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Aerosols as a source of dissolved black carbon to the ocean

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Outline

- Background
- Method
- Results and discussion
- Conclusion

Background

Dissolved black carbon (DBC) is the largest known slow-cycling organic carbon pool in the world's oceans.

DBC, an intermediate component of BC degradation, is an important component of the ocean-dissolved organic carbon pool, covering global ocean carbon revenues and payments and influencing global climate change.

Method

Sample collection

Location:Aerosol samples were collected from the China coastal seas to the northwestern Pacific Ocean

Period:from 28 March to 4 May 2015

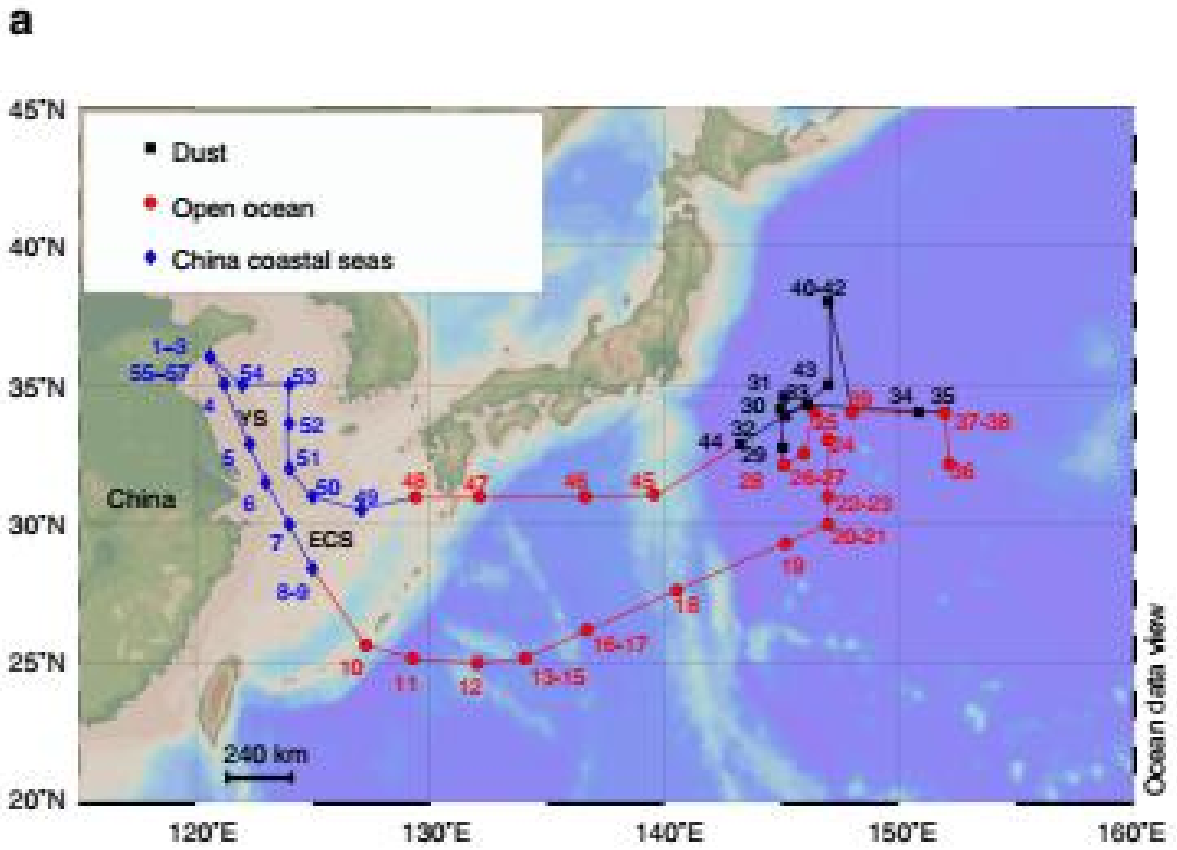


Fig. 1 Sampling map.

Method

Sample classification

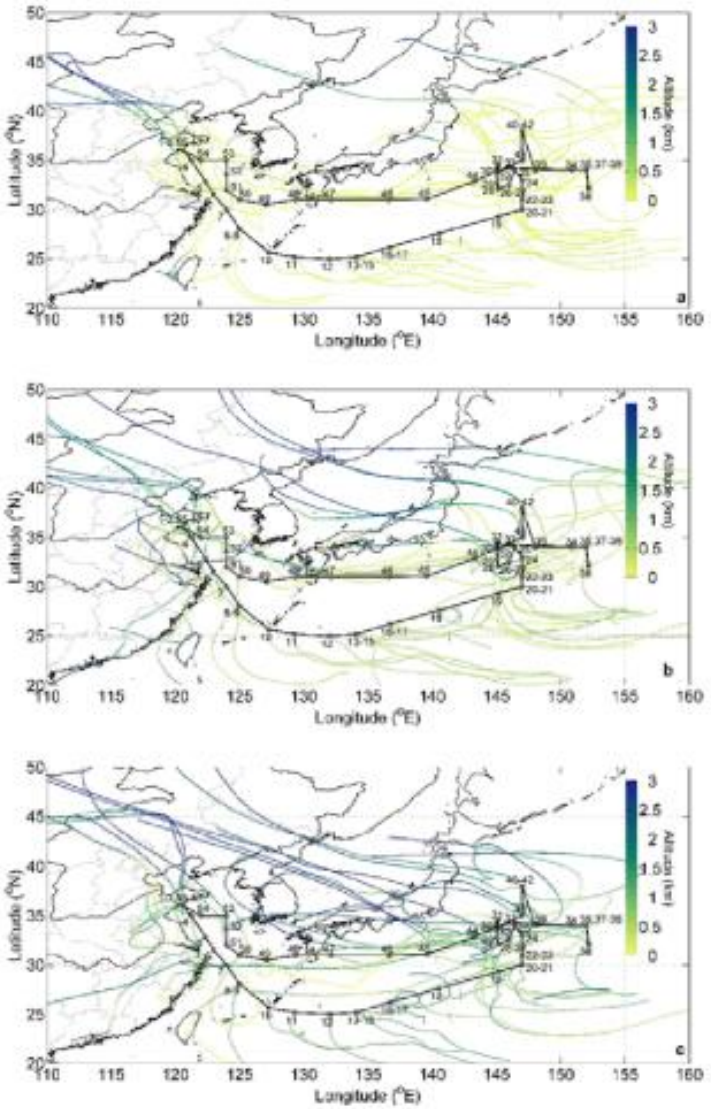


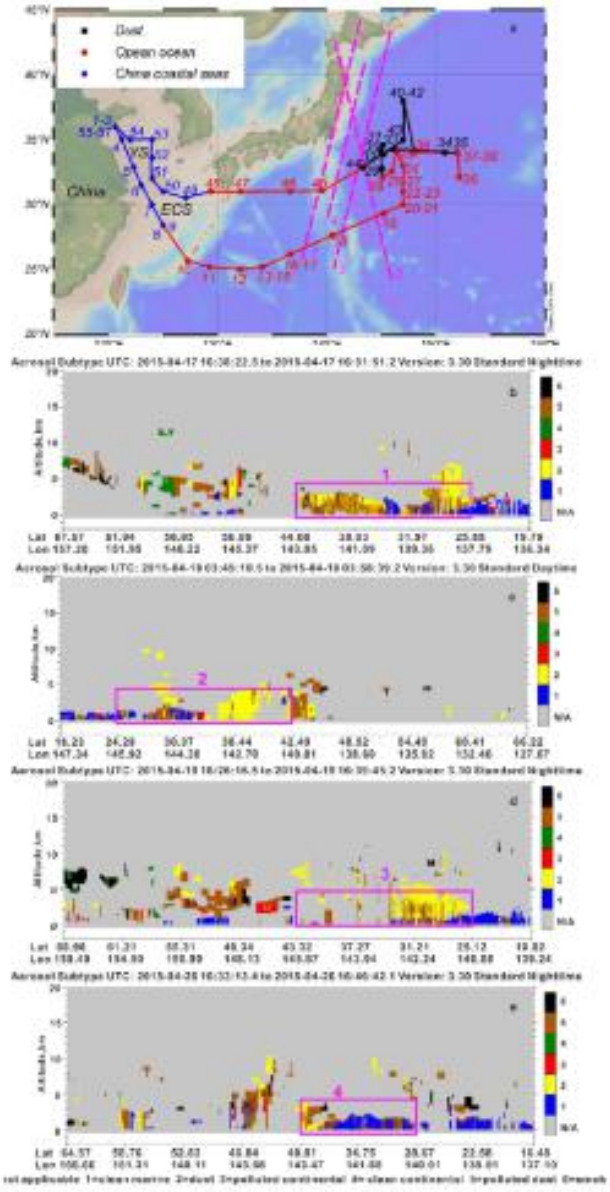
Fig. 2: Three-day backward trajectories of all the aerosol samples

Method

Sample classification

Fig. 3: NASA satellite images showing the dust effect during our sampling.

Extension of the four transects in a) is indicated on the map b, c, d and e.



Method

DOC analysis:

DOC was measured using a TOC analyser.

WSBC quantification:

WSBC was determined on a molecular level using the BPCAs method.

Method

FT-ICR-MS analysis:

The number of molecular formulas for each sample was between 2900 and 6800. According the elemental composition of standard procedures calculated each formula aromaticity index.

Method

Statistical analysis.

Estimation of WSBC deposition **in the China Coastal Seas.**

$$F_D = C \times V$$

F_D is the dry deposition flux of WSBC (mg m^{-2} d^{-1})

C is the concentration of WSBC (ng C m^{-3})

V is the deposition velocity (cm s^{-1})

Method

Estimation of the **global deposition of WSBC** in the ocean.

$$F_{WSBC} = F_{WSOC} \times (WSBC/WSOC)$$

F_{WSBC} is the annual atmospheric deposition of WSBC to the global ocean.

F_{WSOC} is the annual global atmospheric WSOC deposition to the ocean.

Method

Estimation of **dust WSBC deposition** to the Global Oceans.

$$D_{WSBC} = F_{Dust} \times (WSOC/D) \times (WSBC/WSOC)$$

D_{WSBC} is the dust deposition of WSBC

F_{Dust} is the global dust deposition flux

WSOC/D is the ratio of WSOC in the dust

WSBC/WSOC is the ratio of WSBC to WSOC in dust aerosols

Results and discussion

Sample #	WSOC (nmol m^{-3})	WSBC (nmol m^{-3})	WSBC/WSOC	Concentration group*
1	835	22	0.026	9
2	441	13	0.029	8
3	284	8.7	0.031	6
4	345	11	0.031	7
5	137	3.4	0.025	3
6	114	4.3	0.038	3
7	450	6.7	0.015	8
8	125	0.86	0.0068	3
9	81	1.1	0.014	2
10	35	0.9	0.026	1
12	6.8	0.098	0.014	1
14	17	0.37	0.022	1
15	47	0.9	0.019	1
16	12	0.46	0.04	1
17	45	0.69	0.015	1
18	19	0.6	0.032	1
19	22	0.71	0.032	1
21	15	0.74	0.049	1
22	N.A.	0.33	N.A.	N.A.
23	28	0.4	0.014	1
24	12	0.37	0.031	1
25	48	0.63	0.013	1
26	34	0.52	0.016	1
27	65	0.44	0.0068	2
28	49	2.9	0.059	1
29	88	2.7	0.031	2
30	190	8.5	0.045	4
31	230	9	0.039	5
32	311	8.1	0.026	7
33	N.A.	4.2	N.A.	N.A.
36	33	1.1	0.033	1
38	145	1.1	0.008	3
39	95	1	0.011	2
40	151	3	0.02	4
41	197	8.5	0.043	4
42	329	5.3	0.016	7
44	76	2.1	0.028	2
45	77	4.6	0.059	2
47	22	1.5	0.07	1
48	43	1.8	0.042	1
51	149	2.5	0.017	3
53	236	8.5	0.036	5
54	184	4.9	0.027	4
55	286	8.7	0.03	6
56	321	9.6	0.03	7
57	560	19	0.035	9

WSOC and WSBC concentrations.

The WSOC and WSBC concentrations of the **dust aerosols** in the open ocean were on average **five times** higher than those of open ocean **non-dust aerosols**, reflecting the important role of **dust aerosols** in transporting WSBC to the ocean.

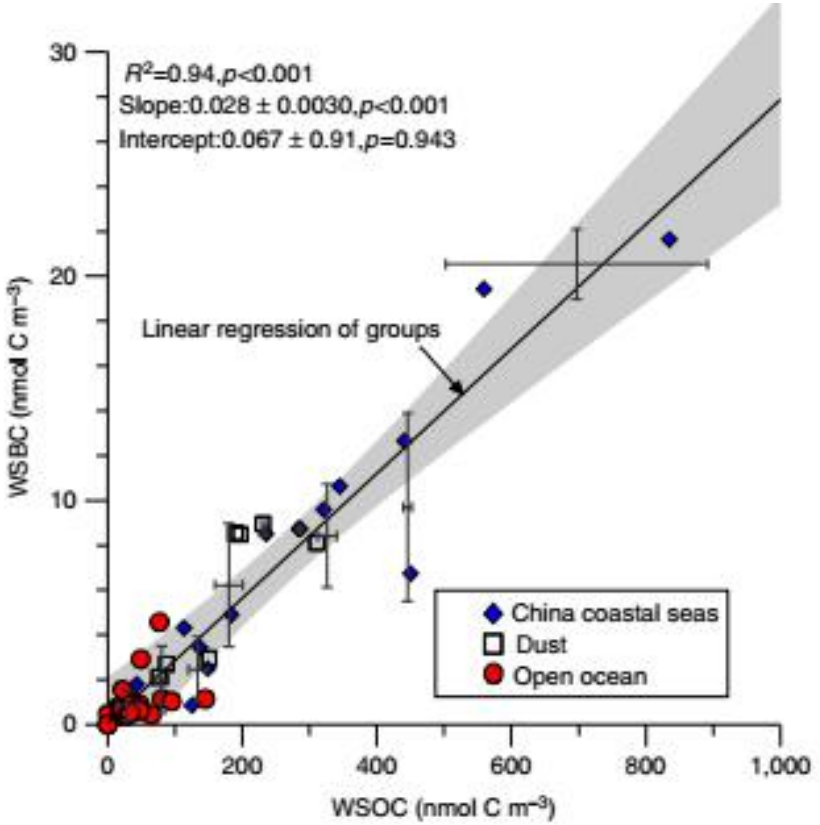


Fig. 4 Relationship between WSBC and WSOC.

Molecular composition revealed by FT-ICR-MS

Table 1: Summary of general molecular characteristics of different groups of aerosols

	China coastal seas (n=15)	Dust (n=9)	Open ocean (n=22)
Number of formulas	4285 – 6678 (5654)	4347 – 5574 (4961)	2984 – 6780 (3976)
Mass	317 – 358 (340)	337 – 393 (361)	316 – 362 (334)
AI_{mod}	0.13 – 0.23 (0.18)	0.18 – 0.33 (0.24)	0.15 – 0.32 (0.23)
H/C	1.4 – 1.6 (1.4)	1.2 – 1.3 (1.3)	1.2 – 1.6 (1.4)
O/C	0.42 – 0.53 (0.46)	0.37 – 0.56 (0.48)	0.31 – 0.51 (1.37)
CHO	30 – 55% (43%)	47 – 67% (56%)	43 – 67% (57%)
CHON	16 – 28% (21%)	17 – 35% (28%)	12 – 34% (23%)
CHOS	22 – 42% (32%)	7.1 – 23% (14%)	5.9 – 36% (16%)
CHOP	0.29 – 1.3% (0.72%)	0.30 – 2.0% (1.1%)	0.8 –2.7% (1.4%)
CHONS	0.97 – 6.2% (2.9%)	0.16 – 1.4% (0.64%)	0.31 – 1.3% (0.80%)
CHONP	<0.1%	<0.1%	<0.1 – 0.36% (0.15%)
CHOSP	0.10 – 0.80% (0.32%)	0.10 – 0.57% (0.28%)	0.24 – 1.1% (0.61%)

Results and discussion

signal intensity :1.3--10%

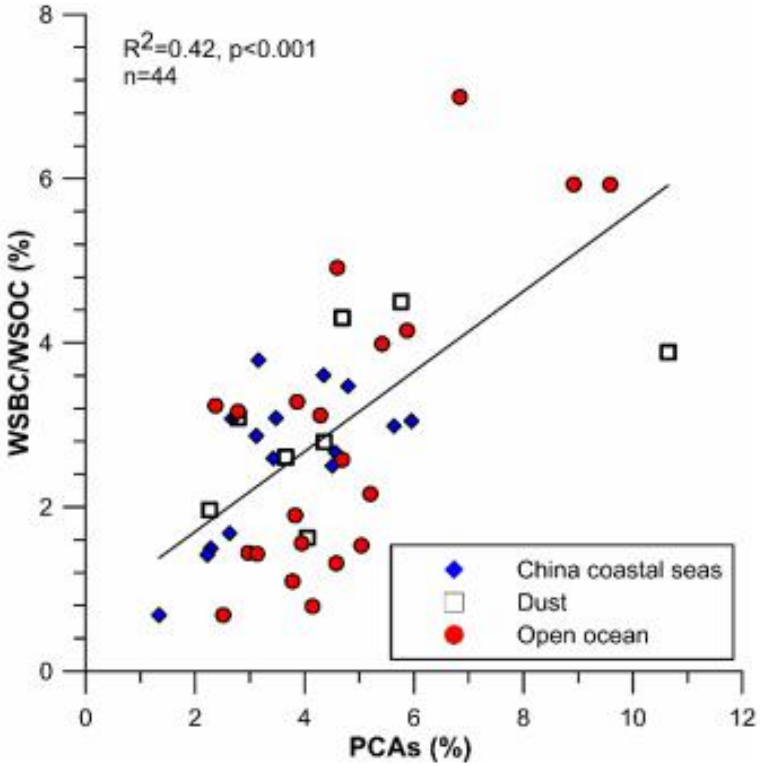


Fig. 5: Correlation between the relative signal intensity of combustion-derived PCAs determined by FT-ICR-MS and WSBC to WSOC (WSBC/WSOC) ratios

the sourse of WSBC

This significant correlation suggests that WSBC and WSOC might be released by **similar processes.**

Possible sources of WSBC :

dissolution of soil particles

the oxidation of soot

sea spray

The composition of the PCAs can further explain the potential sources of WSBC in the ocean atmosphere .

Burning of forest landscapes normally produces N-depleted DBC, and the heteroatom- (N- and S-) containing PCAs may be related to human activities, e.g., agriculture.

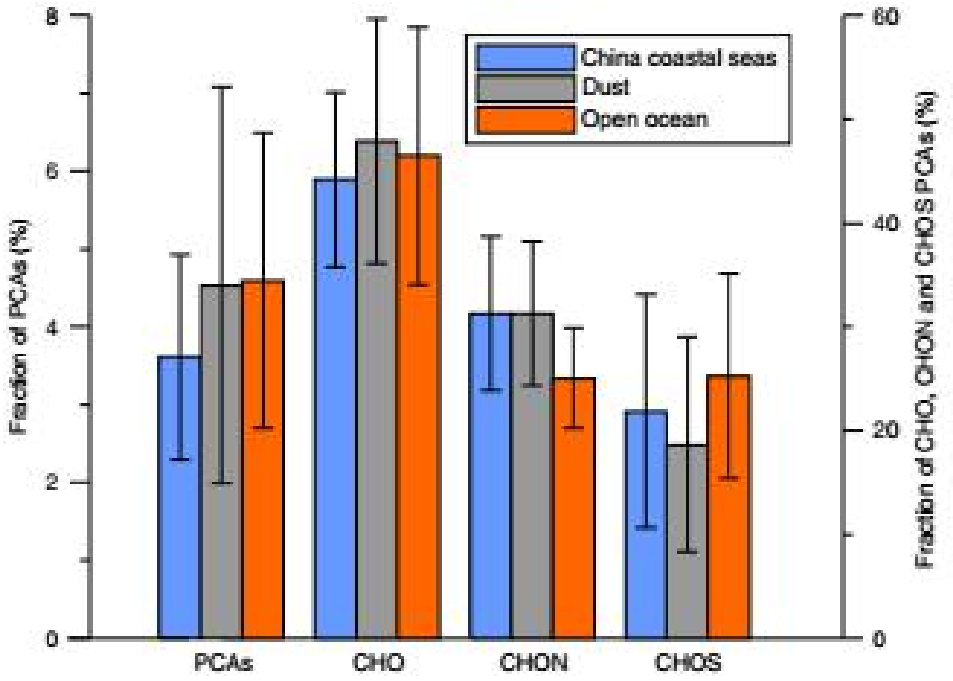


Fig. 6 The fraction of polycyclic aromatic compounds in the different types of aerosols

Table 2: Fraction of PCAs compounds in different samples and contribution of different PCAs compounds to all PCAs in the respective sample.

	China coastal seas (n=15)	Dust (n=9)	Open ocean (n=22)
PCAs (% of total intensity)	1.3 – 5.9 (3.9)	2.3 – 11 (4.5)	2.3 – 9.6 (4.5)
H/C (PCAs)	0.58 – 0.62 (0.60)	0.59 – 0.60 (0.59)	0.58 – 0.60 (0.59)
O/C (PCAs)	0.23 – 0.35 (0.30)	0.29 – 0.37 (0.33)	0.26 – 0.37 (0.30)
PCAas (% of PCAs)	38 – 58% (46%)	41 – 49% (44%)	35 – 53% (46%)
PCAar (% of PCAs)	72 – 92% (86%)	79 – 93% (86%)	73 – 93% (85%)
AI_{mod}as	0.71 – 0.73 (0.72)	0.72 (0.72)	0.71 – 0.73 (0.72)
AI_{mod}ar	0.74 – 0.75 (0.75)	0.74 – 0.75 (0.75)	0.74 – 0.76 (0.75)
Mass_as	235 – 258 (246)	239 – 245 (242)	226 – 254 (239)
Mass_ar	243 – 268 (254)	241 – 255 (248)	231 – 258 (244)
H/Cas	0.63 – 0.66 (0.64)	0.62 – 0.64 (0.64)	0.63 – 0.65 (0.64)
O/Cas	0.23 – 0.32 (0.28)	0.26 – 0.34 (0.30)	0.25 – 0.35 (0.28)
H/Car	0.57 – 0.61 (0.58)	0.56 – 0.58 (0.58)	0.57 – 0.58 (0.57)
O/Car	0.34 – 0.43 (0.36)	0.33 – 0.36 (0.35)	0.32 – 0.37 (0.35)
CHO (% of PCAs)	30 – 61 (44)	28 – 70 (48)	20 – 73 (46)
CHON (% of PCAs)	20 – 45 (31)	19 – 41 (31)	16 – 36 (25)
CHOS (% of PCAs)	7 – 36 (22)	7 – 40 (19)	10 – 47 (25)
Others (% of PCAs)	0.72 – 6.6 (2.6)	0.25 – 5 (2.2)	0.76 – 9.6 (3.2)

Dissolution from soil particles is a major source of riverine DBC.

By comparing the PCAs of aerosols and river water samples, fingding **86 ± 5%** of the PCAs in aerosols can be found in rivers (defined as PCAar) .

suggest that dissolution from soil consistent with the molecular composition of the PCAs in ocean aerosols.

Exploring whether **DBC in atmospheric deposition** contributes to the oceanic DBC.

Comparing the PCAs in aerosols with seawater collected in the same region,finding 45% of the PCAs in aerosols were also found in seawater (defined as PCAas).

Suggesting a potential contribution of atmospheric deposition to the oceanic DBC pool.

Conclusion

- During the dust outbreak season, the atmospheric dry deposition of WSBC is **40%** of the riverine input to the China coastal seas.

- the global atmospheric deposition of DBC to the ocean is estimated to be **1.8 ± 0.83 Tg yr^{-1}**.

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Thanks for your listening!