6.3   Environmental Protection

6.3.1 Environmental Situation

(1) Weather Conditions

  1)   General Affairs

  Mongolia is a large and sparsely populated country with a harsh climate and about 2.4 million people live within the whole area of the country (1.56 million square kilometers).

  The climate of Mongolia is dry with extremely cold temperatures in winter. Annual precipitation in Ulaanbaatar is only 293 mm. The 70% - 80% total precipitation is concentrated in a three-month period (from late June to mid September).

  The whole country is situated at a high northern latitude and at a high elevation (average 1,580 meters). The annual average temperature is very low (the annual average temperature was -0.6°C during 1986 to 1990 in Ulaanbaatar). As the country is also landlocked, the temperature during a year fluctuates widely (-39℃ to +38℃ in Ulaanbaatar). The climate also features a long, cold and dry winter season with low wind velocity and temperature inversions in the upper layer. These unique climate conditions have a direct influence on environmental conditions in Mongolia. The climate in Ulaanbaatar city is shown in Table 6.3-1.

Table 6.3-1 Temperature, Precipitation and Humidity in Ulaanbaatar City

Month	1	2	3	4	5	6	7	8	9	10	11	12	Ave
Temp. (℃)	-20.9	-17.1	-8.0	1.5	9.8	14.3	16.7	15.1	8.8	1.1	-11.6	-17.3	-0.6
Precipitation (mm)	2.4	2.4	6.6	5.8	14.6	55.6	64.0	92.7	26.9	12.0	5.4	4.8	*293
Humidity (%)	81	77	66	52	52	58	65	70	65	64	72	81	67

(Data: 1986~1990)   Meteorological research July 1991

*Total precipitation in a year

  2)   Main Factor of Air Pollution

  As Ulaanbaatar city is located in a basin surrounded by mountains with heights of 1,652 to 1,949 meters above sea level, the air pollution induced by the temperature inversion is heavier than that in other cities. The temperature inversions tend to occur from October to

April in general. The temperature inversion is usually located at a level 650~920 meters above ground level. However, sand storms also occur intermittently (about 26 times a year), and the air pollution is caused by the uncontrolled emission from industries using coal-fired plants and also emission from households burning coal for room heating.

The wind rise in Ulaanbaatar shows the main direction as being from west to northwest, and the wind velocity is 1 to 2 meters per second. The smoke and flue gases in Ulaanbaatar City have been mainly emitted from the stacks of coal fired thermal power stations and traditional Mongolian houses (called as "gher"). About 48% of the population of Ulaanbaatar city live in "ghers" and use stoves fueled with coal or wood, or both for house-warming and cooking purposes without using any anti-air pollution devices. From these fuel sources, toxic substances such as carbon monoxide are emitted into the atmosphere.

In recent years, the increasing number of private transportation vehicles has doubled the deterioration of the environment, since Mongolia imports old vehicles that operate inefficiently and lack the appropriate air emission control devices.

3) Weather Status in 2000

Temperature, wind direction, wind velocity and atmospheric stability data recorded by the Tahilt meteorological observatory near TES4 are shown in Table 6.3-2 to 6.3-5, and Fig. 6.3-1 to 6.3-2. The outline of the weather status in 2000 is as follows:

(a) Temperature

The average temperature measured by the ground weather survey was -0.7℃ in 2000. As for the monthly average temperature, the highest was 20.0℃ in June and the lowest was -24.9℃ in January. Moreover, the average temperature by season was 3.1℃ in spring, 18.5℃ in summer, -2.8℃ in autumn and -21.5℃ in winter, respectively.

(b) Wind Direction

The wind direction that appeared the most frequently throughout the year was north-northwest (7.8%) and south (7.9%).

As for seasonal variation, the most numerous wind direction was north-northwest 12.1% in spring (from March to May), north-northwest 9.2% in summer (from June to August), south 9.1% and north-northwest 8.3% in autumn (September to November) and south 9.1% in winter (December to February).

(c) Wind Velocity

The outline of the annual and seasonal wind velocity and appearance frequency recorded by the ground weather survey is shown in following Table.

Moreover, the appearance frequency of wind velocity "less than 0.4 m /s (calm)" was approx. 50% throughout a year and 70% or more in winter.

Items	Average wind velocity m/s	Wind velocity class with the most appearance frequency		Appearance frequency of Calm (less than 0.4 m/s)
		Wind velocity class	Appearance frequency	
Annual	3.3	More than 6.0 m/s	15.1%	47.4%
Spring	4.0	Ditto	28.0%	30.9%
Summer	4.0	Ditto	19.5%	34.6%
Autumn	2.2	Ditto	11.4%	50.0%
Winter	1.9	1.0~1.9 m/s	8.7%	74.5%

(d) Atmospheric Stability based on the Mongolian Method

The monthly average value of atmospheric stability was 70% or more, showing strong stability in the period from January to March and from October to December, 30 to 53.3% in the period from April to September. (Refer to Table 6.3-2)

In addition, the grounding inversion layer occurred frequently in October to March over Ulaanbaatar City.

(e) Occurrence Situation of Temperature Inversion

Investigation using a weather balloon twice (morning 8 o'clock and night 8 o'clock) every day.

Table 6.3-6 shows the mean weather condition (temperature, wind direction and wind velocity) of the inversion layer generated every month except July.

Most of the generated inversion layer was a grounding inversion, and the maximum mean depth of inversion attained was 830 m in January (all day inversions).

Moreover, the inversion layer (half-day inversion) was also generated in the summer season except July, and the mean depth was 620 m in June.

Although the average wind velocity at the time of inversion layer generation was 1 to 2m/s on the ground except for March (Ave. 9 m/s) and June (4 m/s), the average wind velocity was 4 to 6 m /s in the upper layer.

Moreover, the wind direction in the upper layer differed considerably from that on the ground and it was reversed especially in the winter season (January, February and December).

For example, of the mean data in January, the wind direction was southwest with 6 m/s in the upper layer at a height of 2140m (-19.5°C of air temp.), when the north wind with 1 m/s blew on the ground (altitude of 1310 m, -25.6°C).

Table 6.3-7 shows the occurrence frequency of the inversion layer in 2000.

The occurrence frequency of the inversion layer was 60.1% in the whole year. It occurred in more than 20 days in the morning and evening every month from January to March and October to December.

From April to September except July, the inversion layer occurred in 9 to 16 days only in the morning.

Table 6.3-2   Meteorological Data in 2000 (Tahilt Meteorological Observatory)

	Average Wind Velocity (m)	Average Air Temperature (°C)	Air Pressure (hPa)	Amount of Cloudiness	Monthly Sum of Global Radiation (Kw/m^2)	Monthly Sum of Radiation Balance (Kw/m^2)	Atmospheric Stability (%)
January	2.1	-24.9	874	3.0	254.2	-75.0	81.1
February	1.8	-18.6	871	2.2	472.7	-2.0	93.1
March	3.8	-5.5	868	3.7	716.1	198.7	74.5
April	4.1	2.5	865	4.0	1,023.0	382.2	30.0
May	4.0	12.4	864	5.6	1,078.8	549.9	32.2
June	4.5	20.0	864	5.3	1,053.0	549.9	40.0
July	3.9	19.1	863	6.2	905.2	560.0	--
August	3.6	16.5	865	6.9	654.1	421.3	45.1
September	3.1	11.4	870	2.6	774.0	292.8	53.3
October	3.6	-2.3	871	4.1	514.6	100.4	77.4
November	3.1	-17.5	870	4.4	240.0	-33.3	100
December	1.7	-21.1	868	4.1	210.8	-55.5	100
Annual	3.3	-0.7	--	--	--	--	--

Recorded by: Meteorological Agency

Average Air Temperature and Atmospheric Stability in four seasons

	Ave. Air Temperature (°C)	Ave. Atmospheric Stability (%)
Spring (Mar-May)	3.1	45.6
Summer (Jun-Aug)	18.5	42.6
Autumn (Sep-Nov)	-2.8	76.9
Winter (Jan-Feb, Dec)	-21.5	91.4

Table 6.3-3 Appearance Frequency of Wind Direction in 2000

(Unit: %)

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm
Jan	1.6	0.4	0	0.4	0	0.4	0.8	0.8	7.3	3.2	0.8	0.4	0	1.2	3.6	1.6	75.4
Feb	0	0.4	0	0	0.9	0.9	1.3	3.4	9.1	3.4	0.4	1.7	1.7	2.1	2.1	0.9	71.6
Mar	3.2	2.4	2.4	1.2	0.4	0.4	4.0	4.0	10.9	2.4	3.2	2.0	1.2	4.8	8.1	14.1	35.1
Apr	10.8	6.7	4.6	0.4	0	0	0	3.3	7.1	5.4	4.2	0.8	5.0	4.2	6.7	12.9	27.9
May	12.0	5.2	0.8	0.4	0	0.8	0.4	2.0	4.8	4.8	6.8	4.8	7.6	4.8	6.0	9.2	29.6
Jun	5.0	5.0	4.2	3.8	0.8	2.1	4.2	2.9	8.8	2.5	3.8	1.7	4.2	5.8	5.8	5.4	34.2
Jul	8.5	8.9	2.0	0.4	2.0	0.4	4.4	4.4	3.6	2.0	0.8	1.6	4.0	5.6	4.4	15.7	31.0
Aug	3.3	3.3	5.8	3.3	1.3	1.7	3.3	11.3	6.3	2.1	3.8	2.5	2.1	2.5	2.5	6.3	37.5
Sep	3.6	3.6	2.4	0	0	0	0.8	3.2	10.9	2.0	4.0	2.4	2.8	3.2	5.6	7.7	47.6
Oct	5.0	3.8	1.7	0.8	0.4	0.4	0.8	7.5	7.1	4.6	3.8	2.5	2.9	4.6	7.1	12.1	35.0
Nov	2.0	0.8	0.8	0	0.4	0.8	0.4	1.6	9.3	3.2	0.4	2.0	2.8	1.2	2.0	5.2	66.9
Dec	1.6	0	0	0.4	1.2	0.8	0.4	0.4	8.9	4.4	0.4	0.4	2.4	0	1.2	1.2	76.2
Annual	4.7	3.4	2.0	0.9	0.6	3.3	1.7	3.7	7.8	3.3	2.7	1.9	6.7	3.3	4.6	7.9	47.4

Recorded by: Meteorological Agency

(Unit: %)

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm
Spring	1.6	4.7	2.6	0.7	0.1	0.4	1.5	3.1	7.6	4.2	4.7	2.6	4.6	4.6	6.9	12.1	30.9
Summer	1.6	5.8	4.0	2.5	1.4	1.4	4.0	6.2	6.2	2.2	2.7	1.9	3.4	4.7	4.3	9.2	34.6
Autumn	1.6	2.7	1.6	0.3	0.3	0.4	0.7	4.1	9.1	3.3	2.7	2.3	2.9	3.0	4.9	8.3	50.0
Winter	1.6	0.3	0	0.3	0.7	0.7	0.8	1.5	8.4	3.7	0.5	0.8	1.4	1.1	2.3	1.2	74.5

Table 6.3-4　Wind Velocity for Each Wind Direction in 2000

(Unit: m/s)

		NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	AVE
January	Max. Velocity	2.0	0.0	4.0	0.0	1.0	2.0	2.0	4.0	3.0	1.0	2.0	0.0	5.0	5.0	8.0	5.0	2.8
	Ave. Velocity	2.0	0.0	4.0	0.0	1.0	1.5	1.5	1.8	1.5	2.0	2.0	0.0	4.0	3.3	4.7	4.0	2.1
February	Max. Velocity	1.0	0.0	0.0	2.0	2.0	2.0	3.0	5.0	4.0	1.0	3.0	4.0	5.0	6.0	7.0	0.0	2.8
	Ave. Velocity	1.0	0.0	0.0	2.0	1.5	1.5	1.6	2.4	2.5	1.0	2.0	2.4	3.0	3.8	4.5	0.0	1.8
March	Max. Velocity	7.0	4.0	10.0	1.0	1.0	13.0	12.0	6.0	2.0	8.0	5.0	4.0	10.0	8.0	11.0	10.0	7.0
	Ave. Velocity	4.2	3.4	7.0	1.0	1.0	5.8	3.7	2.8	2.0	3.8	2.8	2.3	4.1	4.2	6.3	6.1	3.8
April	Max. Velocity	12.0	6.0	4.0	0.0	0.0	0.0	10.0	9.0	8.0	11.0	5.0	10.0	8.0	10.0	15.0	13.0	7.6
	Ave. Velocity	6.3	3.7	4.0	0.0	0.0	0.0	5.2	3.4	4.6	4.8	4.5	4.5	3.6	5.7	7.9	7.4	4.1
May	Max. Velocity	6.0	6.0	3.0	0.0	4.0	6.0	8.0	8.0	9.0	11.0	8.0	6.0	7.0	8.0	12.0	11.0	7.1
	Ave. Velocity	3.7	5.5	0.3	0.0	2.5	5.5	3.2	3.3	4.7	6.6	4.9	3.8	3.1	4.1	6.7	6.4	4.0
June	Max. Velocity	10.0	7.0	6.0	2.0	7.0	8.0	7.0	8.0	8.0	11.0	8.0	6.0	6.0	9.0	10.0	10.0	7.7
	Ave. Velocity	5.1	4.1	4.2	1.5	3.6	5.7	5.4	4.4	3.5	5.6	4.2	3.0	3.1	6.0	5.0	7.0	4.5
July	Max. Velocity	8.0	4.0	3.0	6.0	1.0	6.0	9.0	8.0	7.0	8.0	4.0	5.0	12.0	9.0	12.0	12.0	7.1
	Ave. Velocity	4.2	2.8	3.5	3.0	1.0	4.1	5.3	3.9	3.8	6.5	2.0	3.1	4.6	4.8	5.5	4.4	3.9
August	Max. Velocity	5.0	9.0	6.0	5.0	4.0	12.0	13.0	8.0	6.0	8.0	10.0	3.0	4.0	8.0	8.0	7.0	7.3
	Ave. Velocity	3.6	3.5	3.9	3.7	2.2	4.6	6.3	4.3	3.4	3.0	5.4	2.2	2.3	3.5	3.3	2.9	3.6
September	Max. Velocity	5.0	6.0	0.0	0.0	0.0	1.0	14.0	10.0	9.0	6.0	6.0	5.0	6.0	10.0	9.0	8.0	5.9
	Ave. Velocity	4.0	3.5	0.0	0.0	0.0	1.3	5.4	4.4	4.6	2.7	3.4	3.8	3.2	3.9	4.6	5.1	3.1
October	Max. Velocity	6.0	5.0	4.0	2.0	1.0	7.0	14.0	8.0	8.0	7.0	4.0	6.0	8.0	8.0	9.0	7.0	6.5
	Ave. Velocity	3.9	2.6	2.5	4.5	1.0	3.2	5.7	2.6	4.2	3.8	2.8	3.1	3.8	3.9	4.7	4.9	3.6
November	Max. Velocity	6.0	4.0	0.0	1.0	1.0	1.0	7.0	4.0	3.0	3.0	4.0	6.0	11.0	7.0	9.0	8.0	4.7
	Ave. Velocity	5.0	3.0	0.0	1.0	1.0	1.0	2.8	2.3	2.0	3.0	3.2	2.3	5.7	4.2	5.8	7.0	3.1
December	Max. Velocity	0.0	0.0	2.0	2.0	1.0	2.0	1.0	3.0	5.0	3.0	0.0	3.0	0.0	9.0	2.0	8.0	2.6
	Ave. Velocity	0.0	0.0	2.0	1.3	1.0	2.0	1.0	2.0	1.7	3.0	0.0	1.7	0.0	5.7	1.7	4.0	1.7

Ave. Wind Velocity in four Seasons		
Spring (Mar-May)	4.0	m/s
Summer (Jun-Aug)	4.0	m/s
Autumn (Sep-Nov)	2.2	m/s
Winter (Jan-Feb, Dec)	1.9	m/s

Recorded by: Meteorological Agency

6.3-7

Table 6.3-5 (1)　Appearance Frequency of Wind Velocity Class in 2000

(Unit: %)

	1.0~1.9m/s	2.0~2.9m/s	3.0~3.9m/s	4.0~4.9m/s	5.0~5.9m/s	6.0 or more m/s	Calm
Spring	4.9	11.4	8.0	10.8	6.0	28.0	30.9
Summer	4.4	13.7	9.0	11.3	8.4	19.5	34.6
Autumn	7.7	9.8	8.7	7.6	4.8	11.4	50.0
Winter	8.7	8.4	3.4	2.6	1.4	1.1	74.5
Annual	6.4	10.8	7.0	8.1	5.1	15.1	47.4

Table 6.3-5 (2)　Appearance Frequency of Wind Velocity Class in 2000 Winter (Jan-Feb, Dec)

(Unit: %)

|	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
Calm																	74.5
1.0~1.9m/s	0.1	0.1	0	0	0.3	0.5	0.3	0.8	2.3	1.9	0.4	0.3	0.5	0	0.4	0.5	8.7
2.0~2.9m/s	0.1	0.1	0	0.1	0.4	0.1	0.5	0.5	3.8	1.0	0	0.3	0.4	0.3	0	0.5	8.4
3.0~3.9m/s	0.1	0	0	0	0	0	0	0.1	1.5	0.4	0.1	0.3	0.3	0.3	0.3	0	3.4
4.0~4.9m/s	0.3	0	0	0.1	0	0	0	0	0.5	0.3	0	0	0.1	0.3	1.0	0	2.6
5.0~5.9m/s	0.3	0	0	0	0	0	0	0	0.1	0.1	0	0	0	0.3	0.4	0.1	1.4
6.0 or more m/s	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.7	1.1
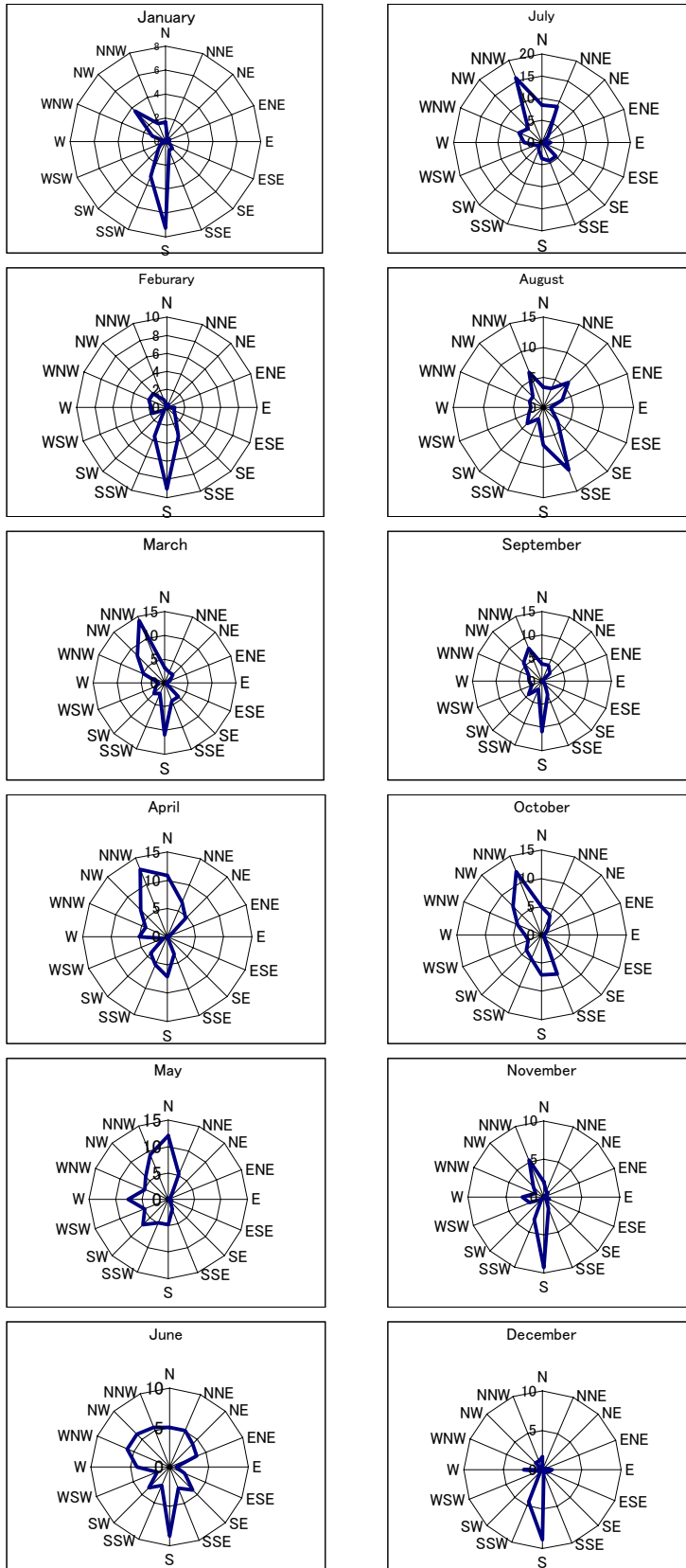
Numerical value:
Frequency (%)

Calm Frequency

	Calm (%)
Jan	75.4
Feb	71.6
Mar	35.1
Apl	27.9
May	29.6
Jun	34.2
Jul	31.0
Aug	37.5
Sep	47.6
Oct	35.0
Nov	66.9
Dec	76.2
Annual	47.4

Fig. 6.3-1   Monthly Wind Rose in 2000

Spring (Mar.～May)

Winter (Jan.～Feb., Dec.)

Summer (Jun.～Aug.)

Annual

Autumn (Sep.～Nov.)
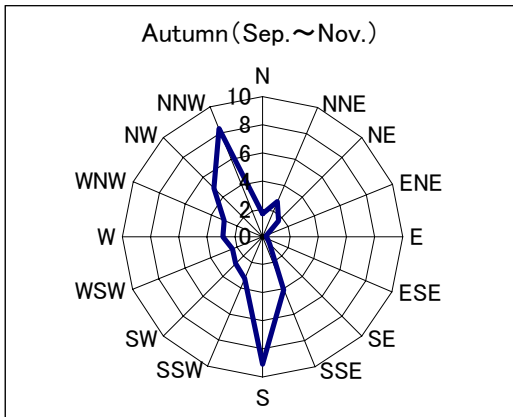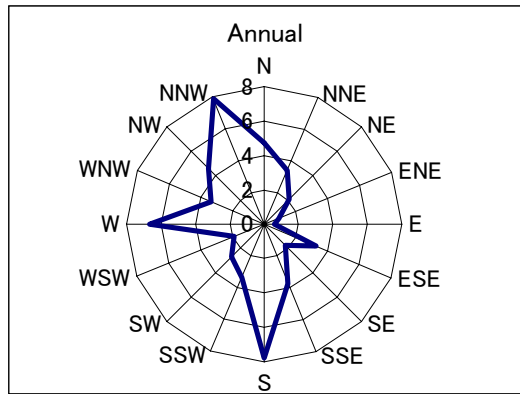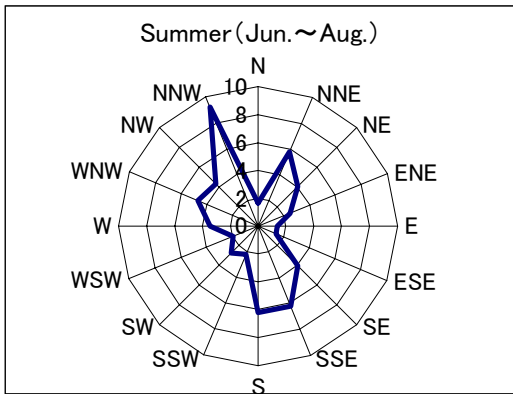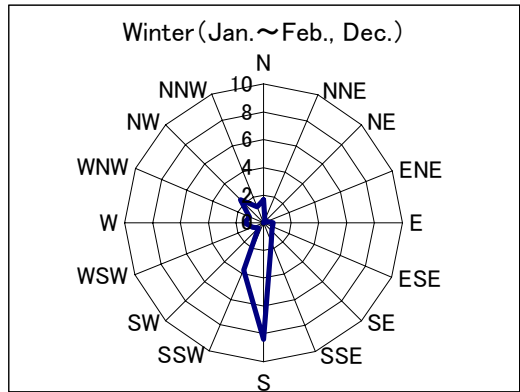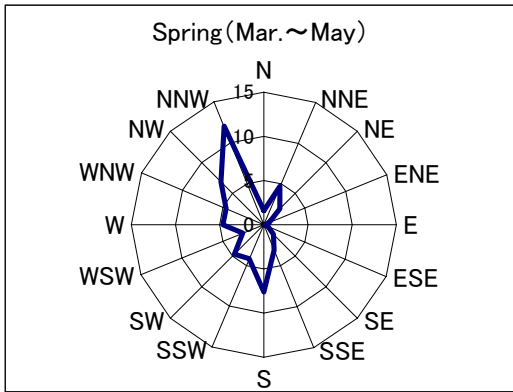
Calm Frequency

	Calm(%)
Spring	30.9
Summer	34.6
Autumn	50.0
Winter	74.5
Annual	47.4

Numerical value:
Appearance frequency of wind direction

Fig. 6.3-2   Seasonal Wind Rose in 2000

Table 6.3-6　Meterological Data at the Appearance of Inversion Layer in 2000 (Monthly Average)

Month	Lower Layer					Upper Layer					Depth of Inversion (m)
	Hight (m)	Air Temp (°C)	Humidity (%)	Wind Direction (°)	Wind Velocity (m/s)	Hight (m)	Air Tem. (°C)	Humidity (%)	Wind Direction (°)	Wind Velocity (m/s)	
Jan	1310	-25.6	74	360	1	2140	-19.5	62	220	6	830
Feb	1310	-20.5	76	360	1	2030	-14.3	61	200	6	720
Mar	1310	-10.9	69	69	9	1750	-7.7	62	210	6	440
Apr	1310	-2	64	132	1	1390	-0.3	54	190	5	80
May	1310	15.9	53	90	2	1780	19.3	46	200	6	470
Jun	1310	16.8	54	111	4	1930	17.6	41	217	5	620
Jul	*1										
Aug	1310	14.2	71	70	2	1610	15.3	61	220	5	300
Sep	1310	5.4	53	54	1	1760	8.9	50	180	4	450
Oct	1310	-4.3	54	120	1	1490	-2	54	200	4	180
Nov	1310	-19.2	74	180.2	2	1710	-14.3	57	260	5	430
Dec	1310	-21.9	78	50	1	1820	-15	58	260	5	510

Hight: above sea level

*1: Invertion layer did not occur in July 2000.
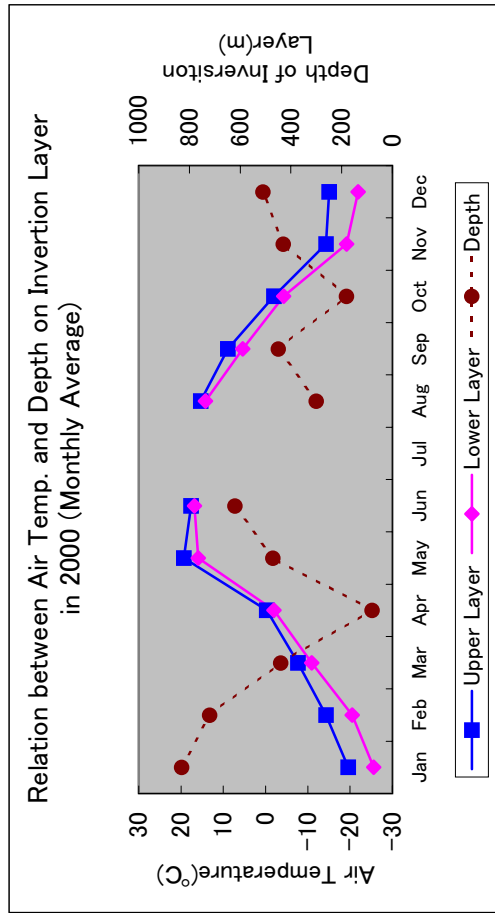
Recorded by: Meteorological Agency

Relation between Air Temp. and Depth on Invertion Layer in 2000 (Monthly Average)

Table 6.3-7 Appearance Frequency of Inversion Layer in Ulaanbaatar (Year 2000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Occurrence number of days	25	27	23	9	10	12	0	14	16	24	30	30	220
Annual occurrence rate (%)	6.8	7.4	6.3	2.5	2.7	3.3	0	3.8	4.4	6.6	8.2	8.2	60.1
Monthly occurrence rate (%)	81	93	74	30	32	40	0	45	53	77	100	97	--
All day Inversion (days)	16	25	2	1	0	0	0	2	0	12	22	26	106
Half day –Morning Inversion (days)	6	1	21	8	10	12	0	11	16	10	6	2	103
Half day –Night Inversion (days)	3	1	0	0	0	0	0	1	0	2	2	2	11

Recorded by: Meteorological Agency

Appearance Frequency of Inversion Layer in 2000