Supplementary Material

1. Observed concentrations of aerosols in China

Table S1. Observed concentrations of sulfate aerosol in China

Location	Period		Concentration ($\mu g\ m^{-3}$)	Reference	Notes on measurements
Beijing (116.4°E, 39.9°N)	Aug 2001 - Sep 2002	Summer	13.43	Duan et al. (2006)	(1) The $PM_{2.5}$ samples were collected on the roof of a 3-m tall building (about 4.5 m above the ground). The samples were collected integrated weekly.
		Autumn	9.61		
		Winter	9.88		
		Spring	6.71		
Nanjing (118.8°E, 32.0°N)	Sep 2001		11.5	Yang et al. (2005)	(2) The $PM_{2.5}$ samples were collected on the rooftop of a two-story building (8-10 m above the ground). Sampling started at about 8 am and ended at about 8 pm every day; each sample was collected for 12 h.
	Apr 2001		8.79	Wang et al. (2002)	(3) The $PM_{2.5}$ samples were collected 1.5 m above the ground. Sampling started and ended at about 8:30 am and 4:30 pm every day; each sample was collected for 8 h.
	Feb 2001		10.04		
Shanghai (121.5°E, 31.2°N)	Dec 2006 – Jan 2007	Winter	9.52	Fu et al. (2008)	(4) The $PM_{2.5}$ samples were collected on the roof of a building (20 m above the ground). The sampling was from 9:00 am to 9:00 am of the next day for 24 h.
	Jul – Aug 2004	Summer	5.43	Wang et al. (2006)	(5) The $PM_{2.5}$ samples were collected on the roofof a building (~15 m above the ground). The samples were collected in daytime (8:00-20:00) for 12 h.
	Mar – Apr 2004	Spring	11.73		
	Sep – Oct 2003	Antumn	8.7		
Fuzhou (119.3°E, 26.1°N)	Apr 2007 – Jan 2008	Spring	10.14±2.66	Xu et al. (2012)	(6) The samplers were mounted on the rooftop of one office building (about 23 m above the ground). The $PM_{2.5}$ samples were collected for 23 h.
		Summer	6.62±1.51		
		Autumn	11.59±4.28		
		Winter	14.78±6.44		
Hong Kong (114.2°E, 22.3°N)	Nov 2000 – Feb 2001		8.10	Ho et al. (2006)	(7) The $PM_{2.5}$ samples were collected at about 6-8 m above the ground. The samples were collected once every 6 days (each sampling lasted for 24-h).
Qingdao (121°E, 36.5°N)	25 Feb – 15 Mar 2002		11.9	Takami et al. (2006)	(8) The sampling site was about 450 m above the sea level. The sampling of $PM_{2.5}$ was carried out for about 24 h from 8:00 am to the next morning.
	17 Feb – 02 Mar 2001		19.1		
Dalian (121.5°E, 39°N)	2006 to 2007	Spring	11.68	Zhang et al. (2012)	(9) The rural stations were right above the ground level. At the urban
		Summer	15.15		

		Autumn	13.58		locations, the samples were usually collected 50-100 m above the ground. The 24-h aerosol filter samples of PM_{10} (0900 to 0900 local time) were collected every three days at the 16 stations. The observed concentrations listed here were those in Zhang et al. (2012) multiplied by 0.6 to convert PM_{10} to $PM_{2.5}$ following the suggestions in Zhang et al. (2002)
Gaolanshan (105.9°E,36.0°N)	2006 to 2007	Summer	7.08		
		Autumn	11.91		
Jinsha (114.2°E, 29.6°N)	2006 to 2007	Spring	13.35		
Lhasa (91.1°E, 29.7°N)	2006 to 2007	Spring	1.74		
		Summer	1.85		
		Autumn	1.63		
		Winter	2.21		
Lin'an (121.2°E, 31.1°N)	2006 to 2007	Spring	13.16		
		Summer	12.09		
		Autumn	12.95		
		Winter	14.32		
Longfengshan (127.6°E, 44.7°N)	2006 to 2007	Spring	4.69		
		Summer	7.32		
		Autumn	4.73		
		Winter	8.15		
Nanning (108.3°E, 22.8°N)	2006 to 2007	Spring	9.22		
		Winter	14.84		
Panyu (113.4°E, 23.0°N)	2006 to 2007	Winter	16.28		
Taiyangshan (111.7°E, 29.2°N)	2006 to 2007	Spring	11.92		
		Winter	16.59		

Table S2. Observed concentrations of nitrate aerosol in China

Location	Period		Concentration (μg m^{-3})	Reference	Notes on measurements
Beijing (116.4°E, 39.9°N)	Jul 1999 - Sep 2000	Summer	4.59	He et al. (2001)	(10) The $PM_{2.5}$ samplers were placed on the roof of a 3 m tall building. The samples were collected integrated weekly.
		Spring	7.26		
	2001-2003	Autumn	9.14	Wang et al. (2005)	--
		Winter	12.29		
Nanjing (118.8°E, 32.0°N)	Sep 2001		3.24	Yang et al. (2005)	Same as (2) in Table S1.
	Apr 2001		4.53	Wang et al. (2002)	Same as (3) in Table S1.
	Feb 2001		5.67		
Shanghai (121.5°E, 31.2°N)	20 Mar 1999 -27 Mar 2000	Spring	5.4	Ye et al. (2002)	(11) The site was 16-m above the ground. The samples of $PM_{2.5}$ were collected integrated weekly.
	Jul-Aug 2004	Summer	2.59	Wang et al. (2006)	Same as (5) in Table S1.
	Sep-Oct 2003	Antumn	3.70		
	Dec 2006 - Jan 2007	Winter	6.76	Fu et al. (2008)	Same as (4) in Table S1.
Hangzhou (120.1°E, 30.2°N)	Sep 2001- Aug 2002	Summer	4.68	Cao et al. (2009a)	(12) PM_{10} samples were collected every three days from 8:00 am for 24h.
		Spring	7.20		
		Autumn	7.07		
		Winter	11.19		

Tianjin (117.12°E, 39.4°N)	Jan 2008		16.6	Gu et al. (2011)	(13) The sampling devices were situated about 10 m above the ground. The 24-h (0900 to 0900 local time) samples of $PM_{2.5}$ were collected.
Hong Kong (114.2°E, 22.3°N)	Nov 2000 - Feb 2001		1.20	Ho et al. (2006)	Same as (7) in Table S1.
Fuzhou (119.3°E, 26.1°N)	Apr 2007 – Jan 2008	Autumn	3.13±2.13	Xu et al. (2012)	Same as (6) in Table S1.
		Winter	8.77±3.17		
		Spring	4.60±1.09		
		Summer	1.10±0.35		
Qingdao (121°E, 36.5°N)	25 Feb–15 Mar 2002		10.3	Takami et al. (2006)	Same as (8) in Table S1.
	17 Feb–02 Mar 2001		12.5		
Fenghuanshan (124°E, 40.5°N)	17 Feb–01 Mar, 2001		7.3		
Dalian (121.5°E, 39°N)	2006 to 2007	Spring	8.32	Zhang et al. (2012)	Same as (9) in Table S1.
Dunhuang (94.7°E, 40.2°N)	2006 to 2007	Spring	1.17		
		Autumn	1.37		
		Winter	1.82		
Gucheng (115.8°E, 39.1°N)	2006 to 2007	Spring	10.21		
		Summer	9.75		
		Autumn	12.06		
		Winter	16.30		
Jinsha (114.2°E, 29.6°N)	2006 to 2007	Spring	3.00		
		Autumn	7.10		
		Winter	5.79		
Lhasa (91.1°E, 29.7°N)	2006 to 2007	Spring	1.38		
		Summer	1.25		
		Autumn	1.33		
		Winter	1.39		
Lin'an (121.2°E, 31.1°N)	2006 to 2007	Spring	5.59		
		Summer	3.37		
		Autumn	5.06		
		Winter	6.99		
Longfengshan (127.6°E, 44.7°N)	2006 to 2007	Spring	2.43		
		Summer	1.44		
		Autumn	2.50		
		Winter	5.42		
Nanning (108.3°E, 22.8°N)	2006 to 2007	Spring	2.92		
		Autumn	3.00		
		Winter	4.39		
Panyu (113.4°E, 23.0°N)	2006 to 2007	Winter	8.83		
Taiyangshan (111.7°E, 19.2°N)	2006 to 2007	Spring	3.01		
		Autumn	7.57		
		Winter	5.73		
Xi'an (108.6°E, 34.3°N)	2006 to 2007	Winter	14.79		

Table S3. Observed concentrations of BC aerosol in China

Location	Period		Concentration (μg m^{-3})	Reference	Notes on measurements
Beijing (116.4°E, 39.9°N)	Jul 1999 - Sep 2000	Spring	6.67	He et al. (2001)	Same as (10) in Table S2.
	Jan-Jul 2003	Summer	4.6±3.0	Cao et al. (2007)	(14) The samplers were set up on rooftops at varying heights 6-20 m above the ground. The sampling time period of $PM_{2.5}$ was 24 h (9 am to 9 am local time).
		Winter	7.1±3.5		
Nanjing (118.8°E , 32.0°N)	Feb 2001 – Sep 2001	Feb	2.88	Yang et al. (2005)	Same as (2) in Table S1.
		Sep	4.01		
Shanghai (121.5°E, 31.2°N)	Apr 2006 – Jan 2007	Summer	1.1	Hou et al. (2011)	(15) The $PM_{2.5}$ samples were collected on the roof of NO.4 teaching building at Fudan University. The sampling time period was generally 24 h.
		Autumn	2.1		
	Oct 2005-Jul 2006	Spring	3.1±1.5	Feng et al. (2009)	(16) The sampler was mounted about 10 m abve the ground. During the four weeks of each sampling month, 24-h $PM_{2.5}$ samples (from morning to morning) were collected.
		Winter	2.3±1.0		
Hangzhou (120.1°E, 30.2°N)	Sep 2001 – Aug 2002	Winter	4.43	Cao et al. (2009a)	Same as (12) in Table S2.
		Summer	2.82		
		Spring	2.96		
		Autumn	4.38		
Changchun (125.3°E, 43.9°N)	Jan - Jul 2003	Summer	2.9±1.4	Cao et al. (2007)	Same as (14) in Table S3.
Qingdao (120.3°E, 36.0°N)	Jan - Jul 2003	Winter	6.3±2.4		
		Summer	1.4±0.5		
HongKong (114.1°E, 22.2°N)	Jan - Jul 2003	Winter	5.8±2.6		
Wuhan (114.2°E, 30.5°N)	Jan - Jul 2003	Summer	3.0±0.07		
Xiamen (118.1°E, 24.4°N)	Jan - Jul 2003	Winter	5.0±1.4		
		Summer	1.4±1.3		
Sheshan (131.2°E, 31.1°N)	Oct – Nov 1999		3.2±1.9	Xu et al. (2002)	(17) The sampler was located on the roof of the monitoring room, and at a height ~7 m above the ground. Daily $PM_{2.5}$ filter samples were collected at 9:00 am to the next morning for 24h.
Changshu (120.8°E, 31.7°N)	Oct – Nov 1999		3.6±1.7		
Akdala (87.97°E, 47.1°N)	Jan-Mar 2005		0.33	Qu et al. (2008)	(18) PM_{10} aerosol samples were collected from a 5 m tall building (3583 above the sea level). The sampling period was 72 hr (normally from 8:00-8:00).
Muztagh (75.01°E, 38.3°N)	2005		0.051	Cao et al. (2009b)	(19) Each filter sample of TSP was nominally collected over a one week period at 4500 m above the sea level.
Zhuzhang (99.72°E, 28°N)	Jan-Feb 2005		0.35	Qu et al. (2008)	Same as (18) in Table S3.

Dalian (121.5°E, 39°N)	2006 to 2007	Spring	2.74	Zhang et al. (2012)	Same as (9) in Table S1.
		Summer	2.12		
		Autumn	3.27		
		Winter	4.53		
Gaolanshan (105.9°E,36.0°N)	2006 to 2007	Summer	1.73		
		Autumn	2.44		
Gucheng (115.8°E, 39.1°N)	2006 to 2007	Spring	4.18		
		Summer	4.24		
		Autumn	6.96		
Jinsha (114.2°E, 29.6°N)	2006 to 2007	Spring	1.35		
		Summer	1.14		
		Autumn	2.58		
		Winter	2.07		
Lhasa (91.1°E, 29.7°N)	2006 to 2007	Spring	1.82		
		Summer	2.09		
		Autumn	2.10		
		Winter	3.27		
Lin'an (121.2°E, 31.1°N)	2006 to 2007	Spring	2.51		
		Summer	2.25		
		Autumn	2.49		
		Winter	2.91		
Longfengshan (127.6°E, 44.7°N)	2006 to 2007	Spring	0.92		
		Summer	0.67		
		Autumn	1.51		
		Winter	2.30		
Nanning (108.3°E, 22.8°N)	2006 to 2007	Spring	1.58		
		Summer	1.64		
		Autumn	3.00		
		Winter	2.99		
Panyu (113.4°E, 23.0°N)	2006 to 2007	Spring	4.90		
		Summer	2.92		
		Autumn	4.48		
		Winter	5.80		
Taiyangshan (111.7°E, 19.2°N)	2006 to 2007	Spring	1.23		
		Summer	1.26		
		Autumn	2.20		
		Winter	1.57		
Xi'an (108.9°E, 34.3°N)	2006 to 2007	Summer	4.56		
		Autumn	6.49		
Zhengzhou (113.7°E, 34.8°N)	2006 to 2007	Spring	4.84		
		Summer	4.18		
		Autumn	5.96		

Table S4. Observed concentrations of OC aerosol in China

Location	Period		Concentration (μg m^{-3})	Reference	Notes on measurements
Beijing (116.4°E, 39.9°N)	Jul 1999 - Sep2000	Summer	13.42	He et al. (2001)	Same as (10) in Table S2.
		Spring	18.21		
Nanjing	2001	Feb	18.34	Wang et al.	Same as (3) in Table S1.

(118.8°E, 32.0°N)		Apr	20.14	(2002)	
Shanghai (121.5°E, 31.2°N)	Apr 2006 – Jan 2007	Spring	8.4±2.2	Hou et al. (2011)	Same as (15) in Table S3.
		Summer	3.8±1.6		
		Autumn	6.5±2.6		
		Winter	10.9±4.5		
Hangzhou (120.1°E, 30.2°N)	Sep 2001 – Aug 2002	Winter	23.81	Cao et al. (2009a)	Same as (12) in Table S2.
		summer	13.54		
		spring	14.03		
Changchun (125.3°E, 43.9°N)	Jan - Jul 2003	Summer	12.5±5.2	Cao et al. (2007)	Same as (14) in Table S3.
Qingdao (120.3°E, 36.0°N)	Jan - Jul 2003	Summer	5.0±2.9		
Tianjin (117.2°E, 39.1°N)	Jan - Jul 2003	Summer	16.5±4.1		
HongKong (114.1°E, 22.2°N)	Jan - Jul 2003	Winter	11.2±4.8		
		Summer	7.3±1.9		
Wuhan (114.2°E, 30.5°N)	Jan - Jul 2003	Summer	14.2±3.7		
Xiamen (118.1°E, 24.4°N)	Jan - Jul 2003	Winter	16.5±5.4		
Muztagh (75.01°E, 38.3°N)	2005		0.51	Cao et al. (2009b)	Same as (19) in Table S3.
Zhuzhang (99.72°E, 28°N)	Jan-Feb 2005		3.1	Qu et al. (2008)	Same as (18) in Table S3.
Chengdu (104.1°E, 30.6°N)	2006 to 2007	Spring	22.82	Zhang et al. (2012)	Same as (9) in Table S1.
Dalian (121.5°E, 39°N)	2006 to 2007	Spring	14.10		
		Summer	9.03		
		Autumn	10.71		
		Winter	13.90		
Gaolanshan (105.9°E,36.0°N)	2006 to 2007	Summer	9.44		
Gucheng (115.8°E, 39.1°N)	2006 to 2007	Spring	15.43		
		Summer	12.90		
Jinsha (114.2°E, 29.6°N)	2006 to 2007	Spring	8.09		
		Summer	7.20		
		Winter	10.17		
Lhasa (91.1°E, 29.7°N)	2006 to 2007	Spring	12.11		
		Autumn	11.48		
		Winter	17.89		
Lin'an (121.2°E, 31.1°N)	2006 to 2007	Spring	9.15		
		Summer	8.08		
		Autumn	8.77		
		Winter	10.57		
Longfengshan (127.6°E, 44.7°N)	2006 to	Spring	7.71		
		Summer	5.79		

	2007	Autumn	11.22		
		Winter	13.01		
Nanning (108.3°E, 22.8°N)	2006 to 2007	Spring	7.75		
		Summer	8.03		
		Autumn	12.67		
		Winter	13.22		
Panyu (113.4°E, 23.0°N)	2006 to 2007	Spring	12.33		
		Winter	16.36		
Taiyangshan (111.7°E, 19.2°N)	2006 to 2007	Spring	6.89		
		Summer	6.84		
		Autumn	10.17		
		Winter	7.95		
Xi'an (108.9°E, 34.3°N)	2006 to 2007	Summer	16.86		
Zhengzhou (113.7°E, 34.8°N)	2006 to 2007	Summer	12.03		
		Autumn	19.65		

Note: A spreadsheet file of aerosol measurements can be obtained by contacting the corresponding author of the paper (hongliao@mail.iap.ac.cn).

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2. Comparisons of simulated (GISS Model 3) and reanalyzed (GEOS-4) surface air temperature, zonal wind, and precipitation for present-day (1996-2005)

Both the simulated and assimilated surface air temperatures show higher temperatures in southern China than in northern China and also higher temperatures in eastern China than in western China (Figure A). The maximum temperatures in southeastern China are simulated to be 280–290 K in DJF, 290–300 K in MAM, 300–310 K in JJA, and 290–300 K in SON, which agree with the assimilated values in all seasons except that the assimilated maximum temperatures in southeastern China are lower than 305 K in JJA. Simulated zonal winds averaged over 100°–120°E longitudes show maximum wind speeds of the jet stream located at 200 hPa altitude of 60, 40, 20, and 30 m s^{-1} in DJF, MAM, JJA, and SON, respectively, which agree closely with the assimilated values (Figure B). The present-day precipitation simulated by the GISS model shows larger values in MAM and JJA than in DJF and SON, which agree with the assimilated precipitation, but the model overestimates precipitation in the middle and lower reaches of the Yangtze River in MAM whereas underestimates precipitation in that region in JJA (Figure C).

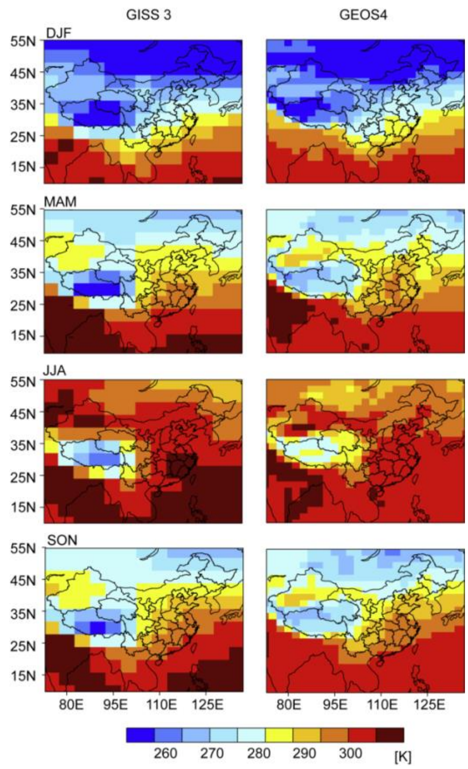

Figure A. Comparisons of simulated (GISS Model 3) and reanalyzed (GEOS-4) surface air temperatures (K) in China for present day (averages over 1996-2005).

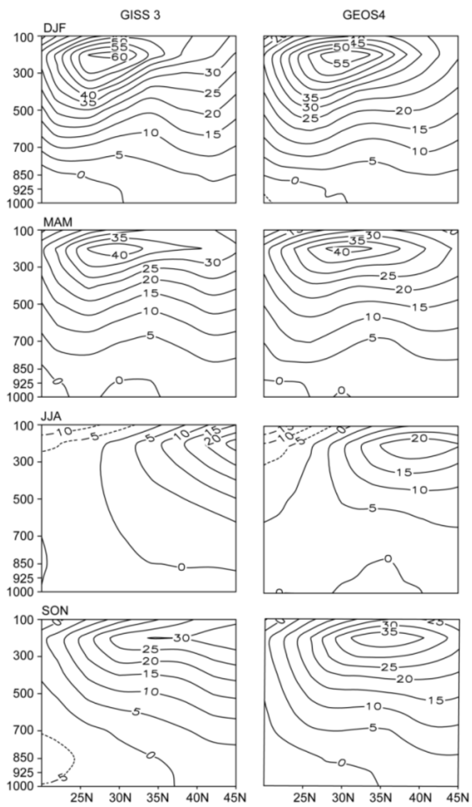

Figure B. Comparisons of simulated (GISS Model 3) and reanalyzed (GEOS-4) zonal winds (m s^{-1}) for present day (averages over 1996-2005). To represent winds over eastern China, winds are averaged over the longitude range of 100°-120°E.

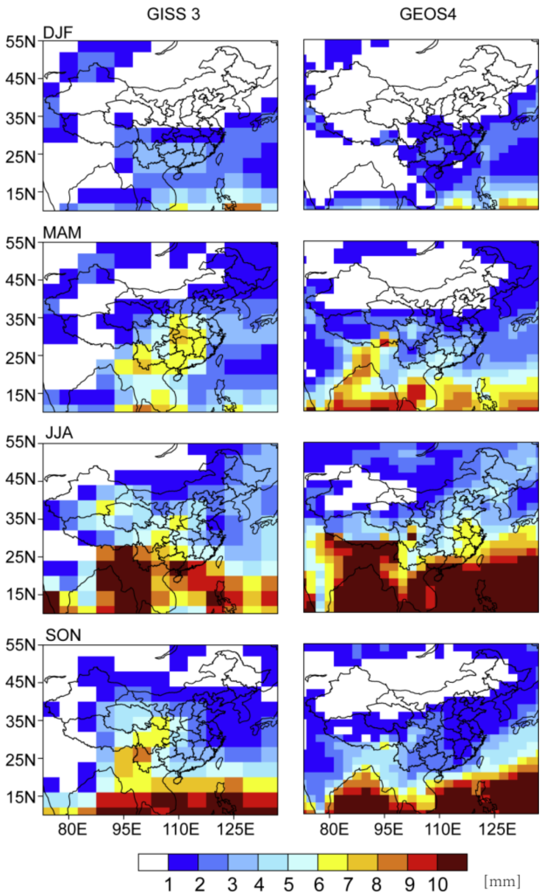

Figure C. Comparisons of simulated (GISS Model 3) and reanalyzed (GEOS-4) precipitation (mm) in China for present day (averages over 1996-2005).

3. The altitude-latitude cross-sections of the changes in aerosol concentrations from the present day to future owing to changes in anthropogenic emissions alone

For the case with changes in emissions alone, since changes in emissions are mostly imposed near the surface, the vertical changes in concentrations of aerosols in the lower troposphere generally follow the sign of changes at the surface-layer, as shown by the altitude-latitude cross-sections of the changes in aerosol concentrations averaged over eastern China (Figure D). Changes in concentrations above 2 km altitude can be influenced by long-range transport. Because our manuscript is already very long, we do not show such plots of vertical changes in concentrations in the manuscript. Instead, we show future changes in long-range transport owing to changes in emissions alone in Figs. 11-13 of the manuscript.

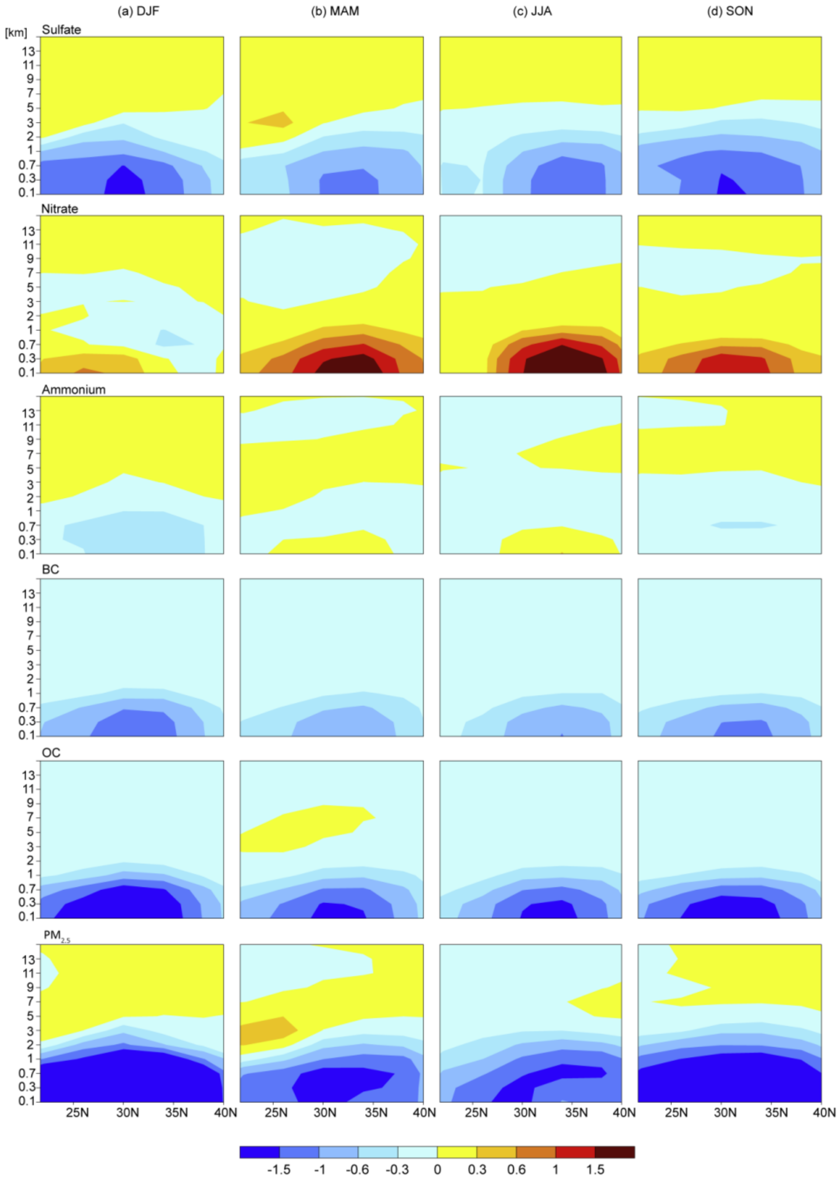

Figure D. The altitude-latitude cross-sections of the changes in aerosol concentrations from the present day (1996-2005) to future (2046-2055) owing to changes in anthropogenic emissions alone. Values are averaged over longitudes from 115°E to 120°E.

4. Explanation about the future changes in PBL depth

The changes in PBL depth result from the simulated changes in atmospheric temperature (or atmospheric stability). As an example, we show in Figure E the 2000-2050 changes in SON air temperatures averaged over 110-120°E and 32-40°N (this area shows large reductions in PBL depth in Figure 4 of the manuscript in SON). The simulated increases in temperature in the 500-700 hPa altitude are larger than those in the lower troposphere, leading to a more stable atmosphere and hence a lower PBL depth in 2050. It should be noted that the negative changes in PBL depth were also found for the US in Pye et al. (2009), with the changes in PBL also simulated by the GISS Model 3.

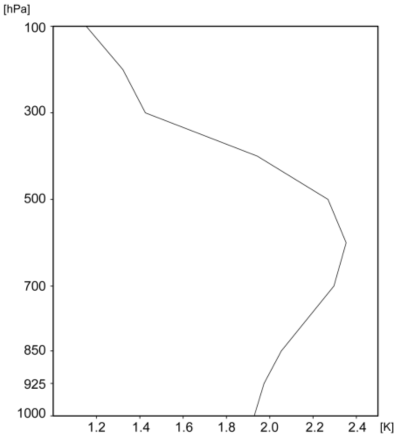

Figure E. The simulated 2000-2050 changes in SON air temperatures averaged over 110-120°E and 32-40°N.

References

Pye, H. O. T., Liao, H.,Wu, S., Mickley, L. J., Jacob, D. J., Henze, D. K., and Seinfeld, J. H.: Effect of changes in climate and emissions on future sulfate-nitrate-ammonium aerosol levels in the United States, J. Geophys. Res.-Atmos., 114, D01205, doi:10.1029/2008jd010701, 2009.