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Interactive comment on "Size-resolved source apportionment of ambient particles by positive matrix factorization" *by* J. S. Han et al.

J. S. Han et al.

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1. Title will be changed to "Size-resolved source apportionment of ambient particles by positive matrix factorization at Gosan background site in East Asia"

2. The detailed description of the sampling techniques was sufficiently shown in previous works referred in this paper. More description will be overlapped with them.

(Reference)

Han, J. S., Moon, K. J., Ahn, J. Y., Hong, Y. D., Kim, Y. J., Ryu, S. Y., Cliff, S. S., and Cahill, T. A.: Characteristics of ion components and trace elements of fine particles at Gosan, Korea in spring time from 2001 to 2002, Environ. Monit. Assess., 92, 73-93, 2004.

3. Episodic analysis using meteorological information will be added to this paper using backward trajectory model (HYSPLIT 4) as shown in response 3 to referee #1.

(a) continental aerosol, (b) soil dust: The difference between continental aerosol and soil dust was definitely observed in the backward trajectory analysis using HYSPLIT4 (Draxler, 2004). Figure 7a and 7b respectively shows the back trajectories in 3 hr intervals observed when the intensities of continental aerosol and soil dust source were independently higher than other periods as shown in Figure 6. The trajectories reveal that continental aerosol was transported from further regions including northeastern China than soil dust.

(c) biomass/biofuel burning: Figure 7c shows that the backward trajectories from 9 to 11 May and at 16 May 2002 when the intensity of biomass/biofuel burning source was relatively high. The trajectories passed by not only the cultivated regions in central China but also the forests and grassland located in northeast China and North Korea. Therefore, it is inferred that this source includes field combustion of agricultural residues as well as biofuel combustion.

(d) ferrous metal source (coarse): (e) ferrous metal source (fine), As shown in Figure 7d and 7e, the difference of trajectories when they respectively have high intensities also supports the separation of two ferrous metal related sources. The source in coarse size range was estimated to be transported from southern industrial regions in South Korea while fine aerosol source regions related to the steel industry could be mainly located in major industrial areas in northeastern China.

(f) volcanic emission : Finally the volcanic emission source, containing large amount of Al, Si, K, Ca, and Fe, was resolved in the fine size range (0.56˜0.75㎛) when the trajectories passed around Kyushu Island in which there are several active volcanoes as shown in Figure 7f.

4. (p. 5230) 3rd paragraph-“confirms” will be replaced to “suggests”.

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5. Although a large portion of sulfur is generally resolved in the form of sulfate, all secondary aerosols were not composed with sulfate. Secondary aerosol is mostly composed by water-soluble ion components including sulfate, nitrate, ammonium, and carbonaceous materials. PMF analysis separates each source in the form of source profile representing the composition of source. Therefore, the result of PMF analysis only using trace elements (including sulfur) can't resolve the secondary aerosol without nitrate, ammonium, or OC.

6. Ferrous metal sources resolved in coarse and fine size range were not an exactly same source. These sources show definitely different source profile and intensity as described in this paper. Generally, ferrous metal related sources can be emitted by various manufacturing processes including electric furnace dust, medium steel furnace, special steel furnace, stainless steel furnace, electric steel furnace, and so on. In addition, two sources are distributed in different size ranges. Therefore, it is inferred that they can be originated from different ferrous metal related sources and different source regions. On account of these facts, the ferrous metal sources in coarse and fine size ranges have to be separately counted as a different aerosol source.

(Reference)

Philip K. Hopke (1985) Receptor Modeling in Environmental Chemistry, John Wiley & Sons, New York.

7. The profiles of fifteen sources were determined by not integrating the mass of each element over all sizes but taking an average of the profiles resolved as a same source in different size ranges. On the other hand, the known profiles in previous works were mostly obtained from the analysis of TSP aerosol samples collected at emission sources. Therefore, they can be described by averaged source compositions in all size ranges.

8. The analysis of backward trajectory efficiently shows that these two ferrous related sources were originated from different source regions. The fact supports that two fer-

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rous metal related sources are independent meteorologically.

9. The brief description on the Beta-ray absorption method is added to the contents. : The total PM (<12um) mass collected by the DRUM sampler was calculated from the PM10 mass concentration obtained at Gosan ambient air quality monitoring site (33° 15'N, 126° 12'E) operated by the Ministry of Environment Korea. PM10 concentration was measured by a Beta-ray absorption method, having a detection limit of 7ug/m3 with 2ug/m3 resolution with an interval of 1-hour.

10. Weighting factor of 1.02 was used, which is induced from the previous result that the PM10 mass occupies about 98% of PM12 mass on the average at Gosan (Han et al., 2005).

(Reference)

Han, J. S., Moon, K. J., Lee, S. J., Kim, J. E., and Kim, Y. J.: Size distribution characteristics of particulate mass and ion components at Gosan, Korea from 2002 to 2003, Journal of Korean Society for Atmospheric Environment, 21 (E1), 23-35, 2005.

11. The uncertainty associated with PMF analysis can be estimated by the correlation between measured and predicted PM mass. In this study, the correlation coefficient is 0.82, meaning that the total uncertainty of the resolved source contributions in eight size ranges is about 18%. In previous works, ion components such as sulfate, nitrate, and ammonium and organic carbon occupied about 30% of TSP and 40˜70% of PM2.5 collected at Gosan back ground site. These results well support that the unresolved mass contribution (46.6ś18%) in this study can be described by the contribution of secondary aerosols mainly composed by ion components and organic carbon.

(Reference)

Lee, J. H., Kim, Y. P., Moon, K. C., Kim, H. K., Lee, C. B.: Fine particle measurements at two background sites in Korea between 1996 and 1997, Atmos. Envirn., 35, 635-643, 2001.

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Kim, Y. P., Lee, J. H., Baik, N. J., Kim, J. Y., Shim, S. G., Kang, C. H.: Summertime characteristics of aerosol composition at Cheju Island, Korea, Atmospheric Environment, 32 (22), 3905-3915.

Han, J. S., Moon, K. J., Ahn, J. Y., Hong, Y. D., Kim, Y. J., Ryu, S. Y., Cliff, S. S., Cahill, T. A.: Characteristics of ion components and trace elements of fine particles at Gosan, Korea in spring time from 2001 to 2002, Environ. Monitor. Assess., 92, 73-93.

Lee, J. H.: A study on the long-range transport of air pollutants in northeastern Asia, Doctor dissertation, Kunkuk University, 1999.

12. The following description including the size cuts on each stage will be added to Table 2 :

*: stage 1: 5.0um~Inlet, stage 2: 2.5~5.0um, stage 3: 1.15~2.5um, stage 4: 0.75~1.15um, stage 5: 0.56~0.75um, stage 6: 0.34~0.56um, stage 7: 0.26~0.34um, stage 8: 0.07~0.24um.

14. In the case of ferrous metal related sources, the source profiles and intensities of them were definitely different in coarse and fine size range indicating that these sources are not a same source. On the other hand, source number five, municipal incineration source, showed considerably similar source profiles and intensities although it is observed in different size ranges such as stage 1, 5, and 7. The discrete size distribution of incineration source could be caused by the difference of the source region. But the similarity of source profiles strongly supports that these factors are a same source.

15. Figure 1 will be replace to the following figure without any symbols.

* Technical Corrections:

16. (p5224) Northeast Asia is known to emit a large amount of Asian dust particles as well as anthropogenic pollutants, due to its high density of industrial activities and increasingly high rate of energy consumption.

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17. (p5225-6) PM and DRUM are spelled out at the first time it used

18. Miscited reference was corrected.

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