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Comment

Interactive comment on “Variability of levels of PM, black carbon and particle number concentration in selected European cities” by C. Reche et al.

C. Reche et al.

cristina.reche@idaea.csic.es

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We thank the reviewer for his/her comments and suggestions which have helped us to improve the paper. Detailed replies to each of them are shown below:

1. The descriptions of the sites should also include typical meteorological features such as insolation, daily patterns of mixing heights and, where applicable, land/sea-breeze systems (including their effects on the aerosol at the measurement sites). This would collect all necessary information for the interpretation of the diurnal variabilities in one spot and would obviate the need for the frequent repetitions in all the sections dealing with one or another variable.

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Answer: Some meteorological parameters have been now included in the description of the sites. Unfortunately, we do not have data for daily patterns of the boundary layer height for all the sites. The following information has been added in the manuscript: Barcelona: “The transport and dispersion of atmospheric pollutants within BCN are controlled mainly by fluctuating coastal winds which typically blow in from the sea during the day and, less strongly, from the land during the night. The sea breezes (originating from the 120-180° sector) are at their strongest around midday, when the boundary layer height maximizes (Pérez et al., 2004). The average annual solar radiation is 180 W/m² and at midday values range between 400 and 950 W/m² within a whole year. The annual accumulated precipitation is 500mm.” London: “On an annual basis, mean solar radiation is 70 W/m², with values ranging from 5 to 760 W/m² at midday. The daily pattern of the boundary layer height shows maximum from 12 to 15 h UTC, contributing to decrease atmospheric pollutants concentration.” Bern: “Attending to the typical meteorological feature, the mean annual solar radiation is 130 W/m² and it ranges from 15 W/m² in winter to 840 W/m² in summer at noon. The accumulated precipitation in the city is about 1700 mm per year.” Lugano: “Precipitations are frequent, with an accumulated value of 3800mm per year. Mean solar radiation is 150W/m² on average, at midday this parameter is between 3 and 900 W/m²” Huelva: “This area is characterized by a dry weather, with a yearly accumulated rainfall of 450mm. The solar radiation is very elevated, reaching average values of 1200 W/m² on an hourly basis at midday. The dispersion and transport of air pollutants in this area are highly influenced by the topographic settings. At night, the wind mostly blows from the north and during daylight, southern airflows linked to thermally driven breezes predominate. This sea breeze favors the entry of industrial plumes and is associated with an increase in ozone concentrations (Millán et al., 2002). The boundary layer height maximizes from 12-15 h UTC.” Santa Cruz de Tenerife: “The urban scale transport of air pollutants in Santa Cruz de Tenerife is mainly driven by breeze circulation. This breeze is characterised by inland (westward) airflows during daylight (3–4 m s⁻¹) and a slight seaward (eastward) airflow at night (1 m s⁻¹). Inland breeze blowing starts at 08:00 h UTC

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and is characterised by an abrupt shift in wind direction (Rodriguez et al., 2008). Solar radiation is 250 W/m² on annual average, with a maximum of 1200 W/m² at midday in summer, coinciding with the maximum height of the mixing layer.”

In addition, we agree with the reviewer comment about some frequent repetitions and therefore we have deleted some explanations related to breeze and, especially, solar radiation

2. I am not quite comfortable with the frequent strong statements about nucleation of new particles (or the absence thereof). Without SMPS measurements showing nucleation bursts one cannot really say whether an increase in N concentration is really due to freshly nucleated (secondary) particles or to the advection of a plume, etc. etc. If indicators for photochemistry increase concurrently with N concentrations of course this is an indication of particle formation, but in the presence of high N concentrations new particle formation should be at least partly suppressed by condensation onto pre-existing particles? In the absence of SPMS data, these strong statements should be qualified.

Answer: We totally agree with this comment and we have decided to include the following information in page 17, line 536: “The occurrence of nucleation events at midday in BCN was supported by means of an SMPS (scanning mobility particle sizers) working during the international DAURE campaign in 2009 (<http://cires.colorado.edu/jimenez-group/wiki/index.php/DAURE>) when it was observed that the increment of N at midday was caused by a marked increment of nucleation mode particles (N5-20) (Figure S4). Because of the similar pattern of N and meteorological parameters (global radiation, wind speed, wind direction and boundary layer), it was estimated that results regarding nucleation episodes from Barcelona could be extrapolated to these sites in south-Europe.” We have added an example of a nucleation event as a supplementary figure (Figure S4).

3 Is there a way to quantitatively estimate the effect of the different lower cut sizes

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of the CPCs? At least give an estimate of the magnitude of this effect, which in turn influences S1 and BC/N ratios, etc.

Answer: This is an interesting question. We think that N1 may be estimated for the same cut size in all sites, but unfortunately we do not think that reliable values of N2 may be estimated. The overall data shows that there is a clear dependence of S1 on the CPC model; S1 take values equal to 3.6, 5 and $\sim 9 \hat{\text{A}}\hat{\text{C}} 106 \text{ ngBC-1}$ for model 3022, 3785 and 3776 during the morning rush hours (Table R1 in the supplement), respectively. This indicates that the same relationship between particle number and black carbon concentrations (measured in the PM10 fraction) is observed in all sites. Consequently, because BC was measured in the same size fraction in all sites (PM10), a S1 value characteristic of any CPC model may be applied to any other site. For example, the slope S1 characteristic of CPC3776 may be used for estimating N1 (>2.5 nm) at Marylebone, Kensington, Bern or Lugano, or inversely, N1 (>7 nm) may be estimated in Barcelona, Santa Cruz and Huelva using the S1 value for CPC 3022A (Eq-1). This will allow comparing N1 in the same cut size in all sites. However, this is not possible for N2. If an estimation of N1 (> x nm) is performed at any site, the estimation of N2 at the same cut and same site (i.e. N2 (> x nm)) would require data of number concentration N at the same cut size (i.e. N(> x nm)), and these will not be available.

$$N1 = S1 \hat{\text{A}}\hat{\text{C}} BC \text{ Eq-1} \quad N2 = N - N1 \text{ Eq-2}$$

4. BC concentrations are compared, although they were measured with different instruments. How well are the instruments really comparable? Only a single conversion factor (based on Sunset Analyzer data) is used for each of the sites, which will not be correct for seasonal differences in light absorbing carbonaceous aerosols (e.g. wood smoke in winter time). This neglect of seasonal differences should at least be discussed – seasonal trends might turn out to be different.

Answer: In page 12, line 390, the following discussion has been included: “On the other

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hand, in spite of this correction, the use of different instrumentations can still influence the seasonal trends of light absorbing carbonaceous aerosols. However, correlations between BC and EC measurements considering the whole year were significant in all the sites under study.” The seasonal trends can be modified in a certain way, but the good correlations between BC and EC in all the stations suggest that this correction is suitable for comparing BC measurement among stations. As an example we include in this answer (although not in the manuscript) the corrections in Barcelona (a) and Marylebone (b) (Figure R1 in the supplement). In the case of Barcelona, the correlation has been plotted distinguishing the fall-winter from the spring-summer period. This correlation doesn’t show a seasonal trend (points are mixed).

5. As Reviewer 1 noted (twice), the interpretation of the N concentration patterns in MR was quite debatable. Actually, the trend of increasing N from Monday to Friday may well disappear if not only the average values are shown, but also the variability of these values. It is highly unlikely that number concentrations show an accumulation effect from day to day – PM2.5 mass might be another matter.

Answer: We agree with both reviewers and we have finally decided not to include this discussion.

6. Regarding the response to Reviewer 1’s comment on the 150 m spatial distance “causing a time shift of hours”: can the “strong local source” be identified? If there is such a source, it should show up in the data intermittently depending on meteorological conditions

Answer: It is not easy to find an explanation for the lack of parallelism between the black carbon peak in the evening and the gaseous tracers; but it is a behaviour that we also observed for the 2008 dataset. The different location of instrumentation is the most likely explanation for it, so we think it may be related with the presence of a specific source near the black carbon monitor. In the figure S2 we can observe how the effect of this source disappears in October, November and December 2009. In sum,

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the cause for this specific BC daily pattern is unclear and, even though we believe that it must be related to the influence of a local source (e.g., some monitoring instrument), we have stated the following in the manuscript:” The cause for the anomalous hourly trend detected in Bern is still unclear, although it is possibly related to the fact that the BC and the gaseous pollutant monitors were not co-located, but instead were distant by approximately 150m on opposite sides of the road. The BC monitor was located closer to road traffic and to a railway.”

7. Minor points: In the “old” section 2.8, there is no separation between the text on SCO and the description of the instrumentation employed at the different sites – there should be a clear heading “Instrumentation”.

Answer: The separation was included after comments of reviewer 1.

8. Please give S content of gasoline and diesel fuel to substantiate the statement that SO₂ levels are related to traffic emissions.

Answer: Unfortunately, we have no information about the S content of lubricants in the different cities. Instead, in page 14, line 435, we have included: “according to data from the UK National Atmospheric Emission Inventory, the emission factor of SO₂ from road vehicle engines is 11.5 Kilotonne/Mt fuel consumed”

Please also note the supplement to this comment:

<http://www.atmos-chem-phys-discuss.net/11/C4089/2011/acpd-11-C4089-2011-supplement.pdf>

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