

## ***Interactive comment on “Weekly patterns of aerosol in the United States” by D. M. Murphy et al.***

**D. M. Murphy et al.**

Received and published: 10 March 2008

Reply to reviewers:

We thank all three referees for their constructive comments.

S18: Anonymous referee #1:

The referee noticed that we had handled sites and clusters differently: we normalized clusters before computing the average over the continental US but did not normalize sites before calculating the weekly cycles for clusters. The referee suggested that it would be more consistent if we normalized the individual sites before averaging into the clusters. In response to this comment, we have performed the calculations both ways and the results are essentially identical. For example, the national average weekly cycle for elemental carbon changes by about 0.2% (out of about 15%) depending on whether sites are normalized or not before the clusters are averaged. This can be qualitatively seen by noting that the weekly cycles of median values (blue curves) on the

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various map figures are often nearly hidden behind the weekly cycle of the averages. This would not be the case if the averages were being determined by a few sites with high absolute concentrations and weekly cycles unrepresentative of the entire cluster.

There are advantages and disadvantages to normalizing sites before averaging to clusters. We agree with the referee that an advantage of normalizing first is that it better accounts for the weekly cycle from urban plumes with different amounts of dilution. The disadvantage of normalizing is that it assigns equal weights to records with incomplete records or greater uncertainty due to low absolute concentrations. On balance, we believe that normalizing clusters but not sites within a cluster is a good compromise. The standard deviations of sites comprising individual clusters are about half the deviations of clusters from the continental average. So the advantage of better handling dilution is more important at the larger scale. The averaging to clusters produces complete records with better signal-to-noise than individual sites, so the disadvantage of amplifying noise from normalization is less important at the cluster level. We have added a paragraph to the manuscript about these issues. Of course, perhaps the most important point is that the two methods of averaging sites into clusters lead to a very small differences in the weekly cycles of the clusters.

This referee also had several technical comments. The first two have been corrected. The word "southern" has been retained because southern California has significantly larger nitrate concentrations than northern California. We have corrected the references.

S20: Anonymous referee #3:

The suggested corrections for the abstract have been made. We are confident that general aviation is the most plausible explanation for the change in the Pb to Zn ratio on weekends. Note that "general aviation" has a specific meaning referring to small, mostly private airplanes.

We have added the references to J. Murphy et al. (2007) and Bäumer et al. (2008).

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We have repeated the exclusion of urban sites in the implications section. We agree that a separate analysis of the urban sites would be interesting but it is beyond the scope of this paper. We have rephrased the sentence on averaging over the United States.

The referee is correct that in the submitted manuscript the overall average for PM<sub>10</sub> was not available. We have added a column to Table 1 with the overall average for this and other species. We have extended the sentence about the Thursday maxima in concentrations. We have added references for the soil equation and issues in the organic-elemental carbon split. References have been added for the comparison to diesel emissions and the stability of ammonium nitrate.

In Figure 4 top left panel the national average minimum for elemental carbon is indeed on Sunday and the wording in the paper has been adjusted accordingly. We have added references for dust from traffic and construction activities. We have expanded the discussion of the indirect effect.

The captions for Figures 1 and 8 have been adjusted and typographical errors in the references have been corrected.

S428: Anonymous referee #2

The referee is concerned about the clustering methods. We agree that different clustering methods will give slightly different clusters, and that other information could have been included besides geographical region to put similar sites into clusters. For example, altitude of the sampling site can affect concentrations. Our exclusion of urban sites does make the clusters more uniform. Beyond that, one criterion is that the sites within a typical cluster are more similar to each other than the cluster is similar to other clusters. This is true for the clusters we have chosen: the average standard deviation of concentration of sites within clusters is about half the standard deviation of clusters from the continental average.

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The referee suggested Gong and Richman (1995) as a reference. That paper compared methods for geographically clustering stations with precipitation data. A few clustering methods using single linkage distance measures were markedly inferior. Most other cluster methods, including one similar to ours (their AL1ED case), had very similar scores to each other. Our method has the advantages of a simple distance measure (geographic distance) and a unique outcome for a given set of sites. In contrast, some non-hierarchical methods start from random seeds and can generate different clusters depending on those random seeds.

The referee states that tests from resampling alone may not enough to guarantee statistical significance. Besides resampling, we also computed 5 and 8-day cycles. Their magnitudes were similar to the magnitudes calculated using randomly resampled data. This suggests that the resampling is providing a reasonable estimate of statistical variability. Only the 7-day cycles were much larger than estimated from resampling. The referee also suggested we try rank sum non-parametric statistical tests. Some spot checks show highly significant cycles. For example, the data shown in the Figure 5 histogram have a random probability of less than 0.00001 using a Wilcoxon Rank-Sum test. Figure 5 is included so readers can judge that statistical significance. The weekly cycles in aerosols are often a substantial fraction of the annual cycle. This makes the statistical analysis much more robust than studies of weekly cycles in temperature or precipitation.

We have added a note that the samples are collected on the same days at every station. The use of third day sampling also results in successive samples being auto-correlated much less than daily samples. This is stated in the manuscript (p. 526, line 24 in the discussion version).

To make them easier to read, the map figures have been modified to increase the vertical scaling of the weekly cycles of the individual clusters. We have corrected the discussion of summer nitrate to say the weekly minimum is on Sunday.

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Additional changes not requested by referees:

We have added references to additional papers about weekly cycles of emissions and precipitation (Chinkin et al., 2003; Bell et al., 2008).

#### References

Gong, X.-F. and M.B. Richman, 1995: On the application of cluster analysis to growing season precipitation data in North America east of the Rockies. *J. Climate*, 8, 897-931.

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Interactive comment on *Atmos. Chem. Phys. Discuss.*, 8, 521, 2008.

ACPD

8, S648–S652, 2008

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