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The role of oceanic ventilation and terrestrial outflow in atmospheric non-methane hydrocarbons over the Chinese marginal seas

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Table S1 Precision and detection limit of the analytical method for different gases

Species	Precision (%)	Detection limit (ppt)	Species	Precision (%)	Detection limit (ppt)
Ethane	5	3.0	DMS	5	3.0
Ethylene	4	1.0	Benzene	5	20
Propane	7	3.0	Ethylbenzene	4	14
Propylene	7	0.5	Toluene	3	15
i-butane	6	1.0	CFC-11	1	5.0
n-butane	5	1.0	$CHBr_3$	7	0.03
n-pentane	6	2.0	CH_2Br_2	6	0.04
i-pentane	7	2.0	CH_3I	2	0.1
Isoprene	4	1.0			

Table S2 Parameters for inlet, oven, and detector of the gas chromatography

Parameters	Setting
Inlet temperature	150 ℃
Temperature program	45 ℃ for 3.5 mins; increase to 120 ℃ with a rate of 10 ℃ min^{-1} and hold for 15 mins; increase to 170 ℃ with a rate of 30 ℃ min^{-1} and hold for 3 mins
Flow rate of carrier gas	N_2: 2.0 mL min^{-1}
Split ratio	5:1
Detector temperature	300 ℃
Flow rate of the combustion/auxiliary gas	H_2: 30 mL min^{-1}; air: 400 mL min^{-1}
Flow rate of exhaust gas purge	N_2: 60 mL min^{-1}

Table S3 Precision and detection limit of the analytical method for seawater non-methane hydrocarbons (NMHCs)

NMHCs	Precision (%)	Detection limit (pmol L^{-1})
Ethane	6	1.0
Ethylene	4	0.7
Propane	4	0.7
Propylene	3	0.5
i-butane	6	0.5
n-butane	5	0.8
Isoprene	3	0.5

Table S4 Information for urban air samples collection and concentrations of atmospheric non-methane hydrocarbons (NMHCs)

City	Latitude (N)	Longitude (E)	Date	Time (UTC+8)	Ethane	Propane	i-butane	n-butane	Ethylene	Propylene	Isoprene
								(ppb)			
Tianjin	38.96	117.71	2021/3/27	09:00	5.39	20.08	27.57	30.24	0.283	0.065	0.025
Tianjin	38.96	117.71	2021/3/27	23:00	5.72	7.70	2.31	6.56	0.186	0.121	0.015
Dongying	37.40	118.89	2021/3/28	09:00	3.48	2.36	0.43	1.05	0.390	0.029	0.007
Dongying	37.40	118.89	2021/3/28	23:00	3.47	2.40	0.43	1.04	0.389	0.033	0.008
Qingdao	36.09	120.34	2021/3/28	09:00	1.63	0.63	0.03	0.11	0.101	0.007	0.006
Qingdao	36.09	120.34	2021/3/28	23:00	1.41	0.44	BD	0.02	0.035	BD	0.007
Ningbo	29.99	122.23	2021/3/28	09:00	2.65	1.98	0.69	0.79	0.200	0.019	0.009
Ningbo	29.99	122.23	2021/3/28	23:00	2.62	3.06	3.20	3.84	0.390	0.130	0.023
Xiamen	24.45	118.08	2021/3/27	09:00	1.31	0.25	0.03	0.02	0.050	BD	0.025
Shenzhen	22.53	114.05	2021/3/28	09:00	1.62	1.52	0.86	1.85	0.102	0.016	0.177
Shenzhen	22.53	114.05	2021/3/28	23:00	0.83	0.15	0.01	0.08	0.092	0.018	0.008
Qinzhou	21.87	108.61	2021/3/29	09:00	0.95	0.15	0.13	0.05	0.101	0.006	0.076
Sanya	18.39	109.02	2021/4/1	09:00	0.28	0.22	0.08	0.15	0.077	0.023	0.014
Sanya	18.39	109.02	2021/4/1	23:00	0.34	0.43	0.23	0.32	0.122	0.040	0.250

BD: below the detection limit

Table S5 Information for oceanic air samples collection and concentrations of non-methane hydrocarbons (NMHCs) in oceanic atmosphere

Station	Latitude (N)	Longitude (E)	Date	Time (UTC+8)	Ethane	Propane	i-butane	n-butane	Ethylene	Propylene	Isoprene
								(ppb)			
E1	31.35	122.6	2021/4/26	20:09	0.969	0.236	0.018	0.025	0.083	0.023	0.0051
E2	31.3	126.49	2021/4/27	20:33	0.815	0.195	BD	0.036	0.11	0.038	0.0163
E3	30.04	122.71	2021/4/29	18:09	1.723	1.571	0.403	0.511	0.199	0.034	0.0056
E4	29.32	122.38	2021/4/29	23:33	1.471	1.215	0.384	0.424	0.143	0.03	0.0039
E5	28.78	123.09	2021/4/30	5:32	1.114	0.587	0.092	0.108	0.101	0.025	0.0129
E6	29.27	125.43	2021/4/28	7:40	0.686	0.226	BD	0.035	0.05	0.049	0.0177
E7	27.88	121.33	2021/5/1	18:26	1.67	1.787	0.806	0.694	0.295	0.036	0.0016
E8	27.46	124.97	2021/4/30	19:10	1.076	0.443	0.078	0.086	0.142	0.038	0.0055
E9	26.57	120.96	2021/5/2	5:19	1.505	1.297	0.289	0.461	0.133	0.03	0.0432
E10	26.03	121.75	2021/5/2	12:17	0.99	0.437	0.063	0.082	0.076	0.022	0.003
H1	39.51	123.9	2021/4/20	15:12	1.23	0.439	0.54	0.082	0.13	0.031	0.0036
H2	38.75	122.99	2021/4/20	11:20	0.702	1.7	BD	0.447	0.028	0.034	0.0133
H3	37.99	122.04	2021/4/19	17:20	1.58	1.197	1.168	0.596	0.253	0.029	0.0061
H4	37.95	123.91	2021/4/21	6:05	1.448	0.318	0.194	0.045	0.075	0.023	BD
H5	35.03	123.03	2021/4/24	12:15	1.255	0.654	0.229	0.222	0.244	0.06	0.0022
H6	33.95	121.85	2021/4/25	9:39	1.007	0.361	0.189	0.091	0.129	0.03	0.0016
H7	34.02	123.79	2021/4/25	1:22	1.276	0.816	0.233	0.259	0.286	0.037	0.0134
H8	32.99	122.98	2021/4/27	9:16	1.355	0.804	0.139	0.203	0.123	0.023	0.0007
H9	32.43	123.84	2021/4/26	8:06	1.072	0.332	0.05	0.056	0.152	0.034	0.0035

BD: below the detection limit

Table S6 Atmospheric non-methane hydrocarbons (NMHCs) from different reports

Region	Ethane	Propane	i-butane	n-butane	Ethylene	Propylene	Isoprene	Reference
				(ppb)				
The Yellow Sea and the East China Sea	1.24	0.822	0.283	0.256	0.151	0.033	0.008	This study
Bengal Bay	0.561	0.191	0.107	0.143	0.299	0.192	ND	Sahu et al., 2011
Bengal Bay	0.861	0.093	0.040	0.156	0.099	0.059	ND	Sahu et al., 2011
Northwest Pacific Ocean	0.61	0.24	0.12	0.07	0.42	0.60	ND	Li et al., 2019

ND: No data.

Table S7 Information for seawater samples and concentrations of non-methane hydrocarbons (NMHCs)

Station	Latitude (N)	Longitude (E)	Date	Time (UTC+8)	Ethane	Propane	i-butane	n-butane	Ethylene	Propylene	Isoprene
					(pmol L^{-1})						
E1	31.35	122.6	2021/4/26	20:32	9.11	6.69	9.81	BD	80.8	26.2	31.9
E2	31.3	126.49	2021/4/27	20:57	11.7	11.5	2.79	BD	109	13.4	22.5
E3	30.04	122.71	2021/4/29	18:22	22.8	32.3	6.17	10.38	136	27.6	105
E4	29.32	122.38	2021/4/29	23:50	11	15.7	14.4	BD	66.2	14.4	59.7
E5	28.78	123.09	2021/4/30	5:55	7.83	3.76	1.54	BD	8.4	2.42	3.43
E7	27.88	121.33	2021/5/1	18:40	14.4	18.9	20.4	BD	69.6	20.8	44.9
E8	27.46	124.97	2021/4/30	19:42	10.5	6.9	4.33	BD	89.9	8.29	17.3
E9	26.57	120.96	2021/5/2	5:44	15.6	14.5	18	1.44	62.5	18	51.3
E10	26.03	121.75	2021/5/2	12:42	4.7	3.68	2.76	BD	17.9	6.43	7.6
H2	38.75	122.99	2021/4/20	11:41	13.3	22	2.92	32.92	79	27	10
H3	37.99	122.04	2021/4/19	17:41	13.6	17.1	3.41	18.85	59.4	16.7	26.3
H4	37.95	123.91	2021/4/21	6:31	13	10.1	35.3	0.56	115	19.8	17.9
H5	35.03	123.03	2021/4/24	12:36	11.3	10.9	4.86	15.03	87.9	11.4	36.1
H6	33.95	121.85	2021/4/25	9:58	8.4	10.7	9.52	BD	35.8	8.43	19.4
H7	34.02	123.79	2021/4/25	1:47	7.96	7.94	5.91	BD	54.8	6.37	20.5
H9	32.43	123.84	2021/4/26	8:41	10.1	9.4	9.22	BD	55.2	15.5	22.1

BD: below the detection limit

Table S8 Surface seawater temperature (SST), wind speed(u), and sea-to-air flux of non-methane hydrocarbons (NMHCs) for oceanic stations

Station	SST (°C)	u ($m\ s^{-1}$)	Ethane	Propane	i-butane	n-butane	Ethylene	Propylene	Isoprene
			($nmol\ m^{-2}\ d^{-1}$)						
E1	17	11.6	73.9	50.5	71.4	-0.6	737.1	211.9	227.3
E2	19.6	7.8	47	43.2	9.8	-0.3	489.3	52.7	78.5
E3	19.3	8.9	118.3	157.4	27.8	46.8	774.7	138.9	468.2
E4	18.4	10.6	76.8	104.4	90.4	-0.5	517.1	99.2	365.6
E5	19.5	12.7	81.5	35.6	14.2	-0.8	89.8	23.3	31
E7	20.7	5.5	29.6	36.7	37.1	-0.1	158.2	42	79.9
E8	22	9.9	70.8	43.4	26	-0.5	681.6	54.7	102.2
E9	20.4	4.2	18.3	15.9	18.7	1.4	80.8	20.7	52
E10	25	6.1	12.3	9.1	6.7	-0.2	53.4	17.2	18.2
H2	12.4	4.3	13.1	20.5	2.5	28.7	86.1	26.1	8.5
H3	14.6	1.7	2.3	2.7	0.5	2.8	11	2.7	3.8
H4	9.2	9.8	60.8	44.1	146	2	594.6	90.7	72.3
H5	13.3	11.5	81.8	73.5	31	96.1	706	80.5	226.3
H6	13.6	4.6	9.8	11.9	10	-0.1	46.5	9.7	20
H7	14.4	0.7	0.2	0.2	0.1	ND	1.7	0.2	0.5
H9	15.5	5.5	17.9	15.7	14.7	-0.1	109.4	27.2	34.4

Table S9 Distance from station to nearest land (L), transport time of air mass from it leaving the land to the station (t), and retention of air mass over the land (R_L)

Station	L (km)	t (hour)	R_L-48	R_L-72	R_L-96	R_L-mean
E1	68.34	19	0.19	0.39	0.51	0.36
E2	330.99	44	0.07	0.07	0.16	0.58
E3	29.19	11	0.79	0.86	0.89	0.10
E4	40.28	20	0.75	0.82	0.86	0.85
E5	113.85	14	0.61	0.72	0.78	0.81
E6	298.68	15	0.29	0.27	0.23	0.70
E7	13.86	12	0.78	0.84	0.88	0.26
E8	319.87	38	0.52	0.64	0.72	0.83
E9	69.24	49	0.14	0.11	0.16	0.62
E10	83.10	46	0.56	0.56	0.63	0.14
H1	34.64	20	0.29	0.47	0.53	0.58
H2	33.43	22	0.35	0.53	0.63	0.43
H3	48.09	4	0.94	0.96	0.97	0.50
H4	61.65	81	0	0	0.09	0.96
H5	199.84	26	0.25	0.27	0.4	0.03
H6	124.22	30	0.17	0.14	0.27	0.31
H7	119.51	33	0.11	0.1	0.13	0.19
H8	158.65	42	0.06	0.26	0.4	0.11
H9	197.59	39	0.23	0.43	0.54	0.24

Table S10 Sea-to-air fluxes of non-methane hydrocarbons (NMHCs) in different studies

Region	Ethane	Propane	i-butane	n-butane	Ethylene	Propylene	Isoprene	Reference
	(nmol m^{-2} d^{-1})							
Yellow Sea and East China Sea	44.6	41.5	31.7	10.9	321	56.1	112	This study
Yellow Sea and East China Sea	31.7±27.8	29.7±25.1	18.5±16.4	15.9±19.1	240±258	67.9±74.5	52.4±82.3	Wu et al., 2021
East China Sea	12.5±14.4	17.9±40.9	4.1±5.3	8.5±10.3	65.0±73.4	22.4±26.8	54.2±67.0	Li et al., 2021
Marginal seas of China	-	-	-	-	529	383	111	Li et al., 2021
North Sea	20.4	17.2	4.31	-	145	57.4	24.4	Broadgate et al., 1997
23-38°N Atlantic Ocean	28.7	21.5	2.87	5.74	315	103	-	Tran et al., 2013
Western Pacific Ocean	6.6	12.4	-	-	74.7	24.1	43.4	Li et al., 2019
Northwest Pacific Ocean	28.0	21.1	12.7	14.2	65.2	48.7	41.7	Wu et al., 2023

"-" indicates no data.

Table S11 Parameters and results of ozone formation potential (OFP) and secondary organic aerosol formation potential (P_{SOAP}) for non-methane hydrocarbons (NMHCs)

Species	Mean conc. of NMHCs (ppb)	MIR ($gO_3\ gVOC^{-1}$)	SOAP	M (g mol L^{-1})	OFP (μg m^{-3})				P_{SOAP} (μg m^{-3})			
					Industrial activities	Exhaust emissions	Ocean emissions	Terrestrial vegetation emissions	Industrial activities	Exhaust emissions	Ocean emissions	Terrestrial vegetation emissions
Ethane	1.21	0.28	0.1	30.07	0.17	0.16	0.08	0.02	0.03	0.03	0.02	0.01
Propane	0.769	0.49	-	44.1	0.51	0.10	0.05	0.04	-	-	-	-
i-butane	0.288	1.23	-	58.12	0.52	0.04	0.01	0.03	-	-	-	-
n-butane	0.234	1.15	0.3	58.12	0.60	0.04	0	0.04	0.08	0.01	0	0.01
Ethylene	0.145	9.00	1.3	28.05	0.47	0.46	0.45	0	0.04	0.04	0.04	0
Propylene	0.033	1.66	1.6	42.08	0.05	0.03	0.03	0.02	0.01	0.02	0.02	0.01
Isoprene	0.008	10.61	1.9	68.12	0.01	0.02	0.02	0.12	0.01	0.01	0.01	0.01

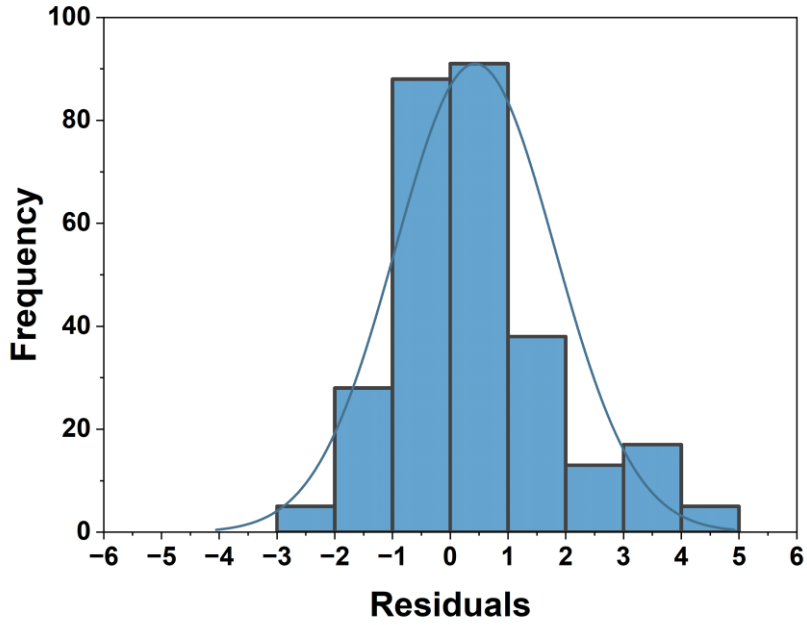


Figure S1 The scaled residuals given by positive matrix factorization (PMF).

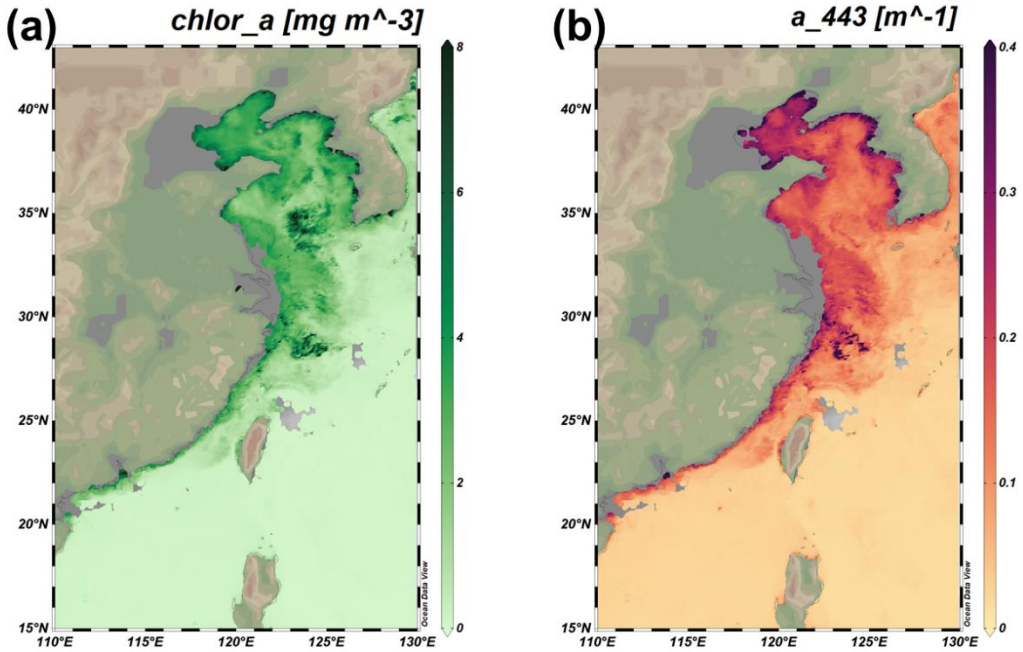
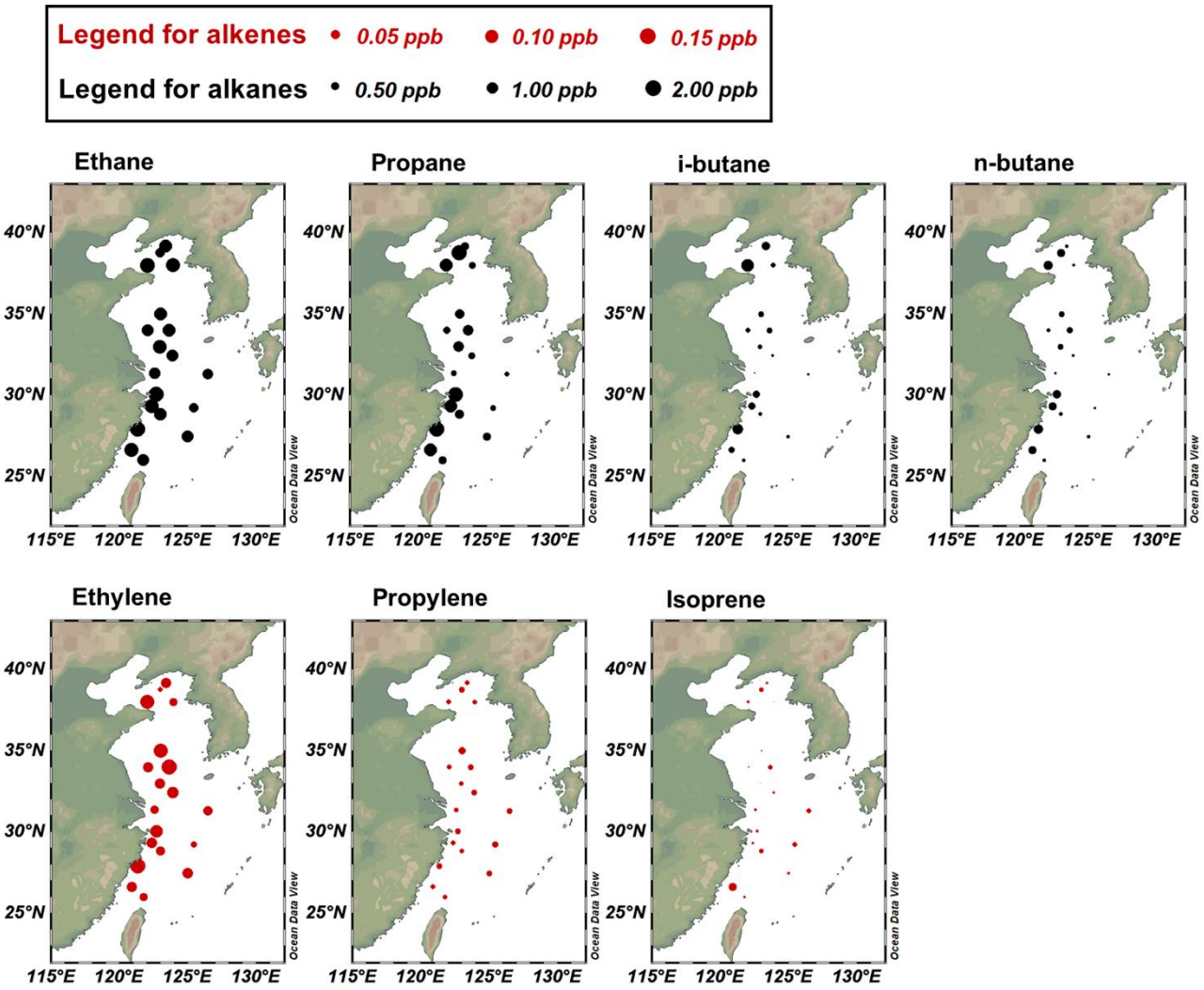


Figure S2 Romte sensing monthly Chl-*a* concentration (panel a) and total absorption coefficient at 443 nm (panel b) in April 2021. Data of Aqua-MODIS at resolution of 9 km were downloaded from https://oceancolor.gsfc.nasa.gov/ (Schlitzer, Reiner, Ocean Data View, odv.awi.de, 2023).



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337 **Figure S3** Distributions of alkanes (black dots) and alkenes (red dots) in the atmosphere over the Yellow Sea and

338 the East China Sea (Schlitzer, Reiner, Ocean Data View, odv.awi.de, 2024).

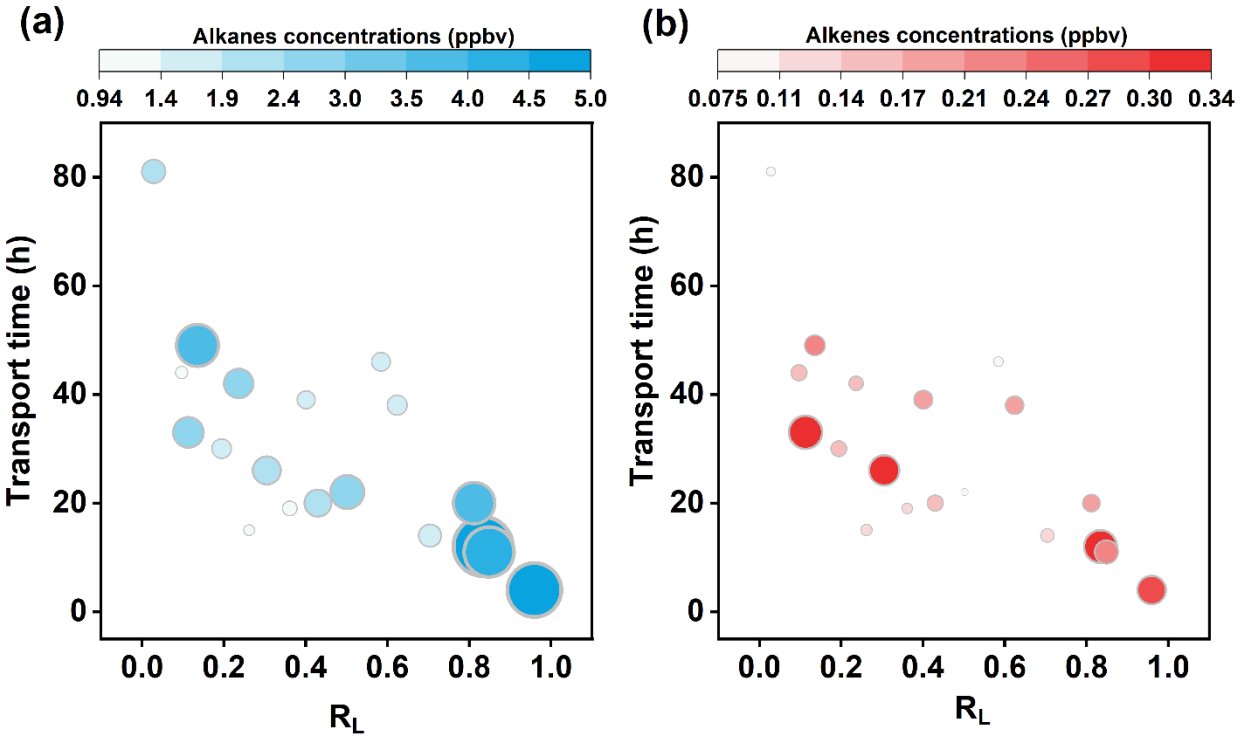

Figure S4 Impacts of air mass (indicated by transport time and R_L) on atmospheric alkanes (a) and alkenes (b) over the Yellow Sea and the East China Sea.

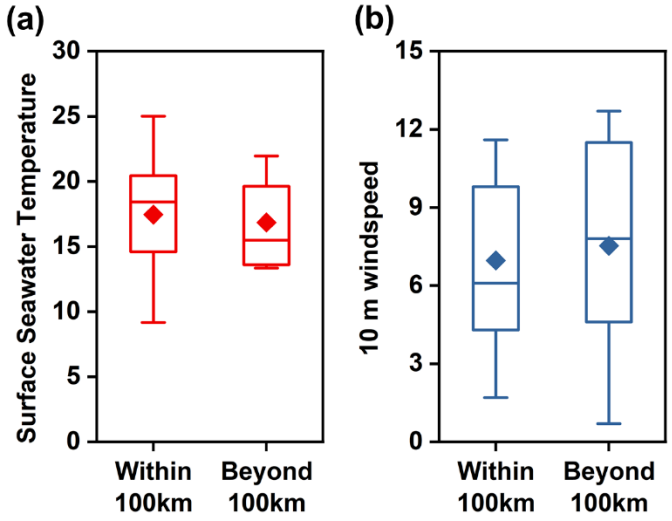

Figure S5 Comparison in surface seawater temperature (panel a) and wind speed (panel b) between regions within/beyond 100 km from the coastline. Boxes span the interquartile range, with lines at the median. Diamonds indicate mean values, and whiskers span the 5-95 percentiles.