Some characteristics of ozone concentrations and their linkages with meteorological factors in Kashgar, northwestern China

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Abstract. Observations of O$_3$ and NO$_2$ have been performed in Kashgar, northwestern China, from January to December 2015. We analyze the variations of O$_3$ and NO$_2$ daily, the diurnal variations of O$_3$ and NO$_2$ as well as the relation between O$_3$ and NO$_2$ concentrations. We focused on the variations of O$_3$, with the meteorological factors. We find that there exist to some extent between meteorological factors and O$_3$ concentrations. High O$_3$ concentrations were related to high temperature, low relative humidity, low cloudiness, and light wind speed. The local meteorological conditions on certain situations also influenced the ozone concentration. Preliminary statistics of the occurrence frequencies of high ozone concentration days corresponding to some meteorological factors are given in this paper.

1. Introduction

The conditions and sources for producing photochemical smog have been discussed extensively recently [1,2]. As the most important index of photochemical smog, ozone has been thought as one of the primary pollutants influencing air quality. Kashgar is one of the largest cities in Central Asia, where a large quantity of nitrogen oxides, precursor and hydrocarbons are emitted. With the population growth and socio-economic development in Kashgar, the threat of air pollution due to photochemical smog is growing. Thus, we have made a series of simultaneous observations of O$_3$ and NO$_2$ in the lower atmosphere in Kashgar since 2015. In this paper, we analyze the characteristics of O$_3$ concentrations and compare it with meteorological factors in order to find some conditions favoring production of high ozone concentration. Ozone concentration measurement system (ML9810, Monitor Labs Company, Australia) and Nitrogen Oxides Analyser (ML9841, Monitor Labs Company, Australia) was used to the measurements of O$_3$ and NO$_2$.

2. Relations between NO$_2$ and O$_3$ concentration

In 2015, we performed 345 d of observations of O$_3$ and NO$_2$ simultaneously at a height of 3 m above the ground. The measurement site was located at the southern district of Kashgar City. Figure 1 shows the concentration curves of O$_3$ and NO$_2$ that the O$_3$ curve basically corresponded to the NO$_2$ curve. The correlation coefficients between the individual concentrations of O$_3$ and NO$_2$ were -0.64 for the levels of 3 m. This implies that the O$_3$ concentrations will be higher when the O$_3$ precursors concentration declined, such as NO$_2$, which is very similar to that derived from the correlation between O$_3$ and NO$_2$ in eastern China [3]. Figure 1 also shows the curves of O$_3$ and NO$_2$ were less consistent with each other in winter, especially in February.
3. Relationships between meteorological factors and daily concentrations of O₃

The daily mean concentration of ozone fluctuated significantly. On July 26th, for example, the highest values of mean concentrations were 94 μg/m³. On July 27th, a clear day on which light fog appeared in the morning. The O₃ concentration at the Kashgar observatory was also characterized by the obvious seasonal variation. The O₃ concentrations in spring (Mar, Apr and May), summer (Jun, Jul and Aug), autumn (Sep, Oct and Nov), and winter (Dec, Jan and Feb) were 31.8, 58.1, 27.3, and 10.5 μg/m³, respectively, with the order of winter < spring < autumn < summer. We consider that the strong variations of the ozone concentrations were mainly caused by meteorological conditions. Ozone concentrations produced from photochemical reactions were influenced by meteorological factors (Table 1; significant correlations (p<0.001) indicated in bold font). Ozone concentrations were positively correlated with temperature, suggesting that high temperature led to an increase in the formation of O₃. The favorable meteorological conditions (mild winds, high temperature, and clear skies) have been reported to exert a great influence on O₃ levels (Vecchi and Valli 1999). In the present study, a significant negative correlation coefficient was found between O₃ concentration and relative humidity. These results indicate that high relative humidity with strong solar radiation were important factors causing higher O₃ concentrations during the observation period.

Table 1 Correlation coefficients between O₃ concentration, temperature, relative humidity, solar radiation, mean wind speed and cloudiness during the observation period

|        | O₃  | Temperature | Relative humidity | Solar radiation | Mean wind speed | Cloudiness |
|--------|-----|-------------|-------------------|----------------|----------------|------------|
|        | 345 | 0.85*       | -0.42*            | 0.51*          | 0.33*          | 0.27*      |

* Significant at the 1% level.

4. Daily variations of NO₂ and O₃ concentration

To analyze the feature of diurnal variations, the data of observations made twelve times in daytime and twenty-four times through a whole day are used. The results show that the peaks of NO₂ appeared at 10-12 h and the peaks of O₃ occurred at 14-16 h. The occurrence of the O₃ peak value was 4h later than that of NO₂. Generally, a peak value of O₃ occurred only once during the daytime using the data of twelve times a day; however, 24 h measurement data show that a secondary peak value of O₃ existed at 0-2 h as shown in Figure 2. The meteorological parameter curve correspond clearly to the ozone concentration curve (Figure 2). Temperature usually reached a maximum value around 14-15 h while the O₃ peak value occurred immediately after midday. This might be related to the fact that vertical transfer became active with the development of mixing, perhaps bringing ozone from upper to lower levels [5]. This would cause abnormal increase of O₃ concentration in the atmosphere.
5. Summary

The variations of O$_3$ concentration were basically linkages with the NO$_2$ concentration. Correlations existed to some extent, between meteorological factors and O$_3$ concentrations. High concentrations of O$_3$ were related to high temperature, light wind, low relative humidity and low cloudiness. In daytime, the occurrence of the O$_3$ peak was later by about 4 h than that of the NO$_2$ peak. At night, a secondary peak of O$_3$ existed at 0-2 h. High daily concentrations of ozone usually occurred in the situation of high temperature when the local photochemical reaction mainly caused the increase of ozone in the lower atmosphere.

Acknowledgments

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