Impacts of shipping emissions on O_3 pollution in China

Figures

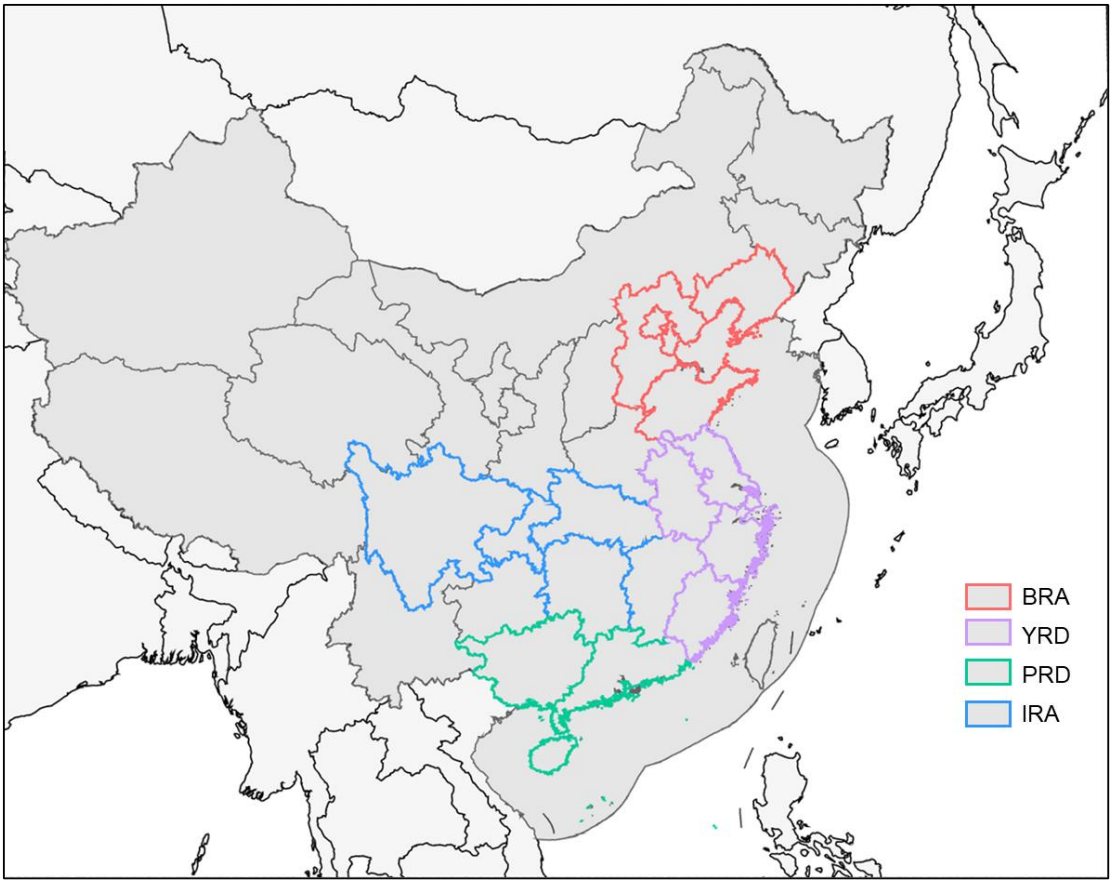

Figure S1. Study domain. Maps created with MeteoInfoMap (http://www.meteothink.org).

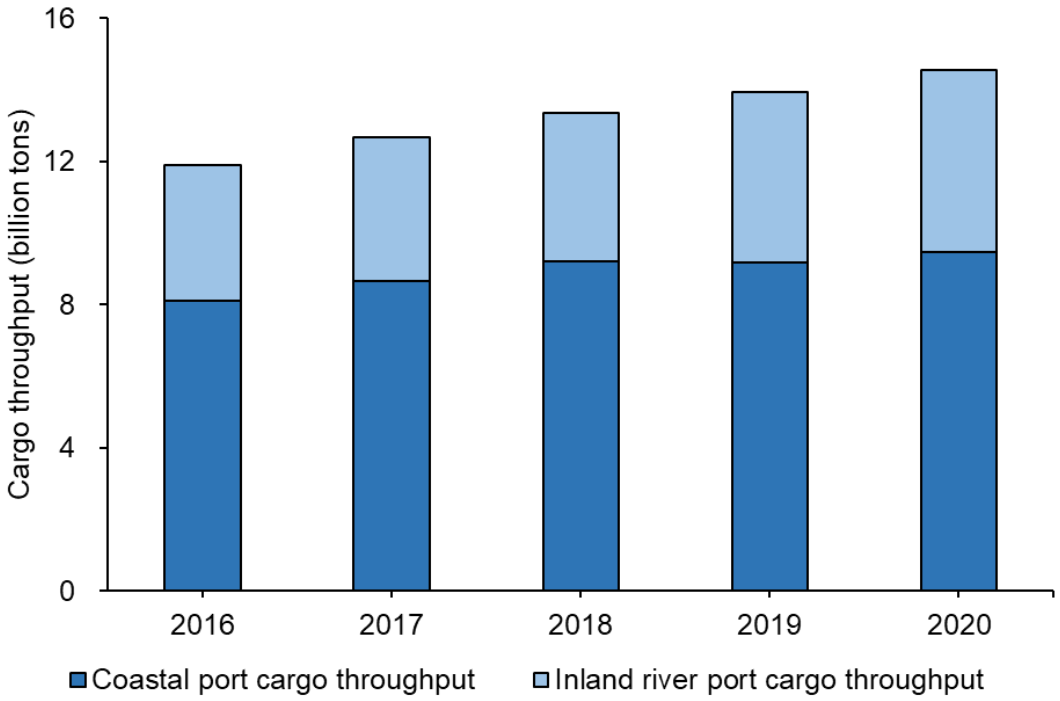

Figure S2. Cargo throughput from 2016 to 2020.

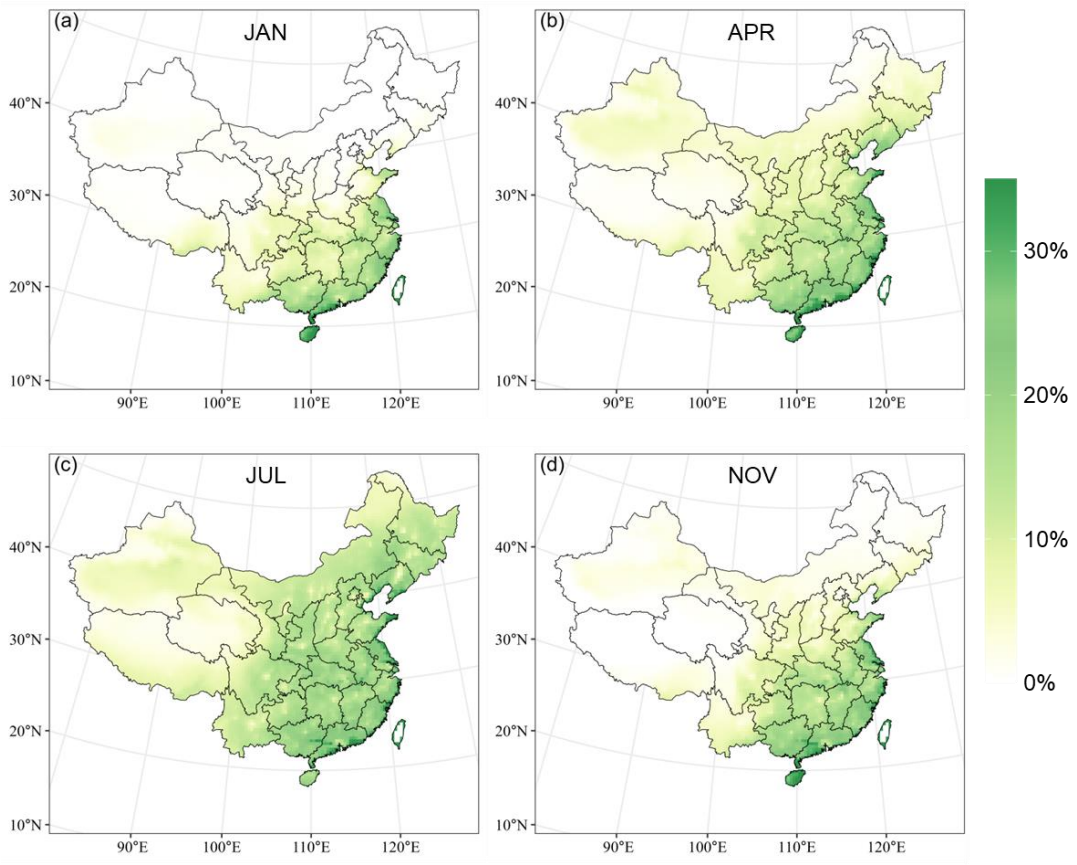

Figure S3. Seasonal relative contribution of shipping emissions to O_3. Maps created with MeteoInfoMap (http://www.meteothink.org).

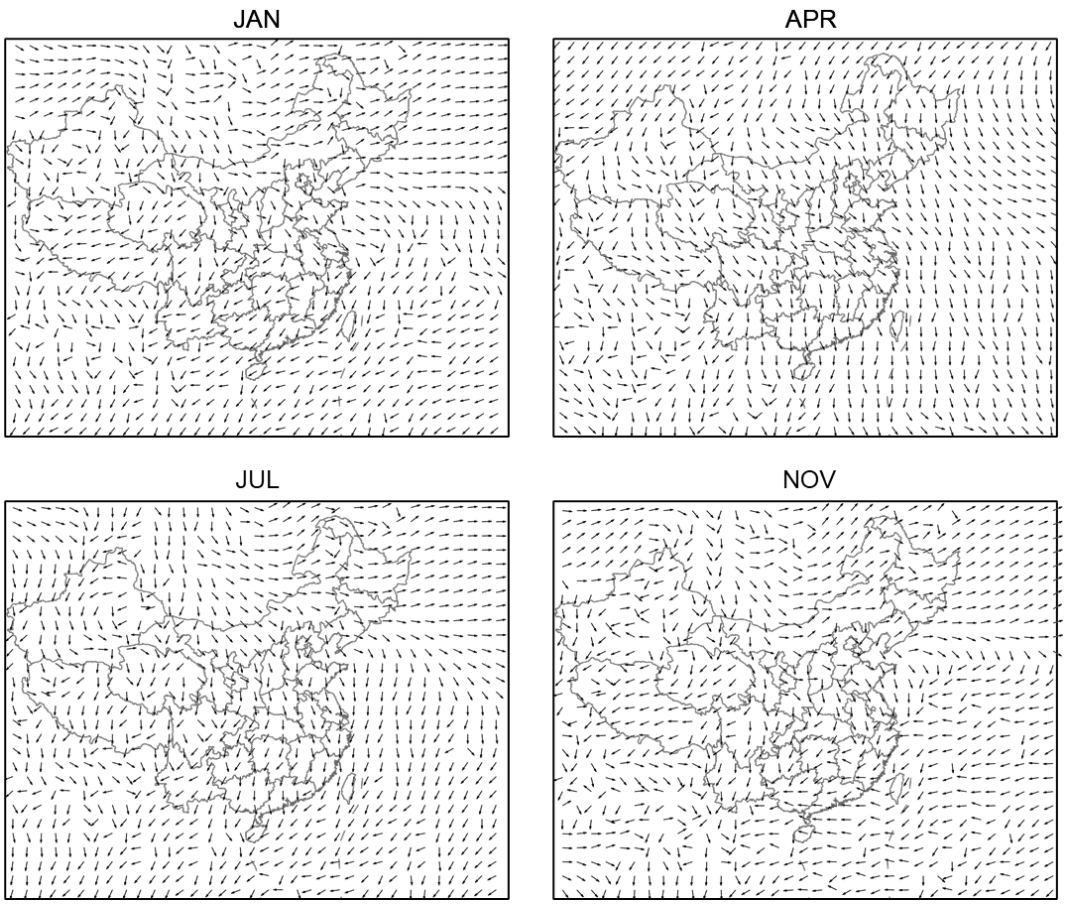

Figure S4. Seasonal wind direction. Maps created with MeteoInfoMap (http://www.meteothink.org).

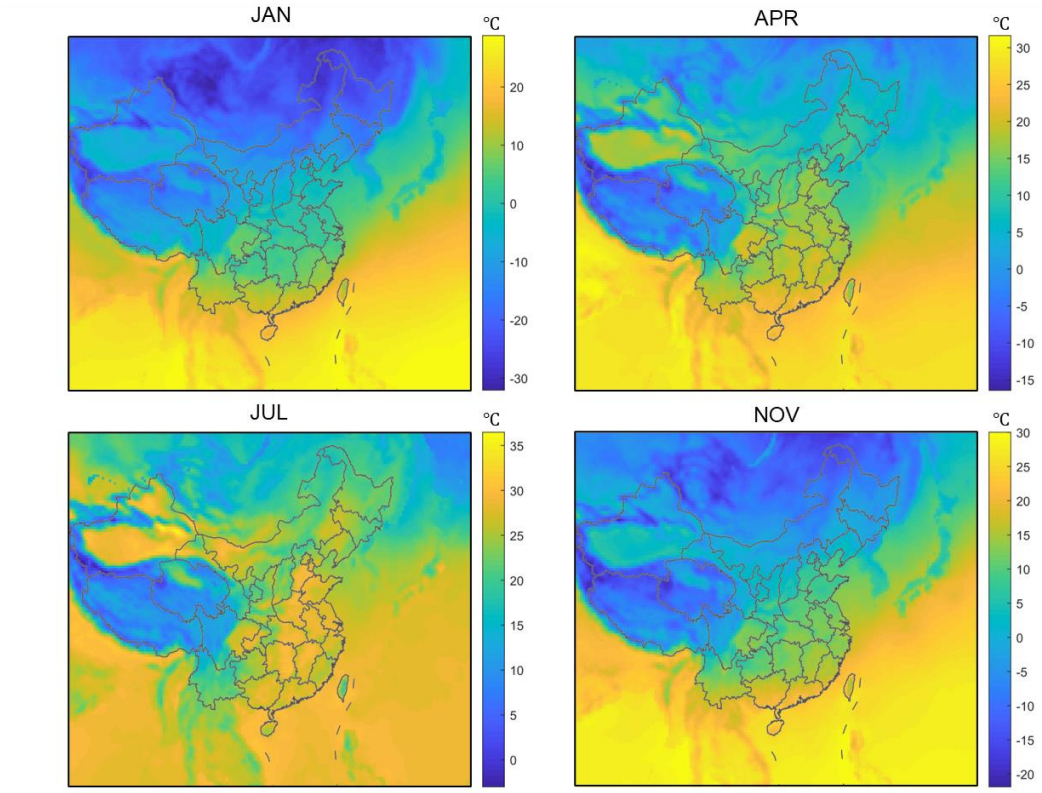

Figure S5. Seasonal temperature. Maps created with MeteoInfoMap (http://www.meteothink.org).

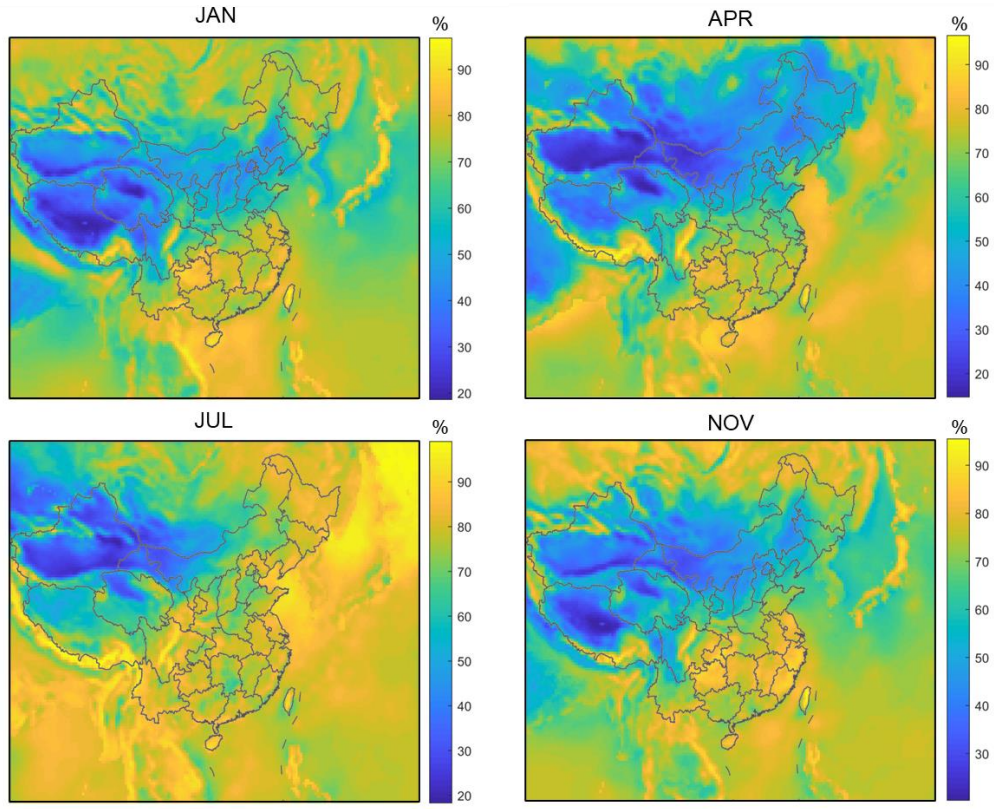

Figure S6. Seasonal relative humidity. Maps created with MeteoInfoMap (http://www.meteothink.org).

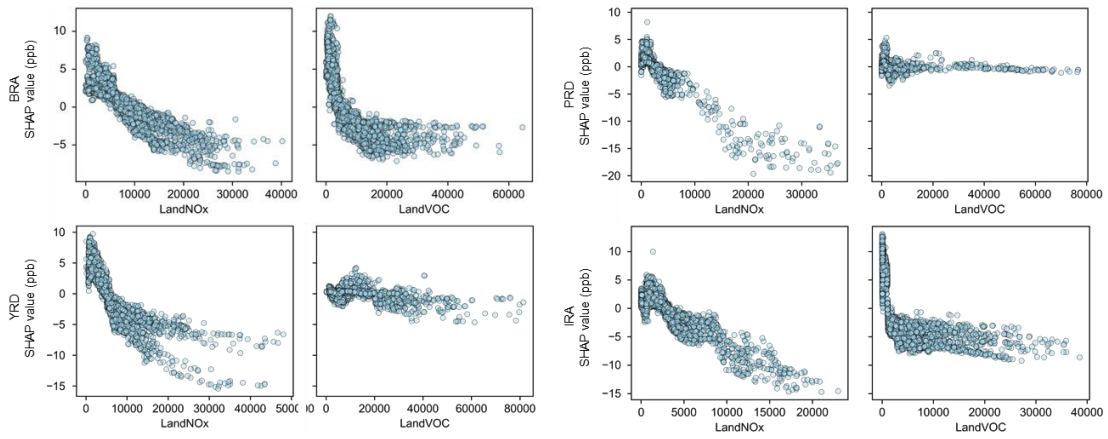

Figure S7. SHAP dependence plot for (a) BRA, (b) YRD, (c) PRD, and (d) IRA.

Tables

Table S1. WRF performance.

Statistics	Month	Mean OBS	Mean SIM	MB	NMB	NMGE	MFB	MFE	R
WS10 (m/s)	Winter	2.69	3.01	0.32	0.25	0.57	0.20	0.55	0.60
	Spring	3.08	3.24	0.17	0.13	0.45	0.11	0.48	0.65
	Summer	2.60	2.56	-0.04	0.04	0.45	0.03	0.49	0.54
	Autumn	2.38	2.53	0.14	0.14	0.50	0.11	0.52	0.58
WD10 (°)	Winter	195.48	176.16	-1.79	-0.01	0.25	-0.08	0.57	0.33
	Spring	186.14	176.72	0.33	0.01	0.26	-0.01	0.49	0.37
	Summer	170.30	159.04	-3.12	-0.01	0.29	0.01	0.49	0.33
	Autumn	183.37	172.62	1.01	0.01	0.29	-0.01	0.60	0.31
T2 (°C)	Winter	-1.55	-1.85	-0.30	-0.13	-0.35	-0.12	0.16	0.92
	Spring	14.73	13.88	-0.84	-0.12	0.27	-0.08	0.16	0.93
	Summer	24.96	24.24	-0.72	-0.03	0.09	-0.04	0.10	0.88
	Autumn	7.45	7.08	-0.36	-0.07	-0.16	0.14	0.14	0.92
RH (%)	Winter	62.80	64.00	1.20	0.05	0.19	0.03	0.19	0.81
	Spring	56.40	57.76	1.36	0.04	0.20	0.03	0.21	0.84
	Summer	72.48	72.30	-0.19	0.00	0.13	-0.01	0.14	0.78
	Autumn	67.65	66.13	-1.52	-0.01	0.16	-0.02	0.17	0.81

Table S2. Emissions used in the CMAQ model.

Emissions	Base Year	Reference
Shipping Emissions	2016-2019	SEIM (Wang et al., 2021)
	2020	This study
Land-based anthropogenic emissions in China (mobiles, industry, power, domestic, and agriculture)	2016-2020	MEIC (http://www.meicmodel.org/, last access: November 2023)
Anthropogenic emission from other countries within the modeling domain	2010	MIX emission inventory (Li et al., 2017)
Open burning	2015	Cai et al (Cai et al., 2017)
Biogenic emissions	Real	Model of Emissions of Gases and Aerosols from Nature (MEGANv3, https://sites.google.com/uci.edu/bai, last access: July 2023)
Emissions from windblown dust	Real	In-line calculated in CMAQ (https://www.epa.gov/cmaq, last access: July 2023)
Emissions from sea salt	Real	In-line calculated in CMAQ (https://www.epa.gov/cmaq, last access: July 2023)

Table S3. CMAQ performance (Number of stations:1455).

Pollutants	Month	Mean OBS	Mean SIM	MB	NMB	NMGE	MFB	MFE	R
O_3	Winter	42.23	40.41	0.20	0.03	0.65	-0.25	0.62	0.57
	Spring	80.17	81.05	-3.51	0.09	0.47	-0.06	0.42	0.65
	Summer	72.09	80.37	6.87	0.14	0.58	-0.11	0.53	0.64
	Autumn	38.79	45.71	9.24	0.30	0.83	-0.11	0.64	0.58

Note: Mean OBS: monthly average of observations (ppb); Mean SIM: monthly average of simulations (ppb); MB: mean biases; NMB: normalized mean biases; NMGE: Mean Normalized Gross Errors; MFB: mean fractional bias; MFE: mean fractional error; R: correlation coefficients.

References

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Wang, X., Yi, W., Lv, Z., Deng, F., Zheng, S., Xu, H., Zhao, J., Liu, H., He, K., 2021. Ship emissions around China under gradually promoted control policies from 2016 to 2019. Atmos. Chem. Phys. 21, 13835-13853.