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Short communication

Aerosol scattering properties in northern China

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Abstract

The aerosol scattering properties were investigated at two continental sites in northern China in 2004. Aerosol light scattering coefficient (σ_{sp}) at 525 nm, PM_{10}, and aerosol mass scattering efficiencies (α) at Dunhuang had a mean value of $165.1 \pm 148.8\,\mathrm{M\,m^{-1}}$, $157.6 \pm 270.0\,\mathrm{\mu g\,m^{-3}}$, and $2.30 \pm 3.41\,\mathrm{m^2\,g^{-1}}$, respectively, while these values at Dongsheng were, respectively, $180.2 \pm 151.9\,\mathrm{M\,m^{-1}}$, $119.0 \pm 112.9\,\mathrm{\mu g\,m^{-3}}$, and $1.87 \pm 1.41\,\mathrm{m^2\,g^{-1}}$. There existed a seasonal variability of aerosol scattering properties. In spring, at Dunhuang PM_{10}, σ_{sp}, and α were $184.1 \pm 211.548\,\mathrm{\mu g\,m^{-3}}$, $126.3 \pm 89.6\,\mathrm{M\,m^{-1}}$, and $1.05 \pm 0.97\,\mathrm{m^2\,g^{-1}}$, respectively, and these values at Dongsheng were $146.4 \pm 142.1\,\mathrm{\mu g\,m^{-3}}$, $183.4 \pm 81.7\,\mathrm{M\,m^{-1}}$, and $1.98 \pm 1.52\,\mathrm{m^2\,g^{-1}}$, respectively. However, in winter at Dunhuang PM_{10}, σ_{sp}, and α were $158.1 \pm 261.4\,\mathrm{\mu g\,m^{-3}}$, $303.3 \pm 165.2\,\mathrm{M\,m^{-1}}$, and $3.17 \pm 1.93\,\mathrm{m^2\,g^{-1}}$, respectively, and these values at Dongsheng were $155.7 \pm 170.1\,\mathrm{\mu g\,m^{-3}}$, $304.4 \pm 158.1\,\mathrm{M\,m^{-1}}$, and $2.90 \pm 1.72\,\mathrm{m^2\,g^{-1}}$, respectively. σ_{sp} and α in winter were higher than that in spring at both the sites, which coincides with the characteristics of dust aerosol and pollution aerosol. Overall, the dominant aerosol types in spring and winter at both sites in northern China are dust aerosol and pollution aerosol, respectively.

Keywords: Dust and pollution aerosol; Integrating nephelometer; Scattering coefficient; PM_{10}

1. Introduction

The effect of aerosols on the climate has drawn much attention in recent years due to their largely uncertain climate forcing (The Intergovernmental Panel on Climate Change (IPCC), 2001). Through scattering and absorption of solar radiation, aerosols directly affect visibility and climate through the modification of the Earth's energy balance. Thus, the aerosol scattering properties are required in evaluating the radiative forcing of aerosols (Vrekoussis et al., 2005; Kim et al., 2005; Xu et al., 2002).

However, the distribution of aerosols is quite patchy and it depends on the presence of aerosol sources (Vrekoussis et al., 2005). The regional climate effects of these aerosols are predicted to increase in the near future (Takemura et al., 2001). More specifically, in Asia, in the context of global warming, the desert and desertification may become much drier than ever before and emit a larger amount of dust aerosol from dust storms. In addition, China is the world's fastest growing economy, which may lead to an increase in pollution aerosols from industrial sources. Asian aerosols have drawn much attention during the last 10 years.

Some observations of Asian aerosols have been carried out during recent years. The Asian Pacific

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Regional Aerosol Characterization Experiment (ACE-Asia) shows that the dust from East Asia mixed with pollutants, resulting in a multi-component aerosol of great complexity and variability (Clarke et al., 2004), and dust aerosols had complex chemical and optical properties (Anderson et al., 2003). However, pollution aerosol was poorly investigated in ACE-Asia. Some measurement conducted in China mainly focused on chemical, physical, and radiative properties of pollution aerosols in urban regions, such as Beijing (Bergin et al., 2001), Wuhan (Waldman et al., 1991), Datong (Salmon et al., 1994), and Yangtze delta region (Xu et al., 2002) for a short period. Besides, the aerosol characters and mass scattering efficiency of different sources transported southeastward from Asian continent to Taiwan were investigated in Taiwan during East Asian winter monsoon (Chang et al., 2006). Similarly, Kim et al. (2005) analyzed the aerosol optical properties for two cases, viz. a heavy dust episode in April and a regional-scale pollution event in November in Korea. It can be concluded that there exist two types of aerosols, namely dust aerosol and pollution aerosol. However, the measurement in the above research was conducted far from their sources or just for a few cases. This study focuses on the seasonal variability of dominant aerosol type on the basis of the continuous measurement of aerosol light scattering coefficient and mass concentration for a whole year of 2004 at two sites in northern China.

2. Experiment

Sampling was conducted at two remote sites in 2004. The first one is located in Dunhuang city (94.6°E, 40.1°N, 1139 m), in Gansu Province, which is near the Takelamagan Desert. The second one is located in Dongsheng city (109.9°E, 39.8°N, 1460 m) in inner-Mongolian Province which is near the Kubuqi Desert. They belong to arid and semi-arid regions in northern China characterized by dry conditions. Spring refers to March, April, and May and winter refers to January, February, and December.

Aerosol light scattering coefficient (σ_{sp}) was measured at these locations with a standard integrating nephelometer (Ecotech-M9003). This instrument measures σ_{sp} at 525 nm at 5 min intervals. The optical and electrical background noise is sufficiently low to allow measures of σ_{sp} (for particles) from $<10\%$ of air Rayleigh ($\sigma_{sp}<0.3$ M m^{-1}) to >2000 M m^{-1}. PM_{10} was measured at these locations with an ambient particulate monitor (Rupperecht and Patashnick (R&P) model TEOM Series 1400a), continuously. This instrument equipped with an inlet having a 10 μm cut-point measures the ambient particulate mass concentration of PM_{10} in real time at 5 min intervals. All PM_{10} and σ_{sp} data in the following were averaged from the smallest 5 min intervals.

3. Results and discussion

3.1. Comparison of PM_{10} vs σ_{sp}

The scatter plot of daily mean PM_{10} and σ_{sp} for Dunhuang and Dongsheng observation stations are presented. At Dunhuang, the PM_{10} daily mean values ranged between 4.2 and 1795.6 μg m^{-3} with a

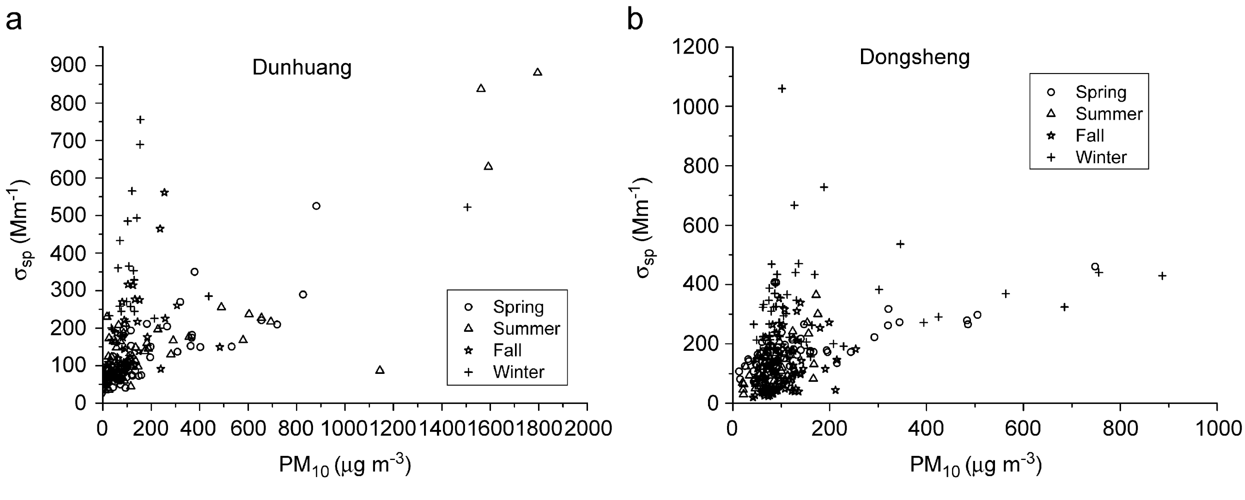

Fig. 1. Scatter plots of daily mean values of PM_{10} and aerosol light scattering coefficient (σ_{sp}) at Dunhuang (a) and Dongsheng (b) in 2004.