

Supplementary Materials: Emission Characteristics of Air Pollutants and CO₂ from 11 Cities with Different Economic Development around the Bohai Sea in China from 2008–2017

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Table S1. The summary of the annual level of air pollutants (Metric kilotonnes) of the industry sector and CO₂ of the industry sector.

City	BC	CO	CO ₂	NH ₃	NO _x	OC	PM _{2.5}	PM ₁₀	SO ₂
Beijing	3.8–4.9	940–1336	54–87	/	33–65	1.8–3.8	10–22	16–36	6–39
Tianjin	2.2–3.8	811–1278	52–71	/	83–112	1.3–2.5	11–18	18–30	33–127
Dalian	2.5–4.4	329–644	33–36	/	53–66	2.6–5.9	15–34	40–83	40–85
Yingkou	1.9–3.4	77–119	8–12	/	11–15	1.5–3.1	2.2–5.1	4.8–11.8	15–39
Jinzhou	2.6–3.0	98–116	10–11	/	32–35	2.3–2.6	10–13	13–16	31–39
Panjin	0.4–0.8	6–10	0.8–0.9	/	3.6–4.5	0.3–0.8	1.1–2.9	1.4–3.9	5–20
Qinhuangdao	1.7–2.8	176–232	23–25	/	36–39	1.5–2.5	6–13	8–20	17–47
Tangshan	3.0–5.0	760–1180	71–81	/	79–130	2.4–4.2	28–51	36–69	120–167
Dongying	2.5–4.4	284–445	21–28	/	12–17	2.2–4.1	14–25	18–34	18–67
Weifang	0.9–1.8	226–300	15–24	/	24–42	0.3–0.9	6–13	9–21	39–107
Yantai	2.3–4.6	184–390	30–32	/	36–45	1.8–4.4	10–23	14–31	39–74

Table S2. The summary of the annual level of air pollutants (kg per capita) per capita and CO₂ (tonnes per capita) per capita.

City	BC	CO	CO ₂	NH ₃	NO _x	OC	PM _{2.5}	PM ₁₀	SO ₂
Beijing	0.4–0.7	80–151	5.7–7.0	1.8–2.1	4.2–10	0.5–1.0	0.8–2.3	1.2–3.1	0.9–6.8
Tianjin	0.4–0.9	126–258	9.4–10	2.2–3.1	15–26	0.5–1.4	1.6–3.4	2.2–4.8	5.2–7.9
Dalian	1.0–2.0	80–183	11–14	3.8–6.7	17–35	1.0–2.3	2.9–7.5	3.5–9.5	8–24
Yingkou	2.1–2.8	84–102	8–15	4.8–8.4	15–18	2.0–3.2	3.9–9.2	4.5–10.7	11–38
Jinzhou	1.9–2.4	82–95	9–10	5.1–6.0	27–39	2.4–3.0	4.8–6.7	5.5–7.8	24–29
Panjin	1.0–1.5	18–24	5–8	8.0–10	20–30	1.1–2.0	3.1–5.1	3.7–6.0	16–36
Qinhuangdao	1.5–2.0	156–204	12–24	4.1–5.6	26–32	1.4–2.3	3.1–6.2	4.1–8.7	7–22
Tangshan	1.2–1.8	282–402	21–25	6.6–7.6	30–53	1.8–3.0	7.3–12	8.1–14	25–38
Dongying	3.1–4.7	255–396	21–29	15–17	16–23	4.0–6.9	11–19	13–24	18–55
Weifang	0.5–0.8	77–124	4.4–6.0	3.0–3.7	10–14	0.5–1.0	2.4–4.2	2.9–5.3	6–17
Yantai	0.9–1.4	75–125	7.9–9.3	3.4–4.0	11–16	1.1–1.9	2.8–5.1	3.3–6.3	7–15

Table S3. The summary of the annual concentration of air pollutants (kg per capita) of the industry sector per capita and CO₂ (tonnes per capita) of the industry sector per capita.

City	BC	CO	CO ₂	NH ₃	NO _x	OC	PM _{2.5}	PM ₁₀	SO ₂
Beijing	0.1–0.3	30–80	2–4	1–2	2–4	0.2–0.4	0.4–0.8	0.6–1.0	0.4–1.8
Tianjin	0.1–0.4	40–90	4–6	1–2	4–6	0.5–1.4	0.9–1.1	1.1–1.3	2–4
Dalian	0.3–0.6	40–90	4–6	2–3	4–6	0.4–1	0.6–0.9	0.8–1.2	3–5
Yingkou	0.6–1.1	40–80	4–7	2–3	4–6	1–2	0.7–1.1	0.9–1.3	5–8
Jinzhou	0.4–0.8	40–80	4–5	2–4	4–8	1–2	2–5	3–6	5–9
Panjin	0.3–0.8	30–60	3–5	2–5	4–8	0.4–1	2–5	3–6	6–8
Qinhuangdao	0.3–0.5	50–90	5–6	2–4	3–6	1.5–2	2–5	3–6	3–8
Tangshan	0.7–0.9	90–150	5–6	2–5	5–9	2–3	5–8	6–9	6–12
Dongying	0.9–1.3	100–160	5–6	3–6	3–6	2–3	4–7	5–8	7–14
Weifang	0.2–0.4	40–90	3–5	1–2	3–5	0.2–0.4	0.4–0.8	0.5–0.9	3–7
Yantai	0.2–0.5	40–90	5–6	1–2	3–5	0.2–0.4	0.4–0.8	0.5–0.9	3–8

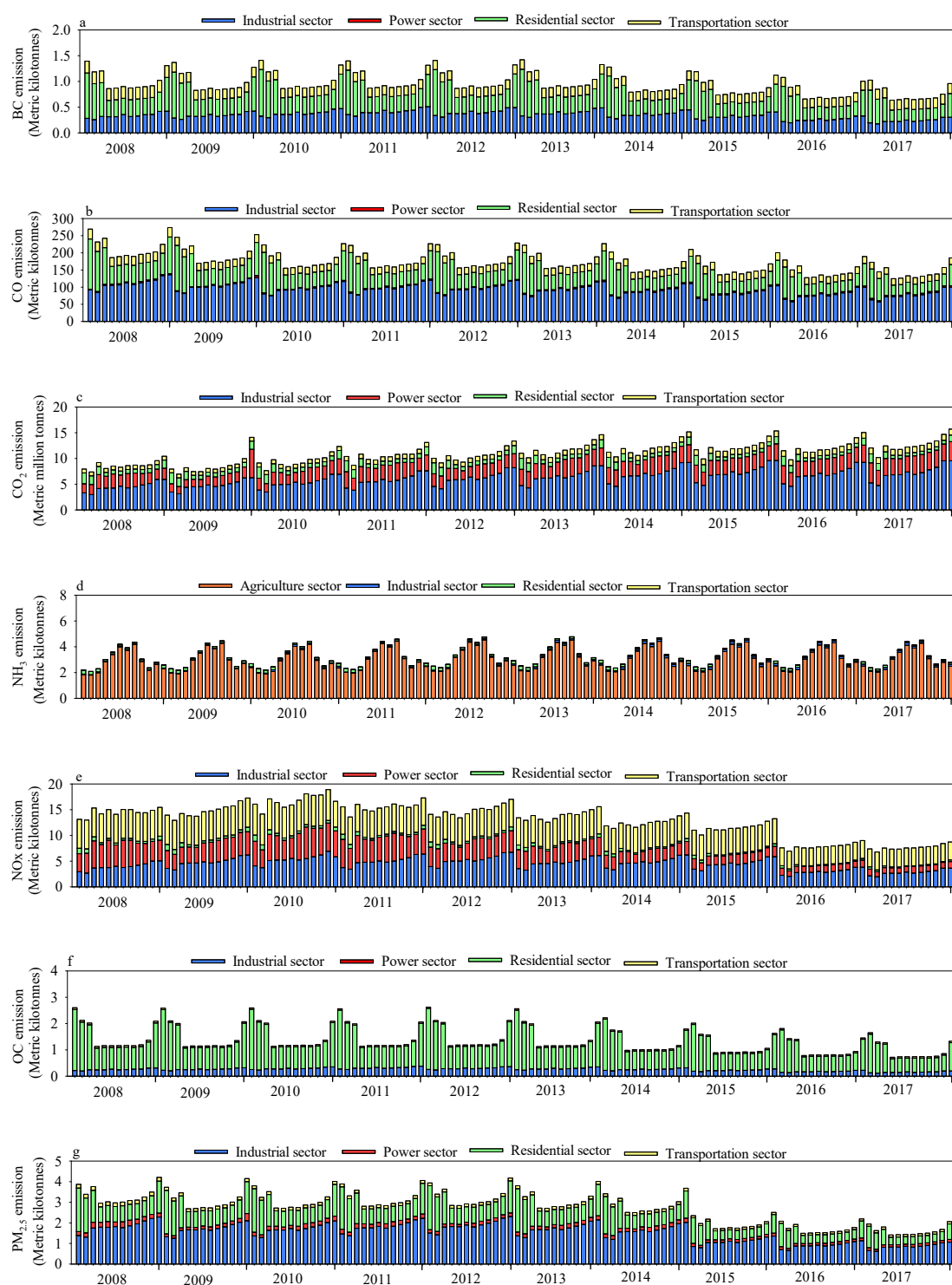
Table S4. Correlation (Pearson's r) between economic development metrics including GDP, GDP per capita, GDP of industry sector, and GDP per capita of industry sector with air pollution, as well as CO₂ emission.

Item	GDP	GDP of the industry sector	Item	GDP per capita	GDP per capita of the industry sector
BC	0.509**	0.448**	BC per capita	0.330**	0.588**
CO	0.566**	0.787**	CO per capita	0.291**	0.602**
CO ₂	0.645**	0.860**	CO ₂ per capita	0.509**	0.583**
NH ₃	0.507**	/	NH ₃ per capita	0.509**	/
NO _x	0.337*	0.643**	NO _x per capita	-0.130	0.050**
OC	0.483**	0.216**	OC per capita	0.409**	0.601**
PM _{2.5}	0.225*	0.440**	PM _{2.5} per capita	0.424**	0.693**
PM ₁₀	0.871**	0.500**	PM ₁₀ per capita	0.424**	0.664**
SO ₂	0.317*	0.441**	SO ₂ per capita	0.330*	0.504**

*p < 0.05, ** p < 0.001.



Figure S1. The sketch map for the locations of the eleven cities.



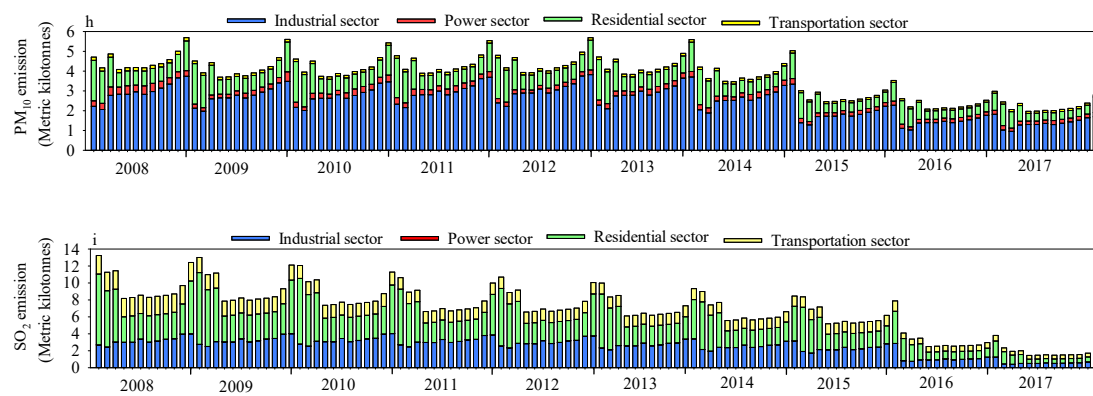
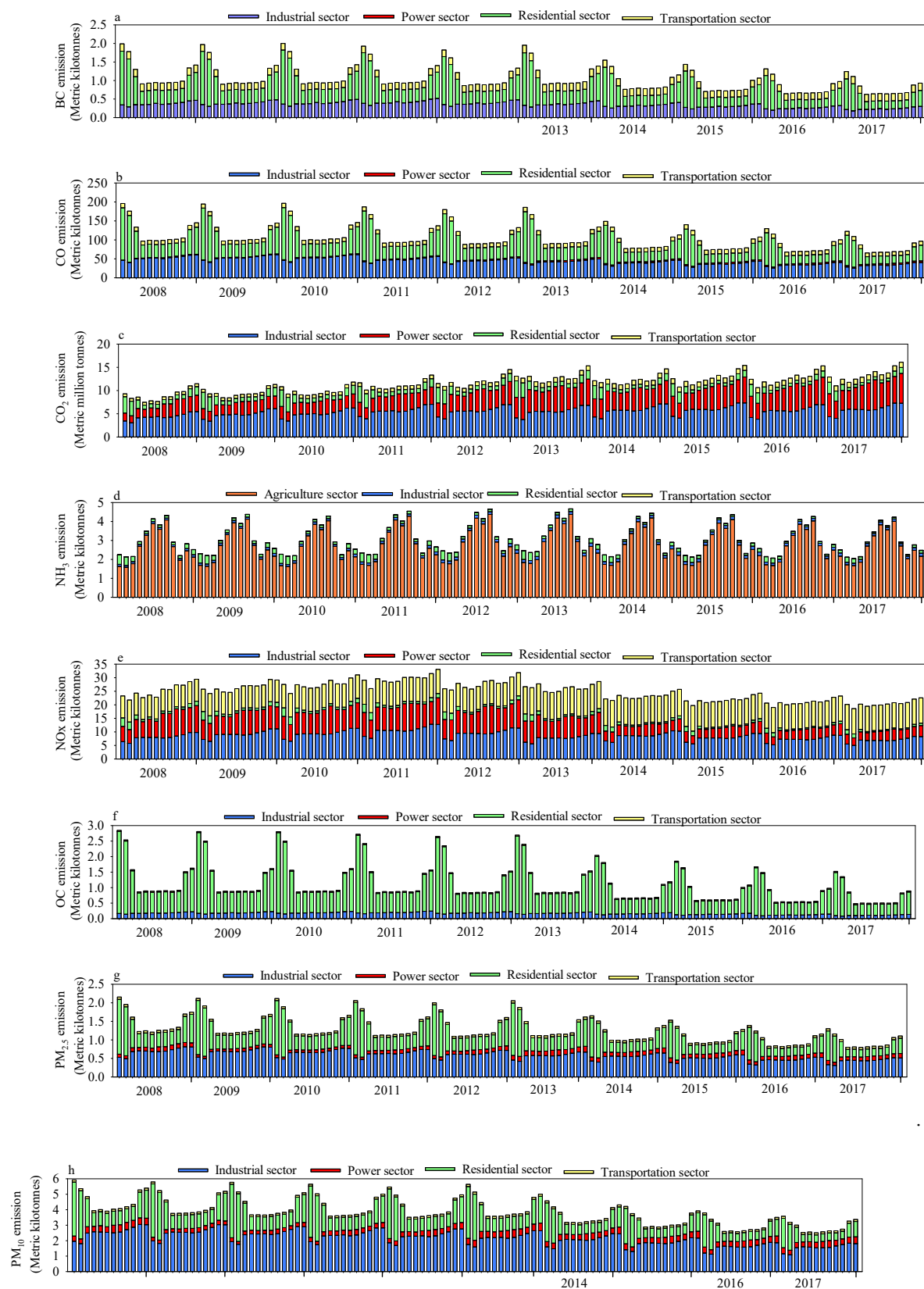


Figure S2. Monthly trends in emissions of air pollutants including BC by sector (a), CO by sector (b), NH₃ by sector (d), NO_x by sector (e), OC by sector (f), PM_{2.5} by sector (g), PM₁₀ by sector (h), SO₂ by sector (i), as well as CO₂ by sector (c) in Beijing from the years of 2008–2017.



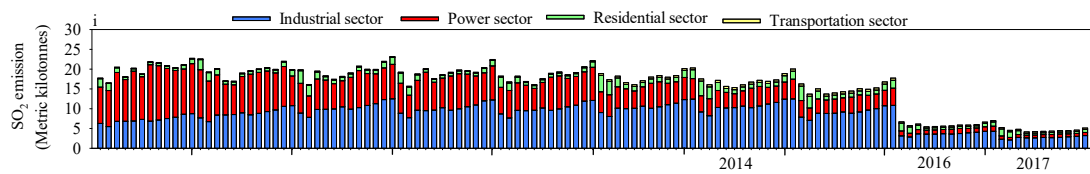
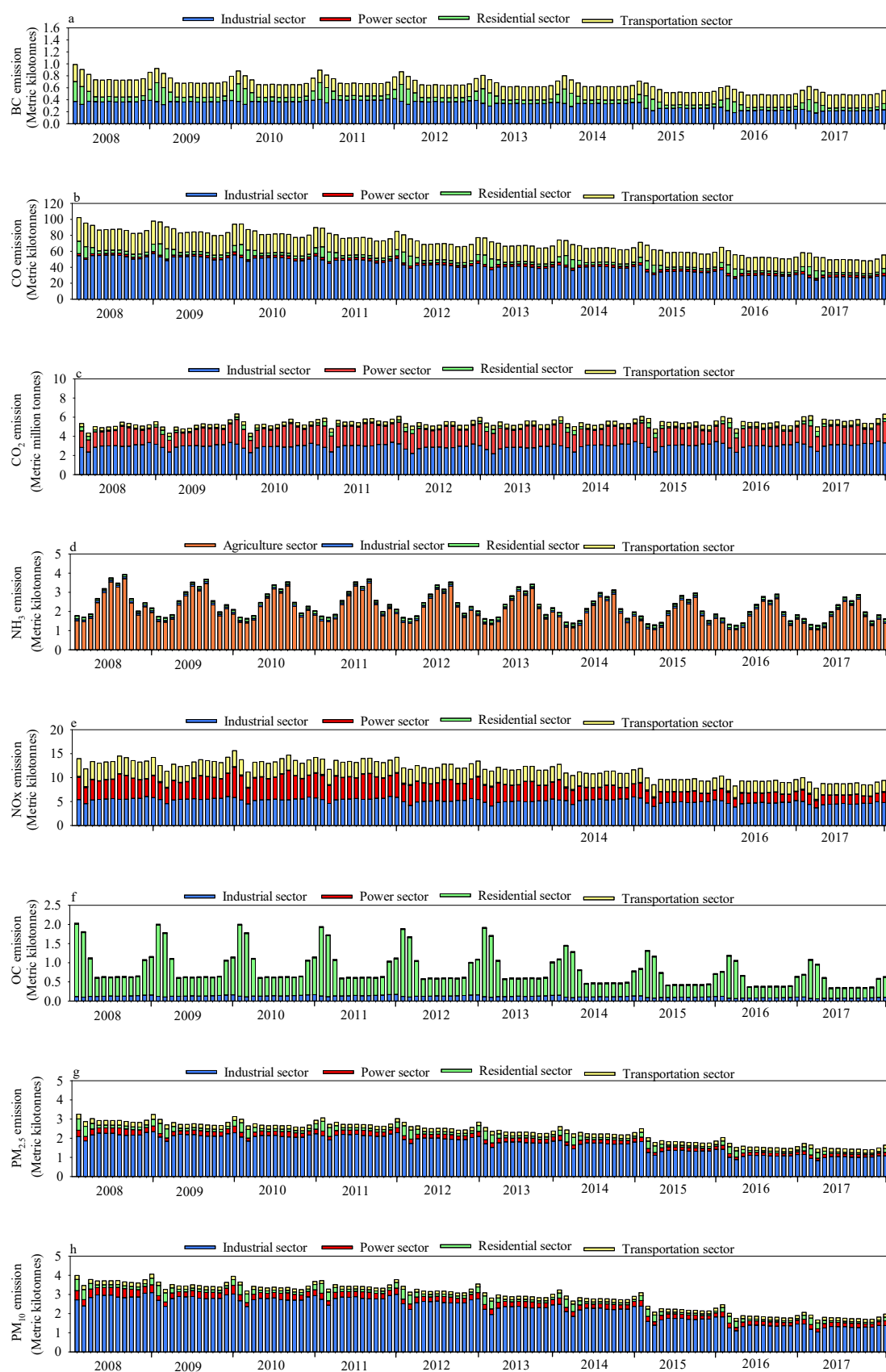


Figure S3. Monthly trends in emissions of air pollutants including BC by sector (a), CO by sector (b), NH₃ by sector (d), NO_x by sector (e), OC by sector (f), PM_{2.5} by sector (g), PM₁₀ by sector (h), SO₂ by sector (i), as well as CO₂ by sector (c) in Tianjin from the years of 2008-2017.



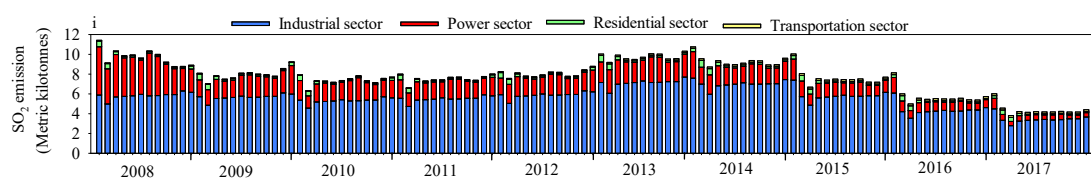
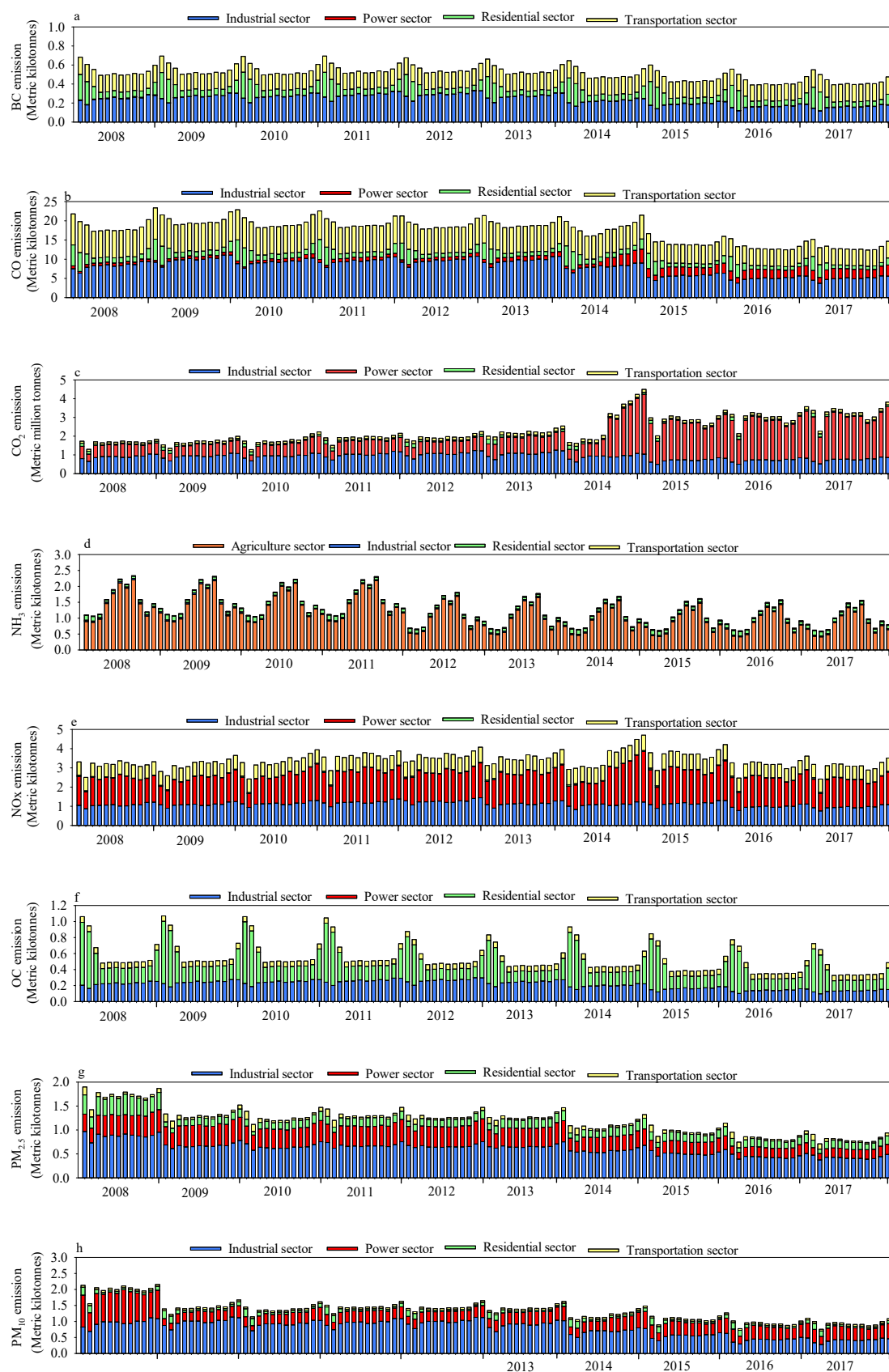


Figure S4. Monthly trends in emissions of air pollutants including BC by sector (a), CO by sector (b), NH₃ by sector (d), NO_x by sector (e), OC by sector (f), PM_{2.5} by sector (g), PM₁₀ by sector (h), SO₂ by sector (i), as well as CO₂ by sector (c) in Dalian from the years of 2008–2017.



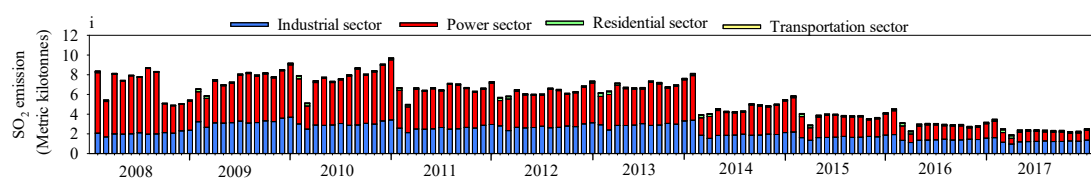
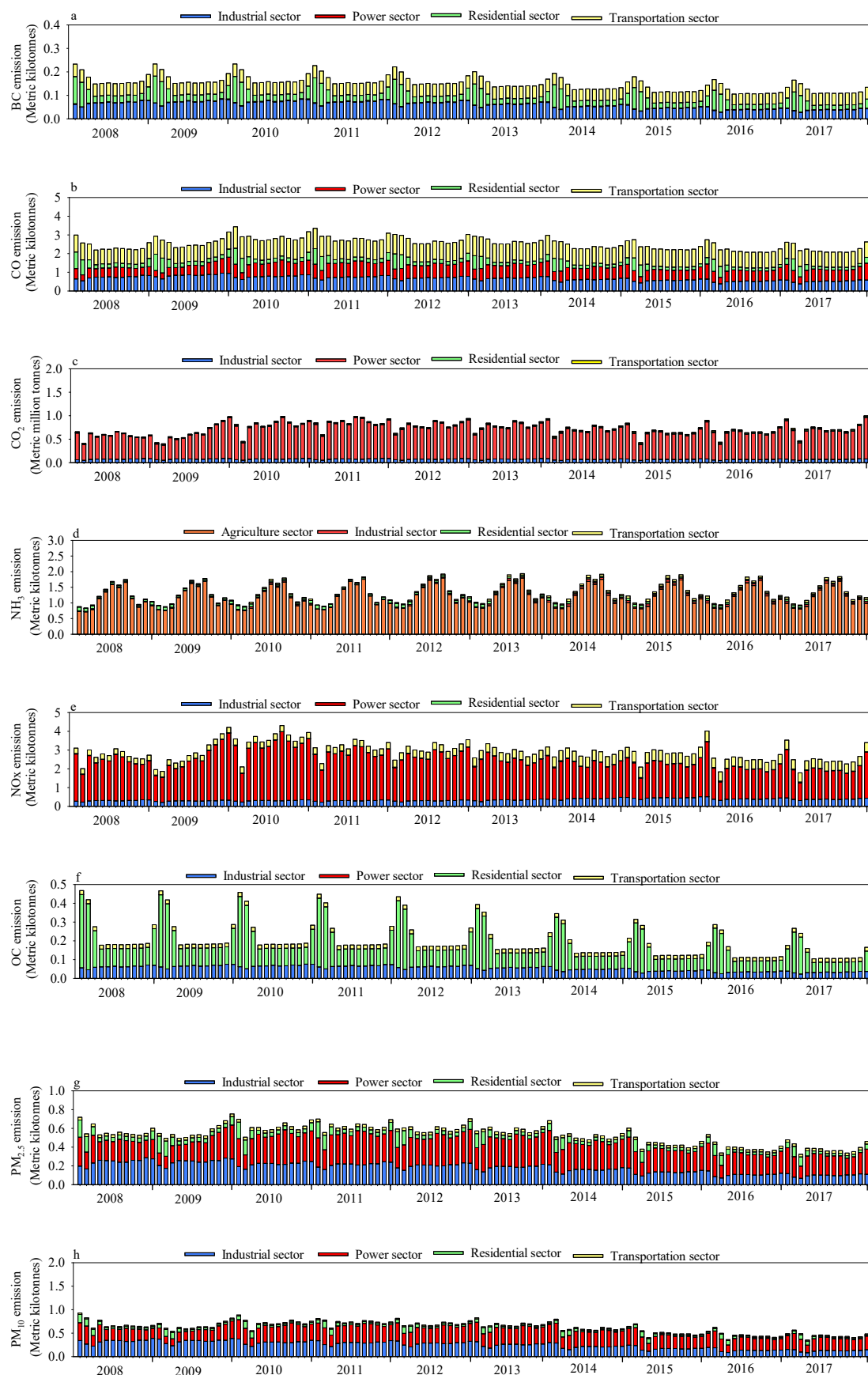


Figure S5. Monthly trends in emissions of air pollutants including BC by sector (a), CO by sector (b), NH₃ by sector (d), NO_x by sector (e), OC by sector (f), PM_{2.5} by sector (g), PM₁₀ by sector (h), SO₂ by sector (i), as well as CO₂ by sector (c) in Yingkou from the years of 2008–2017.



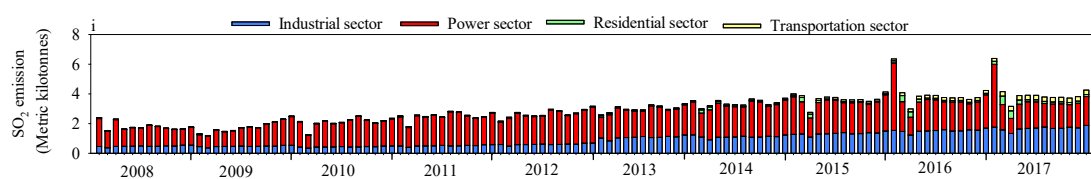
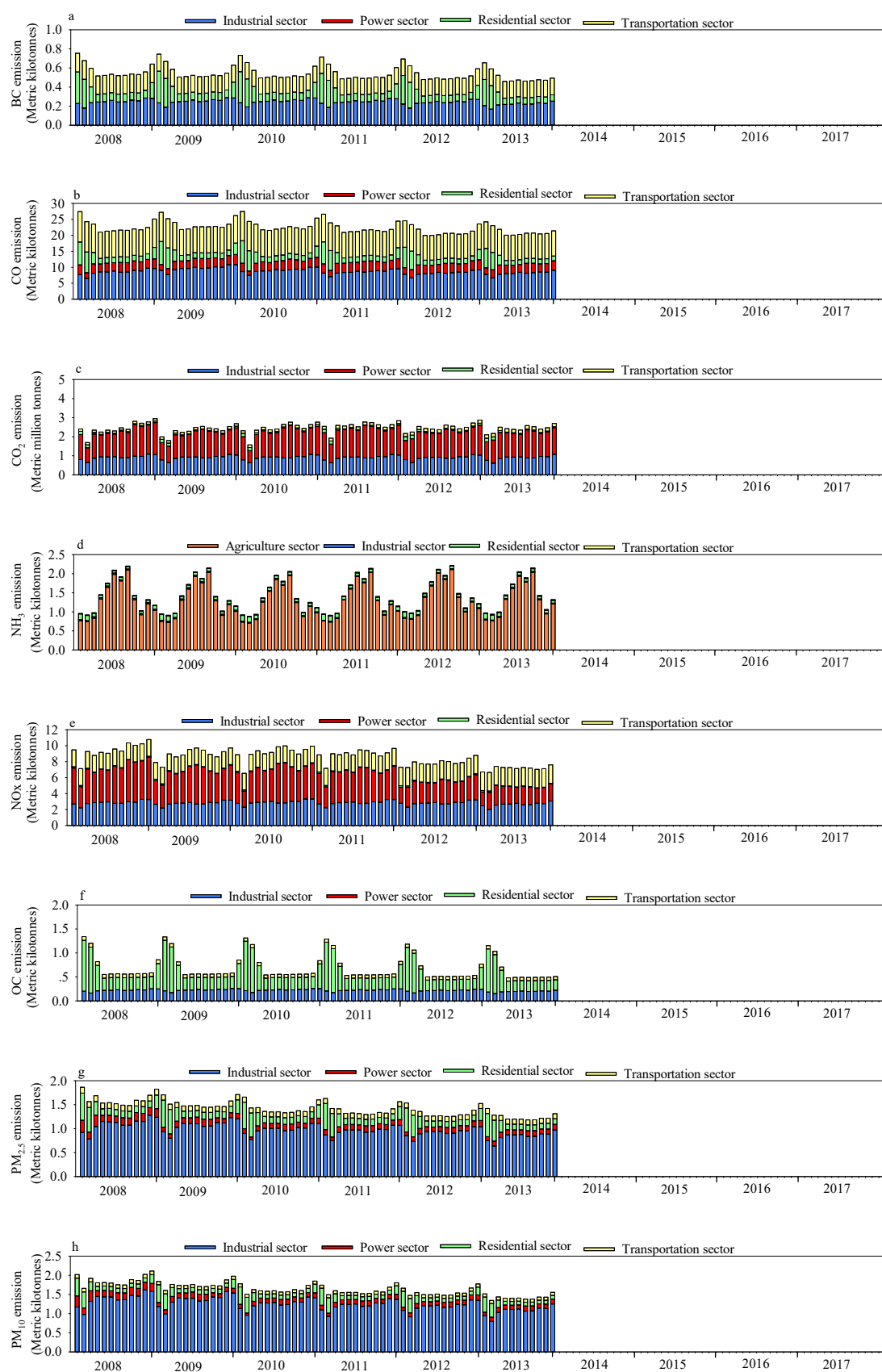


Figure S6. Monthly trends in emissions of air pollutants including BC by sector (a), CO by sector (b), NH₃ by sector (d), NO_x by sector (e), OC by sector (f), PM_{2.5} by sector (g), PM₁₀ by sector (h), SO₂ by sector (i), as well as CO₂ by sector (c) in Panjin from the years of 2008–2017.



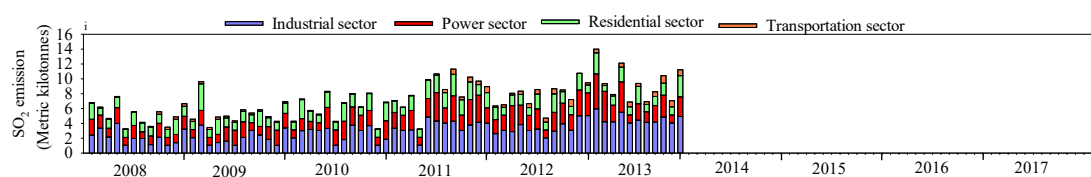
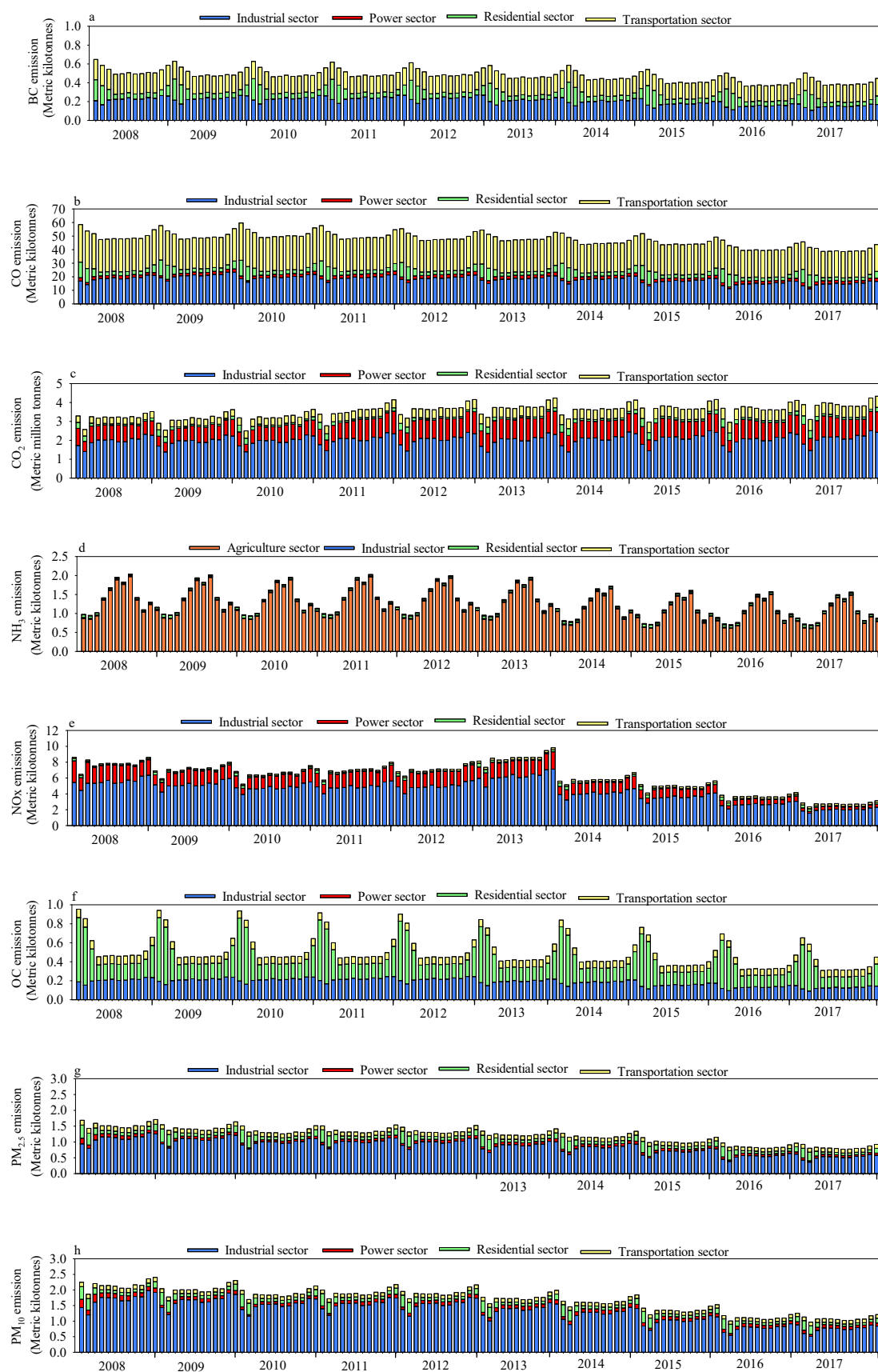


Figure S7. Monthly trends in emissions of air pollutants including BC by sector (a), CO by sector (b), NH₃ by sector (d), NO_x by sector (e), OC by sector (f), PM_{2.5} by sector (g), PM₁₀ by sector (h), SO₂ by sector (i), as well as CO₂ by sector (c) in Jinzhou from the years of 2008-2013.



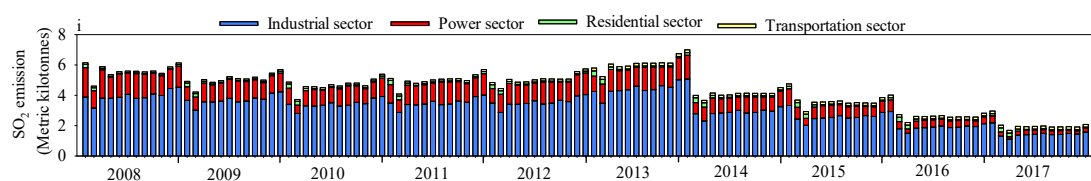
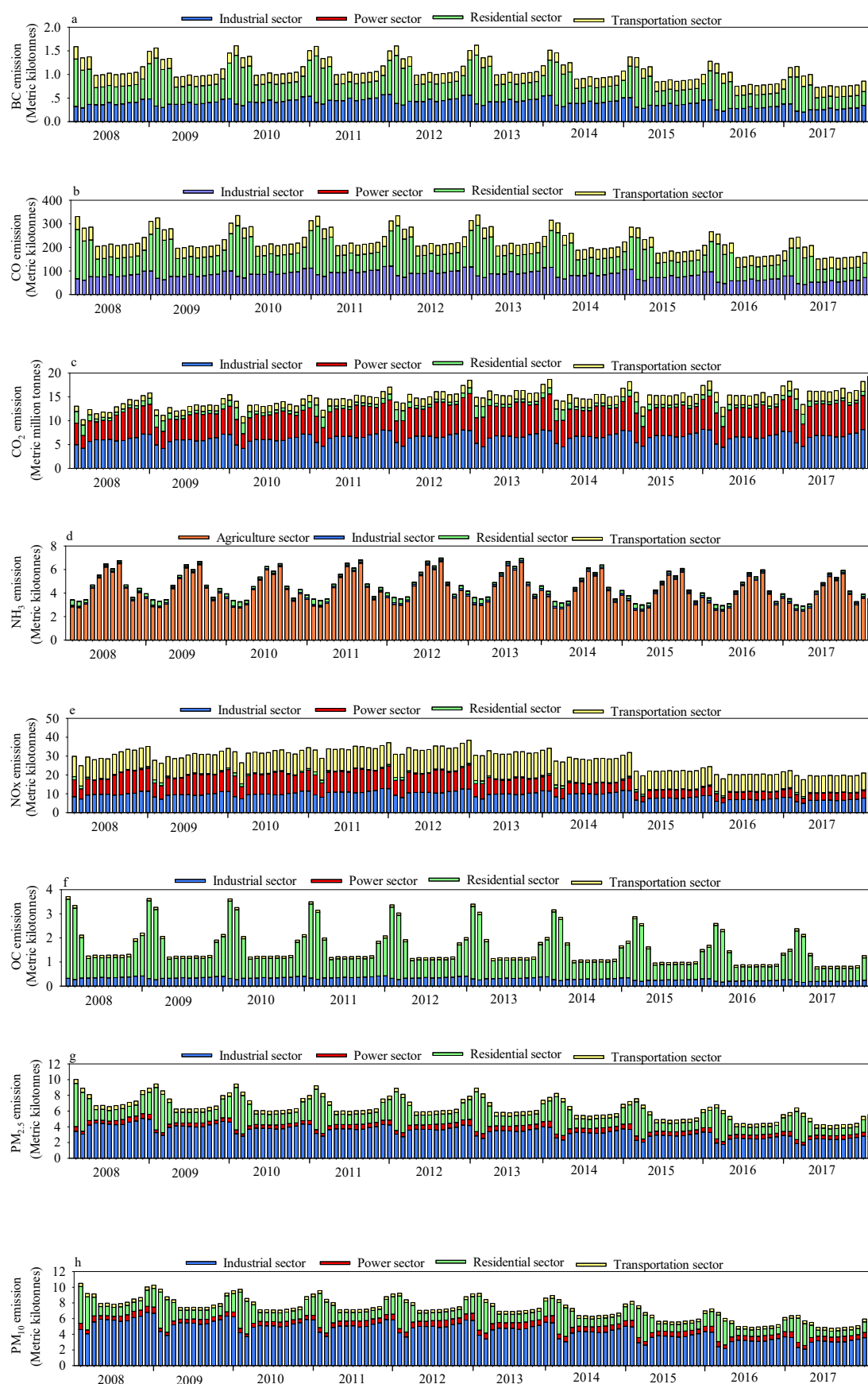


Figure S8. Monthly trends in emissions of air pollutants including BC by sector (a), CO by sector (b), NH₃ by sector (d), NO_x by sector (e), OC by sector (f), PM_{2.5} by sector (g), PM₁₀ by sector (h), SO₂ by sector (i), as well as CO₂ by sector (c) in Qinhuangdao from the years of 2008-2017.



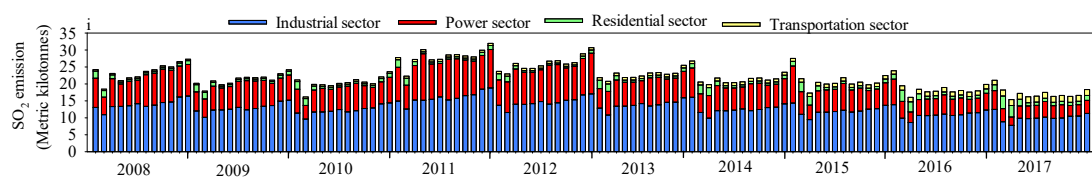
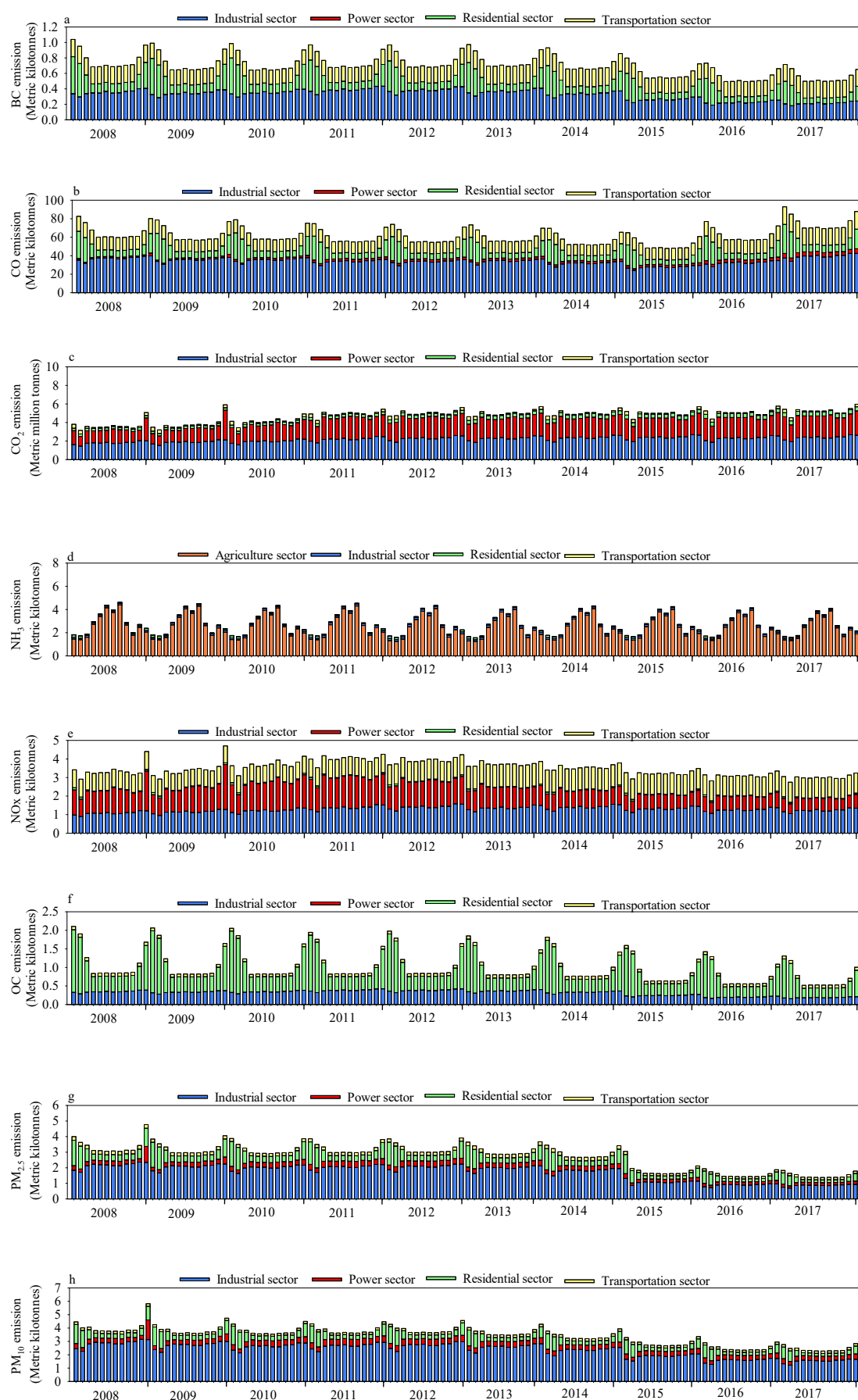


Figure S9. Monthly trends in emissions of air pollutants including BC by sector (a), CO by sector (b), NH₃ by sector (d), NO_x by sector (e), OC by sector (f), PM_{2.5} by sector (g), PM₁₀ by sector (h), SO₂ by sector (i), as well as CO₂ by sector (c) in Tangshan from the years of 2008-2017.



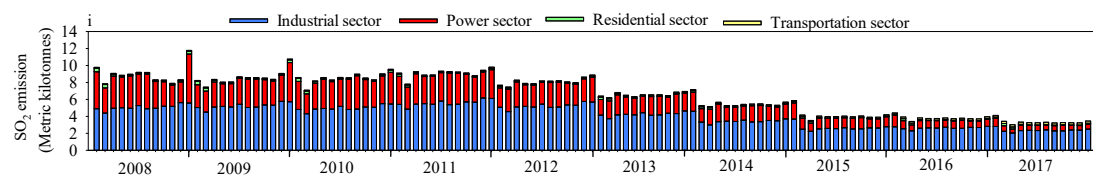
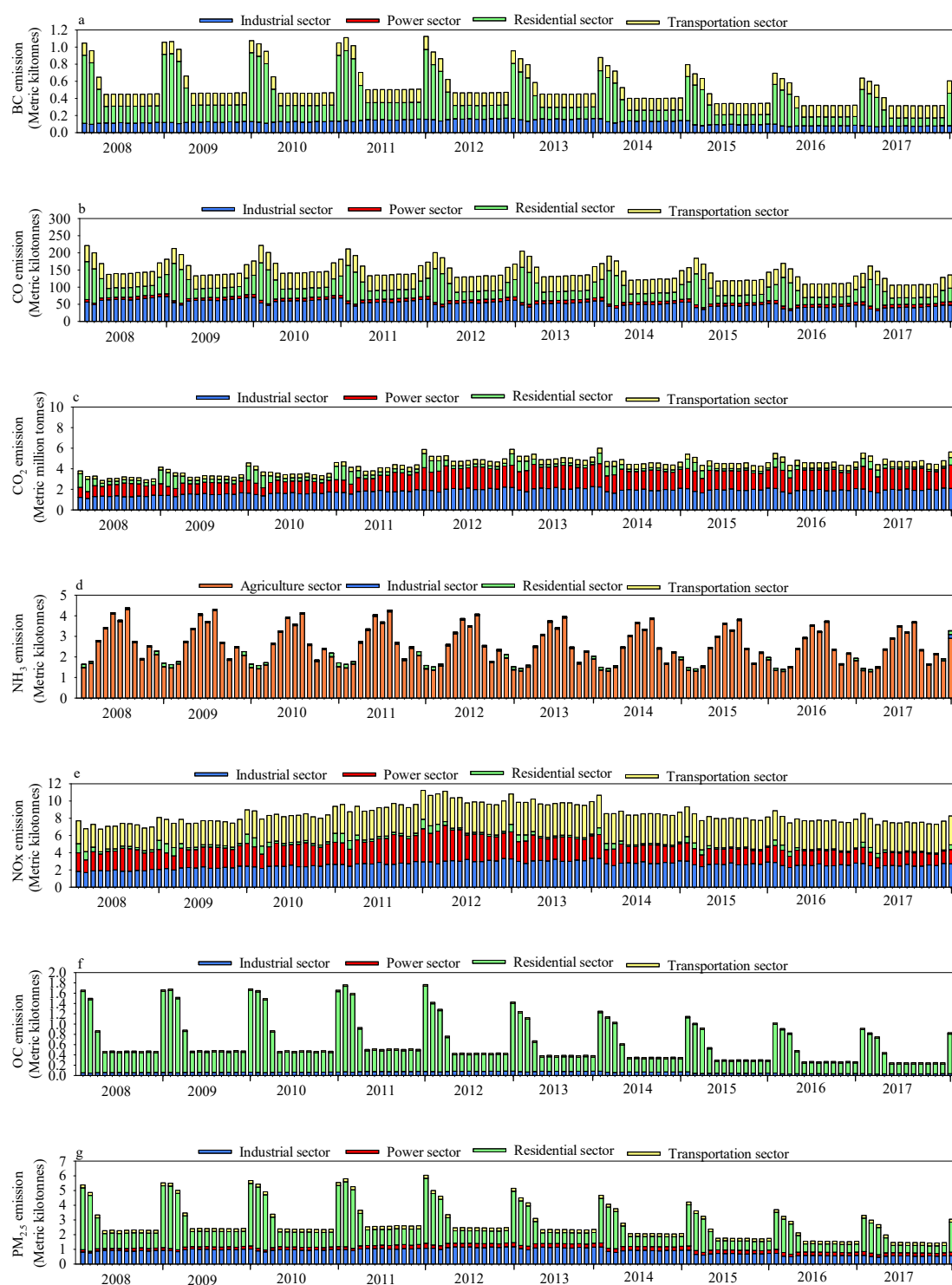


Figure S10. Monthly trends in emissions of air pollutants including BC by sector (a), CO by sector (b), NH₃ by sector (d), NO_x by sector (e), OC by sector (f), PM_{2.5} by sector (g), PM₁₀ by sector (h), SO₂ by sector (i), as well as CO₂ by sector (c) in Dongying from the years of 2008–2017.



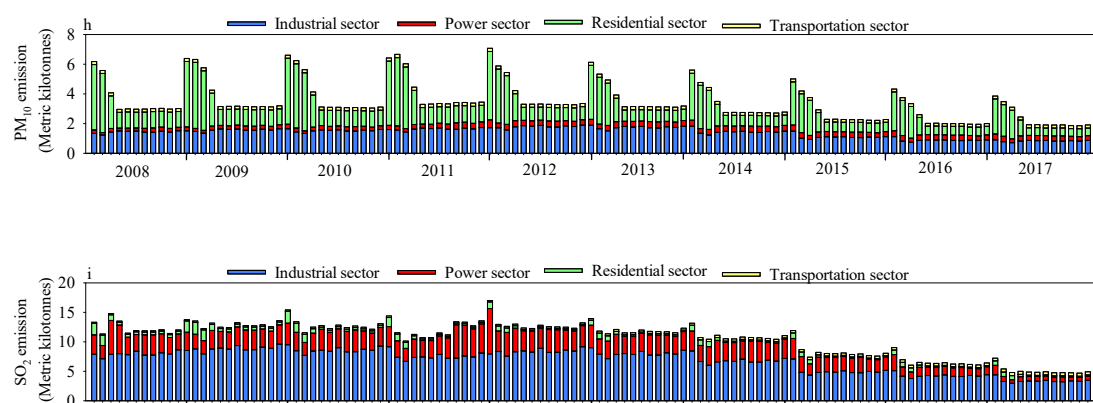
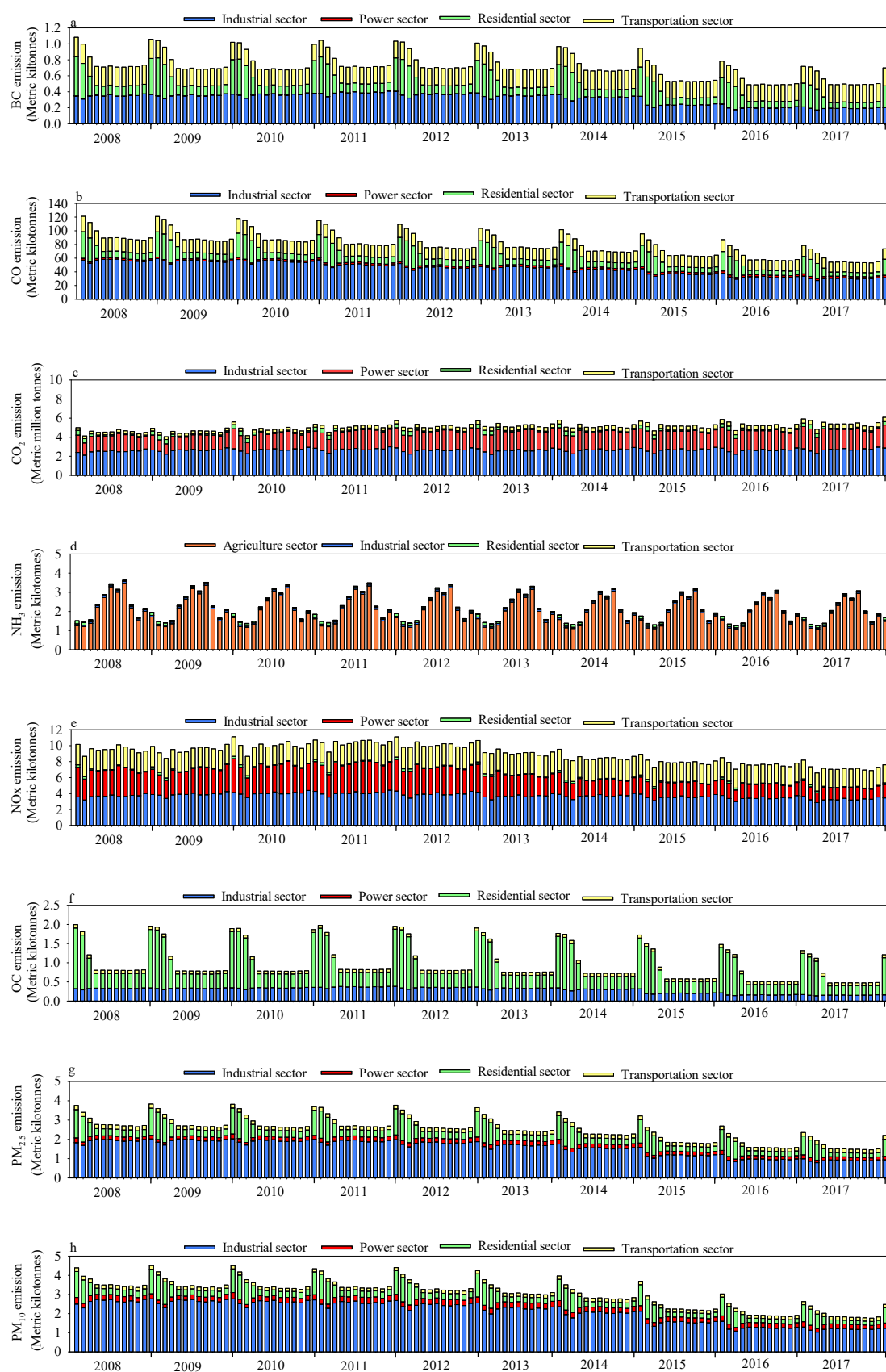


Figure S11. Monthly trends in emissions of air pollutants including BC by sector (a), CO by sector (b), NH₃ by sector (d), NO_x by sector (e), OC by sector (f), PM_{2.5} by sector (g), PM₁₀ by sector (h), SO₂ by sector (i), as well as CO₂ by sector (c) in Weifang from the years of 2008–2017.



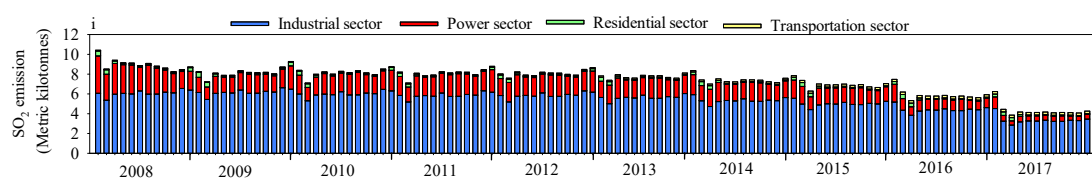
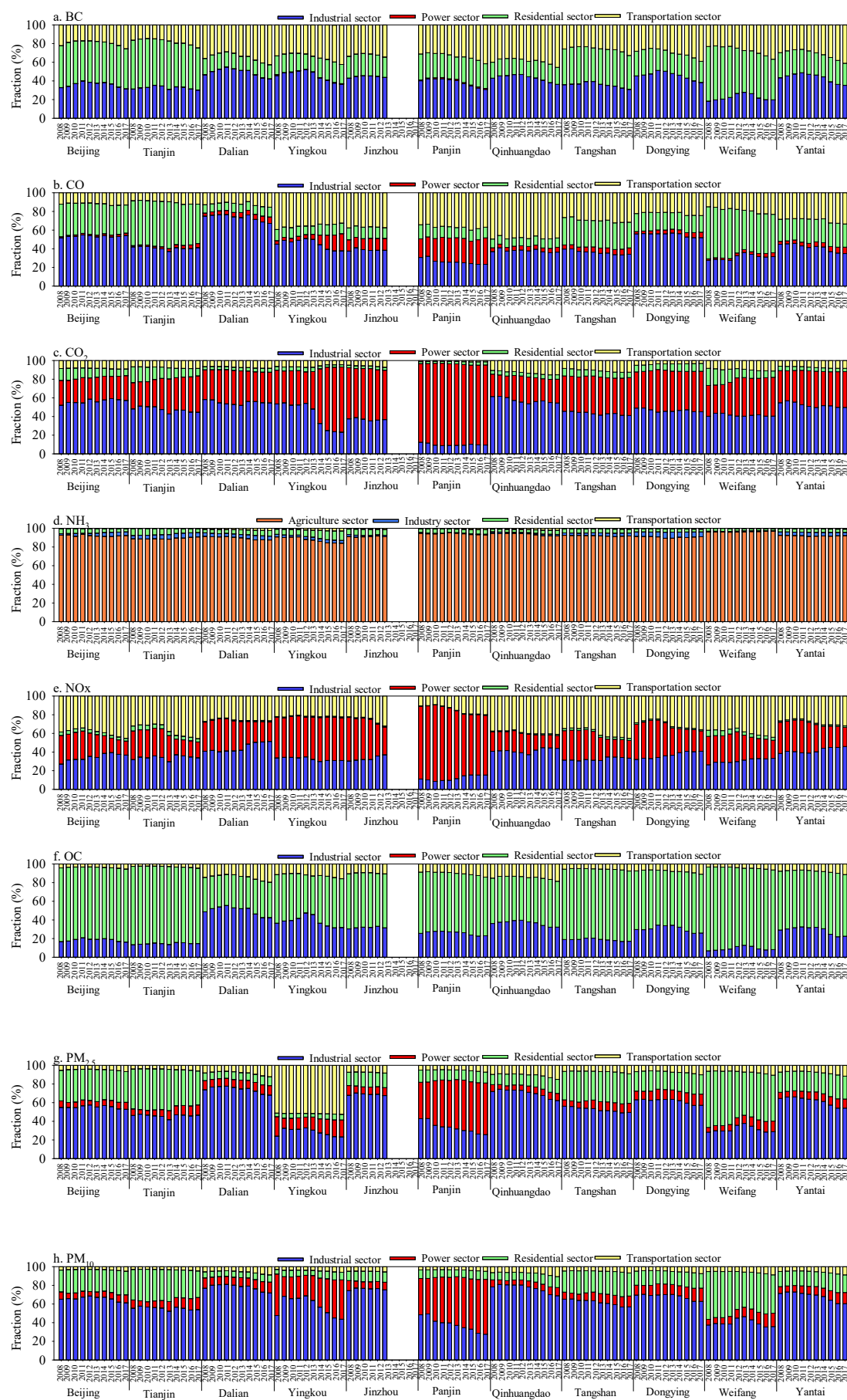


Figure S12. Monthly trends in emissions of air pollutants including BC by sector (a), CO by sector (b), NH₃ by sector (d), NO_x by sector (e), OC by sector (f), PM_{2.5} by sector (g), PM₁₀ by sector (h), SO₂ by sector (i), as well as CO₂ by sector (c) in Yantai from the years of 2008-2017.



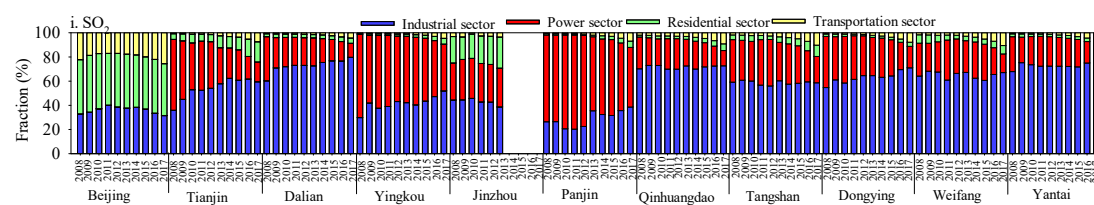


Figure S13. Contribution of the different sectors to the yearly air pollutants including BC (a), CO (b), NH_3 (d), NO_x (e), OC (f), $\text{PM}_{2.5}$ (g), PM_{10} (h), SO_2 (i), as well as CO_2 (c) in the eleven cities from the years of 2008–2017.

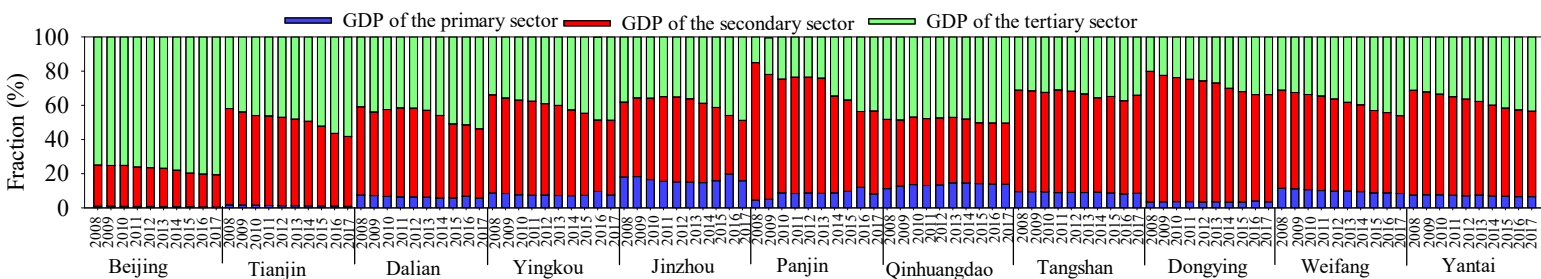


Figure S14. Contributions of the primary sector (agriculture), the secondary sector (industry), and the tertiary sector (excluding agriculture and industry) to GDP from 2008 to 2017 in the 11 cities.

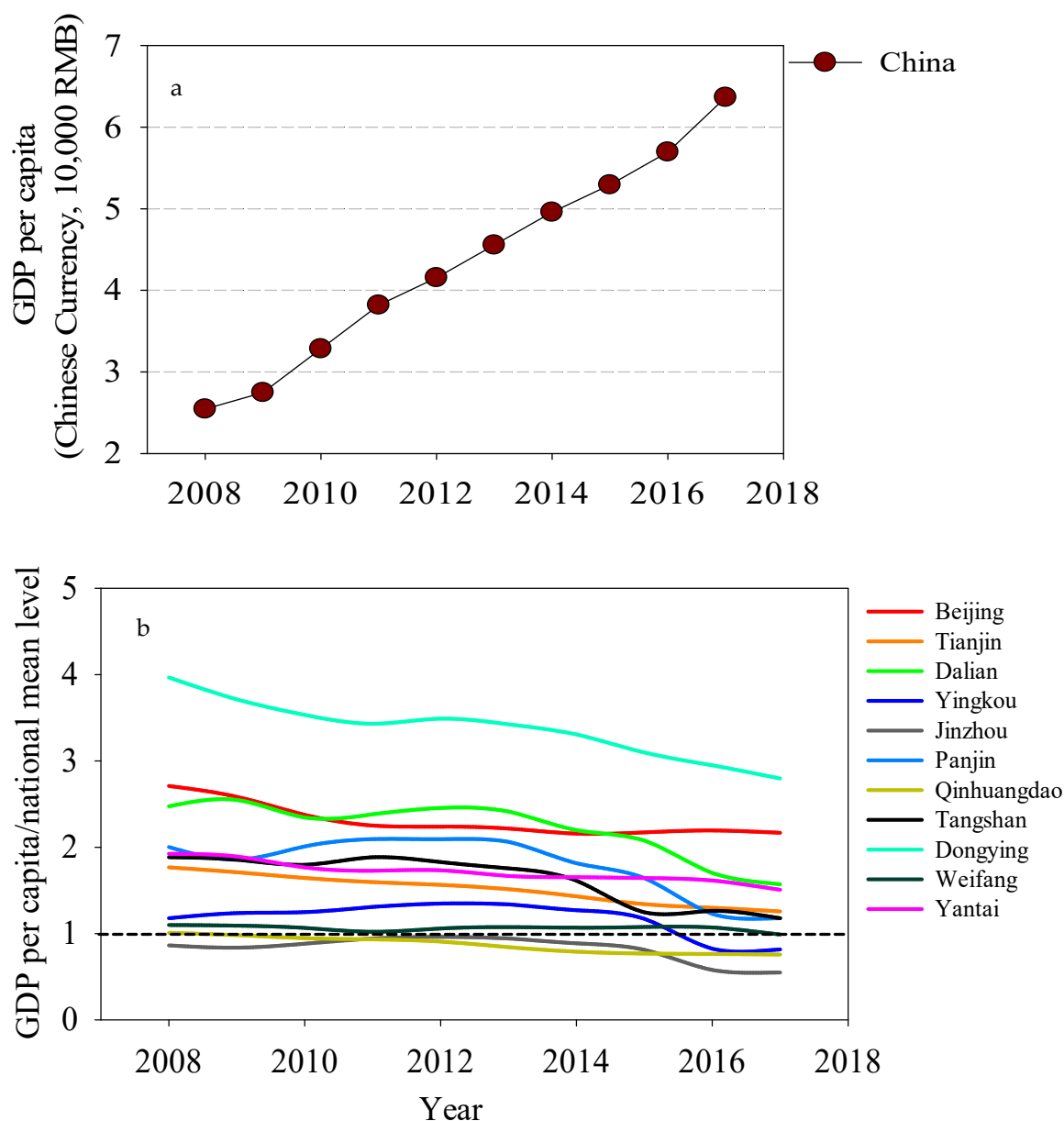


Figure S15. (a) Changes in GDP per capita from 2008 to 2017 in China. (b) Changes in ratio of GDP per capita and national mean level from 2008 to 2017 in 11 cities. Ratio of GDP per capita and national mean level was estimated using GDP per capita for each city divided GDP per capita in China.