ratios. For example, the ratio for SO₂/NO₂

(0.57) was very close to the ship emission ratio of 0.69. Although back-trajectory analysis found that almost all trajectories originated from the NE sector during the nucleation burst events, air masses from the NE were influenced by a number of different sources, such as ship, aircraft, oil refinery and the local vehicle emissions. Therefore, it was difficult to identify the specific source/s which contributed to the nucleation burst events. In addition, primary pollution plumes were observed at Pinkenba 1-3 hrs prior to the start of the nucleation burst events. From these results, we can conclude that the nucleation burst events were most likely influenced by industrial emissions from the area NE of the sampling site.

For nucleation growth events, the CO/NO₂ ratio obtained from South Brisbane was 10.2, which is close to the emission inventory data for vehicles (9.7). Back-trajectory analysis also showed that the air masses originated from S-SW directions, except on 21/10/2009, which suggests that vehicle exhaust emissions contributed to the nucleation growth event.”



Supplementary Figure 1. Back-trajectories calculated during the nucleation burst events.



Supplementary Figure 2. Back-trajectories calculated during the class I nucleation growth events

Comment 4

In general, although the study contains very interesting data and nice observations, I have found this paper weak concerning the data treatment, the discussion and the interpretations. In the current form I do not recommend its publication in ACP. Only after a major revision this paper might be considered for publication but not in its current form.

Response 4

This paper has been revised according to the above comments. Please see the responses corresponding to comments 1-3.

Responses to Referee #2's Comments

General Comments

Comment 1

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”.

In my opinion, these observations do 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.

Response 1

The issue of the source apportionment was discussed in detail in the response to comment #3 from referee #1.

Comment 2

Example-2. Section 3.1, page 22630: “During the period of UFP morning peak, Aitken particle also peaked, which implies that the particle 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 20-60nm, respectively (Morawska et al., 2008)”

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 < 20nm. This occurs during the dilution and cooling of vehicle exhaust due to condensation of sulphur and organic vapours onto sulphur clusters. The formation of these particles < 20nm 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; Bartscher,

2005; Journal of Aerosol Science, 36, 896-932; DeFilippo and Maricq, 2008; Environ. Sci. Technol., 42, 7957-7962).

Response 2

Consideration of the formation of nucleation mode particles by vehicle exhaust has been included in the article. Section 3.1, paragraph 4, sentence 4 *“During the period of UFP... 20 - 60 nm, respectively (Morawska et al., 2008).”* has been revised to *“During the period of UFP morning peak, it was suggested that the Aitken mode particles were contributed by the direct diesel and petrol engine emissions, which produce particles in the size range of about 20 – 130 nm and 20 – 60 nm, respectively (Morawska et al., 2008).”*

Also following sentence has been inserted after the above sentence: *“Also the nucleation mode particles could be formed during the dilution and cooling of engine exhausted sulphuric and organic vapours by condensation onto sulphur clusters (Meyer and Ristovski 2007).”*

Comment 3

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.....”*.

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 aerosol background in the S-SW direction.

Response 3

We agree with the comment in regards to Figure 5b, that higher Aitken mode particle concentration was observed under humid condition, which suggested that atmospheric microphysical processes are involved. In section 3.2.1, lines 26-28, we have mentioned that N_{Aitken} may enhance the coagulation and condensation effects under high humidity conditions.

Section 3.2.2, paragraph 1, sentence 6 *“Therefore, it is likely...vehicle emission sources”* has been revised to *“Therefore, it is likely that the nucleation mode particles were contributed by*

the industrial sources located to the NE, while the Aitken mode particles were emitted from both industrial and vehicle emission sources, as well as the coagulation / condensation of smaller particles under humid conditions (see section 3.2.1), which will contribute to the accumulation mode.”.

Comment 4

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 (NO_x, 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 NO_x/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 Kerminen, 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 sources (see in Kulmala and Kerminen, 2008 how environmental conditions influence on nucleation and growth)

Response 4

The issue of source apportionment was discussed in detail in the response to comments #1 and #2 of referee #1.

Comment 5

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.

Response 5

The microphysical processes of the atmospheric aerosol have been discussed in the article.

Section 3.1, paragraph 4 “Figure 3 shows...number concentration of UFP.” has been revised to *“Figure 3 shows the diurnal variation of particle number concentration for different modes with the diurnal variations of temperature and relative humidity also plotted. Two peaks were observed for UFP during the day, the first of which occurred from around 6 am to 8 am, possibly due to traffic exhaust emissions during the morning peak hours (from around 6 am to 8 am) in Brisbane urban region (Mejía et al., 2007). The second peak is observed from around 12 noon to 3 pm, and this may be due to the formation of new particles. During the period of the second UFP peak, a nucleation mode peak was also observed associated with highest level of solar radiation, which implies that new particles were produced during the early afternoon by photochemical reactions.”*

Comment 6

A. 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 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”

Response 6

The general conclusion of this study is in the characterization of number concentration of ultrafine particles in the subtropical urban area of Brisbane, Australia. We have clearly shown that the nucleation particles come from different sources surrounding Brisbane city, with a clear directional influence (SW vs NE) on the particle size distribution. Also the particle growth rate during the nucleation process was reported for the first time in an urban area of the southern hemisphere.

The comparisons of the results of this study with other similar studies have been included in the revised manuscript. The findings of Fernandez-Camacho et al., 2010 have been discussed in the following sections:

Section 3.1, paragraph 1, sentence 3 has been revised:

“The N_{UFP} measured in Brisbane was relatively lower than that in other coastal urban areas, including the Yangtze River Delta, China (Gao et al., 2009), Barcelona (Pey et al., 2008) and Huelva and Santa Cruz de Tenerife, Spain (Rodríguez et al., 2008; Fernández-Camacho et al., 2010), which were 28.5×10^3 , 14.2×10^3 and $22.0 - 26.3 \times 10^3 \text{ cm}^{-3}$, respectively.”.

Section 3.1, paragraph 4 has been revised:

*“**Figure 3** shows the diurnal variation of particle number concentration for different modes with the diurnal variations of temperature and relative humidity also plotted. Two peaks were observed for UFP during the day, the first of which occurred from around 6 am to 8 am, possibly due to traffic exhaust emissions during the morning peak hours (from around 6 am to 8 am) in Brisbane urban region (Mejía et al., 2007). The second peak is observed from around 12 noon to 3 pm, and this may be due to the formation of new particles. During the period of the second UFP peak, a nucleation mode peak was also observed associated with highest level of solar radiation, which implies that new particles were produced during the early afternoon by photochemical reactions.”*

In regards to the suggestion: “in coastal areas where aerosol precursors are emitted, new particle formation processes (photo-chemically induced nucleation) is favoured in the inland sea breeze”

Our measurement site was not located close to the coastline and therefore we cannot come up to the same conclusion. In our case the air mass had to travel significant distance over polluted areas before reaching the measurement site. Any particle sources and precursors for new particles could have come from the polluted urban areas.

Specific Comments

Specific comment 2.1

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

Response 2.1

The term “traffic emission or vehicle emission” has been changed to “vehicle exhaust emissions” in article.

Specific comment 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 measurement site.

Response 2.2

Although the channelling effect of river on the inland breezes was found in other studies, there is no similar study conducted for our study region. Also the river meanders through Brisbane City. Thus, the channelling effect of the river in our study location is not clear. Therefore, we will not include it in the article.

Following sentence has been amended in section 2.1: “*The Brisbane River meanders through the Brisbane region.*”

Specific comment 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 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 decrease in temperature.

Response 2.4

30min averaged data for solar radiation measured 10 km south of the QUT site has been applied instead of temperature data, which shows that nucleation mode particle number concentration is then highly related to the strength of the solar radiation. The corresponding paragraphs have been revised.

See the response to comment #2 to referee #1.

Specific comment 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.

Response 2.5

Wind data has been added to Figure 3 and a discussion on land and sea breeze has been added in section 3.1, paragraph 4.

Section 3.1, paragraph 4 has been revised: See response to comment #6.

Specific comment 2.6

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

Response 2.6

We do not feel that shortening this section will improve the manuscript and therefore, we will keep it.

Responses to Referee #3's Comments

Comment 1

Page 22637, line 19: use of UFP without first defining the acronym. The definition is given next.

Response 1

Definition of UFP has been added.

Section 2.3, first paragraph, first sentence "The size distribution... December 2009." has been revised to "*The size distribution of ultrafine particles (UFPs) was measured at the QUT monitoring site from 1st January to 31st December 2009.*"

Section 2.3, second paragraph, first sentence "ultrafine particles (UFP)" has been revised to "*UFPs*".

Comment 2

Page 22628, line 21: The temperature is used as an indicator of solar radiation. However, solar radiation data were measured at Brisbane Airport. So the authors, either they use the solar radiation data at the airport or the temperature data instead, they have to thoroughly explain the limitations of such an approach.

Response 2

The available solar radiation data measured at Brisbane airport were daily averaged data. Therefore, the authors applied the temperature data instead of the solar radiation for data analysis in the original manuscript. In the revised manuscript, we have applied the 30min averaged solar radiation data which was measured at Rocklea, a QLD EPA station located 10 Km south to QUT site.

Corresponding sections have been revised (sections 2.3, 2.4, 3.1, 3.2.1 and 3.3.2). See response to referee #1's comment #2.

Comment 3

Page 22629, line 4,5: What is the range of these values? Perhaps a statistical quantity referring to the variability of the average concentrations (e.g. standard deviation) should be mentioned as well.

Response 3

Standard deviations of particle number concentrations have been added.

Section 3.1, paragraph 1, first sentence “The overall average..., respectively” has been revised to “*The overall average concentration of ultrafine particles (N_{UFP}), Aitken mode (N_{Aitken}) and nucleation mode (N_{nuc}) measured in this study were 9.3×10^3 ($\pm 15.3 \times 10^3$), 3.7×10^3 ($\pm 5.1 \times 10^3$) and $5.6 \times 10^3 \text{ cm}^{-3}$ ($\pm 12.6 \times 10^3$), respectively.*”.

Comment 4

Page 22631, line 5-7: Could that peak in Aitken mode at low temperatures come from central heating?

Response 4

The contribution of Aitken mode particles from central heating in Brisbane is not important, since the central heating does not exist in Brisbane even during winter season.

Comment 5

Page 22631, lines 9-19: No information is given on the attribution of air mass origins to a certain direction and/or source. Does that come only from the wind direction measurements at the other site (Kangaroo, 1 km east QUT)? Is this direction representative of the whole area? Because in areas of dense building blocks as I suppose the central business district is, the wind direction might be misleading. In that case, wouldn't it be a better way to use back trajectories analysis and perform a more sophisticated cluster analysis and/or source apportionment technique?

Response 5

The air sampling location at QUT site is located at the top of the building, and there are no tall buildings surrounding the sampling point. Also the QUT site is not close to the high rise buildings; therefore the wind data measured at Kangaroo Point (~ 1 km next to QUT site) is appropriate to represent the synoptic wind of the study region.

Section 2.3, paragraph 2, below sentence has been inserted after sentence 2:

“The QUT and Kangaroo Point sites were not blocked by high rise buildings and therefore the use of wind data measured at Kangaroo Point was representative of the synoptic wind direction of the study region.”

Comment 6

Page 22631, lines 20-25: Fig. 7 is not referred anywhere, probably referring to these lines.

Response 6

Description of Fig. 7 has been added into the content.

Section 3.2.2 Paragraph 2, Sentence 2:

*“Higher particle number concentration was associated with lower wind speeds (see **Figure 7**), which can be explained by the stronger dispersion associated with high wind speeds (Hussein et al., 2006).”*

Comment 7

Page 22633, line 17: In Fig. 9 the information is misleading. The authors should refer to an “event to non-event ratio”, which is indicative of the frequency of occurrence of these events taking into account the available measuring dates.

Response 7

A “Class I / Total days ratio” has been added into Fig 9.

The caption of figure 9 has been revised to “Seasonal variation in (a) particle growth rates and solar radiation and (b) number of class I event and the precentage ratio of class I event to total sampling days.”

Responses to Referee #4's Comments

Comment 1

Section 2.1, first paragraph: The description of the first sector of the economic activity in Brisbane is not important for this study and could be left out.

Response 1

The description of Brisbane in Section 2.1, first paragraph has been revised.

Section 2.1 first paragraph "Brisbane is the...of Brisbane River." has been revised to *"Brisbane is the capital city of the state of Queensland, Australia, located at 27°30'S and 153°E. Brisbane city is surrounded by mountains from south to north, and faces the Pacific Ocean to the East. It is the fastest growing urban region in Australia (2 million inhabitants). The major pollution sources affecting the CBD region are traffic exhaust emissions generated in the inner city, and aircrafts, ships and industrial emissions transported from the lower reaches of Brisbane River, approximately 15-18 kms NE of the CBD."*

Comment 2

Section 2.3, first line: Give full word for UFPs (instead of in the second paragraph of that section). Exact dates for the measurement period should be given, not just the months.

Response 2

Full word and definition of UFP has been given. Exact dates for the measurement period have been added.

See response to referee #3's comment #1.

Comment 3

Section 2.4, More information should be given on the data analysis. Were the size distributed corrected for multiply charged particles? The criteria set for deleting data should be explained in more detail. How big was the percentage of data which had to be removed?

Response 3

The size distribution data was corrected by using the multiple charge correction function embedded in Aerosol Manager Software (Data logging software provided by TSI).

The description of data quality control has been revised and information on the percentage of data that had to be removed has been included.

i) Section 2.3, Paragraph 1, amended to last sentence:

“Multiple charge correction was applied to the particle size distribution measurements by using an internal algorithm in the Aerosol Instrument Manager Software.”.

ii) Section 2.4, paragraph 1, sentences below have been added.

After first sentence:

“According to Mejía et al. (2007) the lower limit of the particle size distribution dataset was set to 1 cm^{-3} . The upper limit was set to $5 \times 10^5\text{ cm}^{-3}$.”

After sentence “Some data were removed from...”:

“During the one year measurement campaign, 28 % of the data was removed based on the above data reduction procedures and due to instrument maintenance.”

Comment 4

Section 3.2.1: The relationship of particle number concentrations and RH and its implications for atmospheric processes is not sufficiently discussed

Response 4

The discussion about particle number concentration and RH has been extended.

Section 3.2.1, Paragraph 1, line 27: “This result may...humidity conditions” has been revised to *“Also higher N_{Aitken} concentrations were observed under humid conditions (see **Figure 5**). This result may be due to enhanced coagulation and condensation effects under high humidity conditions.”*

Comment 5

Figure 6: It would be more meaningful if the wind direction data could be plotted in a polar graph

Response 5

Presenting the wind direction data in a polar form will not change the meaning of the figure, which the authors feel is better represented by quartile values for wind direction data. We believe that presenting the wind direction data in the current form is more suitable for this publication.

Comment 6

Figure 7: Discuss in more detail the shape of the UFP and nucleation mode curves, e.g. why is there a peak around 4ms^{-1} ?

Response 6

More detail discussion about the shape of the UFP and Nucleation mode related to wind speed has been added.

Section 3.2.2, Paragraph 2, below sentence has been amended:

*“In addition, a larger variation of N_{nuc} was associated with the moderate wind speed ($\sim 4\text{ ms}^{-1}$). N_{nuc} usually reached its daily peak value during early afternoon and the corresponding wind speed was $\sim 4\text{ ms}^{-1}$ (see **Figure 3**).”*

Comment 7

Section 3.3.2: Can you give more information on the seasonal variation of nucleation events, especially on the fact that only very few or none can be observed during November/December? Discuss in more detail the relationship of solar radiation and nucleation events/growth rates, especially in terms of photochemical processing of precursor gases.

Response 7

According to the available meteorological data, the major difference between the meteorological conditions of November and December and other months is the dominant

wind direction. During November and December, the NE winds dominated while during the other months the main direction was from the SE-SW.

Section 3.3.2, paragraph 1, below sentences were inserted after sentence 6:

“In addition to the seasonal variation of temperature, the dominant wind direction measured during November and December was different to other months. NE winds dominated during these warmer months, while the main wind direction was from the SE-SW during other months. The influence of wind direction on the nucleation events will be discussed in the case studies below.”

Comment 8

Conclusions: The lack of nucleation events for maritime air masses is mentioned. But NE winds bring air masses from the port and hence the coast. Please elaborate further.

Response 8

We didn't mention the lack of nucleation events for maritime air masses anywhere in the article. In the study location, the maritime air masses can come from NE to SE directions. The particle number concentrations measured under NE and SE directions were largely different (see Figure 6). The wind blowing from NE direction was passing through the industrial areas that contain more polluted air masses than the air mass from SE direction.

Section 3.2.2, paragraph 1, the following sentences have been amended:

“In addition, air masses blowing from the marine boundary (NE to SE directions) were relatively clean. However, the inland air mass from the NE direction was contaminated by industrial emissions. This interpretation is supported by higher N_{UFP} in north-easterly air masses and lower N_{UFP} in easterly or south easterly air mass (clean maritime air mass).”

Technical comment 1

Revise the use of plural and singular (in verbs versus nouns) throughout the whole manuscript

Response technical comment 1

The manuscript has been revised as follows:

Page 1, line 19: “Local vehicle emissions was” has been revised to “Local traffic exhaust emissions were”.

Page 2, line 20: “natural emission were” has been revised to “natural emissions were”.

Page 7, line 14: “is comparable” has been revised to “are comparable”.

Technical comment 2

Revise use of passive versus active verb forms throughout the whole manuscript (e.g. “contributes to” instead of “was contributed to” in the abstract

Response technical comment 2

The manuscript has been revised as follows:

Page 1, line 20: “which dominated by the Aitken mode particles” has been revised to “which was dominated by the Aitken mode particles”.

Page 1, line 21: “particle formed by secondary formation process” has been revised to “particles formed by secondary formation processes”.

Page 5, line 22: “were suggested that contributed” has been revised to “suggested that the contribution”.

Technical comment 3

Revise use of prepositions and articles throughout the article (e.g. first sentence of abstract)

Response technical comment 3

The manuscript has been revised as follows:

Page 1, line 14: “southern hemisphere” has been revised to “in the southern hemisphere”.

Page 8, line 35: “followed with” has been revised to “followed by”.

Other textual revisions in the manuscripts are as follows:

Page 2, line 11: “, coastal areas” has been revised to “, and coastal areas”.

Page 2, line 19: “were conducted” has been deleted.

Page 2, line 30: “to be conducted” has been revised to “conducted”.

Page 3, line 11: “blowing” has been revised to “are blowing”.

Page 3, line 19: “, the Pacific Motorway,” has been revised to “(the Pacific Motorway)”.

Page 4, line 7: “which” has been revised to “,which”.

Page 4, line 24: “lower than” has been revised to “lower than that”.

Page 4, line 28: “were also compared to the results” has been revised to “were also compared to those”.

Page 4, line 39: “is similar to the result” has been revised to “is similar to that”.

Page 5, line 5: “The second peak is” has been revised to “The second peak was”.

Page 5, line 12: “displayed” has been revised to “display”.

Page 5, line 20: “,low humidity conditions” has been revised to “ and lower humidity conditions”.

Page 6, line 15: “it” has been revised to “its”.

Page 6, line 38: “total” has been revised to “a total of”.

Page 6, line 38: “detail” has been revised to “detailed”.

Page 7, line 25: “sections” has been revised to “sections,”.

Page 8, line 34: “that” has been deleted.

Page 8, line 34: “usually” has been revised to “was usually”.

Page 8, line 36: “are” has been revised to “were”.

Page 9, line 22: “influenced by” has been revised to “the influence of precursors”.