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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Formation and transport of photooxidants over Europe during the July 2006 heat wave – observations and GEM-AQ model simulations" *by* J. Struzewska and J. W. Kaminski

**J. Struzewska and J. W. Kaminski**

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Reply to the Anonymous Referee #2

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1. P1 right column: What does "averaged mean temperature" refers to? Global temperature? Mean ground-level European temperature? Summer temperature? It has to be precise.

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Reply:

It seems that this comment refers to the first version of the manuscript which had been



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corrected before the on-line release. In the current on-line version the term "seasonal mean temperature" is used, which refers to mean ground level temperature in summer months in Europe.

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2. P2: The description of the two previous heat waves are quite interesting but do not bring anything to the rest of the paper if their specificities are not discussed with regards to the 2006 episode. They should be better involved in the understanding of the studied phenomenon or strongly shortened.

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Reply:

The description of two previous European heat waves associated with severe photochemical pollution is given as a part of the introduction. It was our intention to provide a context and a comprehensive overview of the literature concerning heat wave phenomena in Europe. Considering the large number of articles on heat wave cases in 1994 and 2003, the authors decided to separate sub-sections (1.1 and 1.2) to these scientific studies.

Also, the authors wanted to underline the importance of pressure and circulation patterns and the exceptional nature of the 2006 case, giving the detailed description of the synoptic context of previous heat waves, which affected mainly Western Europe.

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3. P2-3, description of the 2006 HW: There is no reference to the origin of the data that are commented.

3.1 First, the sources (especially in Figure 1) should be mentioned.

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Reply:

The meteorological fields shown on Figure 1 are taken from the Canadian Meteorological Centre analysis. The following fields were used: surface temperature (at sigma = 1), sea level pressure and wind (given in knots) near the top of the boundary layer (sigma = 0.842). However, we have decided to remove this figure and keep only the description of the synoptic situation.

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3.2 Second, we don't know if those comments are the "official" description of the phenomenon, and extracted from national weather services reports, or if this is a data analysis provided by the authors of the paper.

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Reply:

The description of meteorological situation over Europe during the first two weeks of July 2006 is based on the analysis of the surface weather maps undertaken by the authors (generated with Digital Atmosphere software from SYNOP reports, and available from European meteorological services). The daily reports from weather prediction service at ICM (Interdisciplinary Centre for Mathematical Modelling - weather.icm.edu.pl) were also used to confirm results of the analysis.

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3.3 The same questions raise for the ozone episode: "High ozone concentrations transported northward" "High pressure ridge enhanced the local ozone production". There are interpretations of local ozone measurements in terms of air mass transport and processing: are they provided by a model study?

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Reply:



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The description of ozone episode was prepared by the authors based on the analysis of available measurements as well as on the information from EEA and some European environmental agencies. For the interpretation of the local ozone measurements the analysis of the products from air quality forecast systems (i.e. EURAD and Chimere) were undertaken.

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4. What does support the enhancement of local production versus the hypothesis of continental transport?

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Reply:

As mentioned, the authors analysed thoroughly the development of the meteorological situation and have used this information to interpret the evolution of the photochemical episode. One can assume that in calm or blocking conditions elevated ozone concentrations are driven by temperature and local emissions. On the other hand, elevated ozone concentrations could be associated with long-range transport due to well defined wind patterns.

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5. P6 : Why is there no measurement station selected in the Nordic countries? As they are at the same longitude as Central Europe, they could have brought an interesting comparative point.

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Reply:

The analysis of the 2006 heat wave case started in September 2006. At that time there were no other observations available for the comparison and there are no measurements for the year 2006 in AirBase yet. However, the authors believe that presented



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analysis for 23 stations are sufficient to prove model performance in different regions in Europe.

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6. P6-8: The ozone statistics and comparison of modelled ozone timeseries to measurements are interesting but some aspects of this model evaluation study are not discussed.

6.1 The 4 graphics (Fig4 to Fig7) show that the model well captures the day-to-day evolution of the HW, in Western Europe as well as in Central Europe. But only the 4 stations that show the lowest MBE combined with the highest Correlation Coefficient are shown. How does ozone behave in the model relatively to measurements in Purnay or Widochowa? And what does it imply for the ability of the model to reproduce means and maxima of ozone all over Europe?

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Reply:

The temporal variability of ozone concentrations observed in the UK, France and Central Europe differs mainly due to dynamical factors. The four figures were selected to represent these differences, and the value of the correlation coefficient was not a criterion. Stations in England showed high ozone concentrations on 3 and 4 July and decreased significantly due to the inflow of clean Atlantic air masses over the following days. Low ozone concentrations were recorded till the end of the analysed period. In France, high ozone values persisted till 4 July and decreased after 5 July, due to frontal activity. However, after 12 July the ozone concentrations again reached high levels. In Poland, at most stations a rapid increase in ozone concentrations was noted till 8 July. During the following days, on some stations the ozone levels did not change until 12 July and decreased slightly at the end of the analysed period. Other stations showed a slight decrease around the 9 and 10 of July and then increased further.



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For the information of the reviewer - at Purnay le Temple station the model follows observed ozone variability in this region. Comparing to results for Rambouliet station shown in Figure 5, the model overestimated ozone levels at Purnay le Temple during night time, which was discussed in section 4.1. For Widuchowa station, located in rural Poland, the model underestimated ozone concentrations during the day in the first week (especially July 6th and 7th). However, the trend of the increase and further decrease was captured well. Underestimation of daily maximum is probably due to underestimated emissions in this region.

In general, based on analysis of error measures and time series, the model performed well and reproduced different variability patterns correctly. The discrepancies have been discussed in the paper.

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6.2 The paper focuses on ozone maxima in Central Europe but the 2 graphics shown for Central Europe (Fig 6 and 7) do not show any peak above 160 ug/m3. Is it representative of what happened? There are many points above this value in Figure 8. Stations where peaks were observed should be better illustrated in the time series.

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Reply:

On Figure 8 (scatter plot of maximum daily ozone concentrations) there are two groups of points: blue squares represent Western European stations and red squares Central European measurement sites. Values exceeding 160 ug/m3 were measured mainly in Western Europe (blue squares). In Central Europe ozone concentrations higher than 160 ug/m3 were observed only on June 6th and June 11th at some stations.

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6.3 The authors explain that the underestimation of ozone maxima between 11 and 13 of July in Central Europe are due to an overestimation of the cloudiness in the model,



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that in turn underestimates temperature and the biogenic VOC emissions. But the only comparison of modelled ground temperature with measurements exactly shows the contrary on July 11 and 12. Is the station well chosen?

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Reply:

As mentioned in section 4.1, the dynamical forcing were not the same over different parts of Central Europe. Due to the very slow movement of the frontal zone, the western part of Poland was influenced by the trough, while the north-eastern part was influenced by the high pressure ridge. The temperature time series in Figure 9 were shown as an example of the GEM-AQ model performance. It would be difficult to find one representative temperature variability pattern for all sites, and temperature measurements were not available at all sites. The effect of temperature underestimation on 11 - 13 of July resulting in too low ozone maximum concentrations was observed only at some stations.

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6.4 The temperature vertical profile in Figure 15 also shows that temperature at ground level on July 12 is overestimated at the selected station of Central Europe, although the text mentions the contrary (P10, right column).

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Reply:

This remark refers to the first version of the manuscript, where vertical profiles of meteorological parameters were generated for wrong observation periods. In the on-line version Figure 15 shows modeled temperature underestimation within the ABL (near the surface: GEM-AQ ˜23C vs. observations ˜30C), which is consistent with the description given in section 4.3.



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6.5 Furthermore, the "emission" aspect is not discussed here: How well are the VOC emissions in Central Europe understood by inventories? It remains strongly possible that the highest peaks are not reproduced by the model due to an underestimation of the VOC emission by the inventory.

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Reply:

Anthropogenic VOC emission over Europe is based on the EMEP inventory for NMVOC. Due to the resolution of the original dataset (50 km) there might be regions where emissions are underestimated. However, the authors have no competence to question the quality of the EMEP inventory.

It is also possible that biogenic emissions used in this simulation are not representative for the heat wave conditions, but this issue requires further investigation and performing additional sensitivity studies.

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7. P9: The differences in the scaling of the graphics make it difficult to compare. The "bad restitution" of NO2 in figure 12 does not seem to be a real problem as the absolute difference is rather low, especially considering the resolution of the model and the possibility of local perturbations at any rural station.

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Reply:

The same scaling factors are strongly recommended for ozone and temperature plots. However, in the case of NO2 concentrations the difference between two stations shown in Figure 11 (Olkusz) and Figure 12 (Mscigniew) is nearly the order of magnitude, hence the same scaling does not improve the clarity of Figure 12. Referring to the poor



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resolution of emission data we meant EMEP emission inventory used in this study. It should be underlined that two stations shown on these figures are examples of variability patterns, and the description given in section 4.2 is more general and refers also to other measurement sites.

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8. P11: The discussion of air quality indices is interesting but as the discussion is based on modelling results, the words "recorded", "occurred" or "levels did not exceed" should not be used as it is only a model point of view. Along this paragraph, the text maintains a confusion between what actually happened and what was modelled. The word "modelled" should be added in all the related figures captions.

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Reply:

We will make the suggested modification in the way model results are referred to.

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9. P13 : There seem to be a wrong legend in Figure 16b, this cannot be temperature.

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Reply:

Figure 16(b) shows the maximum ozone 8-hour moving average. Again - it seems that this remark refers to first version of the manuscript. There was an error in the figure description, but it was already corrected before the final on-line submission.

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10. P14: The conclusions are a little bit repetitive, they can be shortened.

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Reply:

The Conclusions section itself is not "repetitive". However, some information presented in the Conclusions is a summary of previous sections. As the paper is relatively long, such a summary of the meteorological context, modelling tools, evaluation methods, and the list of analyzed indices can help the reader to follow the main conclusions.

The impact of the 2006 heat wave on photochemical pollution is summarized with respect to geographical location. Moreover, the authors tried to identify mechanisms leading to elevated ozone levels. Such analysis was not provided in previous sections where the detailed description of the results was given.

However, the authors will follow the reviewer's suggestion and will make an attempt to shorten and clarify this section.

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10.1 The sentence about "biogenic VOC flux enhanced (that) did not have a significant impact on ozone production" is not supported by any evaluation of emissions in the text of the paper, nore by ozone production calculation. This should not be affirmed in the conclusions without initial analysis and discussion in the paper.

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Reply:

As already mentioned in the reply to comment 6.5, the estimation of biogenic VOC emission fluxes is uncertain mainly due to insufficient number of measurements representative for different locations and vegetation types. During heat wave conditions this uncertainty could be even larger, especially in the north-eastern part of Europe, where very high temperatures are not normal.

The analysis of the impact of biogenic VOC on ozone formation requires additional simulations (i.e. sensitivity studies), which are beyond the scope of this paper. We will



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leave this statement, underlining that this is a hypothesis.

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Interactive comment on Atmos. Chem. Phys. Discuss., 7, 10467, 2007.



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