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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Haze in the Klang Valley of Malaysia" *by* M. D. Keywood et al.

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Abstract 1. Smoke is smoke from biomass burning. 2. The abstract has been lengthened to include more specific detail about the evidence for smoke from biomass burning being a significant contributor to light scattering. The abstract now includes the following: ŞThe evidence for smoke from biomass burning being a significant contributor to aerosol during periods of excessive haze is discussed. For example, during periods of excessive haze, the chemical composition of the aerosol showed enhanced concentrations of elemental carbon, organic carbon and non-seasalt potassium. The diurnal cycle of Bsp and PM10 was disturbed from its usual cycle of maxima overnight and minuma during the day with morning and afternoon traffic peaks, and instead showed a maximum peak during the middle of the day. Periods of excessive haze were coincident with the presence of forest fires on Sumatra during the southwest (SW) monsoon period, the influence of which are demonstrated by transport modelling for one week of the SW monsoon of 2000Ť. 3. The abstract also now includes more detail about the ubiquitous presence of secondary aerosols. ŞThe study highlights that whilst trans-

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boundary smoke is a major contributor to poor visibility in the Klang Valley, smoke from fires on Peninsular Malaysia is also a contributor. In addition the fairly uniform concentration of non-seasalt sulfate in PM2.5 at both sites over the entire sampling period is interpreted to infer the presence of a domestic source of secondary aerosol production in the Klang Valley.Ť Introduction 4. The size range that scatters light most efficiently is 0.1 to 1 μm (Findlayson-Pitts and Pitts 2000). This is now included in the text. 5. In this paper we describe visibility reduction in terms of aerosol scattering coefficient. We measured EC using the integrated plate method (which is an absorption method) however, it is the scattering coefficient data that we use to discuss the haze. 6.We have amended this sentence to the following ŞThe Malaysian Haze Study (MHS) aimed to improve understanding of the haze phenomenon by investigation of the chemical composition, scattering coefficient and the mass concentrations of atmospheric particles at two sites in the Klang Valley region near Kuala Lumpur (see Figure 1)Ť. Aerosol haze has been replaced with atmospheric particles. 7.Smoke here is used to mean primary particles produced by biomass burning. We used the more constant non-seasalt sulfate time series data to infer a domestic or local secondary particle source. The time series of non-seasalt potassium and estimated organic mass (EOM), which we use to infer the transboundary smoke source, show a pattern similar to the scattering coefficient and PM10 time series with maxima during the periods of excessive haze. So we have amended the sentence to ŞIn this work, two major sources of particles, primary particles from biomass burning (smoke) and secondary production from domestic sources, are discussed in terms of their contribution to the seasonal and diurnal patterns of haze developmentŤ. Methods Measurement Methods 8. The nephelometers were operated at 40žC. The resultant RH was less than 5%. We measured the scattering coefficients of the dry particles because we wished to compare the scattering coefficient at different times of the day and different times of the year, thus we removed water as a possible confounding factor. We have calculated the RH-adjusted scattering coefficient, however this will presented elsewhere in a paper dedicated to the hygroscopic growth of the aerosol. In summary though, between April and De-

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cember 2000 we operated a second nephelometer at the Petaling Jaya site, run at ambient RH. We calculated the RH-adjusted scattering coefficient from the dry scattering coefficient data and compared this with data from the ambient nephelometer. The discrepancy averaged 16% of the ambient scattering coefficient. The extent to which the RH-adjusted scattering coefficients differed from the dry scattering coefficients was obviously dependent on RH. 9. We used the PC filters as these are the most suitable for the analysis of insoluble elements by PIXE analysis. This information is presented in Table 1. 10. The decision to sample PM2.5 on a daily basis was made in communication with the personnel from the Malaysian Meteorological Service, who operated a TEOM at the Petaling Jaya site. Generally once PM10 exceeded 50μg m-3 for several consecutive days daily sampling was initiated. Unfortunately this took place most efficiently towards the end of the study. Analytical Methods 11. The temperature of the furnace was 850 žC. This is now included in the text. 12. The ions discussed in this paper were those that could act as markers or tracers for specific sources. We show that nitrate makes up 3% or the inorganic mass at Petaling Jaya and 2% at Gombak (Figure 8). The reviewer comments a number of times on the nitrate concentrations measured in this study, suggesting that they may be low for an urban site. We found that nitrate showed positive correlation with sodium, potassium and magnesium, all species found in seasalt particles. Nitrate will condense onto the weakly alkaline sea-salt particles, which are predominately in the coarse particle range. In this study PM2.5 is sampled, thus it seems likely that we are not actually sampling most of the nitrate present on the coarse alkaline particles. Note also that the concentrations of the sea-salt species are also low. Observations 13.In this paper we describe visibility reduction in terms of aerosol scattering coefficient, and we use the Koschmeider relationship to determine a visual distance. We do assume that the extinction coefficient (Be) in the Koschmeider equation is due to the scattering coefficient, however as pointed out by the reviewer since EC (and thus absorption) makes up 33% of Gombak aerosol mass and 28% of Petaling Jaya aerosol mass, this may not be a correct assumption. Correcting LVD to take into account the 28% average EC concentration at Petaling Jaya reduces the LVD

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by 19% , similarly for Gombak, the LVD is reduced by 22%. We have corrected the data shown in Figure 2 to take into account the absorbance due to EC. 14. Here we mean that the diurnal pattern in aerosol scattering can be explained by the increase in particles produced from car exhaust during the traffic peaks. Thus it is an overall increase in the concentration of particles rather than any particular chemical component of the aerosol that produces this diurnal pattern. 15. The figures appear to be labeled incorrectly, this has been amended Aerosol Mass. 16. We cannot find reference in the abstract to PM2.5 samples being collected on a daily basis during periods of excessive haze. We did plan to do this but as noted by the reviewer we were only able to for the last haze period in 2000. Aerosol Chemistry 17. The likely sources of SO2 in the Klang Valley are industry and the Port Klang power station coal-fired). According to Manins (1994) the industrial and power station emissions dominate over emissions from vehicle exhaust. The sulfur content of diesel in Malaysia as of 1994 was 0.5%. 18. As noted in section 3.4 we compared 24 measurements of OC with the EOM and found good agreement within the 20 % uncertainty of the OC method. We can use the difference between the EOM and the measured OC (21% n =24) as the uncertainty for the EOM. We believe that any overestimation due to propagations of uncertainties in the EOM equation will be accounted for in this estimate of EOMs uncertainty. A note about unidentified speciesĚfor the ionic analyses, all data reported adhered to USEPA criteria for ionic balance and conductivity (page 621 line ll), suggesting that all significant ionic species had been identified. All major insoluble species usually identified in aerosol chemical composition were identified in the present study. Thus we anticipate that the unidentified species make up an insignificant fraction of the IM portion. However we do acknowledge that the mass of these unidentified species will actually appear as EOM in this study. 19. Reference to section 4.4 is a mistake on our part, it should read Şsee section 3.4 for detailsŤ. Mass Balance 20. We agree that using our method for thermal decomposition we are measuring organic carbon (OC) so have changed all reference to OM to OC. 21. There are 24 points in this plot (12 from Gombak as unfilled circles and 12 from Petaling Jaya as filled circles). 22. We have

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added the average concentration of PM2.5 for each site to the caption of Figure 8. The species that make up ŞothersŤ in the Figure 8 include Br-, NO2-, PO43-, F-, acetate, formate, methanesulfonic acid (MSA),Ti, V, Cr, Mn, Cu, Co, Ni, Zn and Pb (we have included this information in the figure caption also). The difference between the ŞothersŤ measured at the each site arises due to an error, which has been corrected. For both sites IM was calculated using the method of Brook et al. (1997) and for the Gombak the sum of the species making up ŞothersŤ was also calculated using Brook et al.Šs method (which takes into account oxides etc for the insoluble species). However, for the Petaling Jaya site, the sum of the species making up ŞothersŤ was incorrectly calculated simply as the sum of the concentrations. The updated figures show that there is very little difference between the two sites. We have also updated the figure to show the organic acid components (acetic and formic acid). 23. We have modified this statement and included a reference. The text now reads ŞOxalic acid is produced from the combustion of the cellulose material in vegetation (Gao et al. 2003).Ť Discussion 24. The correspondence of EOM and nssK suggests to us that EOM is derived from biomass burning. This is clearly stated in this paragraph. 25.We have added the reviewers suggestion to the text. It now reads ŞNa+ and Si are both minor components of IM, indicating, as expected, that sea-salt and soil-dust are insignificant sources of PM2.5 aerosol.Ť 26.The Br measurements we made in this study were close to the detection limit of our analytical system, and this is not unexpected since unleaded fuel is now used in Malaysia, thus Br is no longer an adequate tracer for vehicle emissions there. 27.We have changed the section title to ŞSmoke from biomass burning- seasonal variationsŤ. 28.We agree that during the SW monsoon, the lack of rainfall will promote the build-up of particles and enhanced Bsp. However the other evidence presented here (the presence of fires on Sumatra and Kalimantan) and the wind directions all suggest that it is the fires that are supplying the particles to the Klang Valley Region. 29.We chose to use TAPM for our modeling study as it outputs variables such as planetary boundary layer and PM10 (Figure 13). We chose the July 2000 haze period as we carried out the modeling study early in the project and the results are definitive

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enough that we didnŠt feel it was necessary to repeat the modeling for the following year. We used the meteorological component of TAPM to generate the wind directions presented in Figure 11 and while we recognize the robustness of data generated by HYSPLIT, the output we required for Figure 11 was not readily available from HYSPLIT. The performance of TAPM has been compared with other air pollution and meteorological models (RAMS and MM5) available at www.dar.csiro.au/TAPM. Conclusions 30. This paper is an overview of the MHS project. It describes the project, how it was carried out and some preliminary overall results. It is not meant to focus on the chemistry of the aerosols, instead the chemistry and other evidence is used to make some preliminary interpretation about the sources of haze in the Klang Valley. We feel that this is adequately presented in the Conclusion. As indicated on line 9 of page 628 and in the Conclusion (page 633 line 15) a more detailed and quantitative source apportionment using the chemical analyses of the aerosols study will be reported elsewhere. 31. We donŠt think it is possible to say which chemical species contributed most to the haze, even with a detailed source apportionment, as it is really the aerosol as a whole that contributes to haze. All we can do is use the chemistry to identify possible sources of the aerosol (and these sources will carry particular chemical signatures). This we have done in a qualitative fashion in this paper and as already stated this will be done quantitatively elsewhere.

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