Supplementary Material for

Fast sulfate formation from oxidation of SO_2 by NO_2 and HONO observed in Beijing haze

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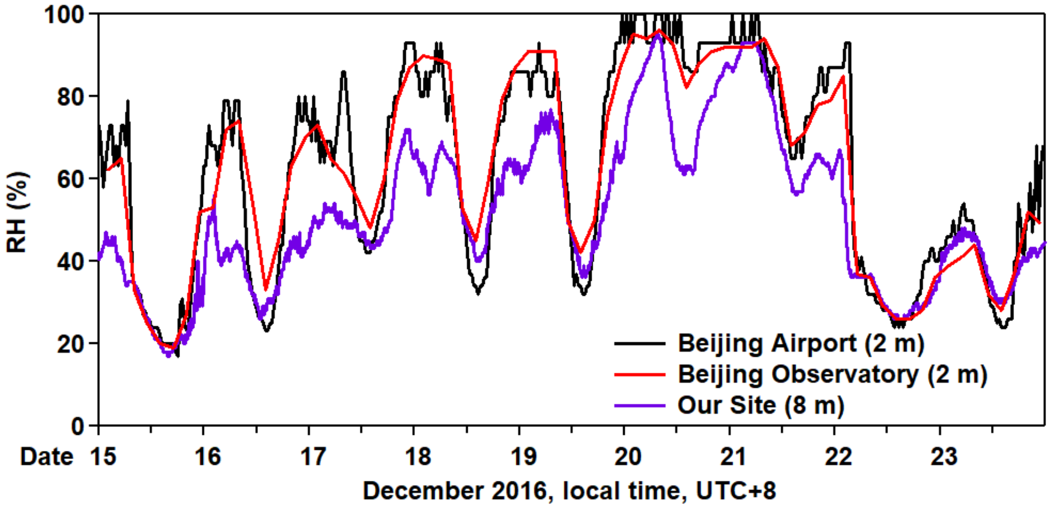
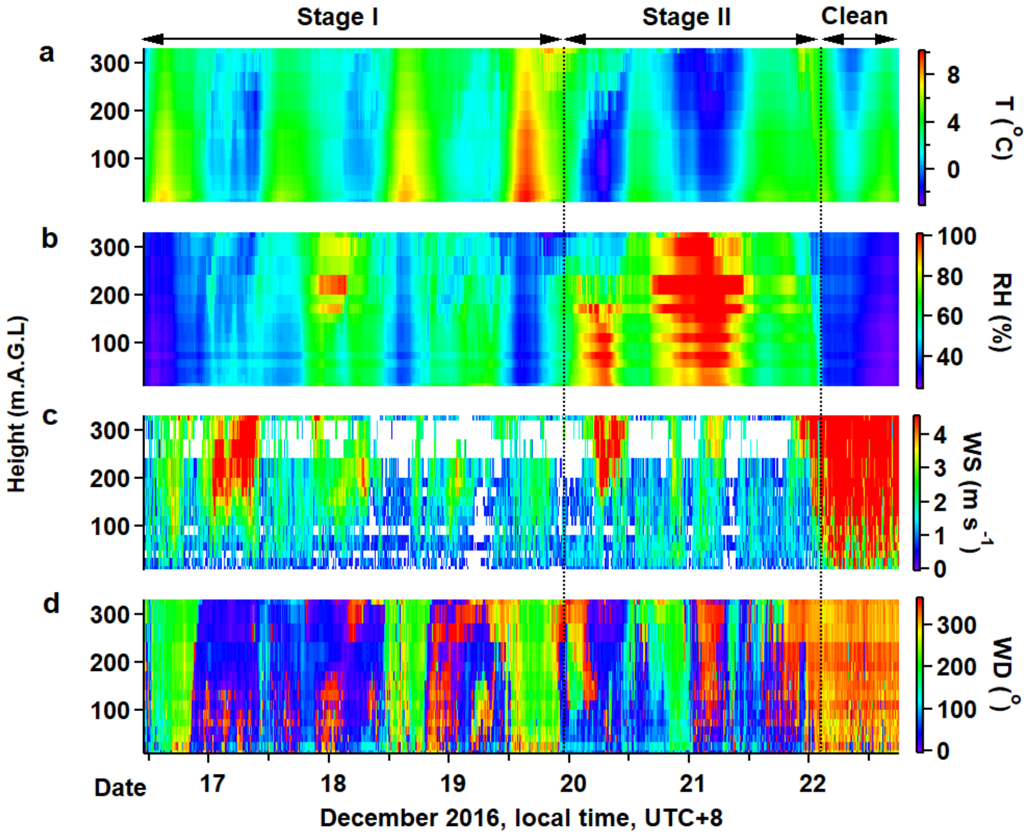
Supplementary Table 1: **Henry's law and acid dissociation constants**[a]

Equilibrium	Equilibrium constant at 271 K
$H_2O \leftrightarrow H^+ + OH^-$	1.0×10^{-15} M
$CO_2(g) + H_2O \leftrightarrow CO_2 \cdot H_2O$	7.7×10^{-2} M atm^{-1}
$CO_2 \cdot H_2O \leftrightarrow H^+ + HCO_3^-$	5.9×10^{-7} M
$HCO_3^- \leftrightarrow H^+ + CO_3^{2-}$	8.5×10^{-11} M
$SO_2(g) + H_2O \leftrightarrow SO_2 \cdot H_2O$	3.3 M atm^{-1}
$SO_2 \cdot H_2O \leftrightarrow H^+ + HSO_3^-$	2.5×10^{-2} M
$HSO_3^- \leftrightarrow H^+ + SO_3^{2-}$	1.1×10^{-7} M
$NH_3(g) + H_2O \leftrightarrow NH_3 \cdot H_2O$	$2. 5 \times 10^{2}$ M atm^{-1}
$NH_3 \cdot H_2O \leftrightarrow NH_4^+ + OH^-$	4.0×10^{-5} M
$NO_2(g) + H_2O \leftrightarrow NO_2 \cdot H_2O$	2.3×10^{-2} M atm^{-1}
$HONO(g) \leftrightarrow HONO \cdot H_2O$	2.4×10^{2} M atm^{-1}
$HONO \cdot H_2O \leftrightarrow NO_2^- + H^+$	3.4×10^{-4} M

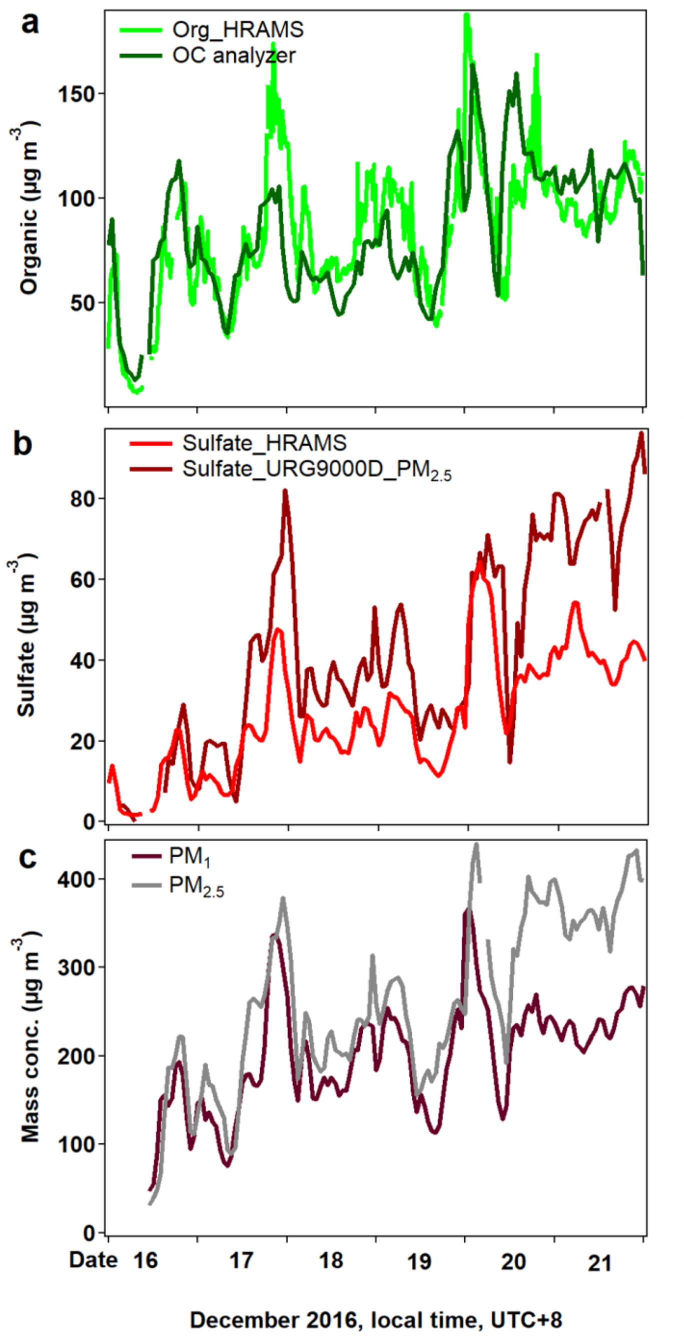
[a] Equilibrium constants as given by Seinfeld and Pandis[1] and adjusted to 271 K using the van't Hoff equation.



Supplementary Figure 1: Relative humidity during the haze event. Observed relative humidity (RH) at Beijing International Airport, Beijing Observatory Meteorological Station, and our sampling site during the December 16-22, 2016 haze event. UTC+8 refers to Coordinated Universal Time + 8 hours and indicates the local solar time in hours.



Supplementary Figure 2: Meteorological profiles above the sampling site. Vertical profiles above ground level (AGL) of (a) temperature (T), (b) relative humidity (RH), (c) wind speed (WS) and (d) wind direction (WD) measured at the IAP 325-m meteorological tower during the December 16-22, 2016 haze event.



Supplementary Figure 3: Differences between PM_1 and $PM_{2.5}$. The plots compare PM_1 and $PM_{2.5}$ (a) organic, (b)sulfate and (c) total mass concentrations during the December 16-22, 2016 haze event. PM_1 organic and sulfate mass concentrations were measured by HR-AMS. $PM_{2.5}$ sulfate mass concentrations were measured with a URG-9000D Ambient Ion Monitor. $PM_{2.5}$ organic carbon (OC) mass concentrations were measured by a thermo-optical ECOC analyzer (Sunset Laboratory Inc., Tigard, Oregon). We assumed an organic mass to organic carbon ratio of 1.9[2] to convert the OC measurement to total organic mass. PM_1 is the total particulate mass concentration inferred from the HR-AMS data. $PM_{2.5}$ was measured 4 km to the northeast of the IAP site.

Supplementary References

1 Seinfeld, J. & Pandis, S. in *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, 3rd Edition* Ch. 26, 1152 (2016).

2 Turpin, B. J. & Lim, H.-J. Species Contributions to PM2.5 Mass Concentrations: Revisiting Common Assumptions for Estimating Organic Mass. *Aerosol Sci Tech* **35**, 602-610, doi:10.1080/02786820119445 (2001).