Quantification of Impact of Climate Uncertainty on Regional Air Quality

Kuo-Jen Liao[1], Efthimios Tagaris[1], Kasemsan Manomaiphiboon[1, 4], Chien Wang[2], Jung-Hun Woo[3, 5], Praveen Amar[3], Shan He[3], Armistead G. Russell[1]*

[1] School of Civil & Environmental Engineering, Georgia Institute of Technology

[2] Joint Program on the Science and Policy of Global Change, Massachusetts Institute of Technology

[3] Northeast States for Coordinated Air Use Management (NESCAUM)

[4] Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, Bangkok, Thailand

[5] Department of Advanced Technology Fusion, Konkuk University, Seoul, Korea

Supplementary Material

Perturbations of the three-dimensional GISS-MM5 climate fields using the two-dimensional IGSM climate fields

The two-dimensional (latitude and vertical) IGSM fields are expanded into the three-dimensional climate fields and are applied to perturb GISS-MM5 fields using the following steps:

Step 1: Decompose a three-dimensional time-dependent variable of the GISS-MM5 climate $C(y,x,z,t)$ into steady and fluctuating terms using Reynolds Decomposition (m=monthly mean specifically):

$$C(y,x,z,t) = \overline{C(y,z,m)} + C'(y,x,z,t)$$

where

$C(y,x,z,t)$: Original GISS - MM5 climate

$\overline{C(y,z,m)}$: Longitude - average term of $C(y,x,z,t)$ (steady component of $C(y,x,z,t)$)

$C'(y,x,z,t)$: Fluctuating term of $C(y,x,z,t)$ *and* $\sum_t C'(y,x,z,t) = 0$

y: latitude, z: altitude, x: longitude

m: monthly-averaged values

t: MM5 temporal resolution of every 6-hr

Step 2: Replace the longitude-average term $\overline{C}$ with the 0.5th, 50th and 99.5th percentile cases of meteorological fields from IGSM results

Step3: Reversely convert the new $\overline{C}$ back to C using C' to derive needed three-dimensional meteorological fields

Table S1. Annual average zonal (longitude-average) temperatures and their difference from the IGSM outputs for percentiles of 0.5th, 5th, 50th, 95th and 99.5th for five latitudes in 2050.

		2050 Average Zonal Temperature (K)				
Latitude Index	Latitude	0.5%	5%	50%	95%	99.5%
1	19.6	295.3	295.3	295.9	296.6	297.5
2	27.4	292.0	291.9	292.8	293.1	294.1
3	35.2	288.2	288.4	288.6	290.0	291.1
4	43.0	282.4	282.8	283.3	284.2	285.4
5	50.9	277.3	277.8	278.2	279.1	279.8
		2050 Average ΔT (K)				
Latitude Index	Latitude	0.5%-50%	5%-50%	-	95%-50%	99.5%-50%
1	19.6	-0.6	-0.6	-	0.7	1.6
2	27.4	-0.8	-0.9	-	0.3	1.3
3	35.2	-0.4	-0.2	-	1.4	2.5
4	43.0	-0.9	-0.5	-	0.9	2.1
5	50.9	-0.9	-0.4	-	0.9	1.6

Table S2. Annualized and summer-averaged emissions of NO_x, SO_2 and NH_3 (tons/day/grid) for the base, low-extreme and high-extreme scenarios in 2050.

		Annualized (ton/day/grid)			Summer average (ton/day/grid)		
		Base	Low-extreme	High-extreme	Base	Low-extreme	High-extreme
WS	NO_X	2.47	2.46	2.49	2.90	2.86	2.91
	SO_2	0.61	0.61	0.61	0.75	0.75	0.75
	NH_3	1.47	1.47	1.47	1.66	1.66	1.66
PL	NO_X	3.41	3.38	3.50	4.11	4.09	4.24
	SO_2	1.81	1.81	1.81	2.12	2.12	2.12
	NH_3	1.64	1.64	1.64	1.96	1.96	1.96
MW	NO_X	6.19	6.17	6.28	6.51	6.50	6.67
	SO_2	8.22	8.22	8.22	8.74	8.74	8.74
	NH_3	3.44	3.44	3.44	3.95	3.95	3.95
NE	NO_X	7.30	7.30	7.29	6.78	6.76	6.78
	SO_2	4.96	4.96	4.96	4.43	4.43	4.43
	NH_3	2.46	2.46	2.46	2.88	2.88	2.88
SE	NO_X	6.58	6.55	6.60	6.81	6.77	6.83
	SO_2	5.13	5.13	5.13	5.69	5.69	5.69
	NH_3	3.24	3.24	3.24	4.19	4.19	4.19
US	NO_X	4.42	4.39	4.47	4.83	4.81	4.91
	SO_2	3.35	3.35	3.35	3.63	3.63	3.63
	NH_3	2.21	2.21	2.21	2.63	2.63	2.63