Supporting Information for

Assessing the formation and evolution mechanisms of severe haze pollution in Beijing–Tianjin–Hebei region by using process analysis

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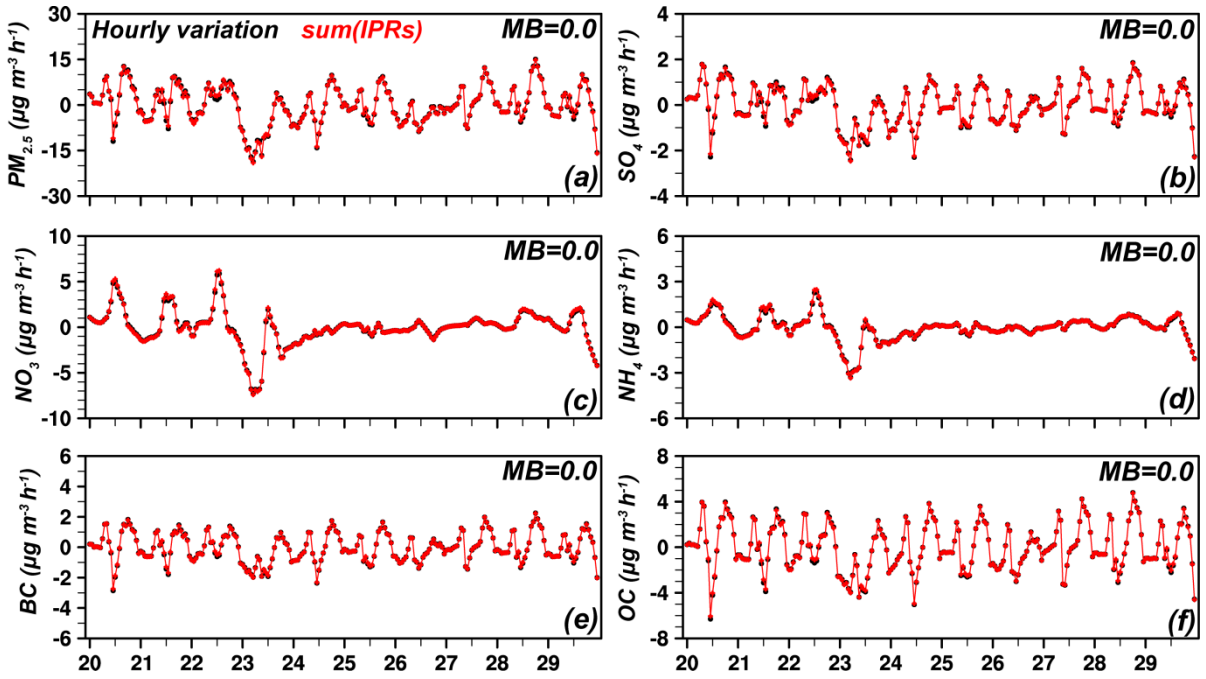

Figure S1. Hourly variations in aerosol concentrations (shown in black dot lines) and the sum of hourly IPRs of the nine processes (shown in red dot lines) averaged over the analyzed domain during 20-29 December 2015. The mean biases (MBs) are also shown.

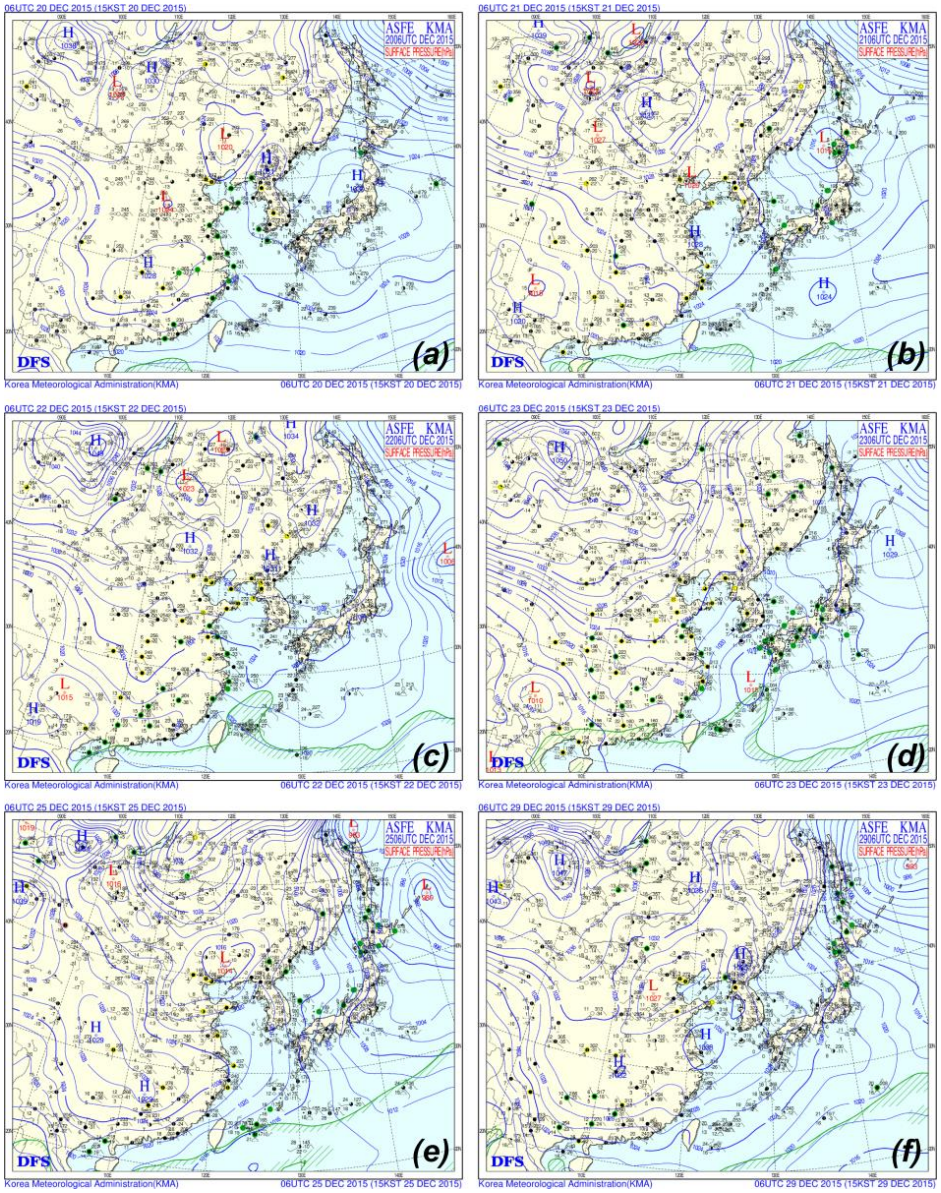

Figure S2. Surface weather charts over East Asia at (a) 0600UTC 20, (b) 0600UTC 21, (c) 0600UTC 22, (d) 0600UTC 23, (e) 0600UTC 25, and (f) 0600UTC 29 December.

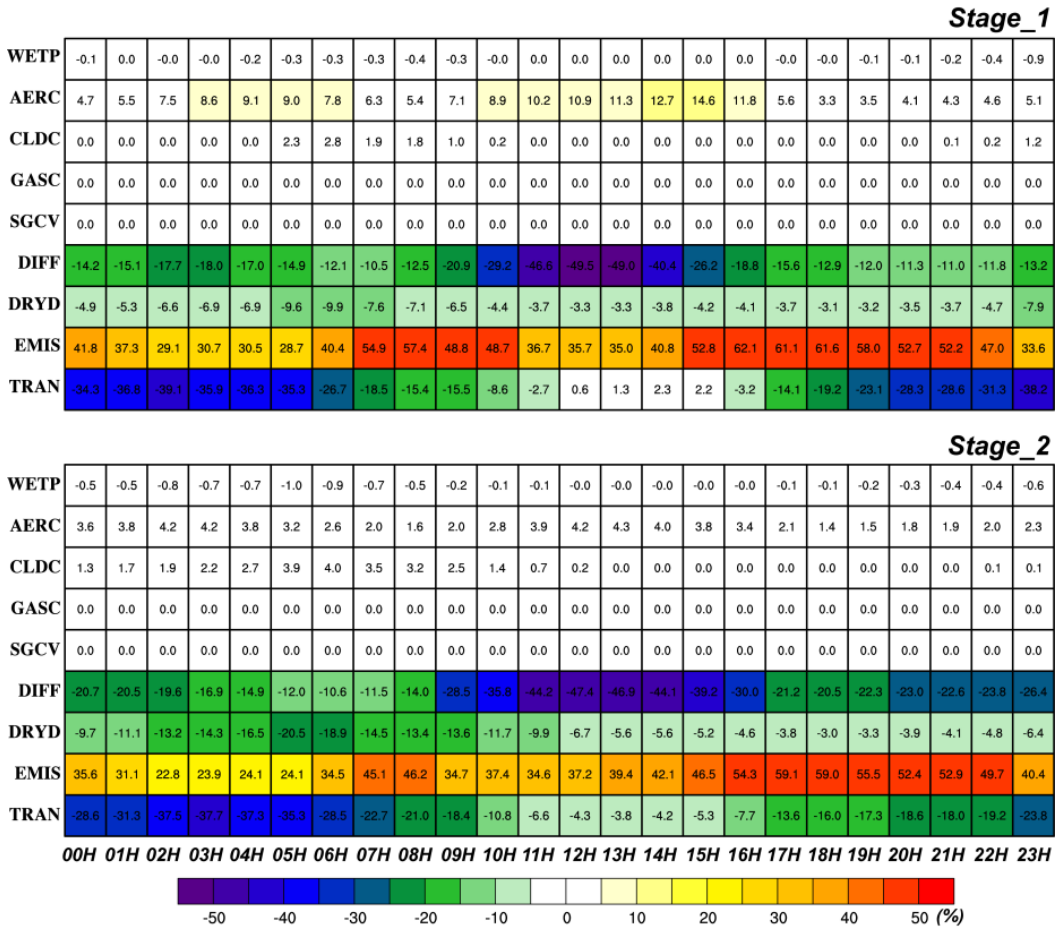

Figure S3. Percentage contributions of each physical/chemical process to hourly $PM_{2.5}$ changes in Stage_1 and Stage_2. The contributions are calculated using the equation $\%PC_i = \frac{PC_i}{\sum_{i=1}^{n}|PC_i|}$ (Goncalves et al., 2009), where $\%PC_i$ is the percentage contribution of process *i* and PC_i is the absolute contribution (i.e., the change in $PM_{2.5}$ concentration induced by process *i*). Note that the sum of $\%PC_i$ for all processes may not be 100%, but the sum of $abs(\%PC_i)$ is exactly 100%.

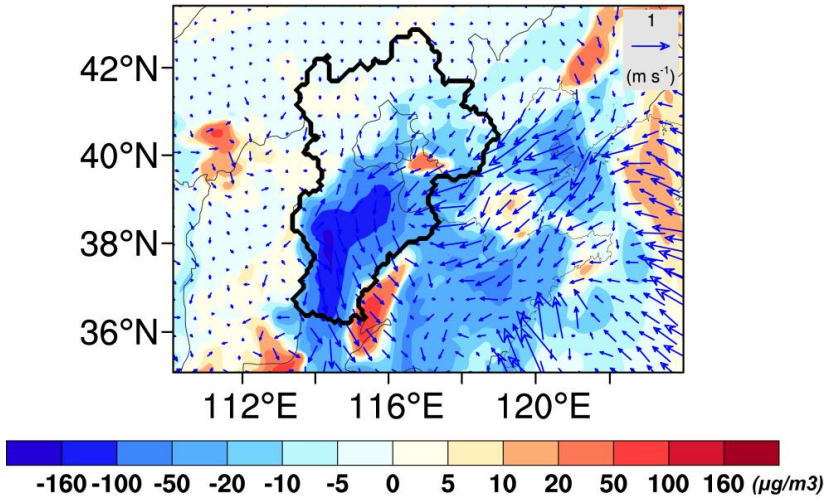

Figure S4. The differences in simulated surface-layer $PM_{2.5}$ concentrations (shaded, μg m^{-3}) and wind vectors (arrows, m s^{-1}) between CTL and NoABS cases during December 23-24. Same as CTL, but the direct radiative effect of absorbing aerosol (black carbon) is not considered in NoABS case. The direct radiative effect is turned off by removing the mass of black carbon from the calculation of aerosol optical properties, following Qiu et al. (2017).

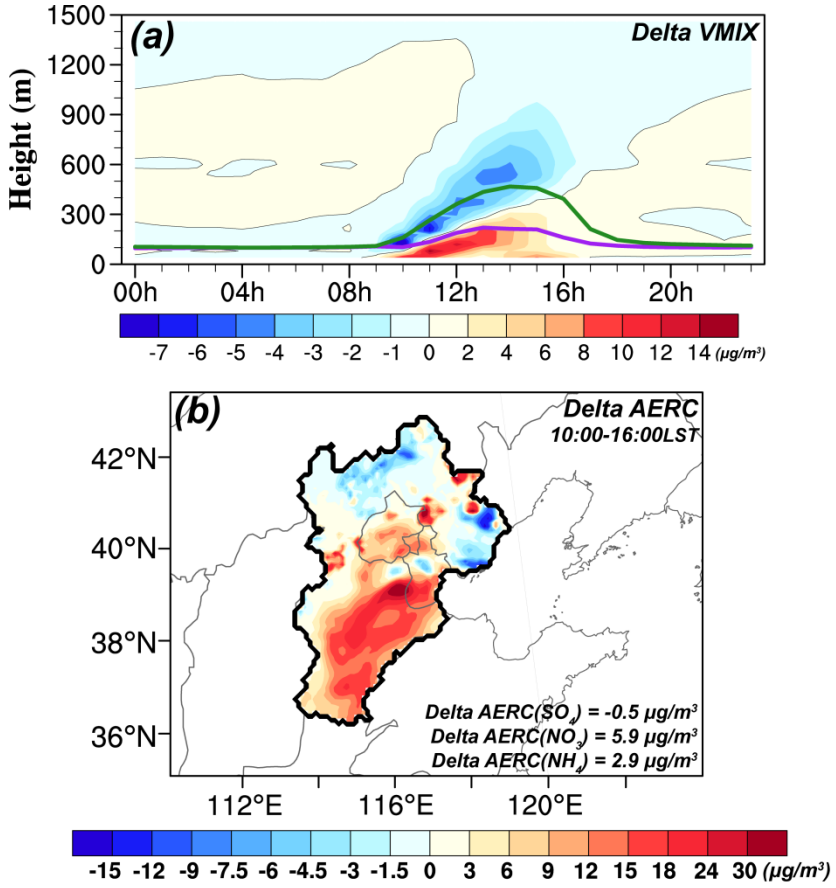

Figure S5. (a) Differences in contributions of VMIX process to $PM_{2.5}$ changes between CTL and NoARE cases (CTL minus NoARE) averaged over the BTH region in Stage_1. The purple and green lines denote the simulated PBLH in CTL and NoARE cases, respectively. (b) Differences in contributions of AERC process to $PM_{2.5}$ changes between CTL and NoARE cases (CTL minus NoARE) during the daytime (10:00-16:00LST) in Stage_1. Also shown at the lower right corner are differences in contributions of AERC process to changes in $PM_{2.5}$ components between CTL and NoARE cases (CTL minus NoARE) averaged over BTH during the daytime.

Reference

Gonçalves, M., Jiménez-Guerrero, P., and Baldasano, J. M.: Contribution of atmospheric processes affecting the dynamics of air pollution in South-Western Europe during a typical summertime photochemical episode, Atmos. Chem. Phys., 9, 849-864, 10.5194/acp-9-849-2009, 2009.

Qiu, Y., Liao, H., Zhang, R., and Hu, J.: Simulated impacts of direct radiative effects of scattering and absorbing aerosols on surface layer aerosol concentrations in China during a heavily polluted event in February 2014, Journal of Geophysical Research: Atmospheres, 122, 5955-5975, 10.1002/2016jd026309, 2017.