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Size distribution of carbonaceous aerosols at a high-altitude site on the central Tibetan Plateau (Nam Co Station, 4730 m a.s.l.)

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Outline

- 1 Introduction
- 2 Experimental methods
- 3 Results
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▸ 1 Introduction

● Carbonaceous aerosols are the key components of atmospheric aerosols, which are composed of either elemental carbon (EC) or organic carbon (OC)

●Few relevant studies have conducted and reported from remote background environment, detailed knowledge of the characteristics of size- segregated carbonaceous aerosol from the background site is obviously necessary and fundamental.

● The Tibetan Plateau (TP) in southwestern China is the highest and most extensive highland in the world, a key region where many mountain glaciers exist and the headwaters of many of Asia's largest rivers

● The primary objective of this study is to characterize the size distribution of carbonaceous aerosols over different seasons on the TP, improving our knowledge of their possible sources. This information will also be valuable for climate modeling of this ecologically fragile region.

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2 Experimental methods

2.1 Measurement site

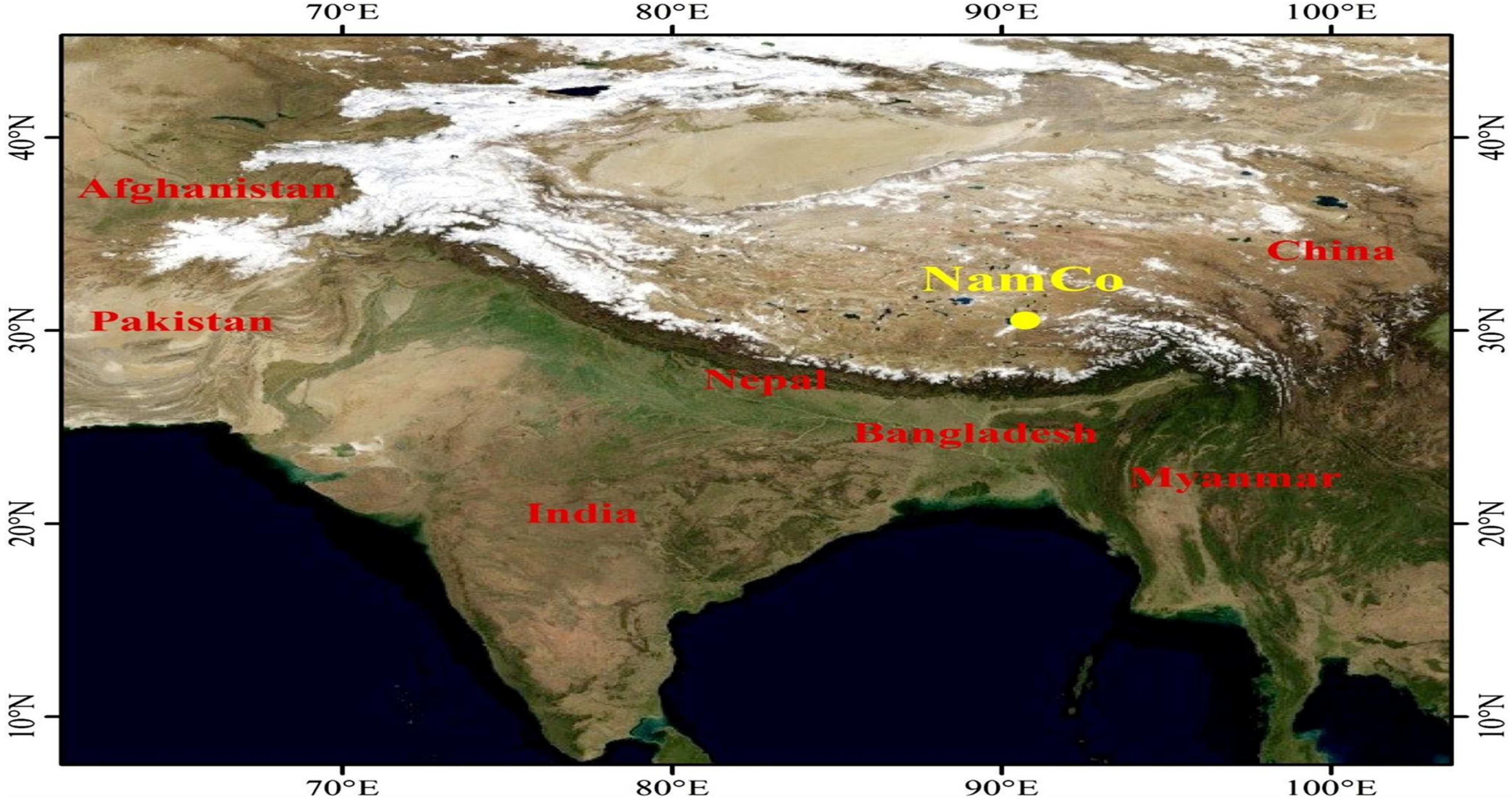

Fig. 1. Location map of Nam Co Station (30° 46′N, 90° 59′E, 4730 m a.s.l).

2.2 Sample collection

The ambient eight stage cascade impactor sampler was used for collecting the size-segregated atmospheric aerosol samples with equivalent aerodynamic cut-off diameters at 50% efficiency: 0.43, 0.65, 1.1, 2.1, 3.3, 4.7,5.8, and 9.0 μm. The air flow rate was 28.3 L min^{-1}

级数	切割直径（μm）
切割前	10
0 级	9
1 级	5.8
2 级	4.7
3 级	3.3
4 级	2.1
5 级	1.1
6 级	0.7
7 级	0.4

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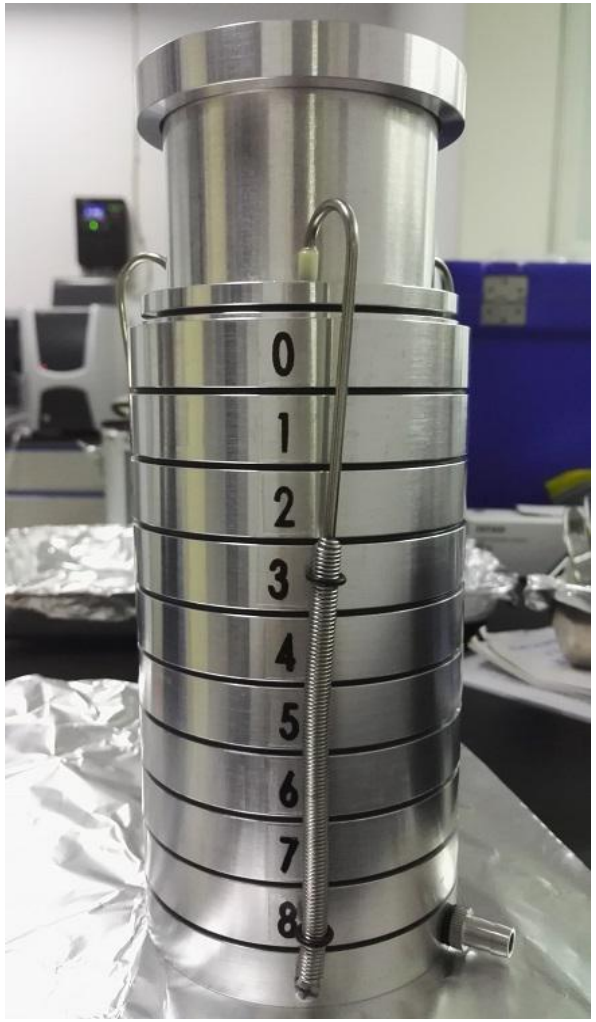
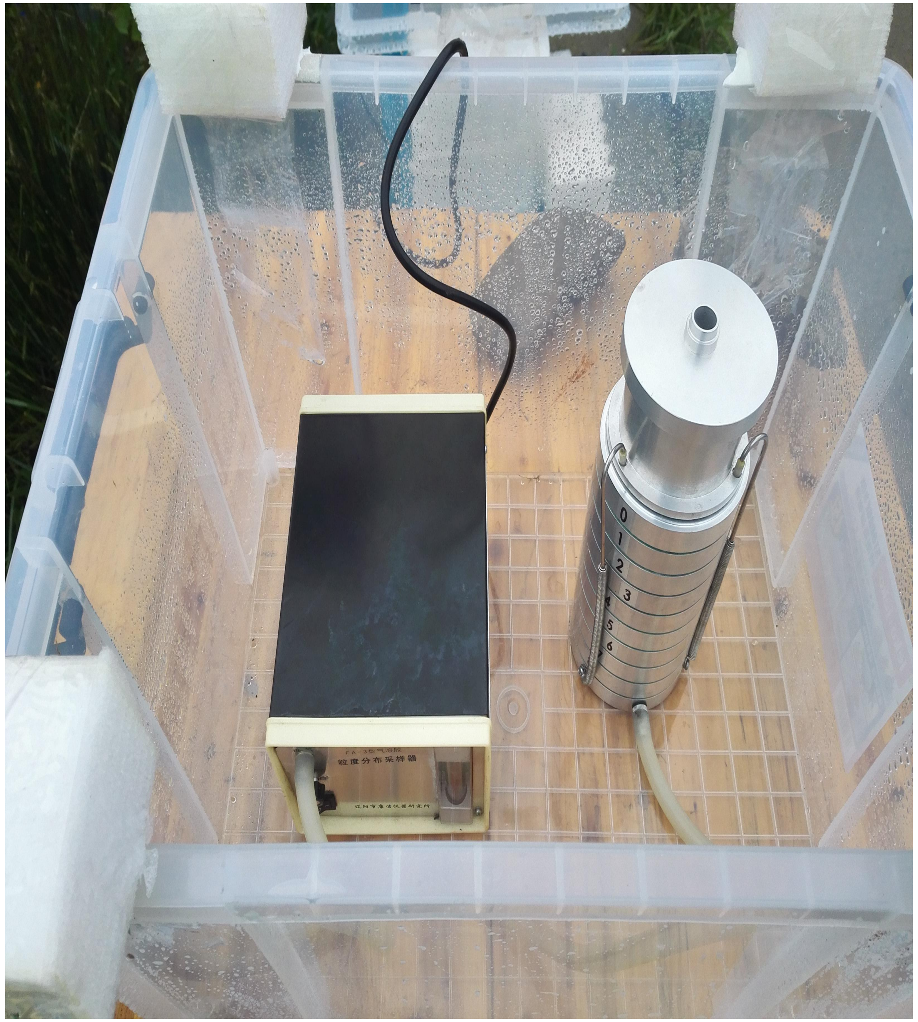
Compared to our lab equipment





Theory principle

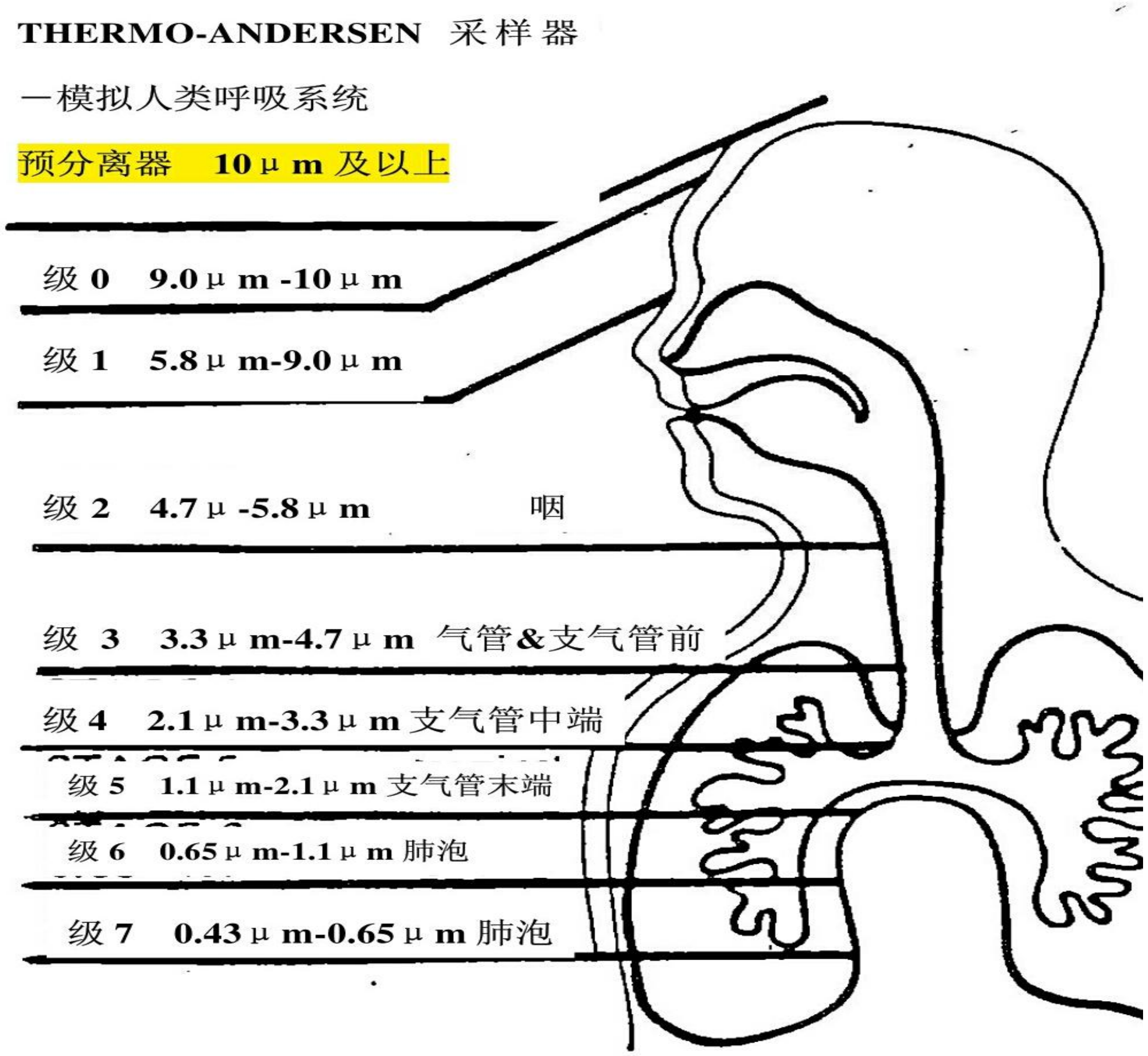


Fig.2.Andersen schematic diagram simulating human respiratory system

The first and most basic study of inertial impact theory was initiated by Ranz and Wong in early 1950. This function was defined as the inertial impact parameter

$$K = \frac{C\rho U D_p^2}{18\mu D_c} \quad \text{..............................1.1}$$

U： relative velocity **ρ： particle density**

Dρ： particle diameter **D_c： hole diameter**

u： gas viscosity

C： cunninham correction faction

$$C=1+0.16\times10^{-4}/Dp \quad \text{...................1.2}$$

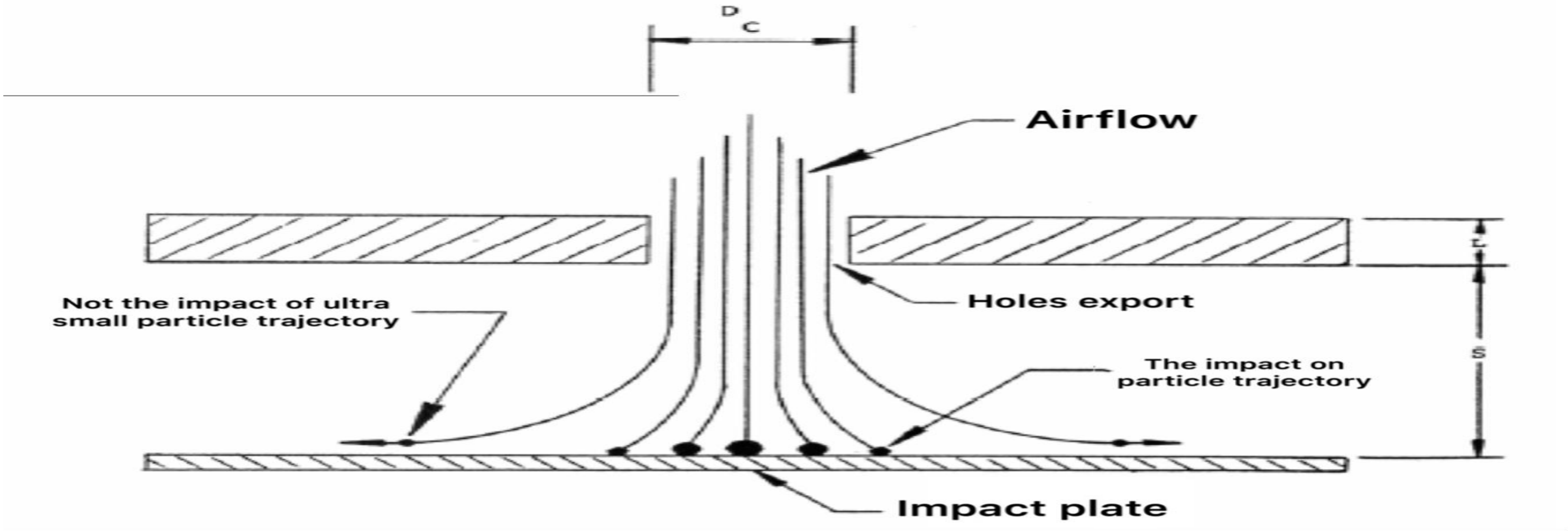


fig.3.Impact plate of schematic diagram

2.3 OC and EC analysis

Samples were analyzed for OC and EC using the thermal/ optical carbon aerosol analyzer and the TOR method

2.4 meteorology

According to the AWS meteorological data (Fig. 2) , author divided the entire year into four seasons:

pre-monsoon(from 5 April to 14 June)

monsoon (from 15 June to 20 September),

post-monsoon(from 21 September to 13 December)

winter (from 1 January to 4 April)

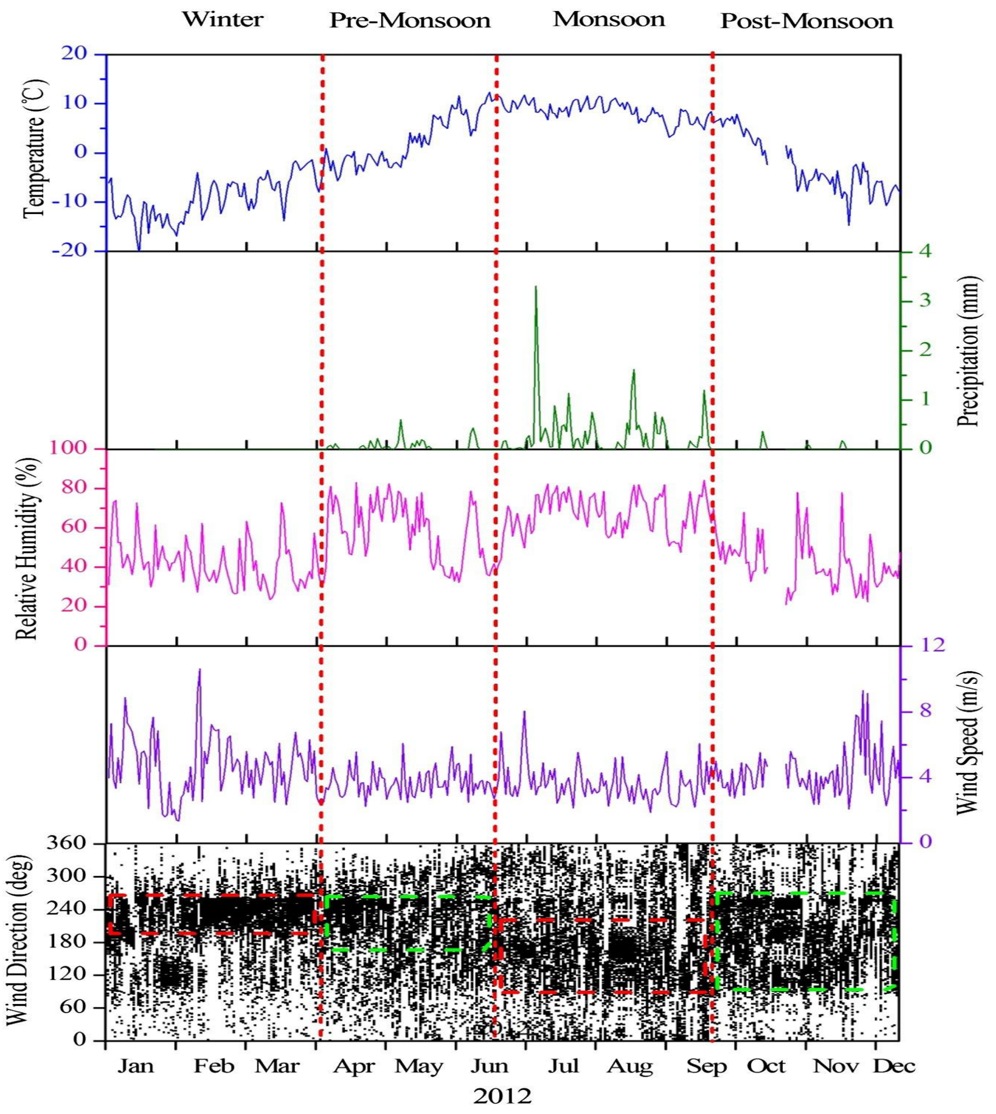


fig.4.The different seasonal factors

3 Results

3.1 concentration of OC and EC

Table.1

The concentration of OC.EC in different seasons

	Season	$PM_{1.1}$ (μg m^{-3})	$PM_{2.1}$ (μg m^{-3})	$PM_{9.0}$ (μg m^{-3})	TSP (μg m^{-3})	$PM_{2.1}$/TSP (%)	$PM_{2.1}/PM_{9.0}$ (%)
OC	Winter	2.70 ± 0.16	3.69 ± 0.33	6.53 ± 0.92	6.77 ± 0.97	55 ± 6	57 ± 6
	Pre-monson	2.38 ± 1.34	3.03 ± 1.83	5.42 ± 3.05	5.57 ± 3.17	54 ± 4	56 ± 4
	Monsoon	1.74 ± 0.68	2.35 ± 0.93	3.76 ± 1.60	3.78 ± 1.61	64 ± 9	64 ± 9
	Post-monsoon	1.86 ± 0.47	2.15 ± 0.72	3.11 ± 0.54	3.11 ± 0.54	68 ± 13	68 ± 13
	Annual	2.11 ± 0.80	2.72 ± 1.14	4.52 ± 2.07	4.61 ± 2.17	61 ± 10	62 ± 10
EC	Winter	0.14 ± 0.06	0.21 ± 0.08	0.32 ± 0.10	0.34 ± 0.11	59 ± 4	63 ± 5
	Pre-monson	0.08 ± 0.07	0.09 ± 0.08	0.18 ± 0.06	0.20 ± 0.07	46 ± 36	49 ± 39
	Monsoon	0.05 ± 0.03	0.08 ± 0.06	0.15 ± 0.06	0.15 ± 0.05	52 ± 32	53 ± 31
	Post-monsoon	0.09 ± 0.05	0.09 ± 0.05	0.11 ± 0.02	0.11 ± 0.02	80 ± 40	80 ± 39
	Annual	0.09 ± 0.06	0.11 ± 0.08	0.18 ± 0.10	0.19 ± 0.11	59 ± 32	61 ± 32

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3.2 Comparison with other sites

Table.2

OC and EC concentrations at Nam Co Station and those from other remote sites

Location	Size fraction	Type of location	Period	Mean OC (μg m^{-3})	Mean EC (μg m^{-3})	OC/EC	Carbon analysis method	References
Nam Co, TP	TSP	Remote (4730 m a.s.l.)	Jan. 2012–Dec. 2013	4.61	0.19	23.4	TOR	This study
	$PM_{9.0}$			4.52	0.18	24.7	TOR	
	$PM_{2.1}$			2.72	0.11	25.1	TOR	
	$PM_{1.1}$			2.11	0.09	24.3	TOR	
Nam Co, TP	TSP	Remote (4730 m a.s.l.)	Jul. 2006–Dec. 2009	–	0.13	–	TOR	(S.Y. Zhao et al., 2013)
Lulang, TP	TSP	Forest (2930 m a.s.l.)	Jul. 2008–Jul. 2009	4.28 ± 2.05	0.52 ± 0.35	9.3	TOR	(Z.Z. Zhao et al., 2013)
Muztagh Ata, TP	TSP	Remote (4500 m a.s.l.)	Dec. 2003–Feb. 2005	0.48	0.06	8.7	TOR	(Cao et al., 2009)
Manora Peak, Himalayas	TSP	High-alpine (1950 m a.s.l.)	Feb. 2005–Jul. 2008	7.1	1	6.5	TOT	(Ram et al., 2010)
Mcmurdo, Antarctic	PM_{10}	Remote	1995–1998	0.15	0.13	1.2	TOR	(Mazzera et al., 2001)
Gosan, Jeju Island	PM_{10}	Island (70 m a.s.l.)	Aug. 2007–Sep. 2008	4.7 ± 2.5	1.7 ± 1.2	2.8	TOR	(Lim et al., 2012)
Qinghai Lake, TP	$PM_{2.5}$	Remote (3260 m a.s.l.)	Jul.–Aug. 2010	1.58	0.37	6	TOR	(Li et al., 2013)
Langtang, Nepal	$PM_{2.5}$	High-alpine (3920 m a.s.l.)	Dec. 1998–Oct. 2000	2	0.38	5.3	TOT	(Carrico et al., 2003)
Montsec, Spain	$PM_{2.5}$	Remote (1600 m a.s.l.)	2009–2010	1.6	0.13	12.3	TOT	(Querol et al., 2013)
Gosan, Jeju Island	$PM_{2.5}$	Island (70 m a.s.l.)	Aug. 2007–Sep. 2008	4.0 ± 2.5	1.7 ± 1.3	2.3	TOR	(Lim et al., 2012)
NCO-P, Himalayas	$PM_{1.0}$	High-alpine (5079 m a.s.l.)	May–Sep. 2006	2	0.2	10	TOT	(Decesari et al., 2010)
Gosan, Jeju Island	$PM_{1.0}$	Island (70 m a.s.l.)	Aug. 2007–Sep. 2008	3.2 ± 1.8	1.4 ± 0.8	2.2	TOR	(Lim et al., 2012)

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3.3 size disributions of OC and EC

Atmospheric aerosols generally include four modes: nucle- ation mode (b 0.01 μm), Aitken mode (0.01-0.1 μm), accumu- lation mode (0.1–2 μm) and coarse mode (N 2 μm) (Seinfeld and Pandis, 2012). Particles in each mode have specific formation mechanism; these modes affect the life time and physical and chemical characteristics of aerosol in the atmosphere

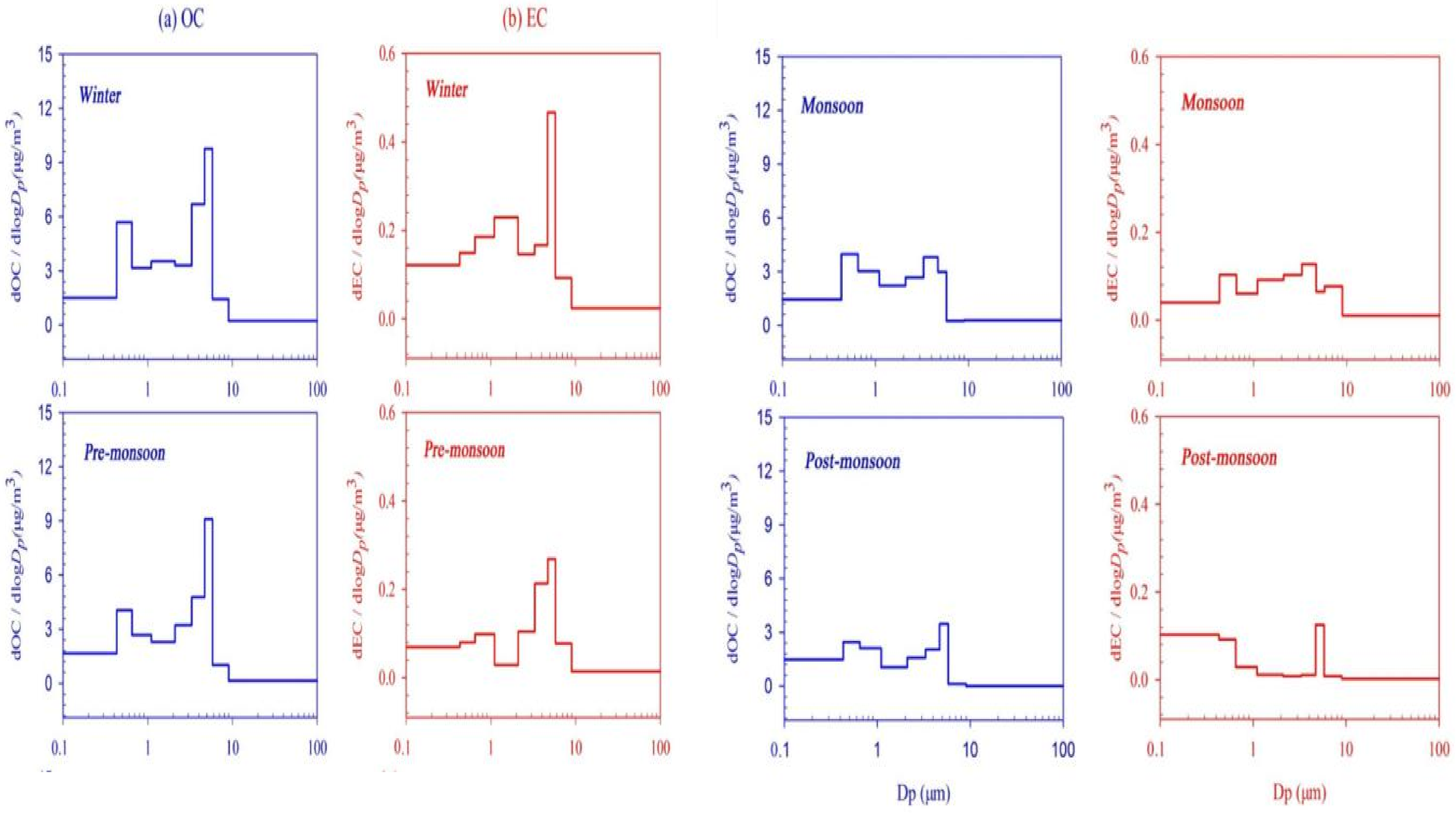

fig.5.Size distributions of OC and EC in diferent seasons at Nam Co Station

3.4 Sources analysis of OC and EC

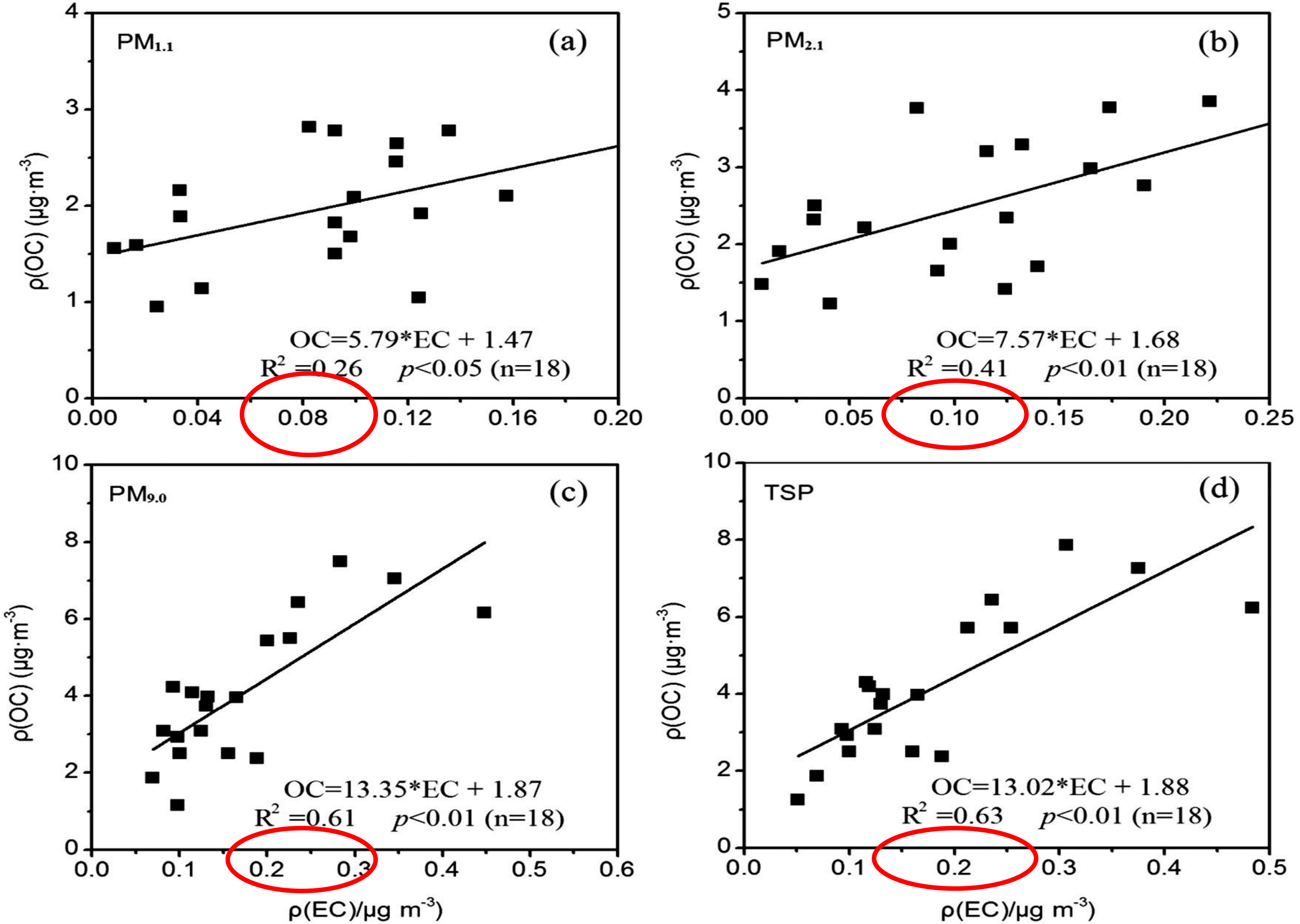

Fig.6. The relationship between OC and EC in PM1.1,PM2.1,PM 9.0and TSP at Nam Co station

Table 3
Average ratios of OC/EC in different sizes for different seasons.

Season	OC/EC			
	$PM_{1.1}$	$PM_{2.1}$	$PM_{9.0}$	TSP
Winter	19.3	17.6	20.4	19.9
Pre-M	29.8	33.7	30.1	27.9
Monsoon	34.8	29.4	25.1	25.2
Post-M	20.7	23.9	28.3	28.3
Annual	23.4	24.7	25.1	24.3

> 17.6

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4 Conclusions

The size distributions of the concentrations of OC and EC exhibit bimodal variations.

For OC, the dominant peaks are at coarse particles, which was possibly due to dust particles and biogenic aerosols. The second peak at droplet mode could be explained by the growth process of particles.

For EC, the dominant peak at coarse particles was possibly due to the re- suspension of EC-containing soil/dust particles; the second peak was present in droplet mode during winter, pre-monsoon, and monsoon, while in finer mode (i.e. condensation mode) during post-monsoon. The peak concentrations are much higher in winter and pre-monsoon than monsoon and post-monsoon.

The aerosol processing such as deposition, gas/particles exchange, hygroscopic growth, external mixing, and secondary organic carbon formation may affect the size distribution variations. Significant correlations were observed between OC and EC in PM9.0 and TSP, indicating their common emission sources for coarse particles.The OC/EC ratios of Nam Co aerosols during different seasons were all larger than 17.6.

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Thank you

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