

Interactive comment on “Overview of the synoptic and pollution situation over Europe during the EUCAARI-LONGREX field campaign” by T. Hamburger et al.

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We thank the reviewer for her/his valuable comments on the manuscript. The reviewer's comments are in regular type and our responses are outlined in italic type.

The paper has been written as an overview paper on the meteorological situation over Europe, during May 2008, related to temporal and spatial variations of particulate pollution inside BL and FT. (i) The meteorological situation is well described and should serve the EUCAARI community working on the IOP period data as a reference and synthesis paper. (ii) The related pollution situation is described utilizing

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key measurements from 6 EUSAAR stations. In general the manuscript is well written, the meteorological situation with anticyclonic blocking situation dominating the first half of May is described in sufficient details. Also the meteorological details given for the second half of the month are sufficient. From the pollution point of view the synthesis given in the manuscript is somewhat poorer. The authors have to think about an adequate solution to present main features of spatiotemporal pollution trends over Europe during May 2008 (in a rather condensed manner, since there will be accompanying papers going much more into details). The manuscript might be published after additional work and refinements due to the below general and more specific comments.

General Comments

- The authors use a limited set of 6 EUSAAR stations to give, from the experimental point of view, an overview of observed pollution levels within the domain of F20 and BAe-146 LONGREX flights performed during May 2008. Observational pollution parameters (stations, aircraft), discussed in the manuscript, were unfortunately limited to particle number concentrations and BC content. It is somewhat regrettable that observational parameters and number of stations have been so small despite the ambitious objective to present a synthesis paper. Of course then the paper has to be limited with respect to the amount of information presented. The approach to describe the pollution situation from aerosol concentration and BC data collected at 6 EUSAAR stations is somewhat poor, since stations might be more subject to small scale pollution (including predominant diurnal cycle, see MPZ), rather than being affected by long range transport. Moreover particle deposition (particularly cloud scavenging) may play an important role, thus affecting particulate matter (see authors' argumentation for SMR station) etc...

This paper is not intending to present an integrated synthesis of all observational data and model analysis of EUCAARI-LONGREX. It's main role is to present two

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scientific aspects of the EUCAARI-LONGREX aircraft field campaign, which form the base on which future work and publications can build on: The paper aims at presenting (1) an overview on the meteorological situation encountered during the measurement flights of BAe-146 and DLR Falcon 20 in May 2008, and (2) an (first) overview on the pollution situation over Europe with respect to aerosol properties measured during these flights. To accomplish this, the time series measured at selected ground stations is also analyzed in order to present a temporal framework for the airborne measurements. The six ground stations of which we present data in the manuscript were selected to cover the regions where the extensive airborne measurements were performed. To describe the temporal evolution of particulate pollution, only parameters were chosen that were simultaneously available at almost every selected ground station and aboard the two aircraft. In addition, the parameters had to be measured using comparable measurement methods. Thus, only BC-mass concentration and accumulation mode number concentration remained as parameters most useful for a consistent analysis. In contrast to CN number concentrations, the accumulation mode number concentration also gives the possibility to analyse long range transport due to its resemblance of aerosols with relatively long atmospheric residence time. A synthesis of results of implications of all the measurements performed aboard the BAe-146 and the DLR Falcon 20 goes beyond the scope of this paper and will be published in forthcoming papers.

- The authors claim their paper being a reference or synthesis paper relating meteorology and particulate pollution. We suggest that authors take into account more inert pollution tracers (CO, etc.) to better settle their conclusions from experimental measurements of particulate matter. It may turn out that particulate pollution is well correlated to more inert gaseous tracers of pollution. However, it may turn out that removal processes significantly influenced the presented results, which might be particularly true for the 2nd half of the month.

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The suggestion of the referee to use CO as an inert pollution tracer has its justification particularly in cases where cloud processing and wash out can be possible. Unfortunately, CO time series were available only for the stations at Hohenpeißenberg and Hyytiälä, and CO₂ time series at Mace Head and Cabauw. Thus, a comprehensive analysis using CO as inert pollution tracer was not possible and consequently not used for this paper.

- Another question arises: are 6 stations sufficient to describe the pollution situation related to meteorology over Europe during May 2008? The paper quality could be strengthened, adding more information from model results as done in Fig. 3. This should improve the quality of a synthesis paper and thus, the comprehension of the pollution situation during May 2008. In favor of supplementary material from FLEXPART model output, the discussion of single station measurements could be reduced significantly.

The reviewer is correct in noting that only 6 ground stations are used. However, the use of the analysis of ground based data in this context is to support the interpretation of the aircraft measurements. The 6 ground stations were chosen due to their location close to the areas where the airborne measurements were performed rather extensively (including vertical profiling). Thus, we believe that the choice of these 6 ground stations is sufficient to fit the requirements of the paper.

The reviewer is also correct in pointing out the missing discussion of average spatial distributions merging together model simulations and measured data. While we do not want to turn the paper into a major model study with respect to the assimilation aspect (our expertise rather lies on the observational aspects and modelling is in the focus of other partners in the EUCAARI project), we agree it is useful to include information on the FLEXPART model simulations, because FLEXPART was one of the core tools used for planning the flights. We have added the following text and Fig. S1:

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FLEXPART simulations are used to analyse the average horizontal BC-mass distributions over Europe for period (a) and period (b) that result from European anthropogenic emissions. They are compared to the average BC-mass concentrations measured at the ground stations during the respective period. As discussed above an increase of BC-mass concentration goes along with an increase of accumulation mode number concentration in most cases that were observed at the ground stations. Thus, regions of increased BC-mass concentrations can be associated with regions of increased particulate matter. Fig. xx shows the average BC distribution above Europe at 10 m a.g.l. The average values were calculated for period (a) and period (b) from FLEXPART simulations on a 1°x1° grid. The circles indicate the position of the ground stations and the colour shade the average BC-mass concentration measured at the ground stations during period (a) and (b). Maximum BC-mass concentrations greater than 0.7 µg m⁻³ can be found above the Benelux States, North-east France, the English Channel, and England. A second maximum can be found above southern Poland. Compared to period (b), the regions of maximum BC-mass concentrations have a larger horizontal extension. In contrast, BC-mass concentrations greater than 0.7 µg m⁻³ were mostly limited to urban regions like London, Paris or Rotterdam. The FLEXPART simulations also show that the anticyclonic transport associated with the high pressure system centred over the North Sea and Denmark led to a transport of anthropogenic pollution towards the Atlantic and the Norwegian Sea. The average values retrieved from the FLEXPART simulations agree well with the observed temporal averages and lie within 25 % of the measured BC-mass concentrations.

- Chapter 4 is not really needed here, since no climatological work is presented in this context. For this reason, the chapter might be skipped. The idea, however, is exiting, but could be mentioned elsewhere (outlook etc...). I encourage the authors to materialize the above idea in a separate paper.

The analysis of the Hess-Brezowsky weather pattern classification was used to

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give the analysis (and the campaign) a climatological perspective and to determine how representative the campaign period was. To meet these objectives we believe the short climatological analysis of section 4 of the manuscript should remain in the text. However, we agree that a detailed climatological analysis would be worth a separate paper.

Specific Comments

- Avoid redundancy in the entire text. Sentences are repeated without being modified, this is not necessary. For example: 1. 'Abstract' and 'Introduction' start with same two sentences... 2. Aerosol measurements are presented in chapter 2 and thus, should not be presented already in chapter 1 (page 19133: skip line 11-15, this is extensively presented in chapter 2)

Page 19131, lines 2-5 were changed to:

In May 2008 the EUCAARI-LONGREX aircraft field campaign was conducted within the EUCAARI intensive observational period.

Page 19133, lines 11-15 were removed from the text

- Page 19135 line 4: What is T799/L91?

Text was changed to:

The model has a horizontal resolution of 0.225°x0.225° and a vertical resolution of 91 levels.

- Page 19140 (Chapter 5.1.1): Figure 5 is not referenced

- Page 19141 (Chapter 5.1.2): Figures 6 and 7 not referenced

In addition to page 19139 line 16 ("Time series plots for ground stations are

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shown in Figs. 4-9.”) figures 5, 6, 7, and 8 are now referenced individually in the reviewed manuscript (pages 19149-10142).

- Page 19147 (line 23-25): To be checked with CO data for example

Fig. S2 shows the accumulation mode number concentration vs CO data measured at Hyytiälä. Two pollution events were selected: 01-04 May, pollution from Eastern Europe; 08-12 May pollution from Central Europe circulated within the high pressure system. The comparison of CO data with the accumulation mode number concentration shows that the major effect of the relatively low accumulation mode number concentrations from Central European pollution results from mixing with clean arctic air masses. However, several cases show maximum CO concentrations for the Central European pollution case at minimum accumulation mode number concentrations. Hence, wash out at the Norwegian mountain range cannot be excluded from the analysis.

Page 19147 we changed to lines 23-25:

Analysis of the accumulation mode number concentrations using CO as inert pollution tracer (not shown here) indicate that this is mainly an effect of mixing with clean Arctic air masses during transport. However, washout of particles due to the frequently occurring precipitation at the Norwegian mountain range cannot be neglected.

- Page 19149 (line 12-15): What is the cause of the highly scattered BC signal? Is it local pollution from Rotterdam sources, rather than transported pollution on a mesoscale. Why there are no particulate data at Cabauw for first half of May, what about the French aircraft ATR and the helicopter platform operated around Cabauw?

The SMPS at Cabauw measuring the particle size distribution was indeed not operated in the first half of May.

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Trajectory analysis (see Fig. S3) showed that the dominant air mass transport pathway followed a track from Germany towards Cabauw in particular during period (a) but also during period (b). Polluted air masses originating from local source regions like Rotterdam or Amsterdam had only a minor influence on the probed air masses at Cabauw regarding the trajectory analysis.

The following sentence was added to Page 19149 line 15:

Trajectory analysis and the observed wind field at Cabauw which was east and northeast in May 2008 support the finding that polluted air masses originated from Germany rather than local source regions like Amsterdam or Rotterdam, which are located north and west of the station, respectively. However, mixing of aged pollution with fresh pollution originating from source regions along the transport pathway east of Cabauw has to be taken into account.

- Page 19149 (line 27ff): What is your definition of CN number concentration? Larger 10 nm? Is there a risk that you included nucleation particles already grown beyond 10 nm that then appear in the EUCAARI profiles, thus, pretending high pollution level (which may not necessarily be the case)?

The reviewer is right to point out the missing definition of CN particles in this section of the manuscript. The CN particles discussed in the analysis are larger than 10 nm in diameter.

Nucleation events within the boundary layer, indicated by our measurements if particles larger 4 nm and smaller 10 nm were present, did occur (mainly on the May 9, 2008, flight) but were in general rather rare. Nevertheless, if there are very high concentrations in the Aitken mode (of particles larger than 10 nm), these are likely to be secondary particles which have grown from condensation of precursor gases after they have been initially formed by nucleation processes. We don't see this as a

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“risk”, as the reviewer states, but rather as an intrinsic property of the small particle population. Most precursor gases and therefore secondary particles measured during the campaign are likely to have originated from anthropogenic emissions over the densely populated regions where the measurements were performed.

*The following sentence was added to the manuscript:
CN number concentrations were analysed for particles larger than 10 nm in diameter.*

- Figure 11 and corresponding chapter 5.2: The correlation in figure 11 is not that strong. In contrast, the figure is simultaneously demonstrating the difficulties to relate HPB ground-based station observations to aircraft vertical profiles. The correlation is certainly a function of the meteorological situation (wind direction, etc. . .). The high aerosol concentrations seen in the Falcon profiles may be due to precedent nucleation events of aerosol particles. In contrast the potential for nucleation at HPB might have been different (as compared to Falcon airport) as a function of environmental conditions. HPB shows quite some precipitation after May 15th, thus cleansing the air from particles, difficult to argue that at F20 airport the situation was identical. The authors should be more careful extrapolating station data into the BL and beyond. Measurements on ground-based stations may highly depend on small scale processes and meteorology.

The authors do not claim to find a correlation between the CN time series measured at Hohenpeißenberg and during take off and landing of the DLR Falcon 20. On the contrary, they point out the difficulties of using CN number concentrations for the comparison of ground based and airborne measured data (p. 19149, line 16ff) and emphasise the better usability of accumulation mode number concentration for this comparison.

- Using the European lidar network EARLINET would be another idea (i) to gain

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insight into the pollution situation over Europe during May 2008 and (ii) on an even smaller scale to relate ground-based in situ data to aircraft data.

This is a valid suggestion, but, again, including EARLINET results is out of the scope of this paper and should be in the focus of forthcoming work

Conclusions

The manuscript is worth being published. Claiming it a synthesis paper for meteorology and related pollution, the paper needs significant additional work on the spatiotemporal distribution of (particulate) pollutants. This could be done for example by a model approach or by using extended networks (EARLINET, AERONET...) yielding if possible information on a vertical scale. The description of meteorology is fine.

Please also note the supplement to this comment:

<http://www.atmos-chem-phys-discuss.net/10/C11483/2010/acpd-10-C11483-2010-supplement.pdf>

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 19129, 2010.

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