

## ***Interactive comment on “Cluster analysis of WIBS single particle bioaerosol data” by N. H. Robinson et al.***

**N. H. Robinson et al.**

niall.robinson@metoffice.gov.uk

Received and published: 21 December 2012

We thank Dr Pan for his comments on our paper, and will address them as detailed below.

1. The cluster indicated in the comment (C, Tab. 3) cannot be dominated by 1  $\mu\text{m}$  non-fluorescent PSL aggregates, as that cluster is itself associated with single 1  $\mu\text{m}$  PSL aggregates. We assume, therefore that the reviewer is referring to clusters D, E or F potentially being aggregates of C.

The PSL suspension was diluted with deionised water before being nebulised using a collision nebuliser. Subsequent tubing was minimised before the aerosol was intro-

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duced to the WIBS. If we understand the question properly, the reviewer is asking if clumps of smaller PSLs are contributing to data that are associated with larger PSLs. Note that Fig. 5 is time resolved on the x-axis, meaning that we can see that no data belonging to large clusters are associated with the nebulisations of the smaller PSLs.

2. The reviewer is right that the separation of AF between clusters A and B is small on the full scale of the WIBSs AF measurement response, which is approximately 5–40 in practice. However, we would point out that the range of AF in the instance of PSL measurements is between approximately 3 and 7 (as they are all presumably close to spherical). It should also be noted that the two clusters indicated have average AFs at either end of this range (3.9 and 7.2). Therefore, this separation in AF values, whilst absolutely small, is significant as far as the cluster analysis is concerned. As we have said in the comments to the first reviewer, we do not know if this separation in AF is due to a physically bimodal PSL AF distribution, an artificially bimodal instrument AF response, or just statistical noise. It should be noted that the cluster analysis of PSLs was far more robust when just using size alone, however, we wanted to test the approach we were going to use to analyse ambient data. It should also be noted that the complete separation of different PSLs using WIBS measurements may be expected to be challenging, as one would expect PSLs to be similar in all attributes apart from size, and the size range of nebulisable PSLs is only a fraction of the dynamic range of the WIBS.

3. We very much agree with the reviewer's point in that the AF may be different for different aggregates of the same PBAP type. We would make the point that this is potentially an advantage of the analysis: the analysis routine should only separate particles with bimodal distributions, meaning that, while the constituent PBAP may be the same, the clusters are different. For instance, this could lead to the separation of fresh bacterial clusters from aged bacterial clusters, the latter of which may be expected to have a higher AF.

While we accept that we do not explicitly discuss this issue with respect to AF measure-

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ments, there is a broader point made on P6394, I23 – P2395, I2 which encompasses all physical and chemical processing. If the reviewer is amenable, we would rather not weight this discussion towards AF, as we believe it is equally an issue with the other measured variables.

4. Please see the response to Q2 and the response to the first reviewer. Briefly, all the AF values are small compared to more asymmetric aerosols meaning this spread in values is likely to be merely due to the precision of the measurement.

5. In principle we agree with the reviewer, however, we have attempted to use various different ratios. In particular we tried to normalise the fluorescence of the particles to their size (p6395, I9) but we found that this did not give a stable indication of particle quantum yield (by inspection of PSL measurements). There is also an issue with taking channel ratios when comparing channels measuring low fluorescence to those measuring high fluorescence, with division by small numbers leading to very large uncertainties. We also refer the reviewer to the response to Q3 which addresses the point about resolving similar aerosols into different groups.

As such, we took the view that it was more transparent to analyse the data as presented, however, we anticipate that the WIBS community may be able to refine the process in the future as the instrument develops. (Indeed, this WASP analysis software allows different cluster analysis variables to be easily substituted for analysis).

6. We thank the reviewer for bringing these papers to our attention, and will reference them in the manuscript.

7. Similarly, we would like to include the papers highlighted in this comment, as they are certainly relevant to our manuscript. However, upon reading the papers, we have not been able to find any examples of cluster analysis being applied to long term online PBAP measurements. As we read the papers, the data coverage is as follows:

- Pan et al. 2007: CT site 24th to 25th of October 2006, NM site 22nd to 23rd of October 2006

January 2007

- Pan et al. 2012: CT site states measurements were made during January 2008 with no indication of dates or if the measurement was continuous. Adelphi site states that measurements were made during September 2008. This section in the introduction:

Fig. 1 shows the integrated UV-LIF spectra from atmospheric aerosol particles, the associated intensity contour map, and total number of detected aerosol particles for every 10-min interval. They are measured from 17:00, Jan. 4 – 23:00, Jan. 5, 2008 in New Haven, CT (left column) and 17:00, Sept. 15 – 18:00, Sept. 16, 2009 in Adelphi, MD

seems to say that the measurements covered approximately two separate days.

- Pinnick et al 2013: It appears that this study covers four 24h periods

Assuming we have not misunderstood the indicated papers, we maintain that this is the first time this type of analysis has been performed on long term ambient data. Such datasets are relatively rare as there are only a handful of field deployable online instruments such as the WIBS. As such, we will indicate that there are other similar studies, but that this is the first one employing long term continuous measurements.

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Interactive comment on Atmos. Meas. Tech. Discuss., 5, 6387, 2012.