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*Supplement of*

## **Effectiveness of short-term air quality emission controls: a high-resolution model study of Beijing during the Asia-Pacific Economic Cooperation (APEC) summit period**

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**Table S1.** Comparison of observed and simulated meteorological variables for the entire period using FNL and ECMWF fields

|                                      | Number of<br>Stations | Obs. avg. | Sim avg |       | Bias  |       | RMSE |       | r    |       |
|--------------------------------------|-----------------------|-----------|---------|-------|-------|-------|------|-------|------|-------|
|                                      |                       |           | FNL     | ECMWF | FNL   | ECMWF | FNL  | ECMWF | FNL  | ECMWF |
| 2-m Temperature (°C)                 |                       |           |         |       |       |       |      |       |      |       |
| Beijing                              | 1                     | 9.68      | 11.52   | 11.44 | 1.84  | 1.76  | 3.28 | 3.36  | 0.88 | 0.87  |
| D03                                  | 30                    | 8.91      | 8.98    | 8.95  | 0.07  | 0.04  | 2.47 | 2.46  | 0.94 | 0.94  |
| D02                                  | 77                    | 7.87      | 7.53    | 7.55  | -0.34 | -0.32 | 2.39 | 2.35  | 0.95 | 0.95  |
| D01                                  | 324                   | 9.62      | 7.77    | 7.79  | -1.85 | -1.83 | 3.23 | 3.23  | 0.94 | 0.94  |
| 2-m Relative Humidity (%)            |                       |           |         |       |       |       |      |       |      |       |
| Beijing                              | 1                     | 54.7      | 34.1    | 39.1  | -20.6 | -15.6 | 26.9 | 22.4  | 0.77 | 0.81  |
| D03                                  | 30                    | 54.9      | 44.8    | 48.9  | -10.1 | -6.0  | 19.6 | 16.7  | 0.75 | 0.78  |
| D02                                  | 77                    | 54.4      | 47.8    | 51.1  | -6.6  | -3.3  | 17.4 | 15.2  | 0.74 | 0.78  |
| D01                                  | 324                   | 62.8      | 60.4    | 62.6  | -2.4  | -0.2  | 16.8 | 15.6  | 0.73 | 0.76  |
| 10-m Wind Speed (m s <sup>-1</sup> ) |                       |           |         |       |       |       |      |       |      |       |
| Beijing                              | 1                     | 5.41      | 2.27    | 2.24  | -3.14 | -3.17 | 4.98 | 5.09  | 0.72 | 0.69  |
| D03                                  | 30                    | 5.73      | 3.26    | 3.20  | -2.47 | -2.53 | 4.60 | 4.65  | 0.62 | 0.61  |
| D02                                  | 77                    | 6.18      | 3.60    | 3.55  | -2.58 | -2.63 | 4.52 | 4.55  | 0.67 | 0.66  |
| D01                                  | 324                   | 5.67      | 3.38    | 3.36  | -2.29 | -2.31 | 4.29 | 4.30  | 0.60 | 0.61  |
| 10-m Wind Direction (°)              |                       |           |         |       |       |       |      |       |      |       |
| Beijing                              | 1                     | 197.5     | 214.2   | 191.0 | 16.7  | -6.6  | 73.9 | 73.9  | 0.79 | 0.80  |
| D03                                  | 30                    | 215.1     | 210.0   | 206.5 | -6.9  | -8.6  | 62.7 | 63.4  | 0.78 | 0.78  |
| D02                                  | 77                    | 214.4     | 212.2   | 208.9 | -2.8  | -5.5  | 65.4 | 65.4  | 0.76 | 0.76  |
| D01                                  | 324                   | 206.5     | 193.4   | 188.4 | -13.1 | -18.0 | 71.9 | 72.2  | 0.74 | 0.74  |

Hourly values are used for each station from 12 October to 19 November 2014. Where observation data are missing, model values were removed to ensure that sampling was consistent.

**Table S2.** Meteorological performance over Beijing during pre-APEC and APEC period

|                                 | Obs. avg. | Sim. avg. | Mean bias | RMSE | R    |
|---------------------------------|-----------|-----------|-----------|------|------|
| 2 m Temperature (°C)            |           |           |           |      |      |
| Episode 1                       | 14.63     | 16.84     | 2.21      | 3.79 | 0.79 |
| Episode 2                       | 12.15     | 14.47     | 2.32      | 3.28 | 0.74 |
| Episode 3                       | 11.35     | 11.76     | 0.41      | 1.78 | 0.86 |
| APEC period                     | 7.14      | 9.14      | 2.00      | 3.76 | 0.82 |
| Relative Humidity (%)           |           |           |           |      |      |
| Episode 1                       | 61.9      | 41.4      | -20.6     | 26.6 | 0.76 |
| Episode 2                       | 74.3      | 52.7      | -21.5     | 26.0 | 0.74 |
| Episode 3                       | 55.6      | 41.3      | -14.3     | 19.5 | 0.89 |
| APEC period                     | 47.0      | 34.4      | -12.6     | 21.2 | 0.82 |
| Wind Speed (m s <sup>-1</sup> ) |           |           |           |      |      |
| Episode 1                       | 5.30      | 2.45      | -2.85     | 4.86 | 0.74 |
| Episode 2                       | 3.50      | 1.82      | -1.68     | 2.76 | 0.56 |
| Episode 3                       | 5.46      | 2.07      | -3.39     | 5.35 | 0.79 |
| APEC period                     | 6.50      | 2.56      | -3.94     | 6.06 | 0.67 |
| Wind Direction (°)              |           |           |           |      |      |
| Episode 1                       | 176.9     | 172.9     | -4.1      | 63.5 | 0.78 |
| Episode 2                       | 148.6     | 141.4     | -7.3      | 74.9 | 0.85 |
| Episode 3                       | 143.6     | 163.4     | 19.7      | 62.1 | 0.88 |
| APEC period                     | 257.3     | 220.8     | -36.5     | 69.4 | 0.79 |

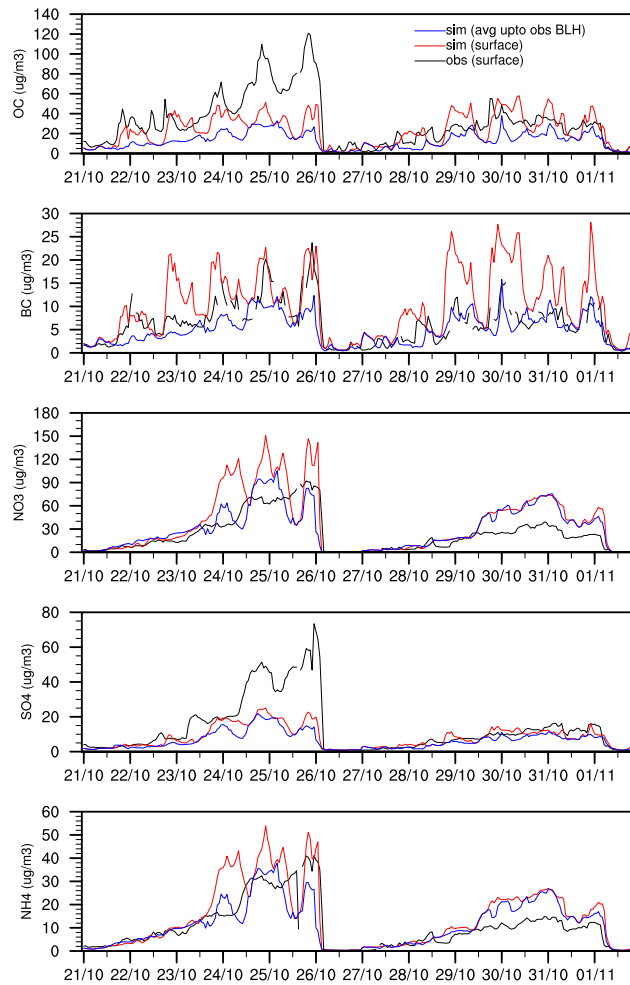
Episode 1: 15–20 Oct, Episode 2: 21–25 Oct, Episode 3: 26 Oct–1 Nov, APEC period: 3–12 Nov

**Table S3.** Comparison of pollutant concentrations with network measurements over the period 12–31 October 2014

|   | Number of<br>Stations | Obs   | Sim   | Bias   | RMSE<br>hourly/daily | r<br>hourly/daily | slope<br>hourly/daily |
|---|-----------------------|-------|-------|--------|----------------------|-------------------|-----------------------|
| PM <sub>2.5</sub> (µg m <sup>-3</sup> ) |                       |       |       |        |                      |                   |                       |
| Beijing stations                        | 12                    | 108.3 | 126.2 | 17.9   | 86.7/66.7            | 0.68/0.78         | 0.83/0.93             |
| D03                                     | 137                   | 92.6  | 109.3 | 16.7   | 72.2/52.2            | 0.63/0.74         | 0.71/0.80             |
| D02                                     | 375                   | 75.8  | 87.9  | 12.1   | 63.9/48.6            | 0.60/0.69         | 0.65/0.71             |
| D01                                     | 1312                  | 71.1  | 74.8  | 3.7    | 61.1/50.2            | 0.47/0.53         | 0.48/0.54             |
| PM <sub>10</sub> (µg m <sup>-3</sup> )  |                       |       |       |        |                      |                   |                       |
| Beijing stations                        | 12                    | 155.4 | 141.5 | -13.9  | 96.5/74.0            | 0.65/0.77         | 0.79/0.98             |
| D03                                     | 137                   | 165.7 | 122.9 | -42.8  | 104.0/82.1           | 0.57/0.68         | 0.50/0.58             |
| D02                                     | 375                   | 138.0 | 98.6  | -39.4  | 94.3/75.8            | 0.54/0.65         | 0.44/0.52             |
| D01                                     | 1312                  | 121.0 | 82.2  | -38.8  | 89.0/76.7            | 0.42/0.47         | 0.32/0.37             |
| CO (ppm)                                |                       |       |       |        |                      |                   |                       |
| Beijing stations                        | 12                    | 1.11  | 0.94  | -0.17  | 0.63/0.43            | 0.60/0.75         | 0.46/0.61             |
| D03                                     | 137                   | 1.17  | 0.83  | -0.34  | 0.87/0.72            | 0.29/0.34         | 0.21/0.22             |
| D02                                     | 375                   | 1.14  | 0.66  | -0.48  | 0.88/0.79            | 0.33/0.37         | 0.20/0.20             |
| D01                                     | 1312                  | 1.00  | 0.50  | -0.50  | 0.79/0.73            | 0.32/0.34         | 0.13/0.14             |
| NO <sub>2</sub> (ppb)                   |                       |       |       |        |                      |                   |                       |
| Beijing stations                        | 12                    | 39.09 | 36.09 | -3.00  | 19.33/11.10          | 0.62/0.80         | 0.66/0.83             |
| D03                                     | 137                   | 29.75 | 25.88 | -3.87  | 18.95/14.32          | 0.47/0.54         | 0.45/0.51             |
| D02                                     | 375                   | 24.86 | 19.45 | -5.41  | 16.99/13.21          | 0.49/0.55         | 0.44/0.50             |
| D01                                     | 1312                  | 22.73 | 12.45 | -10.28 | 18.33/15.44          | 0.42/0.47         | 0.30/0.36             |
| SO <sub>2</sub> (ppb)                   |                       |       |       |        |                      |                   |                       |
| Beijing stations                        | 12                    | 3.92  | 12.27 | 8.35   | 11.88/10.55          | 0.27/0.52         | 0.68/1.74             |
| D03                                     | 137                   | 13.28 | 14.47 | 1.19   | 13.66/9.66           | 0.21/0.31         | 0.22/0.24             |
| D02                                     | 375                   | 12.23 | 13.21 | 0.98   | 13.19/9.01           | 0.24/0.34         | 0.26/0.28             |
| D01                                     | 1312                  | 10.27 | 8.93  | -1.34  | 11.17/8.54           | 0.19/0.28         | 0.18/0.24             |
| O <sub>3</sub> (ppb)                    |                       |       |       |        |                      |                   |                       |
| Beijing stations                        | 12                    | 12.53 | 12.19 | -0.34  | 13.92/6.49           | 0.47/0.67         | 0.44/0.82             |
| D03                                     | 137                   | 17.76 | 18.75 | 0.99   | 15.96/10.88          | 0.45/0.49         | 0.43/0.50             |
| D02                                     | 375                   | 21.23 | 23.08 | 1.85   | 17.19/12.80          | 0.42/0.43         | 0.37/0.40             |
| D01                                     | 1312                  | 21.44 | 32.29 | 10.85  | 22.44/17.03          | 0.29/0.27         | 0.27/0.25             |

**Table S4.** Impacts of model resolution on simulation of hourly pollutant concentrations in Beijing over 12–31 October 2014

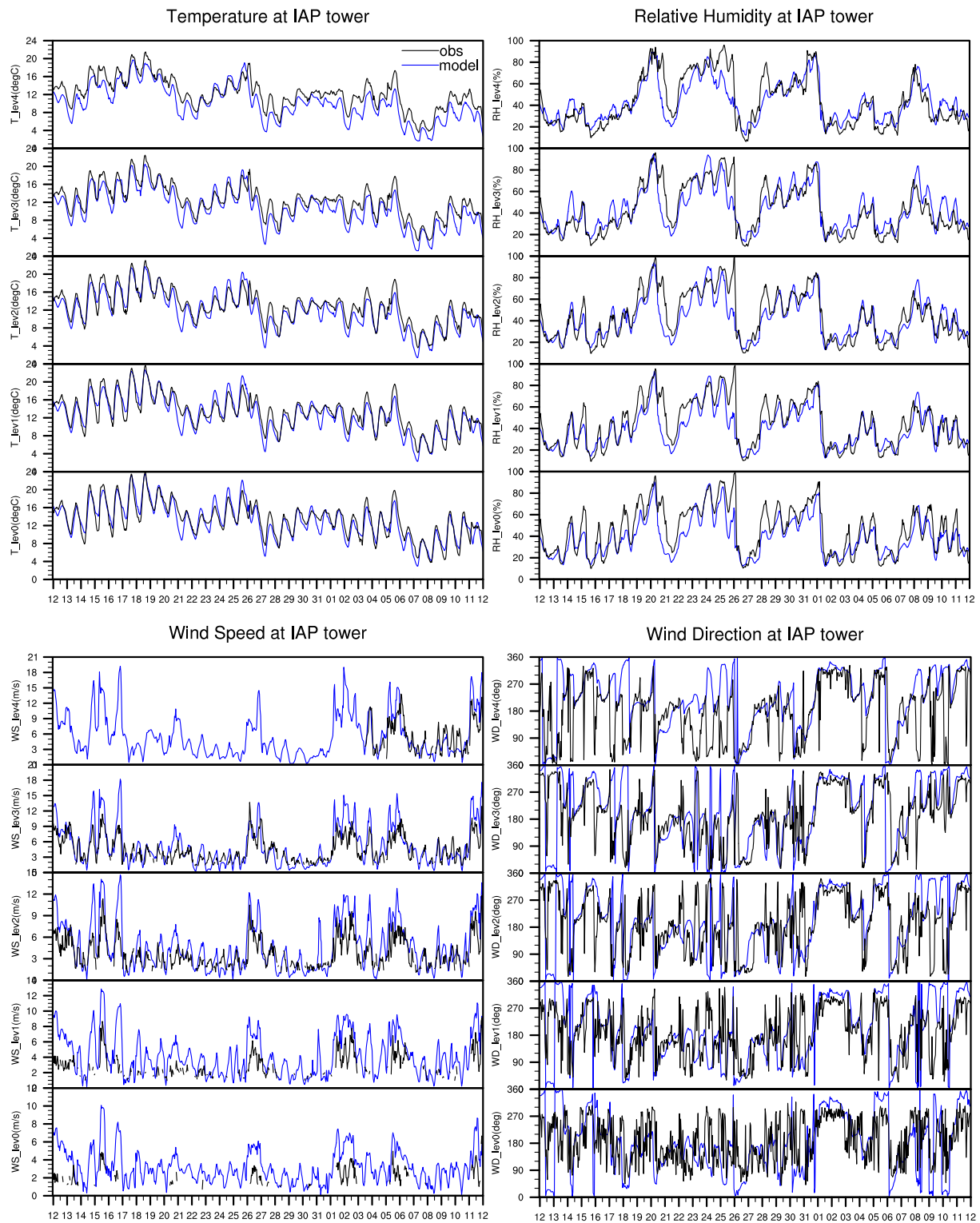
|  | N points | Obs mean | Sim mean | Mean Bias | RMSE  | r    | slope |
|--|----------|----------|----------|-----------|-------|------|-------|
| PM <sub>2.5</sub> ( $\mu\text{g m}^{-3}$ ) |          |          |          |           |       |      |       |
| D03 (3-km)                                 | 3171     | 108.4    | 126.2    | 17.8      | 86.7  | 0.68 | 0.83  |
| D02 (9-km)                                 | 3171     | 108.4    | 128.7    | 20.3      | 87.4  | 0.69 | 0.85  |
| D01 (27-km)                                | 3171     | 108.4    | 123.1    | 14.7      | 86.1  | 0.68 | 0.81  |
| D01 (no nest)                              | 3171     | 108.4    | 99.2     | -9.2      | 83.2  | 0.59 | 0.55  |
| PM <sub>10</sub> ( $\mu\text{g m}^{-3}$ )  |          |          |          |           |       |      |       |
| D03  | 2670     | 155.4    | 141.5    | -13.9     | 96.5  | 0.65 | 0.79  |
| D02  | 2670     | 155.4    | 143.6    | -11.8     | 96.6  | 0.65 | 0.80  |
| D01  | 2670     | 155.4    | 137.9    | -17.5     | 96.6  | 0.65 | 0.79  |
| D01 (no nest)                              | 2670     | 155.4    | 111.2    | -44.2     | 99.8  | 0.58 | 0.54  |
| CO (ppm)                                   |          |          |          |           |       |      |       |
| D03  | 3074     | 1.11     | 0.94     | -0.17     | 0.63  | 0.60 | 0.46  |
| D02  | 3074     | 1.11     | 0.95     | -0.16     | 0.61  | 0.61 | 0.47  |
| D01  | 3074     | 1.11     | 0.88     | -0.23     | 0.61  | 0.64 | 0.44  |
| D01 (no nest)                              | 3074     | 1.11     | 0.68     | -0.43     | 0.73  | 0.62 | 0.31  |
| NO <sub>2</sub> (ppb)                      |          |          |          |           |       |      |       |
| D03  | 3080     | 39.09    | 36.09    | -3.00     | 19.33 | 0.62 | 0.66  |
| D02  | 3080     | 39.09    | 35.55    | -3.54     | 19.34 | 0.62 | 0.64  |
| D01  | 3080     | 39.09    | 31.92    | -7.17     | 18.33 | 0.67 | 0.62  |
| D01 (no nest)                              | 3080     | 39.09    | 21.81    | -17.28    | 24.74 | 0.60 | 0.48  |
| SO <sub>2</sub> (ppb)                      |          |          |          |           |       |      |       |
| D03  | 3074     | 3.92     | 12.27    | 8.35      | 11.88 | 0.27 | 0.68  |
| D02  | 3074     | 3.92     | 12.15    | 8.23      | 11.64 | 0.27 | 0.66  |
| D01  | 3074     | 3.92     | 10.91    | 6.99      | 9.82  | 0.32 | 0.69  |
| D01 (no nest)                              | 3074     | 3.92     | 6.47     | 2.55      | 5.57  | 0.29 | 0.40  |
| O <sub>3</sub> (ppb)                       |          |          |          |           |       |      |       |
| D03  | 3046     | 12.56    | 12.19    | -0.37     | 13.92 | 0.47 | 0.44  |
| D02  | 3046     | 12.56    | 12.71    | 0.15      | 13.94 | 0.47 | 0.43  |
| D01  | 3046     | 12.56    | 14.96    | 2.40      | 13.53 | 0.49 | 0.44  |
| D01 (no nest)                              | 3046     | 12.56    | 17.59    | 5.03      | 14.08 | 0.51 | 0.45  |



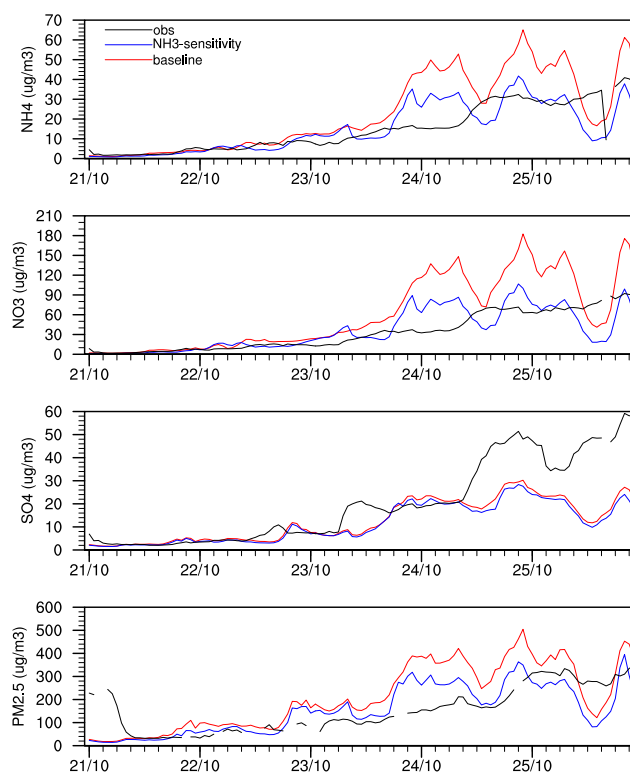
**Figure S1.** Time-series of simulated aerosol components with and without averaging upto observed boundary layer height against surface observations at the IAP site.

**Table S5.** Comparison of simulated aerosol components in  $\mu\text{g m}^{-3}$  with and without mixing up to observed boundary layer height against surface observations at IAP site

| Components | Obs. avg. | Sim avg |       | Mean Bias |        | RMSE    |       |
|------------|-----------|---------|-------|-----------|--------|---------|-------|
|            |           | surface | mixed | surface   | mixed  | surface | mixed |
| OC         | 31.08     | 23.24   | 12.86 | -7.84     | -18.22 | 21.43   | 27.30 |
| BC         | 6.13      | 10.19   | 4.96  | 4.06      | -1.16  | 5.96    | 3.27  |
| NO3        | 23.30     | 36.73   | 29.42 | 13.44     | 6.12   | 25.47   | 18.00 |
| SO4        | 13.16     | 8.12    | 6.27  | -5.03     | -6.89  | 12.05   | 13.67 |
| NH4        | 10.36     | 14.16   | 11.12 | 3.80      | 0.78   | 8.05    | 6.40  |



**Figure S2.** Meteorological evaluation against IAP tower measurements for bottom 5 model levels. lev 0: 0–27 m, lev 1: 27–90 m, lev 2: 90–178 m, lev 3: 178–289 m, lev 4: 289–429 m.



**Figure S3.** Time-series of aerosol components  $\text{NH}_4$ ,  $\text{NO}_3$  and  $\text{SO}_4$  at the IAP site and  $\text{PM}_{2.5}$  at Aotizhongxin showing simulated concentrations (in  $\mu\text{g m}^{-3}$ ) from the baseline model run and reduced  $\text{NH}_3$  emissions run compared to observations.