RESEARCH ON SURFACE O_3 WITH METEOROLOGICAL CONDITIONS UNDER ATMOSPHERIC BACKGROUND CONDITIONS IN NORTHEAST CHINA*

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ABSTRACT

Surface O_3 concentration and its precursors have been observed at Longfengshan station, Heilongjiang Province for a period of one year from August 13, 1994 to July 30, 1995. Relationship between surface O_3 and the meteorological conditions during this period is analyzed in this study. Observation results show that diurnal variation of surface O_3 follows a pattern of double-peaks with amplitude of 27—28 ppb under fine days in summer and autumn. Although the diurnal variation is small (14 ppb), it is still detectable when it is overcast. Diurnal variation of O_3 is irregular under rainy days. Surface O_3 concentration rises when wind speed starts to increase at 0800 BT (Beijing Time) from 0 to 6 m s^{-1} in autumn, winter and summer. Relative high surface O_3 concentration is noticed frequently when S, SSW, SW and WSW wind are encountered at the station during all seasons. At 0800 BT and 1400 BT the surface O_3 concentration increases with the increase of global radiation accordingly during fine days in winter, spring and autumn. During fine days average peak of O_3 concentration in summer is 20 ppb higher than that in winter while the average peak of global radiation in summer is almost twice as high as that in winter. The average surface O_3 concentration under fine days in autumn at Longfengshan station is 14 ppb lower in comparison to the observation results from Lin'an station where Lin'an is at about the same longitude and lower latitude, with same environment, which is mainly caused by the difference of global radiation due to different latitudes in these two areas (difference of average peak global radiation about 100 W m^{-2}).

Key words: surface O_3 concentration, meteorological conditions

I. INTRODUCTION

Comprehensive observation of O_3 concentration and its precursors has been carried out

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at Longfengshan regional station, Wuchang city, Heilongjiang Province for a period of one year starting from August 13, 1994. Observation items include surface O_3, total O_3, NO_x, SO_2, CO_2, methane, CO, NMHC, aerosol, solar radiation and meteorological elements, among which surface O_3, total O_3, NO_x, SO_2 and solar radiation (visible light, infrared, ultra-violet) were continuously monitored using instruments. The instruments used include Model 49 for O_3, Model 43S for SO_2 and Model 42S for NO_x made in TE Co., USA, pyranometers (295, 395, 695 nm) made in APPLEY Co., USA for solar radiation and Brewer O_3 spectrophotometer made in Canada for the total O_3. All the instruments were calibrated before use on site. Surface O_3 measuring instrument was also calibrated during the observation process. Longfengshan station is one of the only three regional stations that administrated by the China Meteorological Administration for atmospheric background concentration, which is also included in the Global Atmospheric Watch (GAW) under WMO. The observation station is 50 km away from Wuchang City. The station is close to a water reservoir, and located on a small hill in Zhangguangcai Mountain region. The hill is covered by vast amount of pine trees. At the bottom of the hill is a large rice field. There are no major pollution sources nearby. In this study relationship between surface O_3 and meteorological conditions is established for the year.

II. RESULTS AND DISCUSSION

1. *Surface O_3 under Different Weather Conditions*

Hourly average O_3 data were compiled from Longfengshan station in autumn under fine, overcast and rain days respectively. The observation periods concerned are 23, 10 and 13 days respectively. Data for cloudy day are not included as the weather condition was not available. Under fine days in autumn, the diurnal variation of surface O_3 shows a typical double-peak pattern: at about 0600 BT surface O_3 concentration reaches a minimum of 28.9 ppb. The concentration gradually increases after sunrise and reaches its maximum of 56.1 ppb at about 1700 BT, and then the O_3 concentration starts to decrease until midnight. After a small peak occurs before early morning, it starts to decrease again until sunrise. Its diurnal variation is 27.2 ppb; the maximum of surface O_3 concentration is almost twice as high as the minimum. Under overcast days, the diurnal variation of O_3 concentration is far from regularity than under fine days. However the variation is still detectable to a certain degree and is seen with the double-peak pattern as well. The minimum occurs 1—2 h later than that in fine days at 24.1 ppb. The maximum occurs 2 h earlier than that in fine days at 38 ppb. After the occurrence of the maximum, O_3 concentration starts to decrease irregularly until sunrise the next day. The diurnal variation under overcast days is 13.9 ppb only about half of that under fine days. The surface O_3 diurnal range is relatively low with minimum of 7.6 ppb under rainy days and diurnal variation changes irregularly very much, which probably relates with different occurrence time of the rain and intensity of the rain as can be seen from Fig. 1. Before 1100 BT the surface O_3 concentration under overcast days is even lower than that under rainy conditions. This phenomenon can also be explained by the variation of rain intensity and occurring time. In addition, less data have been collected for the rainy days.

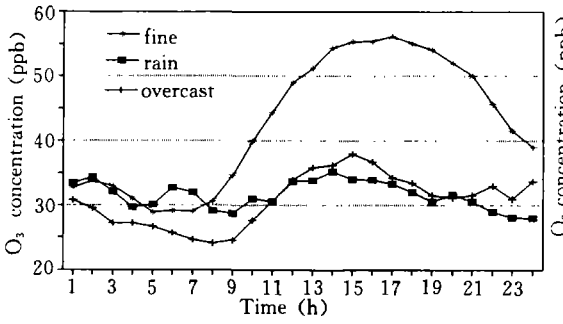

Fig. 1. Surface O_3 concentration under different weather conditions in autumn (Longfengshan Sep. —Nov. 1994).

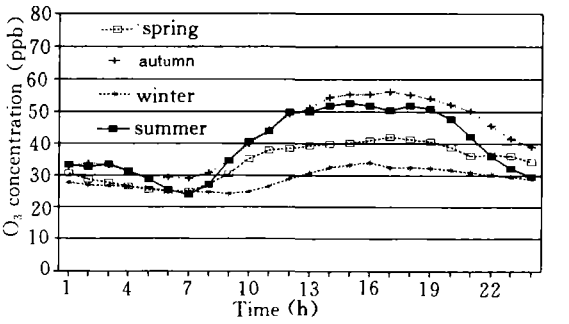

Fig. 2. Diurnal variation of surface O_3 under fine days (Longfengshan station, Aug. 1994 —Jul. 1995).

Under fine days in other seasons, diurnal variation also shows a double-peak trend in summer (see Fig. 2). Its diurnal amplitude (28.7 ppb) is a little higher than that in autumn. Double peak trend can not be seen obviously during transition period from winter to spring. Diurnal amplitude reaches minimum in winter (only 9.7 ppb). Diurnal amplitude in spring is 17.2ppb in between. O_3 concentration in summer afternoons is slightly lower than that in autumn from diurnal variation trend. This is probably caused by higher NO_x concentration in autumn. Although diurnal variation amplitude is smaller in overcast days, diurnal variation still can be seen in other seasons. The maximum diurnal variation amplitude is 16.3, 8.8, 6.9 ppb in summer, winter and spring, respectively. In other seasons, noticeable precipitation including rain and snow is encountered, average diurnal variation of surface O_3 concentration is irregular as in autumn. The diurnal variation is about 7—10 ppb.

The effect of precipitation on surface O_3 is quite obvious and it can be seen easily from the variation of surface O_3 concentration. There was continuously rain at 0700—2000 BT on May 9, 1995. The rainfall amount was 10.3 mm. Before the rain, the surface O_3 concen-tration is above 50 ppb. It became lower after 0700 BT. There is 8.0mm rainfall amountat 0100—1400BT on Sept. 19, 1994. On that day, the hourly O_3 concentration was

Table 1. Typical Diurnal Variation of Surface O_3 Concentration under Rainy Days (Longfengshan Station August 1994—July 1995)

time (BT)	0000	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100
1995-05-09	46.5	52.0	51.8	53.5	54.8	54.2	51.2	50.1	41.6	40.4	36.0	35.7
1994-09-19	34.3	35.9	21.8	18.9	23.3	26.3	30.6	24.9	20.7	19.8	23.7	25.0
Autumn 1994 rainy days	33.5	34.3	32.1	29.7	30.1	32.7	32.0	29.2	28.8	31.1	30.6	33.7
time (BT)	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
1995-05-09	35.9	37.3	39.8	39.4	30.0	26.7	24.8	24.9	23.7	22.0	23.5	24.4
1994-09-19	24.8	26.5	28.6	25.1	24.3	22.0	18.7	21.7	17.5	19.1	18.6	17.9
Autumn 1994 rainy days	33.9	35.2	34.1	34.0	33.3	32.0	30.6	31.7	30.6	29.0	28.1	28.0

lower by 10 ppb than what is derived from the average diurnal variation under rainy days in autumn (see Table 1). Similar phenomenon has been encountered in Lushan (Ding et al. 1991).

2. *Wind*

(1) *Wind speed*

Average surface O_3 concentration has been compiled for four times at 0100, 0800, 1400 and 1900 BT under different wind speeds (see Table 2). Surface O_3 concentration rises with the increase of wind speed at many measurement times. This is typically demonstrated by the measurements obtained at 0800 BT in autumn. O_3 concentration increases by 2.7 ppb with the increase of wind speed by 1 m s^{-1} under wind speed range from 0.1—1.0 m s^{-1} to 5.1—6.0 m s^{-1}. Similar trend presents at 1400 BT test results. Between 0100 and 1900 BT O_3 concentration varied slightly with the increase of wind speed. Surface O_3 concentration increases by about 1.6 ppb and 1.0 ppb respectively with wind speed increase by 1m s^{-1} when wind speed changed from 1.1—2.0 m s^{-1} to 5.1—6.0 m s^{-1}. The relationship between wind speed and O_3 concentration at 0100 BT in winter is opposite to each other. There is no obvious correlation between wind speed and surface O_3 concentration on other measurement times in winter. Surface O_3 concentration rises with the increase of wind speed at 0800 BT in spring. Surface O_3 concentration increases by 2 ppb with the increase of wind speed by 1 m s^{-1} under wind speed range from 0.1—1.0 m s^{-1} to 5.1—6.0 m s^{-1}. O_3 concentration increases by about 5 ppb with increase of wind speed by 1 m s^{-1} under wind speed range from 2.1—3.0 m s^{-1} to 5.1—6.0 m s^{-1} at 0100 BT except for the speed range of 0.1—1.0 m s^{-1} and 1.1—2.0 m s^{-1}. No strong correlation between wind speed and surface O_3 concentration is noticed at 1400 and 1900 BT. The surface O_3 concentration also increases with the increase of wind speed at 0800 BT in summer. Surface O_3 concentration increases by 3.8 ppb with the increase of wind speed by 1 m s^{-1} under wind speed range from 0.1—1.0 m s^{-1} to 5.1—6.0 m s^{-1}. Surface O_3 concentration increases by 1.8 ppb with the increase of wind speed by 1 m s^{-1} at 0100 BT when the O_3 variation is small. O_3 variation is irregular at 1400 and 1900 BT. However higher O_3 concentration presents at higher wind speed. For example, O_3 concentration is as high as 60.9 ppb at 1400 BT under wind speed range of 5.1—6.0 m s^{-1}. The O_3 concentrations at 1900 BT are at 50.2 ppb and 51.8 ppb respectively under wind speed ranges of 4.1—5.0 m s^{-1} and 5.1—6.0 m s^{-1}.

Average surface O_3 concentration tends to increase with the increase of average diurnal wind speed all the year round, especially in autumn and in summer. Surface O_3 concentration increases by 5.1 ppb and 4.3 ppb respectively with wind speed increases by 1 m s^{-1} under wind speed range from 0.1—1.0 m s^{-1} to 5.1—6.0 m s^{-1}. Similar trend is also observed in spring, but O_3 concentration increases only by 1 ppb.

Table 2. Average Surface O_3 Concentration with Different Wind Speed under Different Seasons and Times (Longfengshan, August 1994—July 1995)

wind speed (m s^{-1})			0.1—1.0	1.1—2.0	2.1—3.0	3.1—4.0	4.1—5.0	5.1—6.0	6.1—7.0	7.1—8.0	8.1—9.0
	0100	O_3	36.1	30.6	30.7	33.4	35.9	37.0	47.9	57.2	61.3
		No.	7	10	21	17	13	4	2	3	1
	0800	O_3	25.1	28.8	28.4	35.3	38.9	38.9	53.3	71.9	
		No.	5	10	25	14	12	2	2	3	
Autumn	1400	O_3	38.8	44.9	49.4	43.7	52.7	49.7	44.5	59.6	62.1
(Time BT)		No.	4	13	18	13	10	7	4	3	2
	1900	O_3	46.1	43.8	41.1	49.0	43.1	47.9	57.0	68.8	
		No.	4	20	12	15	14	3	3	2	
	average	O_3	—	32.1	37.4	43.5	48.2	54.0	57.4		
		No.		32	17	13	6	2	2		
	0100	O_3	30.7	30.8	28.4	27.0	26.6	28.9	20.7		
		No.	3	7	16	21	17	1	2		
	0800	O_3	30.4	26.4	22.8	26.1	23.5	25.8	24.4	39.2	
Winter		No.	4	17	11	17	11	5	2	1	
(Time BT)	1400	O_3	36.1	33.4	34.7	34.0	34.3	36.3	34.0	27.0	32.2
		No.	1	14	19	11	10	3	3	2	2
	1900	O_3	35.5	32.6	33.2	30.2	32.5	32.3			
		No.	4	6	16	21	12	5			
	0100	O_3	39.6	32.8	31.3	31.6	34.7	46.5	37.2		
		No.	3	10	20	23	16	5	2		
	0800	O_3	27.5	30.7	31.4	33.0	37.5	37.7	32.4	40.4	
Spring		No.	14	16	14	16	7	11	2	4	
(Time BT)	1400	O_3	39.9	43.6	36.8	42.5	46.7	39.9	39.9	41.5	57.5
		No.	6	10	12	15	10	9	14	4	
	1900	O_3		43.6	38.0	39.0	35.8	41.3	42.6		
		No.		18	22	17	10	12	4		
	0100	O_3	23.5	21.0	23.7	28.8					
		No.	2	9	19	10					
	0800	O_3	25.3	30.2	27.6	30.7	38.5	44.4			
Summer		No.	19	13	11	5	5	2			
(Time BT)	1400	O_3	41.5	41.1	39.0	40.0	36.3	60.9			
		No.	6	13	20	10	3	3			
	1900	O_3	32.9	36.3	38.0	33.9	50.2	51.8			
		No.	3	14	19	14	2	2			

Except in winter, it is worth emphasizing that surface O_3 concentration increases by over 10 ppb with wind speed increase of 1 m s^{-1} when wind speed is over 6.0 m s^{-1} in autumn. Although the increase of O_3 concentration is not as high as that in autumn, clear evidence in spring shows that O_3 concentration rises with the increase of wind speed except for the measurements obtained at 0100 BT. In addition, relative high O_3 concentration is observed with 8 out of 15 measurements all the year round under low wind speed range of 0.1—1.0 m s^{-1}. There is 50% probability of occurrence of high O_3 concentration under calm wind as can be seen from the following section —wind direction, indicating that

relative high surface O_3 concentration occurs under conditions of calm and small wind. It is worthy of paying attention to this phenomenon. however this phenomenon is not very representative because of the limited number of observations.

Through the above analysis, we come to the conclusion that photochemical reaction rate increases with the increase of wind speed under condition of wind speed greater than 1 m s^{-1}. Especially when wind speed is over 6 m s^{-1}, there is a significant rise in photochemical reaction rate. It is observed at Lin' an regional station during PEM-WEAT-A experiment (August — November, 1991) that the surface O_3 concentration did not increase obviously with the increase of wind speed over 6 m s^{-1} (Ding et al. 1995: Zhou et al. 1993). There is only about 100 days of records available during the period of this experiment. Meanwhile there are only few days of strong wind. So we need to do more detailed study before we are able to come to a definite conclusion.

Relationship of average diurnal wind speed with average diurnal surface O_3 concentration is analysed at 0100 BT in autumn (see Fig. 3). It can be seen from the figure that most of the average diurnal wind speed peak values match with the peak values of the average diurnal surface O_3 concentration. It is to be mentioned that during 290—310 Julian day, the three peaks of the average diurnal wind speed under wind speed greater than 6 m s^{-1} (which are the only three peaks available in autumn) are consistent with the three peaks of the average diurnal surface O_3 concentration.

(2) *Wind direction*

Wind direction with occurrence frequency less than 3 is not taken into consideration in our analysis. In autumn high O_3 concentration mainly occurs under S, SSW and SW wind directions at 0100 BT (40.7, 43.0 and 43.5 ppb respectively), while at 0800 BT high O_3 concentration occurs under SSW and WSW wind directions (49.3 ppb and 46 ppb). However at 1400 BT and 1900 BT, no high O_3 concentration is noticed under any wind directions. In summer O_3 concentration under SSW wind direction is higher than that under any other wind directions at 0100 BT (38.4 ppb); at 0800 BT high O_3 concentration is observed under S, WSW and N wind directions (38.7, 42.3 and 42.1 ppb respectively). At 1400 BT high concentration is recorded under SSW, SW, WSW and SE wind directions

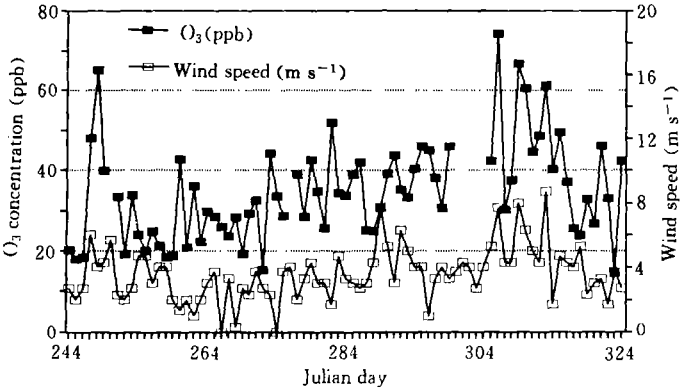

Fig. 3. Average diurnal wind speed in relation to average diurnal surface O_3 concentration (Longfengshan station, September—November, 1995).

(48.6, 53.4, 58.4 and 50.6 ppb). At 1900 BT high O_3 concentration is encountered under SW and WSW wind directions (45.8 and 42.8 ppb). In spring at 0100 BT surface O_3 concentration is relatively high under SSW wind direction (39.4 ppb). At 1400 BT besides surface O_3 concentration is high under S, SSW, SW and WSW, the surface O_3 concentration is also higher under NE and SSE wind directions. At 0800 and 1900 BT, wind directions are not directly in relation with high O_3 concentration. In winter there is no clear relationship between wind directions and surface O_3 concentration (see Table 3). In conclusion surface O_3 transport mechanism exists under S and SW wind directions from the observations at Longfengshan station. Harbin lies at NW of Longfengshan station (about 250 km away). No high O_3 concentration is observed under that direction. It is obvious that NW wind has no significant effect on the surface O_3 concentration at Longfengshan regional station. Therefore we can infer that transport effect on O_3 concentration exists under S and SW directions at Longfengshan station.

Table 3. Surface O_3 Concentration in Different Wind Directions and Seasons (August 1994—July 1995. Longfengshan Station)

			N	NNE	NE	ENE	E	ESE	SE	SSE	S	WSW	SW	WSW	W	WNW	NW	NNW	C
	0100	O_3	38.9	23.5	31.8	—	40.1	28.3	23.4	27.1	40.7	43.0	43.5	26.4	36.3	30.3	34.2	27.4	32.0
		No.	1	1	1		2	1	5	15	25	2	7	3	6	1	2	2	3
	0800	O_3	15.9	25.9	—	—	26.9	—	28.4	30.9	37.6	49.3	32.6	46.0	29.7	28.3	35.5		
Autumn		No.	3	1			1		10	12	24	7	6	3	3	2	1		
(Time BT)	1400	O_3	49.5	63.8	32.9	63.1	60.4	47.8	50.3	57.4	48.7	50.1	52.8	48.2	43.0	50.4	38.4	47.7	
		No.	5	1	2	1	1	1	1	1	15	5	11	2	7	9	8	6	
	1900	O_3	51.3	51.7	44.1	47.4	47.5	—	33.0	45.0	47.2	49.5	46.4	38.1	44.8	56.9	44.1	31.7	
		No.	4	2	6	2	1		3	4	19	4	12	2	6	1	7	3	
	0100	O_3	31.9	—	—	—	32.8	32.4	—	32.6	28.5	27.5	25.1	25.8	22.9	26.6	29.0	—	—
		No.	5				1	1		3	22	6	15	4	5	4	1		
	0800	O_3	—	—	—	—	33.9	31.0	27.6	27.7	26.8	25.7	21.3	29.2	20.1	27.8	27.5	—	—
Winter		No.					1	1	4	5	22	7	16	2	5	3	1		
(Time BT)	1400	O_3	31.3	33.6	—	—	—	—	—	36.4	31.7	31.8	33.3	41.1	34.8	32.3	37.6	35.4	—
		No.	9	1						1	10	7	16	2	8	4	7	7	
	1900	O_3	33.3	32.7	—	34.5	—	—	34.1	32.5	31.4	27.1	32.0	33.3	30.4	37.1	34.4	27.6	41.7
		No.	4	2		1			2	1	17	5	11	5	10	1	5	1	2
	0100	O_3	24.9	30.7	32.2	32.7	41.1	36.3	36.8	35.2	35.1	39.4	30.3	30.6	27.8	—	31.3	28.1	44.7
		No.	3	1	2	1	1	3	1	11	21	14	7	3	6		4	3	1
	0800	O_3	24.9	—	31.6	—	—	36.7	32.2	35.4	37.2	34.3	32.8	28.5	28.0	35.4	24.1	29.1	19.6
Spring		No.	3		3			3	7	7	24	14	11	5	1	1	5	2	1
(Time BT)	1400	O_3	37.2	36.1	51.1	—	—	—	—	47.2	45.0	43.2	45.6	48.6	39.9	38.9	36.2	36.7	—
		No.	7	3	2					5	10	16	5	2	8	5	7	7	
	1900	O_3	—	—	39.9	—	48.4	48.4	42.4	44.4	43.5	41.3	37.9	38.0	32.2	40.3	36.0	34.7	—
		No.			4		2	1	3	1	19	9	7	5	6	7	11	9	
	0100	O_3	24.1	25.0	11.4	—	26.3	23.4	27.4	19.1	25.0	38.4	22.7	—	—	13.2	—	17.7	—
		No.	1	1	2		1	1	4	11	11	5	1			1		1	
	0800	O_3	42.1	—	20.5	22.6	13.1	27.2	23.5	29.3	38.7	33.0	22.0	42.3	17.9	—	27.5	31.9	36.5
Autumn		No.	2		5	2	1	1	13	8	13	8	1	1	1		1	1	2
(Time BT)	1400	O_3	40.0	39.0	29.2	23.3	41.6	39.3	50.6	—	39.1	48.6	53.4	58.3	40.6	-	31.4	37.5	—
		No.	9	3	3	1	4	1	7		11	6	4	2	6		3	2	
	1900	O_3	31.9	—	26.9	40.8	33.9	—	35.3	30.9	38.6	38.3	45.8	42.8	36.0	39.8	32.8	35.1	22.1
		No.	3		3	2	1		3	2	15	4	7	2	1	2	5	7	1

3. *Global Radiation*

Average O_3 concentration is compiled under fine and cloudy days at every 100 W m^{-2} interval of global radiation intensity. At 0800 and 1400 BT, O_3 concentrations are

consistent with global radiation intensity at the same time while O_3 concentrations at 1000 and 1600 BT are consistent with radiation intensity at 0800 and 1400 BT respectively. In autumn at 0800 BT O_3 concentration increases with the increase of global radiation intensity. Average O_3 concentration increases by 1 ppb when radiation intensity increases by about 100 W m^{-2}. At 1000 BT, O_3 concentration shows clear increase with radiation intensity compared with that at 0800 BT and the amplitude of the increase is also higher (O_3 concentration increases by 2.5 ppb with every 100 W m^{-2} of radiation intensity increase). At 1400 and 1600 BT, O_3 concentration increases by over 2 ppb every 100 W m^{-2} rise of global radiation intensity except for the test results obtained at 100—200 W m^{-2} radiation intensity group, due to lack of enough data. Furthermore clearer relationship between O_3 concentration at 1600 BT and radiation intensity at 1400 BT exists comparing the relationship between O_3 concentration at 1400 BT and radiation intensity at 1400 BT (see Fig. 4).

The relationship between O_3 concentration and global radiation is more consistent in winter than that in autumn. Every 100 W m^{-2} rise in radiation intensity, O_3 concentration increases by 3.6 ppb at 0800 BT, by 3.2 ppb at 1000 BT, by 2.8 ppb at 1400 BT, by 3.5 ppb at 1600 BT. The relationship between surface O_3 concentration and global radiation is similar in winter and spring. Surface O_3 concentration increases with the rise in global radiation except for the radiation intensity of 601—700 W m^{-2} at 1600 BT. At 0800 BT, surface O_3 concentration increases by 3.1 ppb every 100 W m^{-2} rise in total radiation; by 2.9 ppb at 1000 BT; by 1.6 ppb at 1400 BT; by 2.1 ppb at 1600 BT. There are no enough data available under fine days in summer.

Through the above analysis we can see: (1) O_3 concentration in the afternoon is higher than that in the morning at 0800 BT by over 20 ppb under the same radiation intensity, which is probably the result of different photochemical reaction rate. Strong turbulence in the afternoon results in higher photochemical reaction rate. (2) The relationship between O_3 concentration and global radiation delayed 2 h is better than that between O_3 concentration and global radiation at the same time. Relationships between surface O_3 concentration and infrared and ultraviolet radiation are similar to what mentioned above.

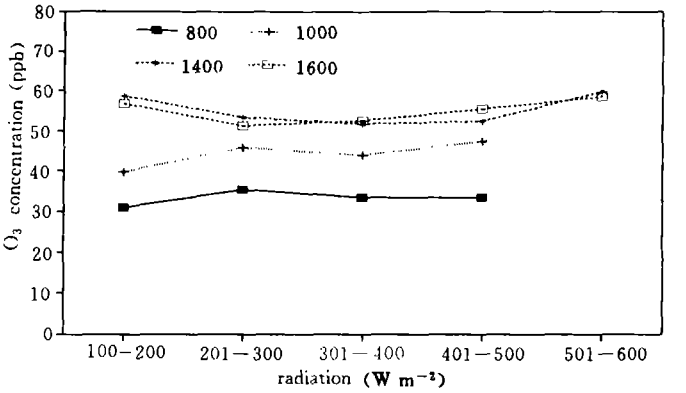

Fig. 4. Surface O_3 concentration versus global radiation intensity in different times (Longfengshan, September—November, 1994).

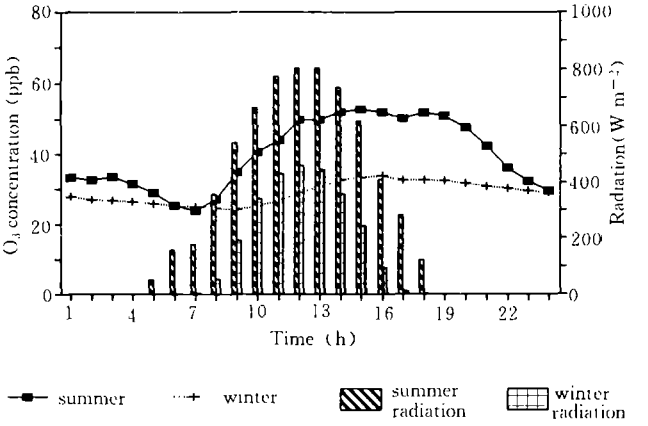

Fig. 5. Diurnal variation of surface O_3 and global radiation in summer and winter (Longfengshan. August. 1994—July. 1995).

The relationship between surface O_3 concentration and radiation also varies with seasons. Hourly average surface O_3 concentration and corresponding radiation are shown in Fig. 5 under fine days in summer and winter. It can be seen from Fig. 5 that, average peak value of surface O_3 concentration in summer is over 50 ppb while in winter lies over 30 ppb. The difference between summer and winter is about 20 ppb. Global radiation in summer is approximately 800 W m^{-2}, while 400—500 W m^{-2} in witer. The difference in global radiation between summer and winter is about one fold.

O_3 concentrations are compared between data collected under 5 fine days at every hour in autumn from Longfengshan station and Lin'an station. These two stations have similar environmental conditions with about same longitude (see Fig. 6). Both diurnal variations are very similar.

However average O_3 concentration at Lin'an station is always higher than that at Longfengshan station. The difference is always around 6 — 24 ppb except for result obtained at 0800 BT. Right after sunrise, this difference is small and becomes bigger

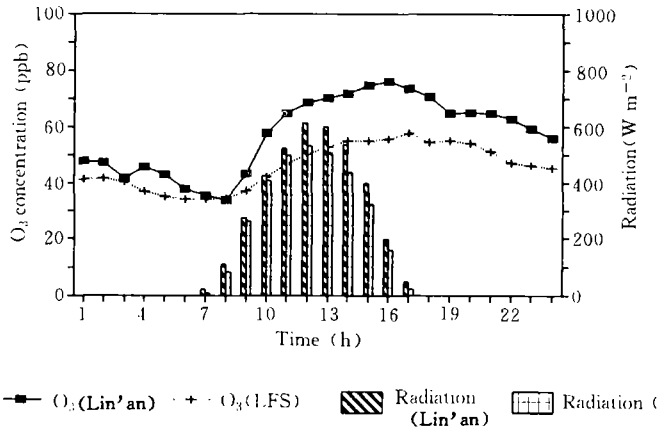

Fig. 6. Surface O_3 and global radiation at south and north stations in autumn (September—November, 1994).

gradually after 1000 BT. The maximum difference occurs at 1500 BT. The average of the difference is about 11 ppb. This difference is mainly caused by the difference in global radiation due to different latitudes of these two stations (44°44′N at Longfengshan, 30°18′N at Lin'an): In the morning the global radiation at these two stations is about the same. However the difference gradually gets bigger after 1000 BT. The maximum difference occurs at 1200 BT (94 W m^{-2}) and then it becomes smaller until sunset.

4. *Temperature and Sunshine Time*

Average daily temperature and its corresponding average daily O_3 concentration are compiled statistically. No straight relationship is seen from the data collected. Also there is no clear evidence to show the relationship between daily accumulated sunshine time and average daily O_3 concentration.

5. *Correlation Analysis*

Table 4 shows the correlation coefficient of the average daily O_3 concentration and wind speed, temperature, SO_2, NO_x, accumulated daily global radiation and accumulated daily sunshine time. As the number of samples varies, we only lists critical correlation coefficient with 0.01 degrees of confidence of 40, 60, 70 and 90 samples. Between the average daily surface O_3 and the average daily wind speed and the average daily SO_2 there shows a strong correlation in all seasons except in winter. This is especially true in autumn. The average daily surface O_3 and the accumulated daily global radiation demonstrate a little correlation in winter and spring. There is a relatively obvious correlation between the average daily surface O_3 and the average daily temperature in spring. Therefore parameters other than the average daily wind speed and average daily SO_2 show no obvious correlation with the average daily O_3 concentration. Hence using only the average daily value of all the parameters concerned to study the relationship between the surface O_3 concentration and meteorological conditions is not adequate. A more detailed analysis needs to be carried out.

Table 4. Correlation Coefficient between O_3 and Other Parameters*

		SO_2	NO_x	G	V	S	T
Spring	*cc*	0.333	−0.159	0.312	0.339	0.201	0.584
	No.	90	90	90	90	90	90
Summer	*cc*	0.474	0.334	0.135	0.392	0.326	0.355
	No.	60	60	60	60	60	60
Autumn	*cc*	0.748	−0.079	0.153	0.618	0.335	−0.029
	No.	72	44	72	72	72	72
Winter	*cc*	−0.183	−0.132	0.461	−0.308	0.222	0.303
	No.	69	69	69	69	69	69

* G global radiation (MJ m^{-2}); V wind speed (m s^{-1}); S sunshine time (h); T temperature (°C); *cc* correlation coefficient. $f = 90$, $\alpha = 0.01$, $P = 0.2673$; $f = 70$, $\alpha = 0.01$, $P = 0.3017$; $f = 60$, $\alpha = 0.01$, $P = 0.3248$; $f = 40$, $\alpha = 0.01$, $P = 0.3932$, where f is the number of samples, α degree of confidence, P critical correlation coefficient.

III. CONCLUSIONS

(1) Diurnal variability of the surface O_3 shows a double-peak pattern with daily amplitude of 27—28 ppb in summer and autumn under fine days. In overcast days diurnal variation of the surface O_3 is noticeable, however its daily amplitude is relatively small (about 14 ppb). In rainy days the variation shows irregular change pattern and its daily amplitude is 7—10 ppb, which depends on the raining time and rainfall amount.

(2) At 0800 and 1400 BT in autumn, at 0100 and 0800 BT in spring, at 0100 and 0800 BT in summer, the surface O_3 concentration increases with the increase of ground wind speed. When wind speed is greater than 7 m s^{-1} the surface O_3 concentration increases rapidly.

(3) In most of the times while there are S, SSW, SW and WSW wind directions, the surface O_3 is high in concentration. This is probably due to the transport effect in these directions.

(4) At 0800 BT under fine days in winter, spring and autumn, surface O_3 concentration tends to increase with the increase of global radiation. This is even more obvious when comparing radiation at 0800 BT and 1400 BT with surface O_3 at 1000 BT and 1600 BT respectively.

(5) The average peak value of surface O_3 concentration under fine days in summer is higher than that in winter by about 20 ppb, while the average peak value of global radiation is almost twice as high as in winter.

(6) Comparing the average hourly surface O_3 concentration during 5 fine days at Longfengshan station with that at Lin'an station, both are similar in longitude, the concentration in the former is always lower than that in the latter station by 6—24 ppb, except at 0800 BT. Its difference maximizes at 1500 BT and the average difference is 11 ppb. The main reason is due to the difference in global radiation (difference of about 100 W m^{-2}) caused by different latitude of these two stations.

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