Characterization of particle matter and its extinction ability under dust storm, haze and fine days in Shihezi and Urumqi, Sinkiang China

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Abstract:

Aerosol optical properties and its extinction ability at Shihezi and Urumqi in Sinkiang were investigated based on a year observation, conducted in the 2015-2016. In Shihezi, $PM_{2.5}$ was lower than 100μg/m^3 for all seasons, especially in summer, stable at about 10μg/m^3. $PM_{2.5}$ in winter was up to 261.26μg/m^3, and PM_{10} was even close to 500μg/m^3 in polluted days in Shihezi, the highest loading of PM_{10} was close to 1600μg/m^3 in Urumqi. And the average concentration of $PM_{2.5}$ in winter was above 200μg/m^3, with serious pollution in Urumqi, where the concentrations of $PM_{0.5}$ and PM_1 in winter were about 50μg/m^3 and 100-200μg/m^3, respectively. The seasonal variation of $PM_{2.5}/PM_{10}$ in Urumqi and Shihezi is as follows: winter> autumn> spring>summer. Under dust storm, haze and fine days, $PM_{0.5} < PM_{0.5-1} < PM_{1-2.5} < PM_{2.5-5} < PM_{5-10}$. For all seasons, Shihezi and Urumqi are the largest proportion of PM_{5-10}, with the highest in summer, 35.70-47.98% and 41.72-58.51%, respectively. The range of organic carbon/element carbon (OC/EC) was 2.02-13.44 μg/m^3 in Shihezi, and 2.40-17.65 μg/m^3 in Urumqi. Visibility fluctuated between 0.58-16.20km in Shihezi, and 0.7-20km in Urumqi. The Extinction coefficient of for above six sizes (0.5, 1, 2.5, 5, 10, 100μm) particles, respectively, and obtain the corresponding values is 2.62, 2.61, 2.34, 2.21, 2.13, and 2.03 during the observation period. It is concluded that the diameter is a more important factor for particle extinction than what？. This is the first study in Shihezi and Urumqi, Sinkiang assessing the characterization of particle matter and its extinction ability.

1. Introduction

In recent years, haze is poisoning in various parts of China, some areas in Sinkiang Uygur Autonomous Region (hereinafter referred to as Sinkiang) have also been enveloped by haze. This has a damaging effect on human health, aquatic and terrestrial ecosystems, and has led to a significant decline in atmospheric visibility, not only affecting the traffic efficiency, but also causing frequent traffic accidents(Hu et al., 2011; Krecl et al., 2017; Li et al., 2011; Zhang et al., 2017). Sinkiang is located in western China and the center of Asia-Europe continent, and it is a typical arid and semi-arid area in central Asia. The ecological environment is different from other regions. Snow and ice will gradual melting and the temperature will rise with the breeze and quiet wind in April of every year. Sinkiang is one of the areas where sandstorm disaster and particulate matter pollution is quite serious in China(Hu et al., 2011).

Urumqi, as the capital of Sinkiang, is political, economic, cultural and industrial center of Sinkiang. It is located in the depths of the Eurasian continent (East longitude: 86 °37 '-88 °58', North latitude: 42 °45 '-44 °08 '), the northern foot of the Tianshan Mountains and the southern margin of the Junggar Basin, which is between the northern Gurbantunggut desert and the southern Taklamakan Desert(Ma and He, 2015). It is surrounded by mountains in the east, south and west, and there is gentle plain in the north. The terrain is higher in the southeast, and lower in the northwest, elevation is between 680 ~ 920 m. Urumqi's annual climate is relatively dry, and temperature difference of daytime and night is significant. There are many times of radiation inversion every year. Shihezi (East longitude: 84 °58'-86 °24 ', North latitude: 43 °26'-45 °20') is followed from south to north by Tianshan Mountains, piedmont hills, piedmont plain, flood plain, aeolian desert area, which has a great influence on the seasonal variation of atmospheric particulates, with an average elevation of 450.8 meters. The climate in Shihezi is a typical temperate continental. Sunshine is abundant. Both Urumqi and Shihezi have a shorter spring and autumn, but a longer winter and summer(wu, 2015).

With the acceleration of urbanization and the expansion of industrial scale in Sinkiang, regional air pollution has caused more attention, especially Urumqi and Shihezi. Central heating supply system is used for the relatively longer winter time period in both cities. As a result, a large amount of SO_2 and soot are emitted from coal burning, which is far beyond the environmental capacity. In 2014, the days reaching up to the air quality standard level only accounted to 57.3% in Urumqi. There are few studies on atmospheric particulate matter in Sinkiang. (He and Wei, 2016) found that urban dust, coal dust and secondary particles are the main sources of $PM_{2.5}$ in Urumqi, accounting for 24.7%, 15.6% and 38.0% respectively, of which secondary sulfate contributes to 28.6%. (Ma and He, 2015)concluded that the motor vehicle and low coal burning are important sources of particulate matter in Urumqi. (Wu et al., 2015) found that the air quality in the main street of Shihezi can reach up to the second (300 $\mu g/m^3$) or third level air quality standard (500 $\mu g/m^3$). The concentration is highest in winter and lowest in summer. High concentrations have been observed through 7 years (2000-2006) study (Mamtimin and Meixner, 2011), ranging within 150-240$\mu g/m^3$ (PM_{10}), 31-50$\mu g/m^3$ (NO_2), and 49-160$\mu g/m^3$ (SO_2).

Above research mainly focus on characteristics of atmospheric particulate matter during the heating period and heavy pollution period the pollution in Sinkiang, but less studies characterize the variation of particulate matter during different seasons, or under different weather conditions, such as fine, haze and dust storm days. Yet both season and dust storm are two special points in comparison with other cities.

Therefore, this study conducted one-year monitoring campaign in both Urumqi and Shihezi, Sinkiang, to characterize the seasonal variations of particulate matter. We also investigated the impact of weather conditions on particulate matter, including fine, haze, dust storm, and haze & dust storm coupling. In addition, the factors on particle extinction ability are discussed for various weathers.

2. Materials and methodology

2.1 Sampling location

The measurements were conducted in Urumqi and Shihezi, Sinkiang from August of 2015 to July of 2016. The geographic orientations of two cities are shown in figure 1. The sampling point in Urumqi was set on the roof of main office building in Sinkiang Industry Center. The sampling point in Shihezi was located on the roof of an office building in Shihezi University. The sampling height was 1.5m from the roof ground. Both surrounding areas were open without dominant emission sources.

Figure 1 The geographic orientations of Urumqi and Shihezi, Sinkiang

2.2 Sampling and analyzing methodology

PM_{10} was sampled using a high-volume Air Sampler, KB-1000, Qingdao Kingstar Electronic Technology Co., Ltd.). The flowrate was 1.05 m^3/min. $PM_{2.5}$ was sampled using a $PM_{2.5}$ sampler

(Minvol Tas, Air Metrics $PM_{2.5}$ sampler) with a flowrate of 6 L/min. The total samples were 151 and 164 for Shiheyi and Urumqi, respectively. A dust particle counter(Handheld 3016IAQ, American Lighthoμse) was adopted to continuously monitor the particle mass in six size bins: $PM_{0.3-0.5}$，$PM_{0.5-1}$，$PM_{1-2.5}$，$PM_{2.5-5}$，PM_{5-10} and TSP. The time resolution was three minutes. The sampling flow was 3L.

$PM_{2.5}$ and PM_{10} were sampled using quartz filters, both lasting for 23 hours every day. The quartz filters were maintained under constant temperature (25 ±2 ℃) and constant relative humidity (30% ±2%) for 48 hours, and then weighed three times using an analytical balance (BSA224S) prior to $PM_{2.5}$ and PM_{10} sampling. The average weighting values of the filter was adopted. After weighing, each fillter was sealed in a clean plastic box with marked number. After sampling, all the filters were preserved in refrigerator and sealed in the original plastic box, and maintained under constant temperature and relative humidity prior to analyzing. In order to ensuring the accuracy of weighing, for both blank filter and sample filters, the weighting difference among 3 times measuring must be within the range of ±0.0002g. The mass concentration was obtained by the difference between the sample film and the blank film dividing by the sampling air volume.

The component of element carbon (EC) and organic carbon (OC) in $PM_{2.5}$ were measured and analyzed using thermo-carbon analyzer (DRI Model 2001A, Desert Research Institute of America). The thermo-reflective methodology proposed by IMPROVE was adopted for the analysis. Under an oxygen-free and pure helium environment, the 0.50 cm^2 filter sheet was heated up to 120℃(OC1), 250℃(OC2), 450℃(OC3) and 550℃(OC4), respectively, aiming to converting the particulate carbon on the filter to CO_2. Next, the samples were gradually heating in helium environment with 2% oxygen, at 550 ℃(EC1), 700 ℃(EC2) and 800 ℃ (EC3), respectively, causing the carbon released. The generated CO_2 was catalyzed by MnO_2, and the CH_4 was detected by flame ion detector (FID) in a reducing atmosphere. The heat intensity of the filter was measured by 633 nm helium-neon laser. The initial time of oxidizing elemental carbon was determined by light intensity change. Organic carbon will form an optical pyrolytic carbon (OP) during the carbonation process. According to the Quality control standard of United States Desert (DRI) ((DRI). 1999), OC= OC1+ OC2+ OC3+ OC4+ OP, EC= EC1+ EC2+ EC3- OP. OC/EC 分离精度 5%-10%。每测定 10 个样品复检 1 个，样品质量浓度在 0.030-0.100 g/L 之间，允许的标准偏差±30%；质量浓度在 0.100-0.150 g/L 之间，允许的质量偏差±20%；样品质量浓度大于 0.150 g/L 时，允许的标准偏差±10%.

Black carbon was monitored for real time using aethalometers (AE-31, Magee technologies). The instrument aspirates ambient air using its inlet tube. Black carbon mass concentration is estimated by measuring the change in the transmittance of a quartz filter tape, on to which particles impinge. The instrument was operated with a time interval of 5 min, and flow rate was 5 L/min. The instrument has been used in the near-infrared at a wavelength of 880 nm, and optical absorption is interpreted in real time as concentration of BC.

The aerosol scattering coefficient was measured using an Integrating Nephelometer (Aurora-1000). The Nephelometer measured aerosol scattering and hemispheric backscattering coefficients at the three wavelengths 450, 525, and 635 nm. The sampled air was forced to pass through a silica gel diffusion dryer before entering the measurement units to keep the RH lower than 40%. Regular checks of particle-free air (i.e., zero check) and the reference gas (i.e., span check) were performed approximately once in every two days. Shifting of the zero and span points were considered. Calibrating stability of 97%, calibrating error by 2.5%, and measurement stability of instrument is greater than 99.5%.

2.3 Season classification and weather category

Season classification in this study is divided according to spring (March - May), summer (June - August), autumn (September-November), and winter (December - February next year). Considering the special weather characteristics in Sinkiang, we classify the weather types in Sinkiang into following categories:

Dust weather: $PM_{10} \geq 150$ µg / m^3, visibility < 3Km;

Heavy haze: visibility < 5 Km, $PM_{2.5} > 250$µg/m^3;

Medium haze: visibility < 5 Km, 150µg/m^3 < PM2.5 < 250µg/m^3 ;

Slight haze: visibility < 5 Km, 75µg/m^3 < PM2.5 > 150µg/m^3.

Fine weather: visibility > 10 Km, $PM_{2.5}$ <75µg/m^3.

2.4 Aerosol optical property

The extinction ability of a single aerosol is called extinction efficiency (Q_{ext}). Algorithms to deduce Q_{ext} for a single particle are classified into Rayleigh scattering regime, Geometric scattering regime, and Mie scattering regime based on aerosol size ranges (Bohren and Huffman, 1983). Generally, Rayleigh scattering is applied for particles with sizes (diameter of D_p) much smaller than the wavelength (λ) of the incident light ($\alpha = \frac{D_p}{\lambda}$, $\alpha \ll 1, \mathrm{Dp} < 0.1\mu\mathrm{m}$). Geometric scattering is appropriate for the circumstance when particle sizes are much greater than the wavelength of incident light ($\alpha \gg 1$, $\mathrm{Dp} > 1\mu\mathrm{m}$). Mie theory provides a solution towards aerosols with sizes comparable to the wavelength of the incident light ($\alpha \cong 1$, $0.1\mu\mathrm{m} \leq \mathrm{Dp} \leq 1\mu\mathrm{m}$) based on assumptions of spherical particles (Mie, 1908; Seinfeld, 2006). For a single aerosol, Rayleigh scattering efficiency (Q_{ext_Ray}) and Geometric scattering efficiency (Q_{ext_Geo}) are described in equation (1) and (2), respectively,

$$Q_{ext\_Ray} = -4\frac{\pi D_p}{\lambda}\mathrm{Im}\left\{\frac{m^2-1}{m^2+2}\right\} + \frac{8}{3}\left(\frac{\pi}{\lambda}\right)^4 D_p^4\,\mathrm{Re}\left\{\left(\frac{m^2-1}{m^2+2}\right)^2\right\} \quad (1)$$

$$Q_{ext\_Geo} = 2\left\{1 + \left(\frac{\pi}{\lambda}\right)^{-2/3} D_p^{-2/3}\right\} \quad (2)$$

3. Result and discussion

3.1 Meteorological conditions

Fig.2 shows both Shihezi and Urumqi had higher RH in winter, reaching up to about 60%-80%. The annual temperature was between 15℃-25℃ and 17-30℃ for Shihezi and Urumqi, respectively. The lowest temperature was -15℃-18℃. Urumqi annual wind direction is roughly NEE wind, monitoring the average wind speed was 0-2.3m/s, and Shihezi area is SEE wind, monitoring the average wind speed is 0-7.1m/s. Especially in the summer, Shihezi area, the dominant wind direction is southeast wind, and the wind speed is higher than Urumqi. Overall, wind speed in summer and autumn was high, and lower in winter.

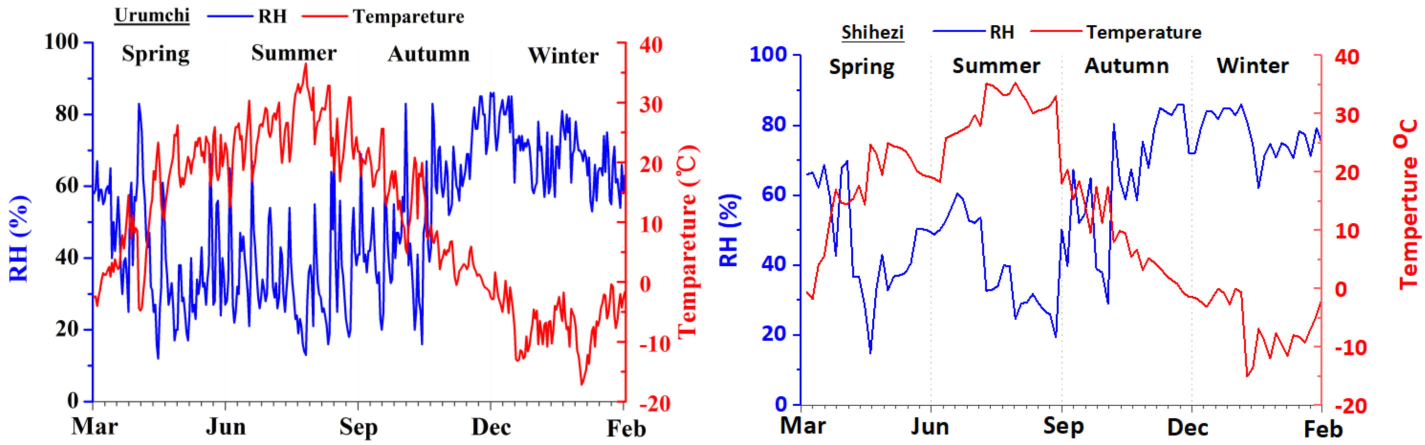


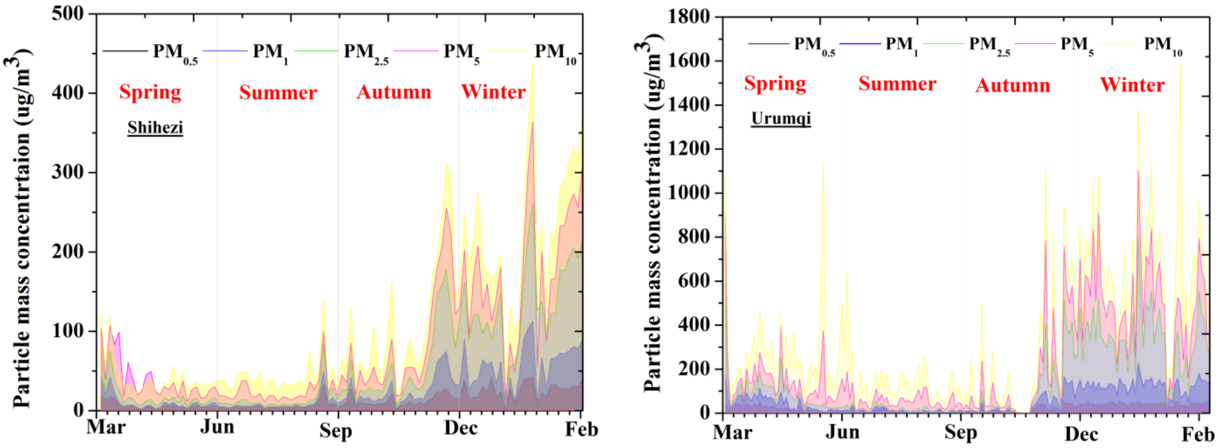
Fig.2 meteorological parameters in in Shihezi and Urumqi

3.2 Particle numbers and mass concentration

Fig.3 shows the concentration of PM in the spring and summer of Shihezi are not too high, and $PM_{2.5}$ was lower than 100μg / m^3, especially in summer, stable at about 10μg / m^3. Only a few days of the early spring and late summer, PM_{10} was more than 100μg/m^3. Autumn and winter changes were very large, and the average particle concentration was also high, $PM_{2.5}$ in winter was up to 261.26μg/m^3, and PM_{10} was even close to 500μg/m^3 in pollution/dust days. $PM_{0.5}$ and PM_1 were only 25μg/m^3 and 55μg/m^3, respectively, even in the most polluted winter. But the pollution level of Shihezi was lighter than that of Urumqi, and the total number of pollution days were lower. PM concentration of Urumqi was very high in four seasons, especially winter, close to 1600μg/m^3, and PM_{10} concentration is also high in spring, the highest timing was more than 1000μg/m^3. $PM_{2.5}$ were almost all 20μg/m^3 or so in summer and late spring, and the average concentration of $PM_{2.5}$ in winter was above 200μg/m^3, with serious pollution. The concentrations of $PM_{0.5}$ and PM_1 in winter were about 50μg/m^3 and 100-200μg/m^3, respectively. The concentration of $PM_{0.5}$ and PM1 in the other three seasons was about 10μg/m^3.

Fig.3 Size-segregated particle mass concentrations of different months and seasons in Shihezi and Urumqi

Fig.4 shows that the trend of $PM_{2.5}/PM_{10}$ in Urumqi and Shihezi is as follows: winter> autumn> spring>summer. $PM_{2.5}/PM_{10}$ in December, January, February and March is higher, and fine particulate matter pollution is more serious in Sinkiang region during the heating. Winter atmosphere was stable, so inversion layer was easy to appear, even if the weather was in good condition during the day, inversion layer roof did not disappear, so the atmospheric particles are not



easy to dilute, especially industrial emissions in winter, heating coal and automobile tail gas emissions, and fine particles of particles failed to spread out of the study area, so that the proportion of fine particles greatly increased to reach the maximum of four seasons. There are similar characteristics in both spring and autumn. Both seasons contain both heating and non-heating periods. The stability of the atmosphere is also in the transitional period. The corresponding ratio in autumn is higher than that in spring, which may be affected by dust in spring. So that coarse particle content increased, and the proportion of $PM_{2.5}/PM_{10}$ decreased. The precipitation is more frequent in summer, and the hydrophilic components are rich in hydrophilic particles, which are easily washed with rain. Therefore, the frequency of precipitation increased, the concentration of fine particles decreased, and the coarse particles are mostly insoluble dust particles, which was not as fine as the fine particles, so the summer $PM_{2.5}/PM_{10}$ reached the lowest value. The change of $PM_{0.5}/PM_{1.0}$ and $PM_{1.0}/PM_{2.5}$ in the two cities in September to April were similar, were decreased in December, January, February to the lowest, followed by increased trend. April, May, June, July and August are closer. Because the main source of $PM_{0.5\text{-}1.0}$ was the motor vehicle exhaust, and the heating coal was the main source of $PM_{1.0\text{-}2.5}$, so the ratio also has seasonal changes.

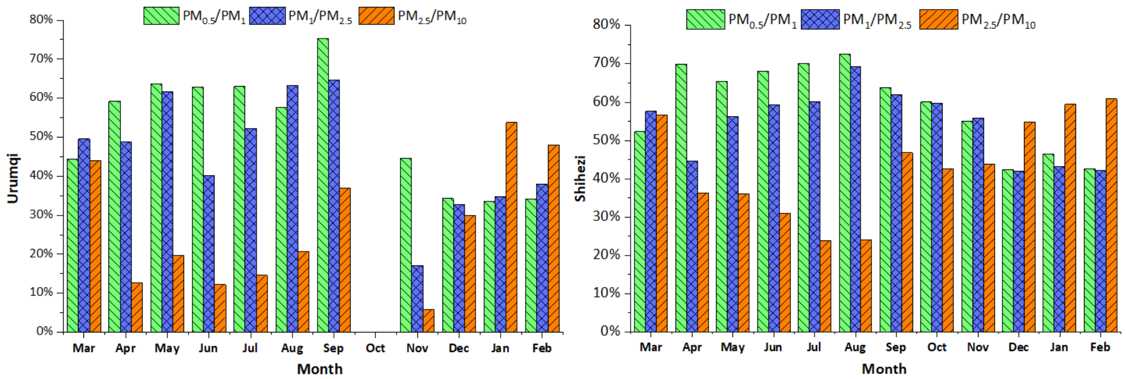


Fig.4 The monthly ratios of $PM_{2.5}/PM_{10}$, $PM_{2.5}/PM_{10}$ and $PM_{2.5}/PM_{10}$ in Urumqi and Shihezi

Fig. 5 shows that for the different types of haze weather, as the particle size increases, the proportion also increases as follows: $PM_{0.5}$ <$PM_{0.5\text{-}1}$ <$PM_{1\text{-}2.5}$ <$PM_{2.5\text{-}5}$ <$PM_{5\text{-}10}$. $PM_{5\text{-}10}$ are accounted for the largest proportion Shihezi and Urumqi, especially dust weather was close to 40%. With the haze situation increased (light haze → mid haze → heavy haze), $PM_{0.5}$ ratio decreased in the two regions, and $PM_{2.5\text{-}5}$ ratio increased, $PM_{0.5\text{-}1}$ and $PM_{1\text{-}2.5}$ appeared the inverted V-type, the mid haze was in a higher proportion, but $PM_{5\text{-}10}$ showed V-type; only $PM_{0.5\text{-}1}$ change is inconsistent, Urumqi showed inverted V- type, Shihezi increased with the haze situation increased.

For different seasons, Shihezi and Urumqi are the largest proportion of $PM_{5\text{-}10}$, with the highest in summer. In winter heating period, $PM_{1\text{-}2.5}$ will be higher than non-heating period. In Urumqi, $PM_{5\text{-}10}$ was highest in summer, accounting for 58.51%. $PM_{1\text{-}2.5}$ and $PM_{2.5\text{-}5}$ are the highest in winter. Shihezi compared to Urumqi, $PM_{1\text{-}2.5}$ increased in the winter, could account for up to 21.66%. In four season, $PM_{2.5\text{-}5}$ of Shihezi was higher than Urumqi, respectively, 12.39 -21.66% and 8.31-18.91%. But $PM_{5\text{-}10}$ is much smaller, respectively, 35.70-47.98% and 41.72-58.51%.

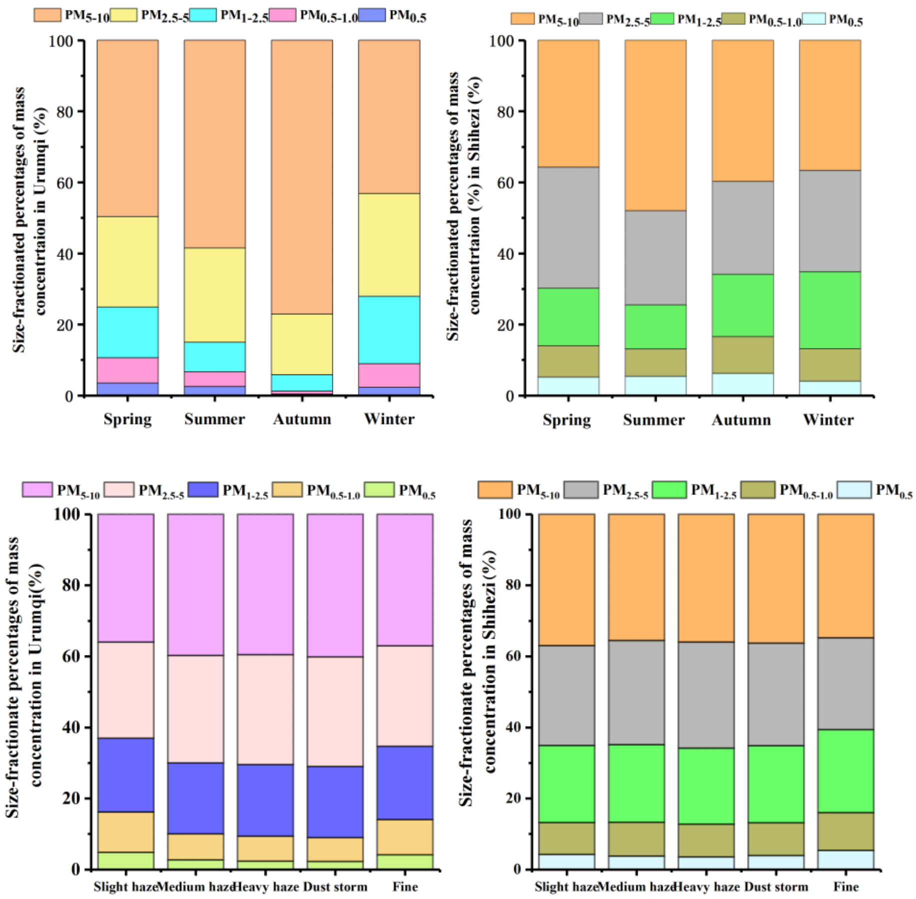


Fig.5 Size-segregated percentages of mass concentration in Urumqi and Shihezi

3.3 Particle components and ions

In Figure 6, the values of OC and EC in the Shihezi area reached a high value in September, which were 58.28 μg/m^3 and 16.79 μg/m^3, respectively. The OC values of other months fluctuated between 0 and 30μg/m^3, EC value of the floating range is 0-10μg/m^3. Visibility fluctuated between 0.58-16.20km and the worst visibility happened in February, which was close to 500m. The best Visibility appeared in September, reaching 14.18km. Urumqi OC value in the winter was to achieve a higher value of 51.18μg/m^3 and the range of EC was 0-10μg/m^3. Visibility fluctuated between 0.7-20km, and the worst visibility in December is as close as possible to 700m. Spring and autumn visibility was better, the maximum was close to 20km. The range of OC/EC range was 2.02-13.44 in Shihezi, and 2.40-17.65 in Urumqi. (Huang et al., 2009) obtain the range of OC/EC is 3.1-5.4 in Shanghai, and the mean visibility was 17.1 km in distance during the study period. And(Zhang et al., 2015) 在北京得到OC/EC is 2-4.1, the range of visibility is 2-20km.

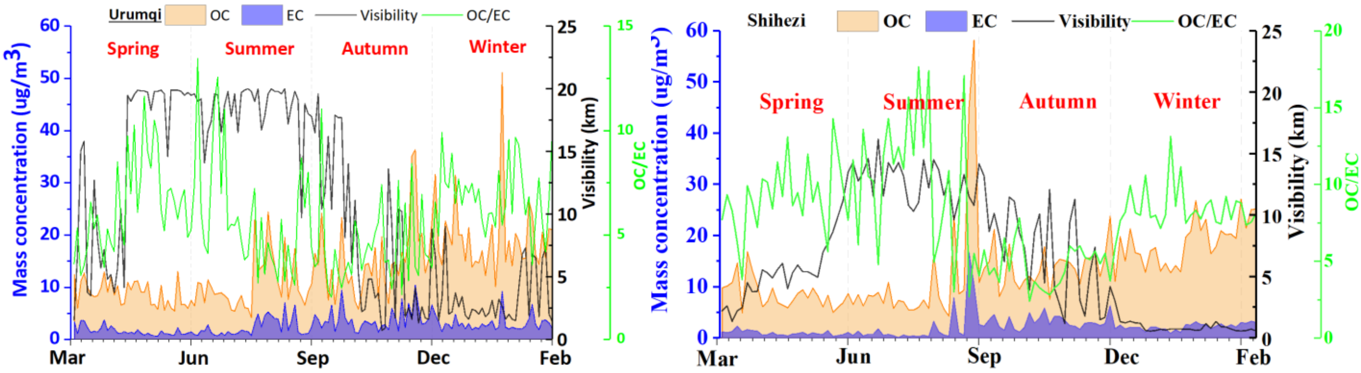


Fig.6 Monitored OC, CO and visibility of Shihezi and Urumqi

3.4 Visibility

Particle sizes in this study were classified into bins as 0.5, 1, 2.5, 5, 10, and 100 μm. In this section, we firstly discussed the extinction ability of single particle with above 6 diameters, respectively. As states previously, 0.5 and 1 μm are classified in Mie range, 2.5, 5, 10, and 100 μm are belong to Geometric scattering range. In the first step, we defined the refractive index of all sizes are identical, and obtained Q_{ext} of for above six sizes is 2.86, 2.62, 2.3, 2.21, 2.13, and 2.03, respectively. If the extinction coefficient of $PN_{0.5}$ was set as 1， the corresponding values for other diameters were 0.92，0.82, 0.77, 0.75, 0.71. Obviously, a particle with diameter of 0.5 μm has the strongest extinction ability if the particle compositions were identical, owning to it is closed to the wavelength of incident light, $\lambda = 0.55$ μm. However, considering dust has large portion of inorganic constituent, therefore, we evaluate the impact of various compositions. The constituents considered include sulfate, nitrate, ammonium salt, sodium salt, chlorine salt, OC, BC and inorganic constituent, and we followed the size-segregated proportion of each component provided by Chen et al. (2016). As the previous five constitutes have close values of refractive index, 1.53, 1.57, 1.52, 1.58, 1.54, 1.55, so we define them as others in this study. The refractive index is 1.55. In addition, we consider Fe and BC as the other two constitutes, of which the refractive index is 3.51-3.95i and 1.96-0.66i, respectively. Therefore, the composition percentage and corresponding refractive index of different sizes particles are given in Table 1.

Table 1

Unit：um	Dp=0.5	Dp=1	Dp=2.5	Dp=5	Dp=10	Dp=100
Others	87.1%	85.4%	68.7%	33.9%	9.4%	4.9%
Fe	8.7%	11.3%	27.9%	65.3%	89.7%	95%
BC	4.2%	3.3%	3.3%	0.8%	0.9%	0.1%
Refractive index	1.60-0.07i	1.61-0.09i	1.69-0.28i	2.05-1.00i	2.76-2.44i	3.10-3.11i

Now we adopt the same methodology to calculate Q_{ext} of for above six sizes, respectively, and obtain the corresponding values are 2.62, 2.61, 2.34, 2.21, 2.13, and 2.03. Although the refractive index of Dp=100 μm is much larger than Dp=0.5 μm, the extinction ability of latter one is 1.3 time over the previous one with the same mass concentration. It is concluded that the diameter is a more dominant factor for particle extinction.

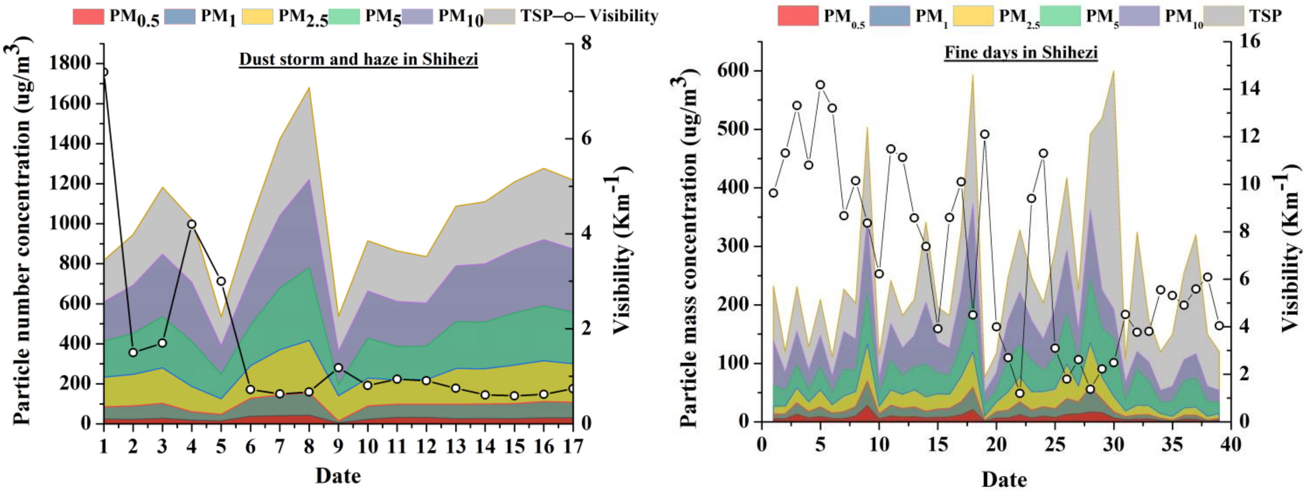


Figure 7 霾天气下不同 size 颗粒物质量浓度和能见度图

4 Conclusion

This paper uses the weather data and particulate data from 2015 to 2016 to analysis the characterization of particle matter and extinction ability under dust storm, haze and fine days. In Shihezi, $PM_{2.5}$ was lower than 100μg / m^3, especially in summer, stable at about 10μg / m^3. $PM_{2.5}$ in winter was up to 261.26μg/m^3, and PM_{10} was even close to 500μg/m^3 in polluted days. PM concentration of Urumqi was very high in four seasons, especially winter, the worst was close to 1600μg/m^3. $PM_{2.5}$ were almost all 20μg/m^3 or so in summer and late spring, and the average concentration of $PM_{2.5}$ in winter was above 200μg/m^3, with serious pollution. The concentrations of $PM_{0.5}$ and PM_1 in winter were about 50μg/m^3 and 100-200μg/m^3, respectively, in Urumqi.

The seasonal variation of $PM_{2.5}/PM_{10}$ in Urumqi and Shihezi is as follows: winter> autumn> spring>summer. For the different types of haze weather, as the particle size increases, the proportion of PM also increases as follows: $PM_{0.5}$ <$PM_{0.5-1}$ <$PM_{1-2.5}$ <$PM_{2.5-5}$ <PM_{5-10}. For different seasons, Shihezi and Urumqi are the largest proportion of PM_{5-10}, with the highest in summer, 35.70-47.98% and 41.72-58.51%, respectively.

The values of OC and EC in the Shihezi area reached a high value in September, which were 58.28 μg/m^3 and 16.79 μg/m^3, respectively. The best Visibility appeared in September, reaching 14.18km. Urumqi OC value in the winter was to achieve a higher value of 51.18μg/m^3, the worst visibility in December is close to 1.5km. The range of OC/EC range was 2.02-13.44 in Shihezi, and 2.40-17.65 in Urumqi. Visibility fluctuated between 0.58-16.20km of shihezi, and 0.7-20km for Urumqi.

Q_{ext} of for above six sizes, respectively, and obtain the corresponding values is 2.62, 2.61, 2.34, 2.21, 2.13, and 2.03. It is concluded that the diameter is a more important factor for particle extinction. Recent research about extinction ability, the research of (Cheng et al., 2017), annual average extinction coefficient in urban China was 759.3 ±258.3 Mm^{-1}, mainly caused by dry $PM_{2.5}$ (305.8.2 ±131.0 Mm-1) and its hygroscopicitical growth (414.6 ±188.1 Mm^{-1}). (Wu et al., 2017) obtained the scattering coefficient of dry aerosols was high, with a mean (±standard deviation) of 338.8 ±209.9 Mm^{-1} (520 nm) during the summer of 2014 at a rural site in the southern North China Plain.

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