Atmos. Chem. Phys. Discuss., 14, C2752–C2758, 2014
www.atmos-chem-phys-discuss.net/14/C2752/2014/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Assessing the regional impact of Indonesian biomass burning emissions based on organic molecular tracers and chemical mass balance modeling" *by* G. Engling et al.

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Received and published: 26 May 2014

Reviewer 2 The paper is written by scientifically sound and concise way and brings new important data about the influence of biomass burning emissions in Indonesia influencing Singapore air quality. They provide broad range of chemical analysis data of ambient aerosol to support and prove the aerosol origin illustrating its biomass combustion origin during polluted days.

Response: We thank the reviewer for the constructive comments on the manuscript. We have provided our point-by-point responses to the comments and suggestions of

the reviewer below and will incorporate the changes into the manuscript accordingly.

Comment #1: However, there is one part that might be improved. The analysis of metals provided several astonishing results that deserve more attention. Copper concentrations increased 30 times to the levels of matrix elements while common biomass tracer potassium was increased 4 times only. Although the explanation given in the paper is possible, it does not say where such high levels of copper may come from. (Are there any copper mines or any other (e.g. agriculture) possible copper sources?) There might be also copper sources emitting copper to the same air masses as those coming with biomass burning products. Zinc concentration is often elevated in biomass combustion emissions, but in this case they are even lower than in clean case. See et al. 2007 e.g. found enrichment factors for PM2.5 equal to 10ËĘ7 for Zn, but only 10ËĘ2-10ËĘ3 for copper in peat fire episode in Indonesia. Coarse part of the aerosol may explain the difference, but this should be reflected in the text. The same results were used for CMB as peat burning source profile, how the Cu could be explained by this factor?.

Response: There is a copper mine (Beutong mine, one of the largest copper mines in Indonesia) in the Sumatra region where peat fires occurred during the haze episode. In addition, agricultural activities are also very prevalent in the region. These are the major possible sources of copper. As for zinc, previous measurements in Mexico City and in Beijing showed that Zn particles were mainly derived from industrial activities and waste incineration (Moffet et al., 2008; Li and Shao, 2009). There is also some Zn emission from biomass burning (Gaudichet et al., 1995). See et al. (2007) carried out the field study in the vicinity of small-scale peat fires. However, the current study was conducted at an urban location in Singapore at a different time period, so there might be differences in the abundance and distribution of metals because of differences in the type and age of biomass burning plumes. Moffet, R. C., de Foy, B., Molina, L. T., Molina, M. J., and Prather, K. A.: Measurement of ambient aerosols in northern Mexico City by single particle mass spectrometry, Atmos. Chem. Phys., 8, 4499–4516, doi:10.5194/acp-

8-4499-2008, 2008. Li, W. and Shao, L.: Transmission electron microscopy study of aerosol particles from the brown hazes in northern China, J. Geophys. Res., 114, D09302, doi:10.1029/2008JD011285, 2009. Gaudichet, A., Echalar, F., Charenet, B., QuiseïňĄt, J. P., and Malingre, G.: Trace elements in tropical African savanna biomass burning aerosols, J. Atmos. Chem., 22, 19–39, doi:10.1007/BF00708179, 1995. During CMB runs some of the chemical species which do not lead to convergence of the source estimates are typically excluded from the model runs. Therefore we did not use Cu as one of the source species in the model for the samples with extreme Cu concentrations. We added the following text in the revised manuscript. "There is a copper mine (Beutong mine, one of the largest copper mine in Indonesia) in the Sumatra region where peat fires occurred during the haze episode which could be one of the additional sources of copper apart from peat emissions. However, whether or not the soil in this local area contains high concentration of copper needs to be further investigated."

Comment #2: p. 2775, line14: reference Muraleedharan et. al., 2000 is missing in reference list

Response: The following reference is now added in the manuscript. Muraleedharan, T.R., Radojevic, M., Waugh, A., and Caruana, A.: Emissions from the combustion of peat: An experimental study, Atmos. Environ., 34, 2733 – 2738, 2000.

Comment #3: p. 2776, line18: reference Sundarambal et. al., 2010 is missing in reference list

Response: The following reference is now added in the manuscript. Sundarambal, P., Balasubramanian. R., Tkalich, P., He, J.: Impact of biomass burning on ocean water quality in Southeast Asia through atmospheric deposition: Field observations, Atmos. Chem. Phy., 10, 11323–11336, 2010.

Comment #4: p. 2776, line 21: SI units are preferred nowadays

Response: We now presented the value in SI units.

Comment #5: p. 2776, line 24 -25. It is not clear from the text when the filters were folded – before or after the analysis as I would expect.

Response: We rewrote the sentence as follows. "The TSP filters were folded in half lengthwise after sampling, so that only surfaces with collected particulate matter were in contact, when placed in the filter holder (glassine envelope)."

Comment #6: p. 2777, line20: reference Birch and Carry, 1996 is missing in reference list

Response: This reference was added in the revised manuscript: Birch, M. E. and Cary, R. A.: Elemental carbon-based method for monitoring occupational exposures to particulate diesel exhaust, Aerosol Sci. Tech., 25, 221–241, 1996.

Comment #7: p. 2778, line4: references Engling et al., 2006 and Iinuma et al. 2009 are missing in reference list

Response: The following references are now added in the manuscript. "Engling, G., Carrico, C. M., Kreidenweis, S. M., Collett, J. L., Day, D. E., Malm, W. C., Lincoln, E., Hao, W. M., Iinuma, Y., Hermann, H.: Determination of levoglucosan in biomass combustion aerosol by high-performance anion-exchange chromatography with pulsed amperometric detection, 40, S299 – S311, 2006. Iinuma, Y., Engling, G., Puxbaum, H., Hermann, H.: A highly resolved anion-exchange chromatographic method for determination of saccharidic tracers for biomass combustion and primary bio-particles in atmospheric aerosol, 43, 1367 – 1371, 2009."

Comment #8: p. 2779, line 19, a short explanation to representativeness of US EPA data for Singapore emission profile should be given

Response: We provide the following discussion in the manuscript as per reviewer's suggestions. "Source profiles of inorganic ions and trace elements used in the model were obtained from SPECIATE 4.3 (SPECIATE, 2011). The source profiles

for petroleum refinery (Cooper et al., 1987) and diesel emissions (Vega et al., 2004; Chow et al., 2002; Vega et al., 2000) obtained from the USEPA database are applicable to Singapore, since the process of refining crude oil, the engineering practices adopted in oil refineries, and the type of diesel used are similar to those in the studies included in the database. In Singapore most of the powerplants continue to use oil as a fuel of choice or as a fuel in tandem with natural gas. Therefore, the source profiles of oil fired powerplants (Henry and Knapp, 1980; Howes et al., 1983) included in the USEPA database were used in the model. Source profiles for Indonesian peat fires were obtained from our previous study (See et al., 2007) while for ship emissions it was obtained from Moldanova et al. (2009) and Popovicheva et al. (2009). The chemical species used in the CMB model were potassium, aluminum, cobalt, chromium, iron, manganese, lead, nickel, cadmium, titanium, vanadium, arsenic, chloride, nitrate, sulfate, ammonium, nitrite, calcium, and sodium."

Comment #9: p. 2781, lines 23-24: OM/OC conversion factor should be mentioned instead of OC/OM factor if its value is 2.

Response: We replaced "OC/OM" with "OM/OC" in the manuscript.

Comment #10: p. 2781, line25: reference Turpin and Lim, 2001 is missing in reference list.

Response: The following references is now added in the manuscript: "Turpin, B. J. and Lim, H.-J.: Species contributions to PM2.5 mass concentrations: Revisiting common assumptions for estimating organic mass, Aerosol Sci. Tech., 35, 602–610, 2001."

Comment #11: p. 2781, line25: using value 2 as OM/OC conversion factor apparently leads to analysed mass concentration higher than gravimetric mass concentration (see Fig. 3), therefore, based on these data, probably lower OM/OC conversion factor would be more appropriate for this type and age of biomass burning plume.

Response: We thank the reviewer for sharing the concern regarding the OM/OC con-

version. There was a typographical error in the TSP mass concentrations used for the haze period in Table 1. It should be 94.1 μg/m3 instead of 84.1 μg/m3. As per the reviewer's suggestion, we think that a conversion factor of 1.4 would make sense numerically for OM/OC, although considering the type and age of biomass burning plume the factor should be higher. We have revised our results and the text in the manuscript accordingly. "In the case of aerosols measured downwind of biomass burning activities, OM/OC factors of more than 1.4 have been suggested in literature for organic aerosols in urban areas (e.g., White and Roberts, 1977; Turpin and Lim, 2001). When applying a factor of 1.4 to the OC levels detected during the haze period, the content of organics in TSP was found to be extremely high (50% on average), while it was only around 25% during clear days."

Comment #12: p. 2782, line 3: a reference should be given after the world Literature.

Response: We have added the reference as per reviewer's suggestion in the revised manuscript.

Comment #13 : p. 2782, line 22: reference Hanningan et al. should be Hennigan et al.

Response: We have rectified the typographical error in the revised manuscript.

Comment #14 : p. 2783, line 20: reference Zhang et al. 2010 should include" a "or "b".

Response: We have rectified the typographical error in the revised manuscript.

Comment #15 : p. 2784, Line 2: diagnostic ratios tend to be dependent on an aerosol age, it should be mentioned.

Response: We have mentioned the following statement in the revised manuscript: "While PAHs are common combustion products of all carbonaceous materials, including fossil fuels and biomass, diagnostic ratios (DRs) of specific PAH species, although dependent on aerosol age, can be used to constrain the predominant influence of emissions from certain types of combustion."

Comment #16 : p. 2785, line 6: The sentence “Other than . . . “ should be corrected.

Response: We have rectified the sentence as follows: “Cu, Al, Fe, and Ti were the most abundant trace metals found in haze samples“

Comment #17 : p. 2788, line 11: the reference “Chandra. . .” is not mentioned in the text; p. 2788, line 18: the reference “Critical. . .” is not mentioned in the text; p. 2788, line 24: the reference “Duncan. . .” is not mentioned in the text

Response: We have removed these references from the list in the revised manuscript

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Interactive comment on Atmos. Chem. Phys. Discuss., 14, 2773, 2014.