Supporting information for:

High-resolution global shipping emission inventory by Shipping Emission Inventory Model (SEIM)

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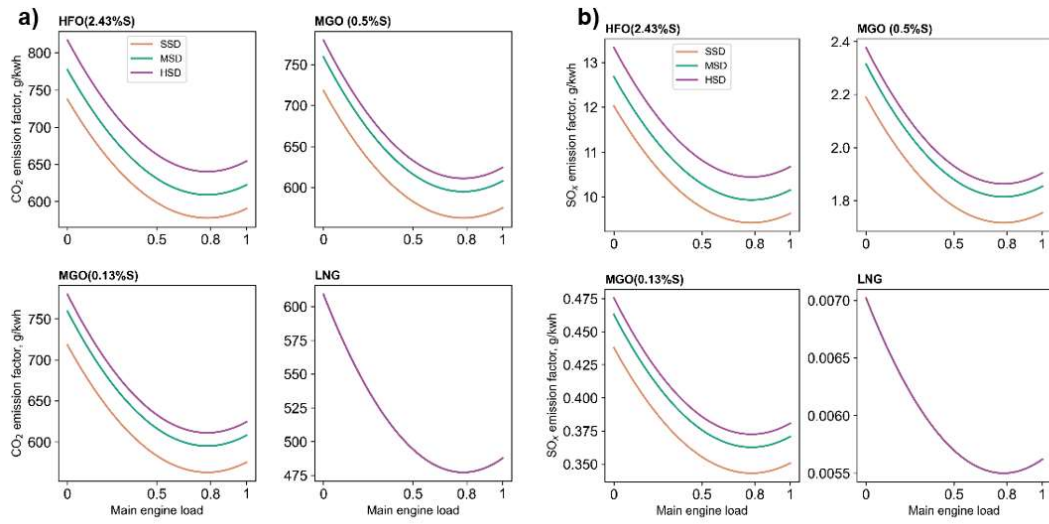
Figure S1: a) CO₂ and b) SO₂ emission factors of different types of fuel as a function of main engine load.
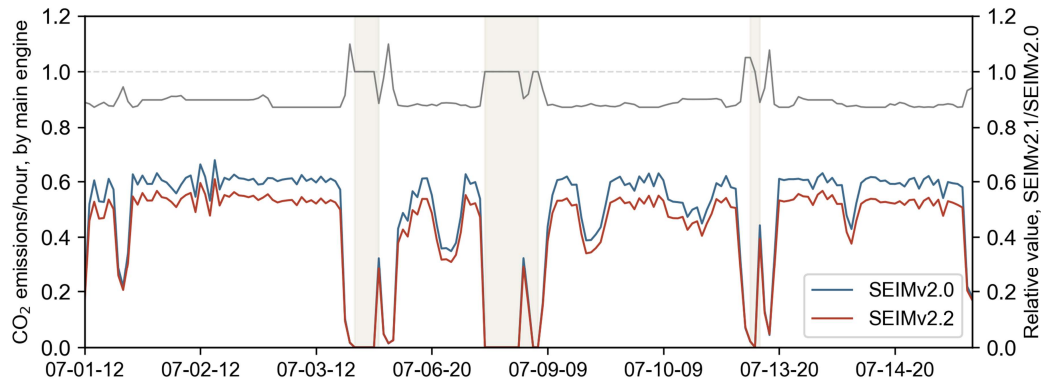
Figure S2: Hourly CO₂ emissions of a typical oil tanker (MMSI code: 414404060) as estimated by SEIMv2.0 and SEIMv2.2. The dark gray line represents the ratio of SEIMv2.2 calculated results to those of SEIMv2.0. The shaded gray regions highlight periods during which the vessel is either at anchorage or berth.
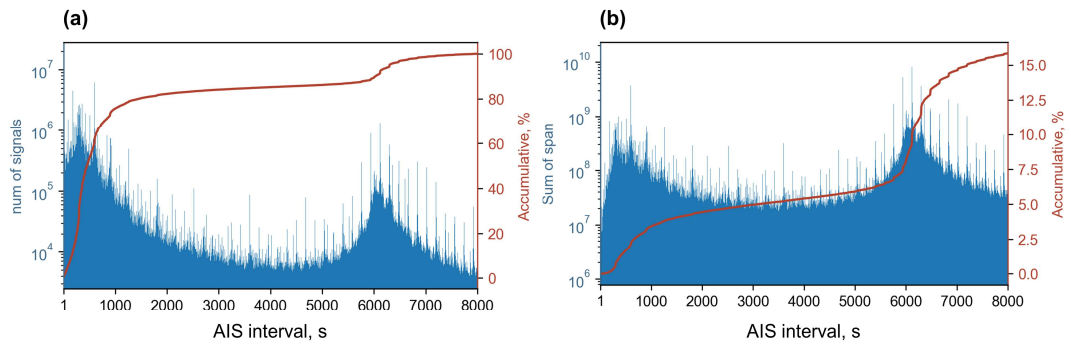
Figure S3: AIS signals intervals frequency statistics. a) Distribution of AIS signals counts; b) Distribution of cumulative AIS signal intervals.
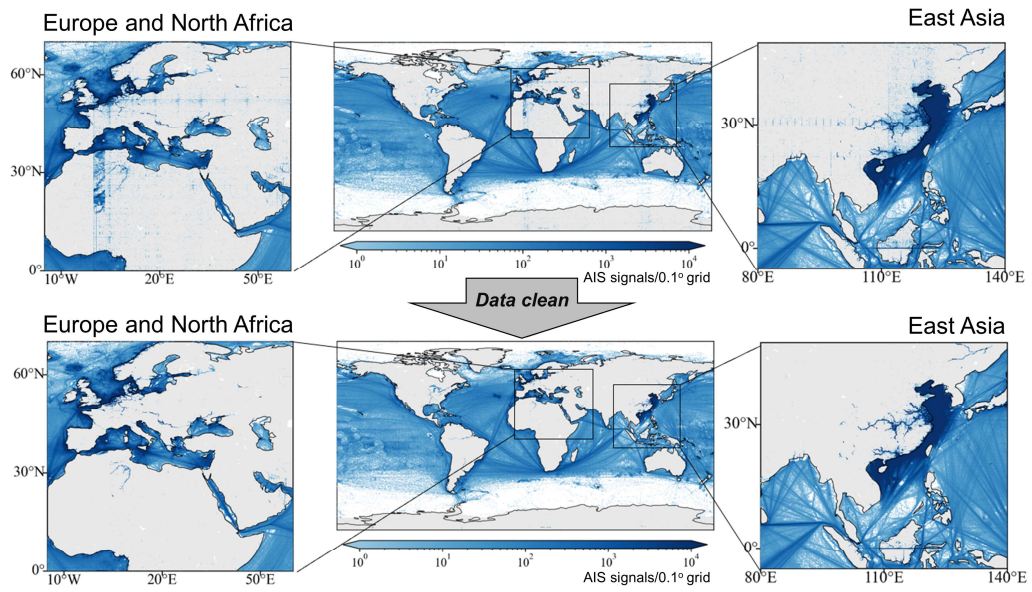
Figure S4: Spatial distribution of ship AIS signals before and after spatial anomalies cleaning.
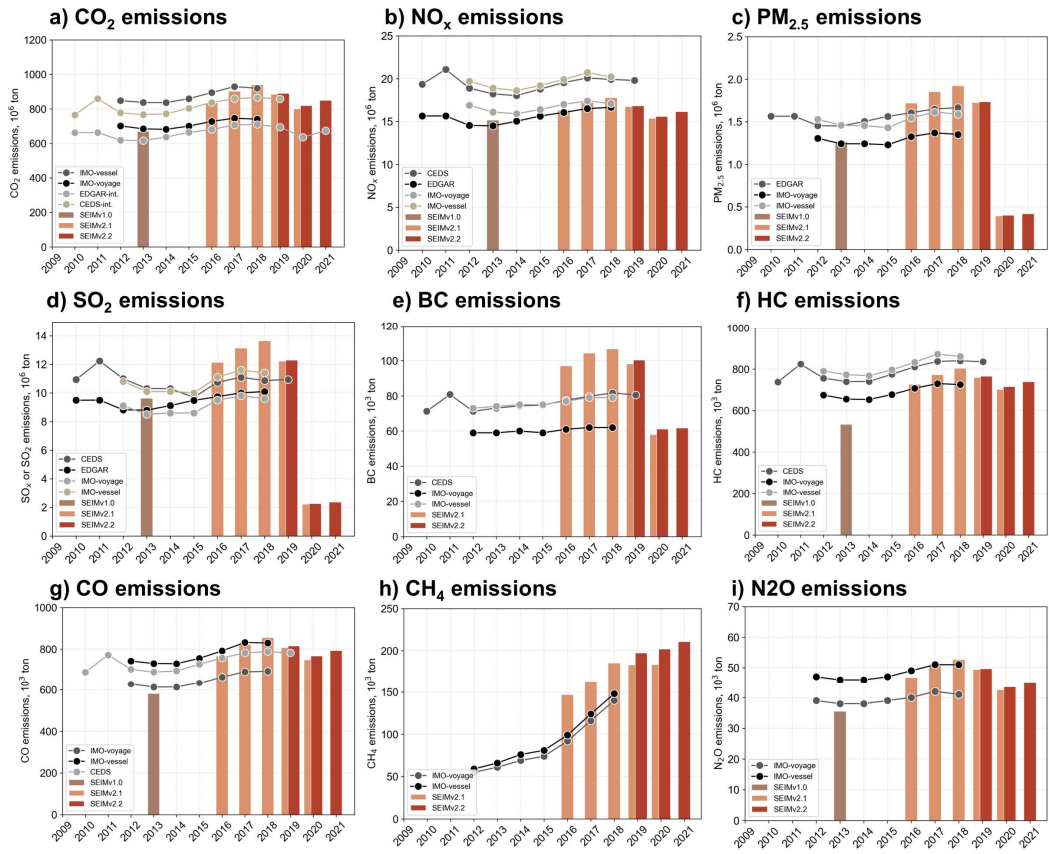
Figure S5: Global trends in shipping emissions from 2010 to 2021 with results from different SEIM version and other data sources.

Tabel S1. Correction coefficients for draft and weather applied in this study

Vessel category	Size (in dwt, unit: ton)	Average draft / design draft	Weather correction
Auto carrier	0-9999	0.961	0.909
	9999-+	0.770	0.867
Bulk carrier	0-9999	0.664	0.909
	10000-34999	0.746	0.867
	35000-59999	0.723	0.867
	60000-99999	0.678	0.867
	100000-199999	0.740	0.867
	200000-+	0.803	0.867
Chemical tanker	0-4999	0.961	0.909
	5000-9999	0.816	0.909
	10000-19999	0.762	0.867
	20000-+	0.754	0.867
Container	0-999	0.586	0.909
	1000-1999	0.473	0.867
	2000-2999	0.410	0.867
	3000-4999	0.363	0.867
	5000-7999	0.676	0.867
	8000-11999	0.652	0.867
	12000-14500	0.645	0.867
	14500-+	0.613	0.867
Cruise	0-+	0.600	0.909
Fishing ship	0-+	0.600	0.909
General cargo	0-4999	0.961	0.909
	5000-9999	0.816	0.867
	10000-+	0.770	0.867
Oil tanker	0-4999	0.742	0.909
	5000-9999	0.855	0.909
	10000-19999	0.754	0.867
	20000-59999	0.551	0.867
	60000-79999	0.580	0.867
	80000-119999	0.568	0.867
	120000-199999	0.580	0.867
	200000-+	0.635	0.867
Other tanker	0-49999	0.758	0.867
	50000-199999	0.832	0.867
	200000-+	0.832	0.867
Others	0-+	0.600	0.867

Table S2. Chemical component of ship-used fuel and corresponding fuel-based emission factors for CO_2, SO_2 and $PM_{2.5}$.

Fuel	Carbon content (m/m%)	$EFCO_2,f$ (g/gfuel)	Sulfur content (m/m%)	$EFSO_2,f$ (g/gfuel)	$EFPM_{2.5},e$ (g/kwh) Main Engine	$EFPM_{2.5},e$ (g/kwh) Auxiliary Engine	$EFPM_{2.5},e$ (g/kwh) Boiler
HFO (2.43% S)	0.8493	3.114	2.6	0.051	1.39	1.4	1.42
MGO (0.5% S)	0.8744	3.206	0.5	0.0098	0.31	0.31	0.31
MGO (0.13% S)	0.8744	3.206	0.13	0.0025	0.2	0.2	0.2
LNG	0.75	2.750	～0	0.0000317[a]	0.02	0.02	0.03

Table S3. SFC_{base} **applied in this study (unit: g/kwh)**

Fuel	Built year of engine	Main engine			Auxiliary engine	Boiler
		SSD[a]	MSD[b]	HSD[c]		
HFO	≤2000	185	195	205	205	340
	>2000	175	185	195	195	340
MGO	≤2000	175	185	190	190	320
	>2000	165	175	185	185	320
LNG	≤2000	173	173	173	173	285
	>2000	122	122	122	156	285

[a,b,c] refers to Slow-Speed Diesel, Medium-Speed Diesel, High-Speed Diesel, respectively

Table S4. Emission factors for specific air pollutants and GHGs applied in this study (unit: g/kwh)

	Main Engine				Auxiliary Engine		Boiler	
	HFO/MGO			LNG	HFO/MGO /GDO	LNG	HFO/MGO /GDO	LNG
	SSD	MSD	HSD					
NO_x (Tier0)	18.1	14	10					
NO_x (Tier1)	17	13	9.8	1.3	11.2	1.3	2.1	1.3
NO_x (Tier2)	14.4	10.5	7.7					
NO_x (Tier3)	3.4	2.6	2					
CO	0.54	0.54	0.54	1.3	0.54	1.3	0.2	0.2
HC	0.632	0.527	0.527	0.5	0.4	0.5	0.1	0.105
CH_4	0.01	0.01	0.01	2.5/5.5[a]	0.01	5.5	0.002	0.04
N_2O	0.03	0.03	0.03	0.02	0.04	0.02	0.045	0.02

[a] 2.5 for SSD, 5.5 for MSD / HSD

Table S5. Energy-based emission factors for BC (g/kwh)

Main engine load (%)	HFO			MDO/MGO			LNG
	SSD	MSD/HSD	AE/BE	SSD	MSD/HSD	AE/BE	
(0,5]	0.077	0.746	0.08	0.002	0.61	0.06	0.003
(5,10]	0.060	0.381	0.08	0.001	0.28	0.06	0.003
(10,20]	0.047	0.195	0.08	0.001	0.13	0.06	0.003
(20,30]	0.040	0.132	0.08	0.001	0.08	0.06	0.003
(30,40]	0.037	0.099	0.08	0.001	0.06	0.06	0.003
(40,50]	0.033	0.081	0.08	0.001	0.05	0.06	0.003
(50,60]	0.032	0.068	0.08	0.001	0.04	0.06	0.003
(60,70]	0.030	0.058	0.08	0.001	0.03	0.06	0.003
(70.80]	0.028	0.051	0.08	0.000	0.03	0.06	0.003
(80,90]	0.028	0.046	0.08	0.000	0.02	0.06	0.003
(90,100]	0.026	0.041	0.08	0.000	0.02	0.06	0.003