GeoHealth

Supporting information for

Statistical emulation of winter ambient fine particulate matter concentrations from emission changes in China

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Supplementary Figure 8: The combined impact of variations in two emission sectors on the ambient fine particulate matter ($PM_{2.5}$) exposure for North East China from (a) residential (RES) and industry (IND), (b) RES and land transport (TRA), (c) RES and agriculture (AGR), (d) RES and power generation (ENE), (e) IND and TRA, (f) IND and AGR, (g) IND and ENE, (h) TRA and AGR, (i) TRA and ENE, and (j) AGR and ENE emissions. Air quality targets shown for the World Health Organization's Air Quality Guideline (AQG), Interim Target 1 (IT−1), Interim Target 2 (IT−2), Interim Target 3 (IT−3), and China's National Air Quality Target (NAQT).

Supplementary Figure 9: The combined impact of variations in two emission sectors on the ambient fine particulate matter ($PM_{2.5}$) exposure for East China from (a) residential (RES) and industry (IND), (b) RES and land transport (TRA), (c) RES and agriculture (AGR), (d) RES and power generation (ENE), (e) IND and TRA, (f) IND and AGR, (g) IND and ENE, (h) TRA and AGR, (i) TRA and ENE, and (j) AGR and ENE emissions. Air quality targets shown for the World Health Organization's Air Quality Guideline (AQG), Interim Target 1 (IT−1), Interim Target 2 (IT−2), Interim Target 3 (IT−3), and China's National Air Quality Target (NAQT).

Supplementary Figure 10: The combined impact of variations in two emission sectors on the ambient fine particulate matter ($PM_{2.5}$) exposure for South Central China from (a) residential (RES) and industry (IND), (b) RES and land transport (TRA), (c) RES and agriculture (AGR), (d) RES and power generation (ENE), (e) IND and TRA, (f) IND and AGR, (g) IND and ENE, (h) TRA and AGR, (i) TRA and ENE, and (j) AGR and ENE emissions. Air quality targets shown for the World Health Organization's Air Quality Guideline (AQG), Interim Target 1 (IT−1), Interim Target 2 (IT−2), Interim Target 3 (IT−3), and China's National Air Quality Target (NAQT).

Supplementary Figure 11: The combined impact of variations in two emission sectors on the ambient fine particulate matter ($PM_{2.5}$) exposure for South West China from (a) residential (RES) and industry (IND), (b) RES and land transport (TRA), (c) RES and agriculture (AGR), (d) RES and power generation (ENE), (e) IND and TRA, (f) IND and AGR, (g) IND and ENE, (h) TRA and AGR, (i) TRA and ENE, and (j) AGR and ENE emissions. Air quality targets shown for the World Health Organization's Air Quality Guideline (AQG), Interim Target 1 (IT−1), Interim Target 2 (IT−2), Interim Target 3 (IT−3), and China's National Air Quality Target (NAQT).

Supplementary Figure 12: The combined impact of variations in two emission sectors on the ambient fine particulate matter ($PM_{2.5}$) exposure for North West China from (a) residential (RES) and industry (IND), (b) RES and land transport (TRA), (c) RES and agriculture (AGR), (d) RES and power generation (ENE), (e) IND and TRA, (f) IND and AGR, (g) IND and ENE, (h) TRA and AGR, (i) TRA and ENE, and (j) AGR and ENE emissions. Air quality targets shown for the World Health Organization's Air Quality Guideline (AQG), Interim Target 1 (IT−1), Interim Target 2 (IT−2), Interim Target 3 (IT−3), and China's National Air Quality Target (NAQT).

Additional Supporting Information (Files uploaded separately)

The trained emulators per grid cell in China that support the findings of this study are available at doi.org/10.5518/953.

Supplementary Table 1: Simulator setup used in the Weather Research and Forecasting model online–coupled with Chemistry (WRFChem) simulations.

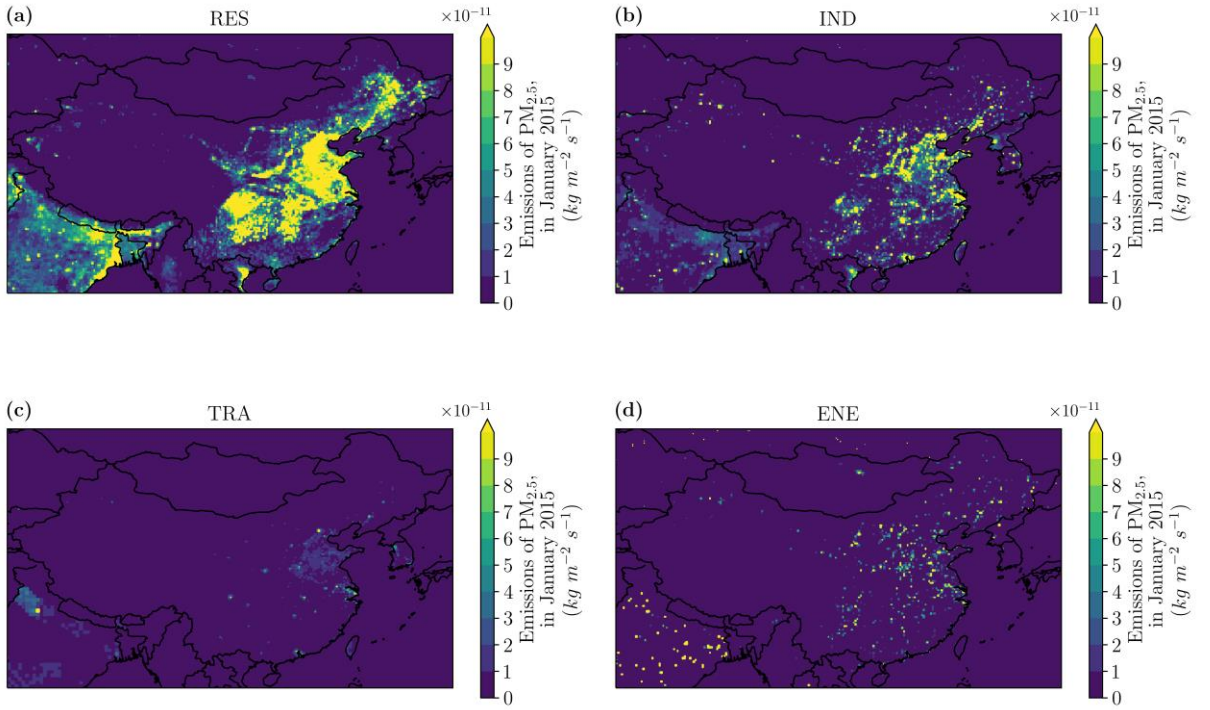
Simulator Setup and Parameterisation	
Process	**Method**
Timestep	180 seconds.
Horizontal	Parent grid on a resolution of 30 km along a 170 × 170 Lambert conformal conical grid, with a 10 km nest over Guangdong–Hong Kong–Macau Greater Bay Area (GBA).
Vertical	33 vertical levels, with 38 meteorological levels.
Microphysics	Morrison two–moment scheme (Morrison, Thompson, & Tatarskii, 2009).
Radiation	Rapid radiative transfer model for general circulation models (RRTMG), short–wave and long–wave (Iacono et al., 2008).
Boundary layer physics	Mellor–Yamada Nakanishi and Niino 2.5 (Nakanishi & Niino, 2006).
Land surface	Noah Land Surface Model (Ek et al., 2003).
Convection	Grell 3–D ensemble (Grell & Devenyi, 2002).
Gas–phase chemistry	Extended Model for Ozone and Related Chemical Tracers (MOZART, Emmons et al., 2010; A. Hodzic & Jimenez, 2011; Knote et al., 2014).
Aerosol	Updated Model for Simulating Aerosol Interactions and Chemistry (MOSAIC) with aqueous chemistry, volatility basis set secondary organic aerosol production, and 4 sectional bins (Alma Hodzic & Knote, 2014; Knote, Hodzic, & Jimenez, 2015; Zaveri, Easter, Fast, & Peters, 2008).
Photolysis	Updated tropospheric ultraviolet-visible (TUV) photolysis based Tie et al., (2003).
Dust	Global Ozone Chemistry Aerosol Radiation and Transport (GOCART) with Air Force Weather Agency (AFWA) modifications (Legrand et al., 2019).
Initial & boundary chemistry	MOZART / Goddard Earth Observing System (GEOS) Model (National Center for Atmospheric Research, 2016).
Initial & boundary meteorology	European Centre for Medium–Range Weather Forecasts (ECMWF) global reanalysis products (Dee et al., 2011).

Supplementary Table 2: Scaling factors for each anthropogenic emission sector of the training runs. Applied to all species within the sector. Sectors are residential (RES), industry (IND), land transport (TRA), agriculture (AGR), and power generation (ENE).

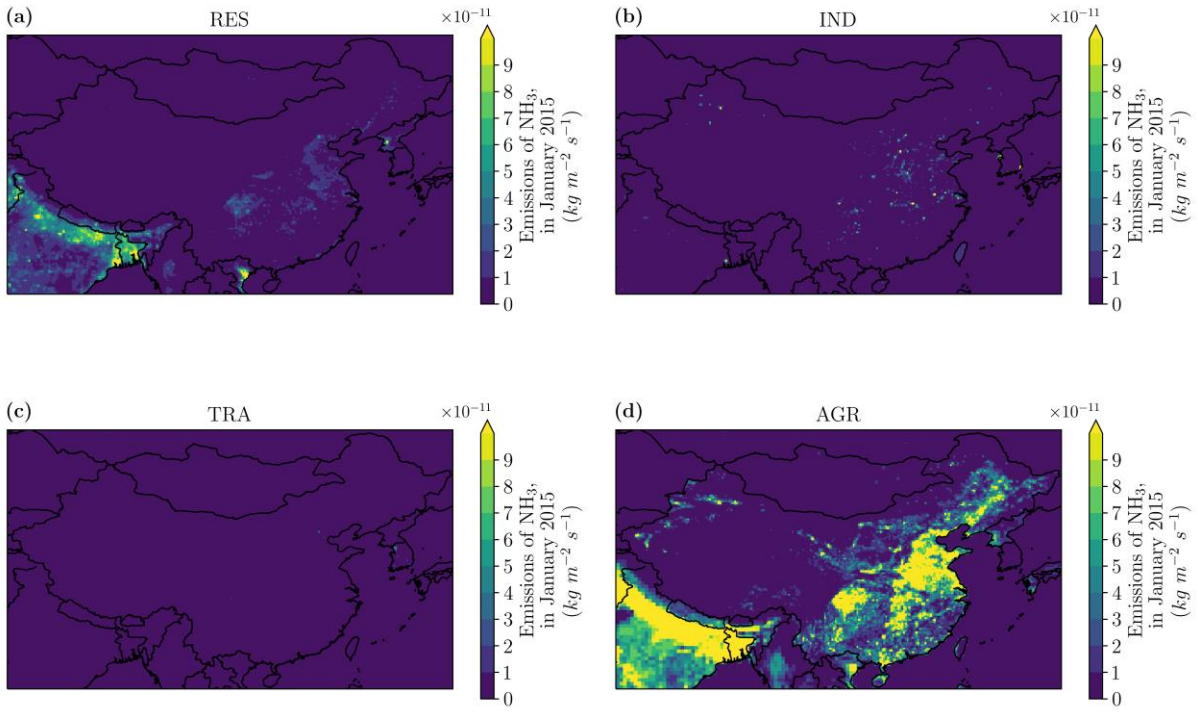
Run	RES	IND	TRA	AGR	ENE
1	0.232290	0.205070	0.299040	0.973740	0.551840
2	1.121200	1.109800	0.870100	1.222200	1.252000
3	0.798430	1.294600	0.090709	0.754010	0.194200
4	0.344450	1.422400	0.751120	1.240900	1.211300
5	0.625620	1.358900	1.058300	0.046880	0.641960
6	1.317300	1.481600	1.260400	0.172230	1.124200
7	0.322090	1.224400	1.358300	0.815870	0.881020
8	0.504950	1.032500	0.623790	0.346780	0.517600
9	1.081500	0.589920	0.174440	0.903560	0.914420
10	1.047700	0.852830	1.021800	0.662300	0.295090
11	0.200370	0.938770	0.787540	0.840040	0.380760
12	0.568470	1.344100	0.243480	1.023100	1.145800
13	0.921400	1.452800	1.308100	1.072500	0.976740
14	1.057700	0.665280	0.449540	0.899190	0.215160
15	0.748300	0.484550	1.404100	0.514490	1.023300
16	0.110840	1.074500	0.008116	1.272900	0.110040
17	1.159500	1.286100	0.591250	0.747910	0.662940
18	0.672560	0.973790	1.148300	0.490410	0.571260
19	0.644860	0.133860	1.209700	0.544930	1.362400
20	0.017270	0.878860	0.418380	0.623740	0.712510
21	0.377570	1.168500	0.991360	0.587440	1.300400
22	0.771580	1.244500	1.253700	1.353400	1.450900
23	1.372900	0.039672	0.325750	1.316900	0.760170
24	0.877930	0.416510	0.374790	0.383360	0.353590
25	0.590670	0.384670	1.112800	1.148300	1.480700
26	0.868720	1.125300	0.847410	0.011413	1.349800
27	0.407450	0.605530	1.423300	0.323490	1.393300
28	1.477600	1.196200	0.834050	1.465600	0.161960
29	0.269510	0.762190	0.665220	1.095000	0.994200
30	0.121540	0.004582	0.971640	0.476100	0.822970
31	0.065047	0.920190	0.223860	0.653380	0.148430
32	0.516280	0.075462	0.123790	0.414790	0.738230
33	1.412200	0.731970	0.486510	0.077169	0.400060
34	1.338100	0.434560	0.569770	1.133200	1.186100
35	0.292180	0.264880	1.341500	0.713830	0.622110
36	0.421000	0.814350	0.076858	0.143540	0.793510
37	1.468700	1.001700	0.954640	1.180100	0.848000
38	0.969310	0.113760	0.536980	0.807060	1.411400
39	0.813420	0.353800	1.470200	1.435800	1.077500
40	0.951620	0.278170	0.331140	1.332800	0.265550
41	1.409400	0.659160	1.194600	0.276410	1.281200
42	1.176900	0.219130	0.461250	0.950480	0.484260
43	0.040073	1.399000	0.640110	0.226400	1.095000
44	0.464430	0.803670	0.195950	1.013500	0.304760
45	0.690130	0.694200	0.692600	0.092788	0.957350
46	1.013800	0.172050	1.083200	1.492200	0.002612
47	1.256200	0.326790	0.048641	0.260750	0.433230
48	0.166260	0.551850	0.908860	1.390900	0.055920
49	1.215500	0.476710	0.747650	0.197950	0.075353
50	1.285700	0.535410	1.452400	0.444090	0.465490

Supplementary Table 3: Scaling factors for each anthropogenic emission sector of the testing runs. Applied to all species within the sector. Sectors are residential (RES), industry (IND), land transport (TRA), agriculture (AGR), and power generation (ENE).

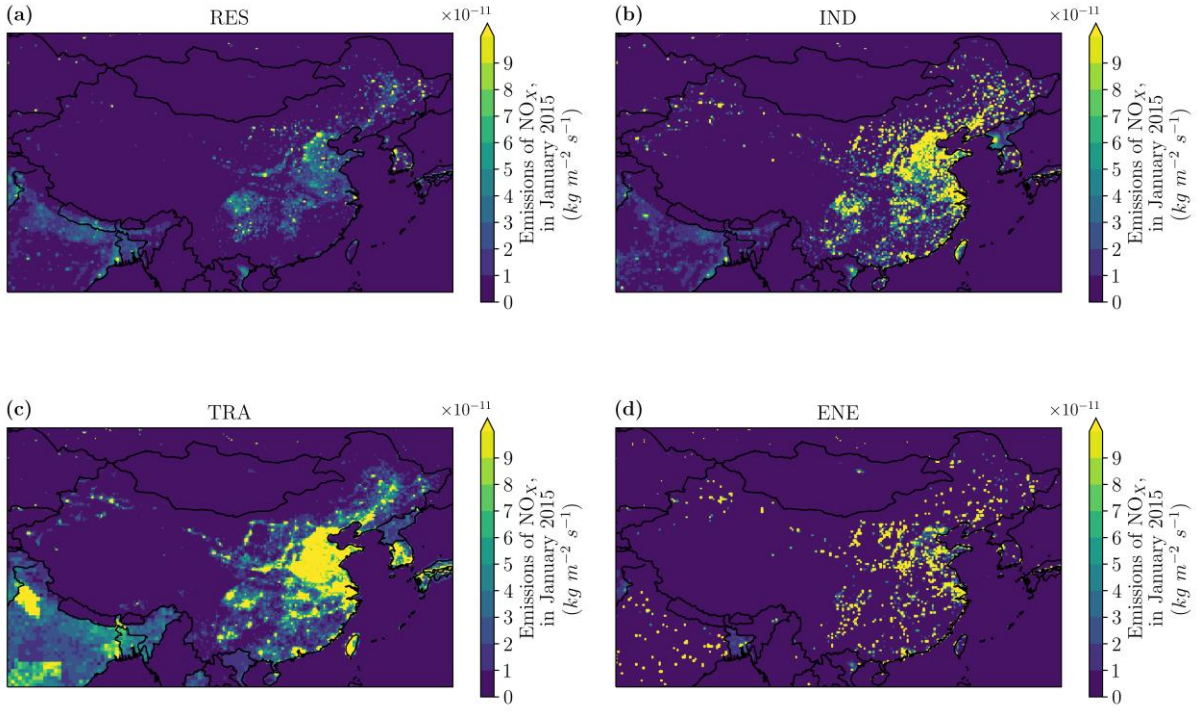
Run	RES	IND	TRA	AGR	ENE
1	0.800999	0.119784	1.370262	0.752336	0.336031
2	0.017744	0.523419	0.600339	0.476919	1.439264
3	1.005595	1.3623	1.147695	1.144138	1.135136
4	1.489352	0.889862	0.530681	0.001446	0.657881
5	0.340401	1.107743	0.265786	1.457797	0.181091



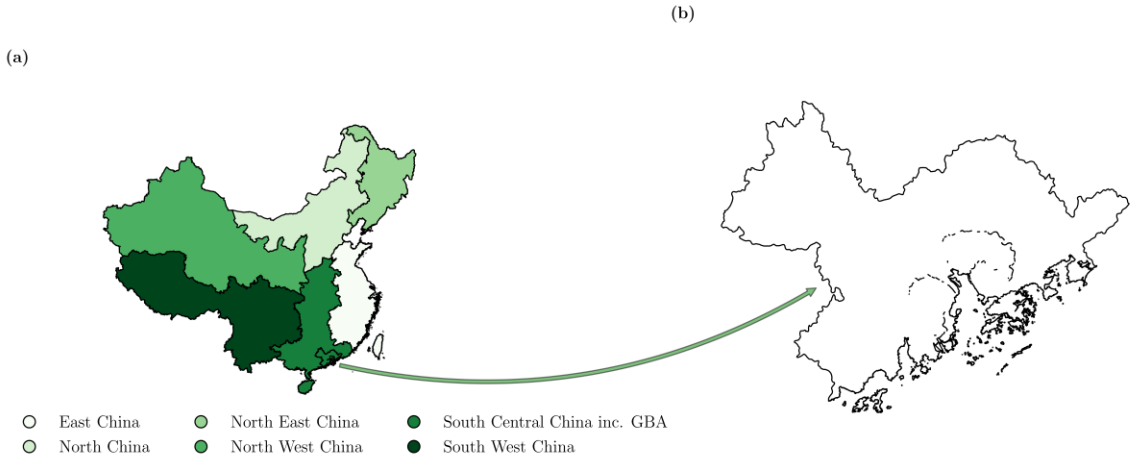
Supplementary Figure 1: Anthropogenic emissions of fine particulate matter ($PM_{2.5}$) in January 2015 across China from the (a) residential (RES), (b), industrial (IND), (c) land transport (TRA), and (d) power generation (ENE) sectors.



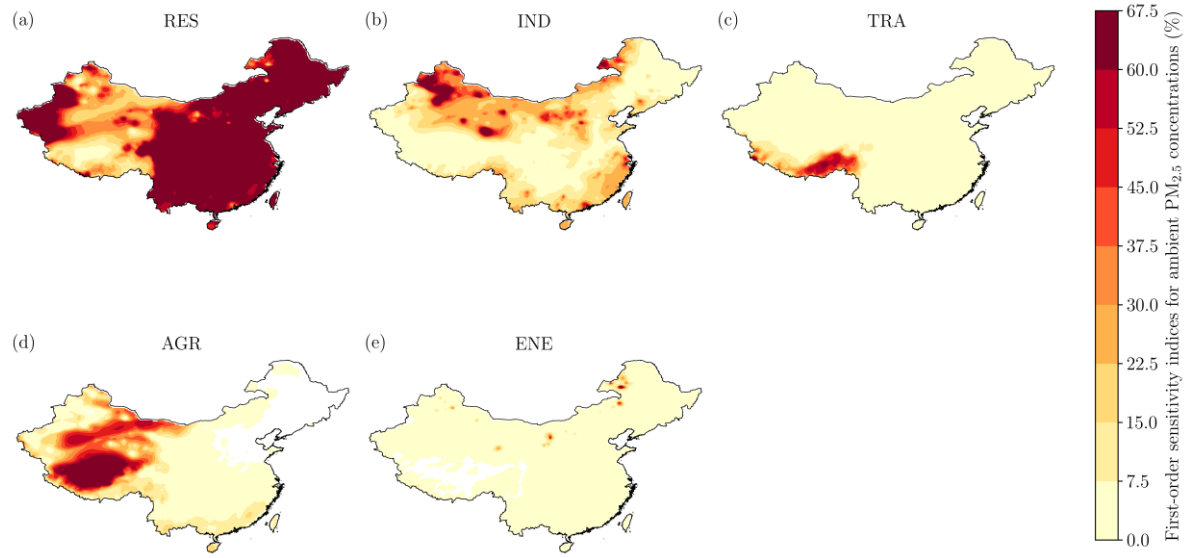
Supplementary Figure 2: Anthropogenic emissions of ammonia (NH_3) in January 2015 across China from the (a) residential (RES), (b), industrial (IND), (c) land transport (TRA), and (d) agricultural (AGR) sectors.



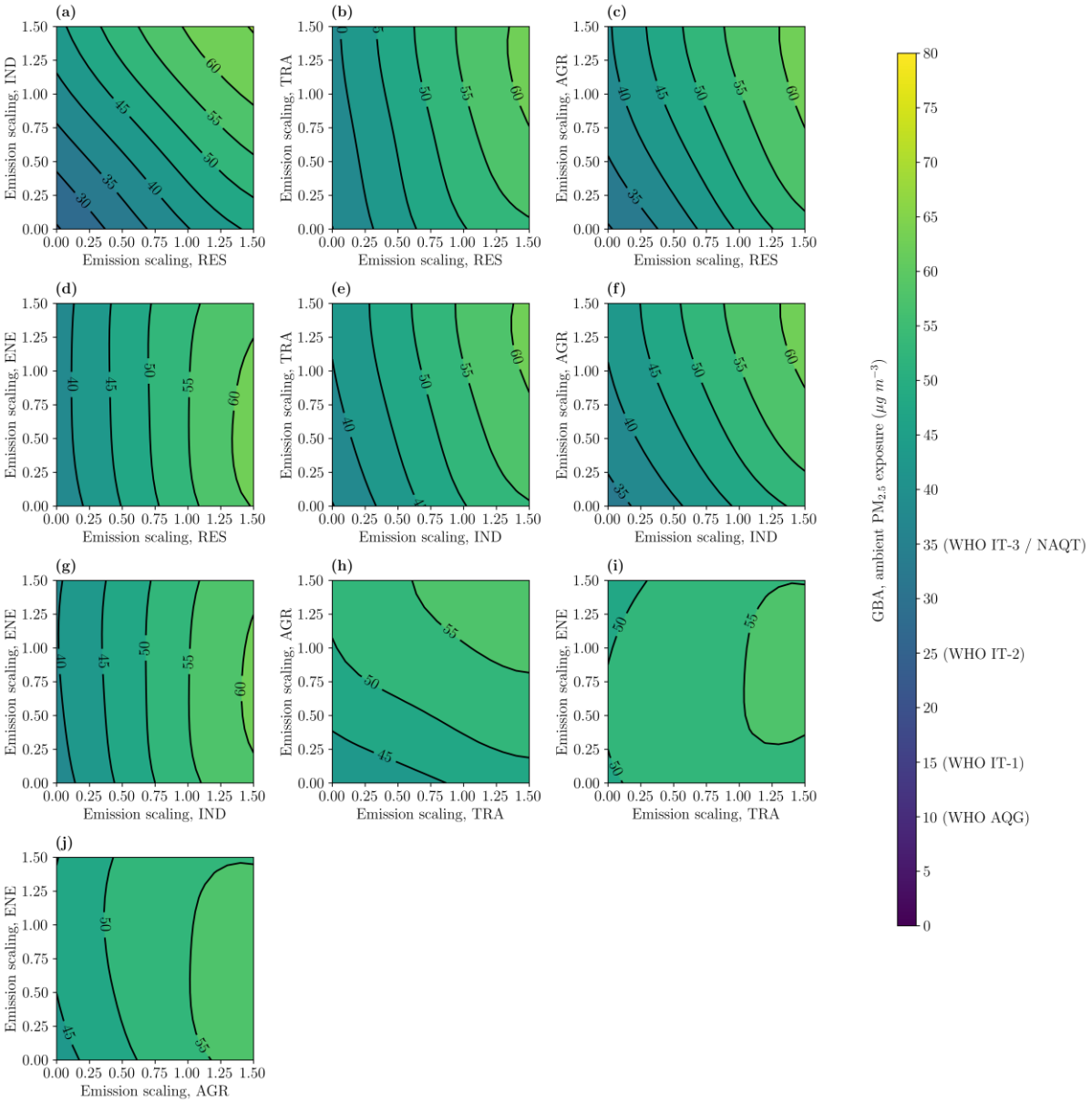
Supplementary Figure 3: Anthropogenic emissions of nitrogen oxides (NO_X) in January 2015 across China from the (a) residential (RES), (b), industrial (IND), (c) land transport (TRA), and (d) power generation (ENE) sectors.



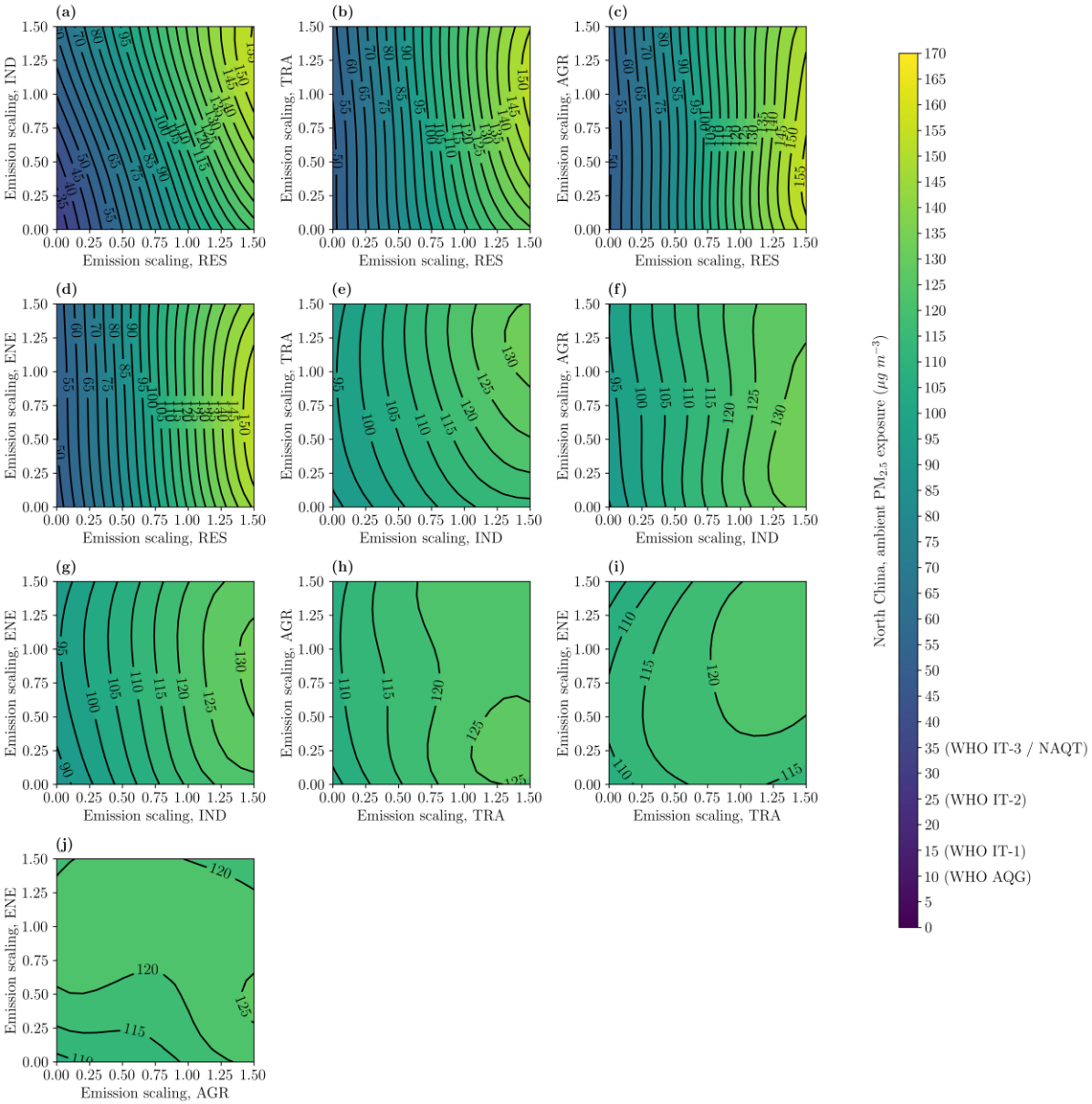
Supplementary Figure 4: Regional groupings for (a) North China (Beijing, Tianjin, Hebei, Shanxi, and Inner Mongolia), North East China (Liaoning, Jilin, and Heilongjiang), East China (Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, and Shandong), South Central China (Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Hong Kong, and Macau) including the Guangdong−Hong Kong−Macau Greater Bay Area (GBA), South West China (Chongqing, Sichuan, Guizhou, Yunnan, and Tibet), North West China (Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang), and (b) the GBA individually.



Supplementary Figure 5: First−order sensitivities of monthly−mean (January 2015) ambient fine particulate matter ($PM_{2.5}$) concentrations across China to each of the five key emission sectors: (a) residential (RES), (b) industry (IND), (c) land transport (TRA), (d) agriculture (AGR), and (e) power generation (ENE).



Supplementary Figure 6: The combined impact of variations in two emission sectors on the ambient fine particulate matter ($PM_{2.5}$) exposure for Guangdong−Hong Kong−Macau Greater Bay Area (GBA) from (a) residential (RES) and industry (IND), (b) RES and land transport (TRA), (c) RES and agriculture (AGR), (d) RES and power generation (ENE), (e) IND and TRA, (f) IND and AGR, (g) IND and ENE, (h) TRA and AGR, (i) TRA and ENE, and (j) AGR and ENE emissions. Air quality targets shown for the World Health Organization's Air Quality Guideline (AQG), Interim Target 1 (IT−1), Interim Target 2 (IT−2), Interim Target 3 (IT−3), and China's National Air Quality Target (NAQT).



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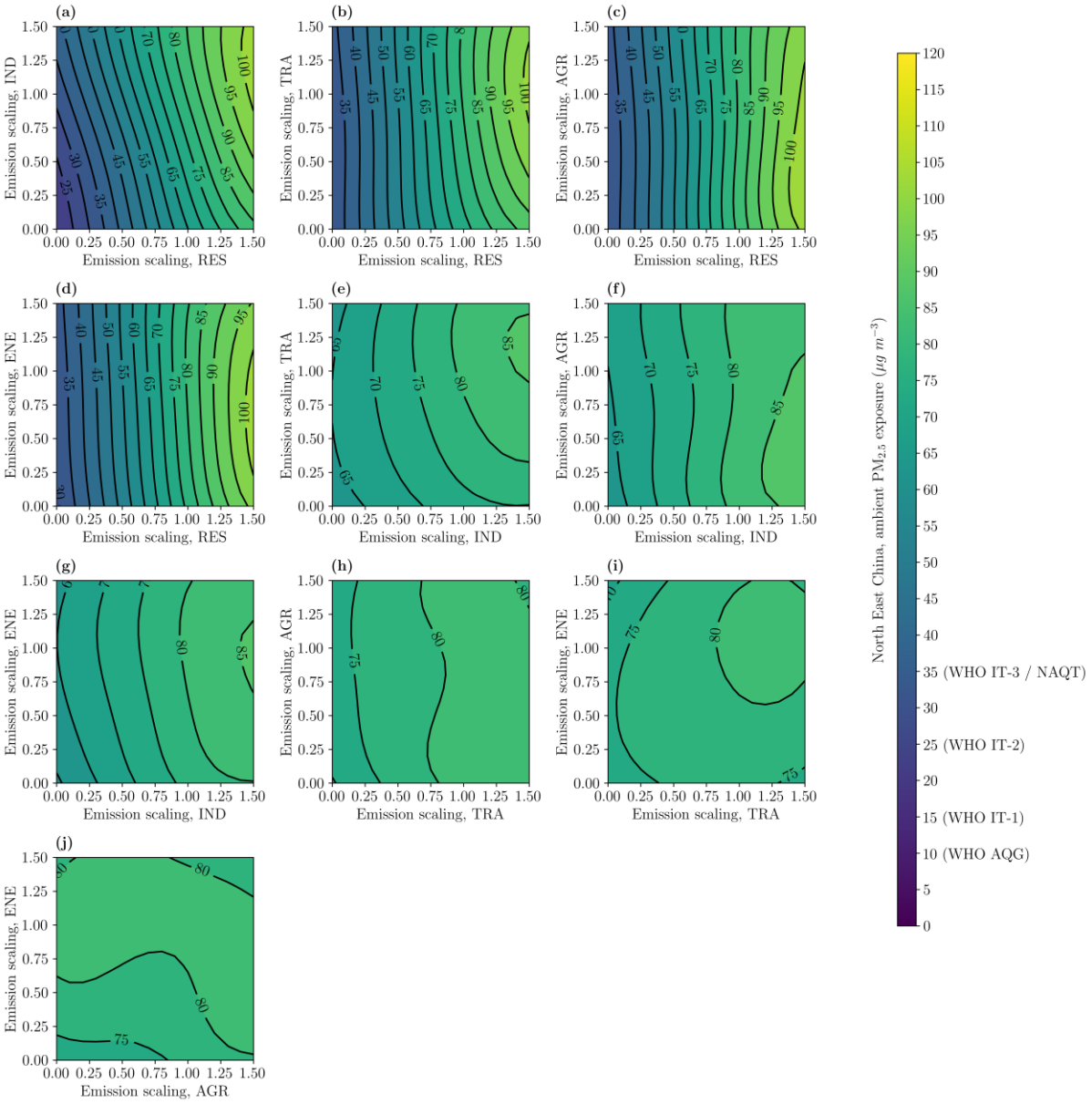

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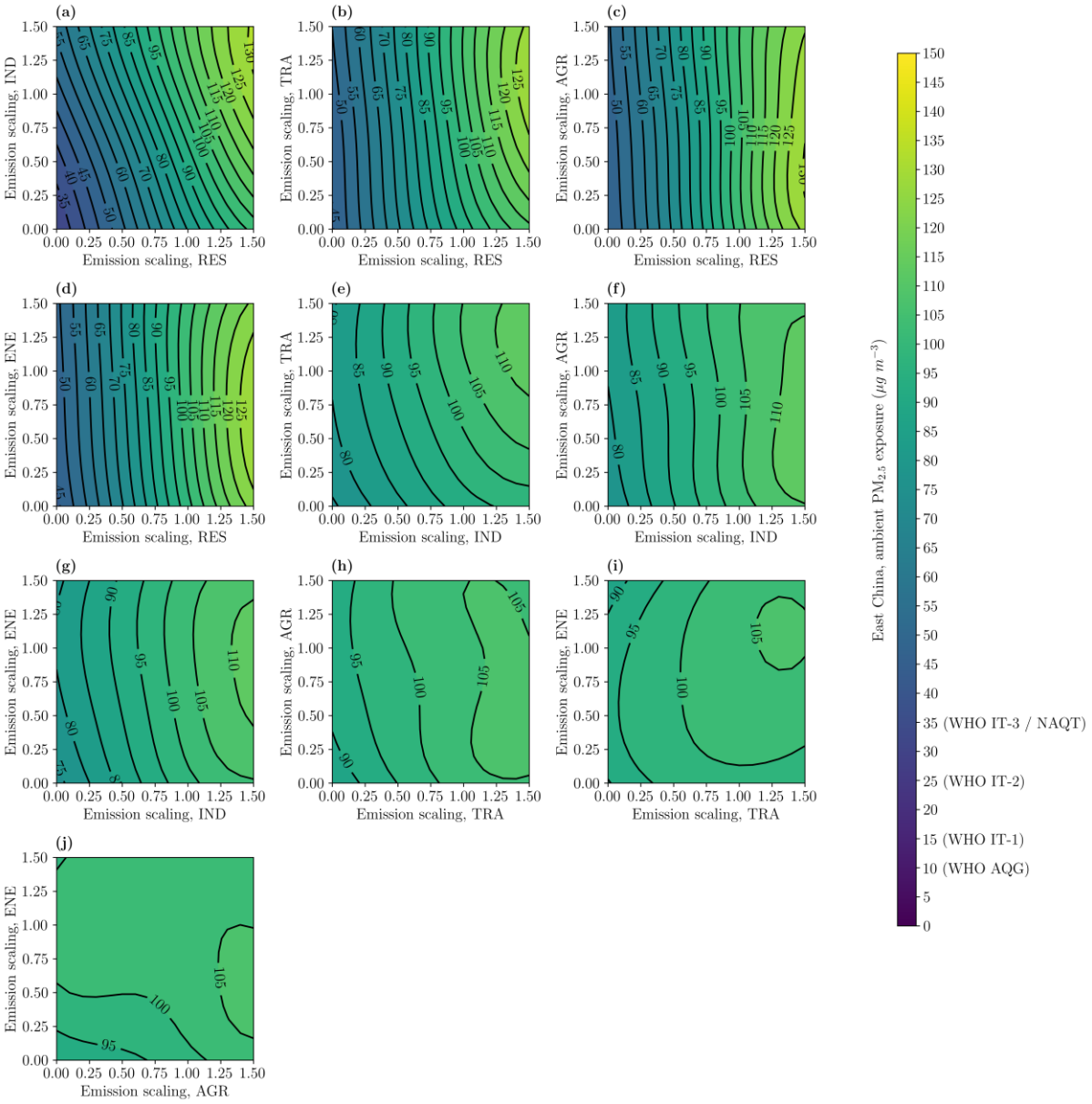

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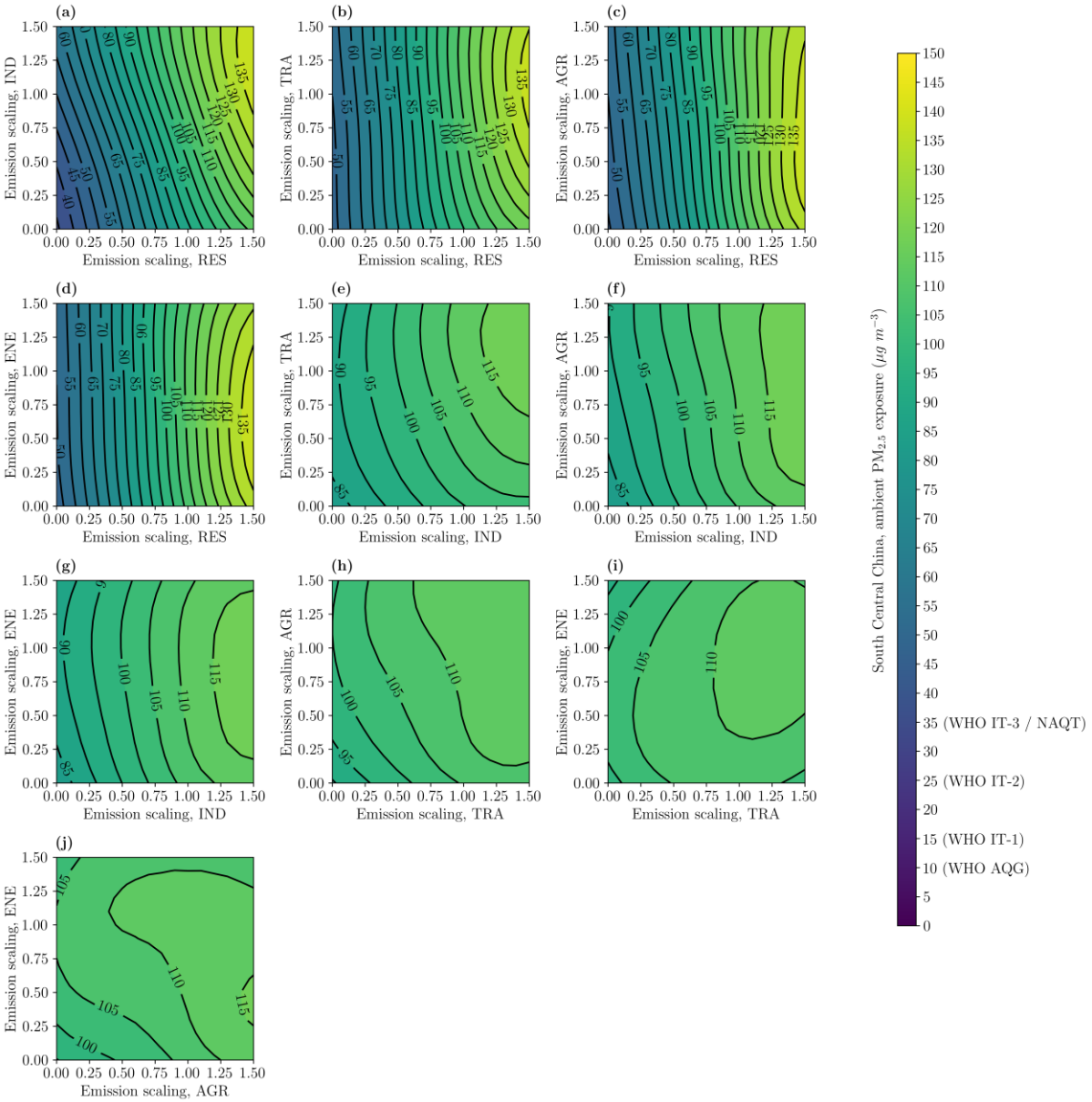

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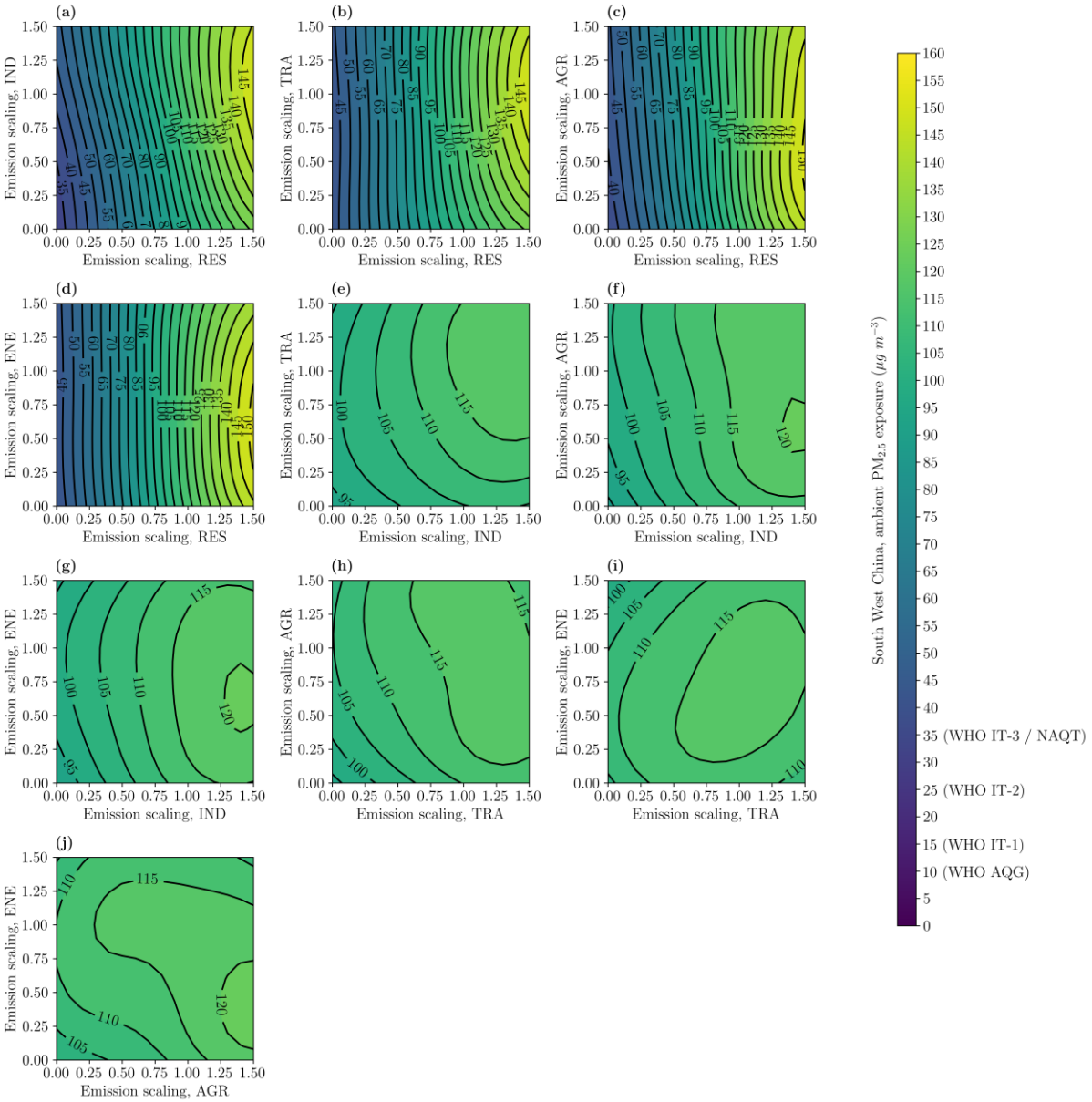

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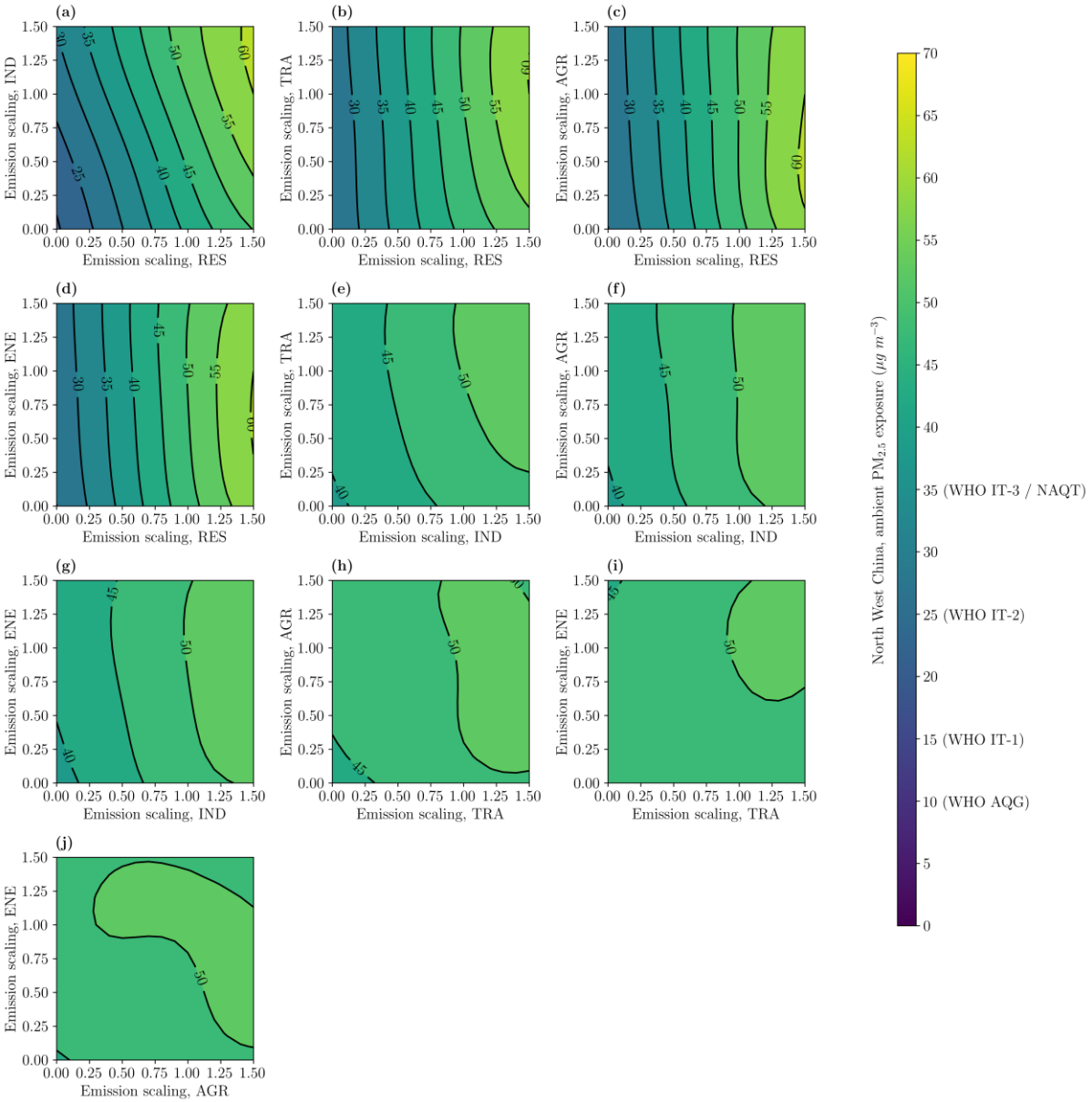

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