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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.

G. Engling et al.

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Reviewer 3

General comments This manuscript provided detailed measurement of TSP and its source characterization in Singapore during both haze and non-haze periods. The results are interesting in indentifying a major PM source of biomass burning from peat fires in Indonesia over polluted days, which will be significant for the local authorities to implement air quality strategies in the region. I would suggest for acceptance and publication after completing the following corrections.

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: In Section 2.3, it is useful to state the original references for each source profile and the fitting species used in the CMB model.

Response: We have now included the original references for each source profile and the fitting species used in the CMB model in the revised manuscript (see below). The chemical species used in the CMB model were potassium, aluminum, cobalt, chromium, iron, manganese, lead, zinc, nickel, cadmium, titanium, vanadium, arsenic, chloride, nitrate, sulfate, ammonium, nitrite, calcium, and sodium.

POWER PLANT

Howes, J.E., Cooper, J.A., Houck, J.E., 1983. Sampling and Analysis to Determine Source Signatures in the Philadelphia Area. Draft Final Report to U. S. Environmental Protection Agency, ESRL, Research Triangle Park, NC. NEA, Inc. 1983.

Henry, W.M., Knapp, K.T., 1980. Compound Forms of Fossil Fuel Fly Ash Emissions. Environmental Science and Technology, 14, 450-456.

PETROLEUM REFINERY

Cooper, J.A., Redline, D.C., Sherman, J.R., Valdovinos, L.M., Pollard, W.L., Scavone, L.C., and Badgett-West, C., 1987. PM10 Source composition Library for the South Coast Air Basin. Volume I and II. Prepared for the South Coast Air Quality Management District, El Monte, CA. July 15, 1987.

DIESEL EXHAUST Vega, E., Reyes, E., Ruiz, H., Garcia, J., Sanchez, G., Martinez-Villa, G., Gonzalez, U., Chow, J.C., and Watson, J.G.: Analysis of PM2.5 and PM10 in the atmosphere of Mexico City during 2000-2002. Journal of the Air & Waste Management Association, 54, 786 – 798, 2004.

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Chow, J.C.; Watson, J.G.; Edgerton, S.A.; Vega, E. (2002). Chemical composition of PM10 and PM2.5 in Mexico City during winter 1997. Science of the Total Environment 287 (3), 177-201.

Vega, E.; Mugica, V.; Carmona, R.; Valencia, E., 2000. Hydrocarbon source apportionment in Mexico City using the chemical mass balance receptor model. Atmospheric Environment 34 (24), 4121-4129.

Comment #2: In Section 3.4 on source apportionment with CMB, it would be better to add a table showing the actual figures of the modeled results for the individual source contribution estimates, as the relative contribution in Figure 4 may mislead the results sometimes. As biomass smoke markers, levoglucosan in this study showed the highest elevation during haze days among all species measured, but in comparison potassium did not show much increase, why?

Response: We have included the table below in the revised manuscript in addition to Figure 4. (μg.m-3) Haze Clear days Ship Emissions 4.46 $\pm$ 1.77 6.48 $\pm$ 1.4 Petroleum Refinery 0.42 $\pm$ 0.17 0.59 $\pm$ 0.3 Power Plant - 0.55 $\pm$ 0.27 Diesel Exhaust 15.64 $\pm$ 6.21 14.88 $\pm$ 3.22 Peat Fires 63.58 $\pm$ 25.25 -

Levoglucosan is a source-specific tracer for biomass burning, as it is generated during thermal breakdown of cellulose and hemicellulose molecules. Potassium, on the other hand, can be derived from various emission sources, including biomass burning, but also from cooking, vegetation, sea salt and soil, especially in the coarse particle fraction. Since in this study we collected TSP, there is a likely substantial contribution of potassium from other sources than biomass burning, i.e., sea salt and soil, for which we didn't apply a correction. Thus, the increase in potassium concentrations during the haze episode is not expected to be as large as that for levoglucosan.

The following text was added in the manuscript "In comparison to levoglucosan, inorganic biomass tracer, potassium didnot show much increase during the haze period. Levoglucosan is a source-specific tracer for biomass burning, as it is generated during

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thermal breakdown of cellulose and hemicellulose molecules. Potassium, on the other hand, can be derived from various emission sources, including biomass burning, but also from cooking, vegetation, sea salt and soil, especially in the coarse particle fraction. Since in this study we collected TSP, there is a likely substantial contribution of potassium from other sources than biomass burning, i.e., sea salt and soil, for which we did not apply a correction. Thus, the increase in potassium concentrations during the haze episode is not expected to be as large as that for levoglucosan."

Comment #3: The total Cu concentration during haze period is about 30 times the value on clear days, but water soluble Cu only showed a factor of just over 4 for days of haze/clear. The authors argue that this may be due to that Cu oxides formed under high temperature combustion are less soluble. On the contrary, metal Al showed a factor around 30 for days of haze/clear for water soluble fraction, whereas similar values were observed for total Al. Explain.

Response: Water solubility of a metal depends on the chemical form in which it is present. The higher fraction of water solubility of Al during the haze might be due to the presence of more soluble Al in haze aerosols. However, additional investigation is necessary to examine the chemical fractionation of particulate-bound metals using a sequential extraction procedure. This investigation will account for (1) soluble and exchangeable metals; (2) carbonates, oxides, and reducible metals; (3) metals bound to organic matter, oxidizable and sulfidic metals; and (4) residual metals, while the current study quantified only the soluble and exchangeable metals. The outcome of the additional investigation will be published elsewhere. The following text was added in the manuscript

"Some of the metals such as Al have shown extremely high water soluble fraction ($\sim$30) during haze. In general, water solubility of a metal depends on the chemical form in which it is present. The higher fraction of water solubility of Al during the haze might be due to the presence of more soluble Al in haze aerosols. However, additional investigation is necessary to examine the chemical fractionation of particulate-bound

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metals using a sequential extraction procedure. This investigation will account for (1) soluble and exchangeable metals; (2) carbonates, oxides, and reducible metals; (3) metals bound to organic matter, oxidizable and sulfidic metals; and (4) residual metals, while the current study quantified only the soluble and exchangeable metals. The outcome of the investigation will be published elsewhere."

Comment #4: The author needs to check the references in both the text and the reference list as there are quite a few number of references in the text are not shown in the reference list, and vice versa.

Response: We have updated the reference list in the revised manuscript.

Comment #5: P. 2775, line11: Check the year in the reference ''Heil and Goldammer, 2002/2001''??

Response: We have corrected the year of the reference in the revised manuscript.

Comment #6: P. 2779, line 2: change ''quipped" to ''equipped"

Response: We have corrected it in the revised manuscript.

Comment #7: P. 2780, line 20-21: Rewrite ''some of the air masses arriving at Singapore arrived from" as ''some of the air masses arrived at Singapore from"

Response: We have rewritten the sentence as per the reviewer's suggestion.

Comment #8: p. P. 2782, line 22: Change ''Hannigan et al., 2010" to ''Hennigan et al., 2010"

Response: We have changed "Hannigan et al.," to "Hennigan et al.," in the revised manuscript.

Comment #9: P. 2783, line 20: Specify in the reference ''Zhang et al., 2010" as a or b

Response: We have rectified it in the revised manuscript.

Comment #10: P. 2785, line 16-17: Rewrite "The low solubility of this metal could

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be due to the chemical form in which it exists. For example, as metal oxides are produced during high- temperature combustion, a metal oxide is in general less soluble as compared to metal nitrates/sulfates." as "The low solubility of this metal could be due to the chemical form in which it exists, such as metal oxides produced during high-temperature combustion is in general less soluble as compared to metal nitrates/sulfates."

Response: We have rewritten the sentence as per the reviewer's suggestion.

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