*Supporting Information*

# Roles of oceanic ventilation and terrestrial outflow in the 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 °C |
| Temperature program | 45 °C for 3.5 mins; increase to 120 °C with a rate of 10 °C $min^{-1}$ and hold for 15 mins; increase to 170 °C with a rate of 30 °C $min^{-1}$ and hold for 3 mins |
| Flow rate of carrier gas | $N_2$: 2.0 mL $min^{-1}$ |
| Split ratio | 5:1 |
| Detector temperature | 300 °C |
| 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

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**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 (ppb) | Ethylene | Propylene | Isoprene | Reference |
|---|---|---|---|---|---|---|---|---|
| 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 (nmol m⁻² d⁻¹) | Ethylene | Propylene | Isoprene | Reference |
|---|---|---|---|---|---|---|---|---|
| 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) calculation for non-methane hydrocarbons (NMHCs)

| Species | Mean conc. of NMHCs (ppb) | MIR (gO$_3$ gVOC$^{-1}$) | M (g mol L$^{-1}$) | OFP ($\mu$g m$^{-3}$) | | | |
|---------|------|------|------|------|------|------|------|
| | | | | Industrial activities | Exhaust emissions | Ocean emissions | Terrestrial vegetation emissions |
| Ethane | 1.21 | 0.28 | 30.07 | 0.173 | 0.164 | 0.083 | 0.017 |
| Propane | 0.769 | 0.49 | 44.1 | 0.507 | 0.103 | 0.046 | 0.039 |
| i-butane | 0.288 | 1.23 | 58.12 | 0.520 | 0.044 | 0.006 | 0.029 |
| n-butane | 0.234 | 1.15 | 58.12 | 0.600 | 0.039 | 0 | 0.041 |
| Ethylene | 0.145 | 9.00 | 28.05 | 0.472 | 0.465 | 0.450 | 0 |
| Propylene | 0.033 | 1.66 | 42.08 | 0.050 | 0.031 | 0.028 | 0.019 |
| Isoprene | 0.008 | 10.61 | 68.12 | 0.012 | 0.022 | 0.024 | 0.125 |

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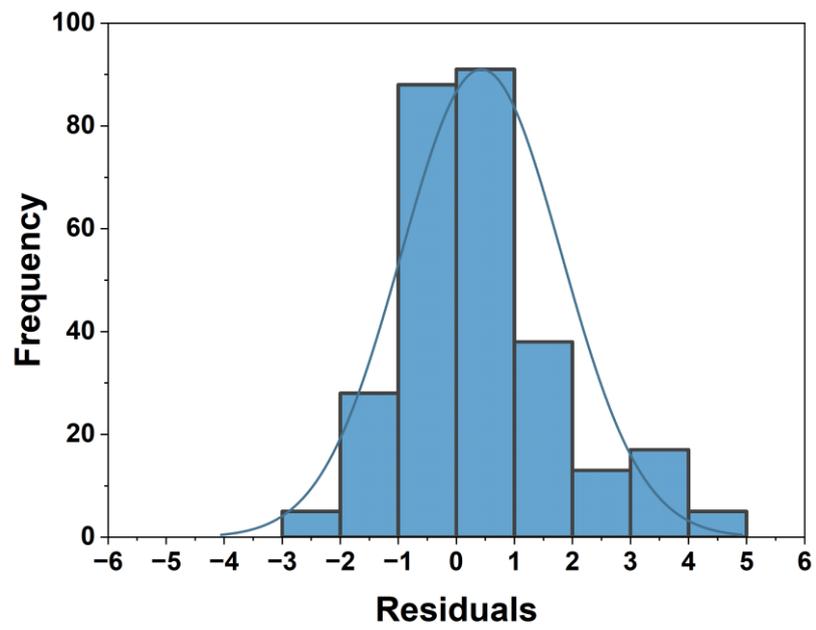
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329           **Figure S1** The scaled residuals given by positive matrix factorization (PMF)
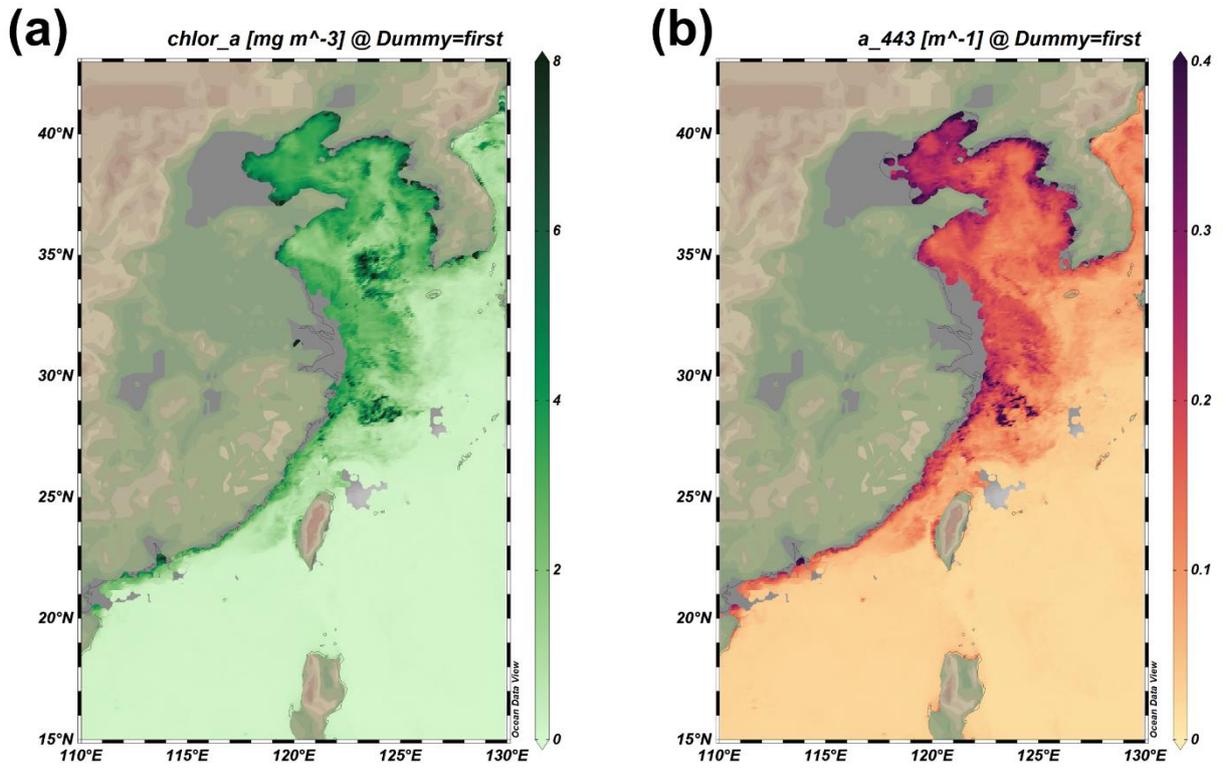
**Figure S2** Romte sensing monthly Chl-*a* concentration (panel a) and total absorption coefficient at 443 nm (panel b) in April 2021. Data of Aqua-MODIS at resolution of 9 km were downloaded from https://oceancolor.gsfc.nasa.gov/.