METEOROLOGICAL DATA AT THE 15 M OBSERVATIONAL TOWER IN TOKYO METROPOLITAN UNIVERSITY

Chieko SUZUKI, Tomoko NAKANO, Kooiti MASUDA and Takehiko MIKAMI

Abstract An observational tower standing on Tokyo Metropolitan University campus has been providing basic meteorological data needed for the satellite remote sensing analysis since April 1997. We will report the characteristics of observed data in terms of seasonal changes of several meteorological elements which are crucial for the energy balance components for understanding the climatology of our campus located in the western suburbs of Tokyo.

Key words: meteorological data, instrumental platforms, observational tower, energy balance components, seasonal change

1. Introduction

On the Tokyo Metropolitan University (TMU) campus, an observational tower (15 m high) stands on the east side of the campus (Fig. 1). The tower is used to observe twelve meteorological parameters and has done so continuously since it was built in March 1997, for the ground level monitoring of remote sensing. The following report covers the compiled data for the last two years.

2. Data

Items and instruments of observation

The locations of TMU and this tower are shown in Fig. 1. TMU is located in the southwest of Tokyo (35° 37' N, 139° 23' E, and about 130 m ASL). The tower stands on the mild slope with a southern exposure, at the edge of groves. From top of the tower, we can observe the surface temperature of grove canopies using a Thermography (NEC TH3102MR), which is used to calibrate the thermal band data from LANDSAT TM. Figure 2 is a schematic diagram of the observational tower. Letters in Fig. 2 indicate positions of instruments listed in Table 1, where the names and positions of the routine observational instruments are presented. The details are as follows:

Global short-wave radiation and direct short-wave radiation have been measured with a pyranometer and a pyrheliometer at the top of the tower ("A" in Fig. 2), and recorded as hourly integrated values. Wind speed and wind direction have also been measured with an

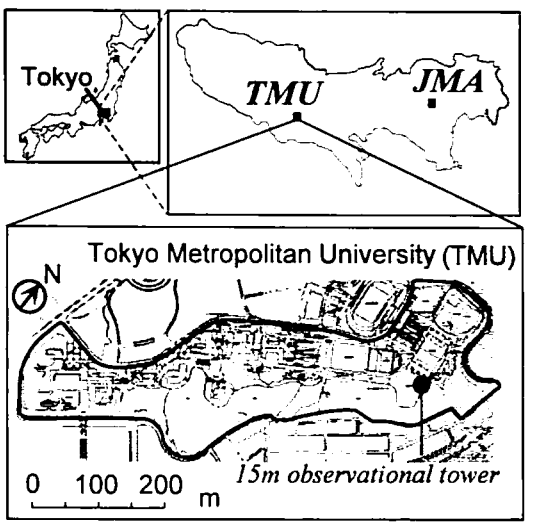

Fig. 1 Location maps of the observational tower in Tokyo Metropolitan University.

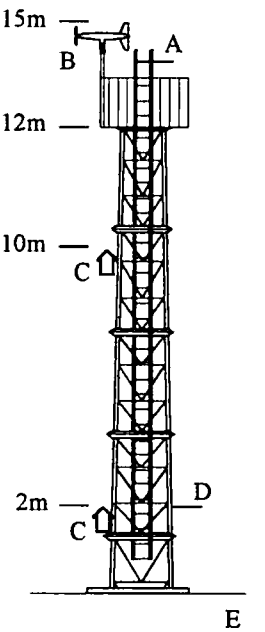

Fig. 2 A schematic diagram of the routine measurement system. A-E: see Table 1.

Table 1 Instruments for the routine observation at the tower
A - E mean the position of the instruments in Fig. 2

POSITION	ITEM	HEIGHT[1]	INSTRUMENT
B	Global Solar Radiation	14.0	EKO, MS-42
B	Direct Solar Radiation	14.0	EKO, MS-101D
D	Net Radiation	2.0	EKO, MF-11
A	Wind Direction	14.5	EKO, MA-110
A	Wind Velocity	14.5	EKO, MA-110
C	Air Temperature	9.5, 1.5	EKO, MH-011PS
C	Relative Humidity	9.5, 1.5	EKO, MH-011PS
E	Soil Temperature[2]	-0.3	EKO, MT-010SS
E	Soil Heat Flux[2]	-0.3	EKO, MF-81
E	Soil Moisture[2]	-0.3	TRIME, P2G

1) Heights of the instruments are above ground level (unit = meter)
2) Soil Temperature, soil heat flux, and soil moisture have been measured at three points of the same depths

aerovane and anemometer at the top of the tower ("B" in Fig. 2), and recorded as hourly mean values. Air temperature and relative humidity have been measured with platinum resistance thermometers and electrical capacitance hygrometers at two heights ("C" in Fig. 2), and

recorded as hourly mean values. Net radiation has been measured with a net radiometer at 2 m above ground level ("D" in Fig. 2), and recorded as hourly integrated values.

Below the ground ("E" in Fig. 2), soil temperatures, soil moistures and soil heat fluxes have been measured with platinum resistance thermometers, TDR (time domain reflectometry) probes to estimate the volumetric soil water content, and heat flow plates respectively. Each instrument has been set at three points beside the tower. The data has recorded hourly mean values. In this report, we will use the average of data at the three points.

Period

The data in this report has been collected and compiled for two years from April 1997 to March 1999. There are periods of missing data during the two years due to required maintenance, problems with instruments, or power failures. The data of net radiation have a lot of erroneous values probably due to a lack of instrument maintenance (Linacre 1992). We will show this monthly data with an underline which means low accuracy in Table 2.

Other data

We also have used the weather station data collected at Otemachi by Japan Meteorological Agency (JMA), in order to compare it with the data collected at TMU. The weather station is located at 35° 41' N, 139° 46' E and 5.3 m ASL. We have used monthly data on air temperature, relative humidity, and global solar radiation from April 1997, to March 1998. The data was published as the annual report of 1997 and the monthly reports from January to March of 1998 by JMA.

3. Climatology of Tokyo Metropolitan University

Characteristics of seasonal change

In this section, we describe the characteristics of seasonal changes in the observed parameters at TMU. Monthly statistics and annual mean values are summarized in Table 2, and daily mean values are plotted in Fig. 3 and Fig. 4. Annual mean values in this report represent the period from April 1997 to March 1998.

Radiation

The annual mean values of net radiation, global solar radiation and soil heat flux are 39.9 W/m^2, 142.8 W/m^2 and -0.7 W/m^2 respectively (Table 2). Annual mean of the global solar radiation is equivalent to representative values in southern Japan from the Kanto district, about 150 W/m^2 (Kondo and Kuwagata 1992). The highest values of monthly mean net radiation and soil heat flux occurred in June and the lowest values occurred in December. These seasonal changes are compatible with those of daily total insolation at the top of the atmosphere (we call it extra-terrestrial irradiance). As shown in Fig. 3 (a), daily total extra-terrestrial irradiance was maximum at the summer solstice and minimum at the winter solstice. Net radiation was much larger than soil heat flux, and they showed both positive values in summer and negative values in winter. But monthly mean global solar radiation on the ground level did not reach a clear maximum in June. The difference of insolation between

Table 2 Monthly values at TMU from April 1997 to March 1999

ITEM		Air Temperature at 2m					Soil Temp.	Relative Humidity	Soil Moisture	Wind		
UNIT		[℃]					[℃]	[%]	[%]	[m/s]		
		Monthly Mean	Mean Daily Max.	Mean Daily Min.	Extremes Highest	Extremes Lowest	Monthly Mean	Monthly Mean	Monthly Mean	Monthly Mean Speed	Monthly Max. Speed	Most Prevailing Direction
1997	Apr.	14.2	19.8	9.1	27.9	3.0	13.8	67.9	36.1	3.2	9.2	S(17)
	May	18.1	23.0	13.8	30.2	6.7	18.0	79.1	36.2	2.9	11.4	S(13)
	Jun.	21.6	26.2	17.8	33.7	12.3	20.7	82.2	37.8	3.1	14.5	S(18)
	Jul.	25.5	29.9	21.7	39.1	17.5	23.7	82.4	35.4	2.8	9.1	SSW(17)
	Aug.	25.7	29.9	22.4	35.3	16.9	23.9	84.3	34.4	2.8	8.9	S(14)
	Sep.	21.5	25.4	18.6	32.9	11.5	21.4	87.5	40.3	2.9	8.2	NNW(23)
	Oct.	16.3	22.1	11.4	26.4	3.6	16.3	75.1	37.6	2.3	6.5	N(10)
	Nov.	12.3	16.7	8.0	23.1	2.5	12.2	77.8	35.9	2.5	14.6	NNW(20)
	Dec.	7.0	11.7	2.6	16.8	-1.7	8.0	71.3	40.0	2.4	7.9	N(16)
1998	Jan.	3.1	8.3	-1.1	13.4	-5.5	3.2	73.3	42.8	2.7	9.4	NNW(19)
	Feb.	5.6	11.7	1.1	20.7	-3.2	4.6	73.2	42.1	3.1	10.9	NNW(17)
	Mar.	7.2	13.4	1.8	17.7	-1.2	6.2	66.3	42.3	3.7	12.8	N(18)
ANNUAL		14.8	19.8	10.6			14.3	76.7	38.4	2.9		
1998	Apr.	17.2	22.1	13.3	28.8	8.2	14.3	84.3	42.6	3.1	12.9	S(16)
	May	19.6	24.1	15.6	29.9	10.2	17.6	81.9	41.5	3.0	10.7	S(16)
	Jun	20.7	24.2	17.5	32.5	12.5	19.2	88.4	42.9	2.6	8.4	N(18)
	Jul.	24.4	28.1	21.6	35.5	16.7	22.5	89.1	40.3	2.7	8.2	S(15)
	Aug.	-	-	-	-	-	-	-	-	-	-	-
	Sep.	-	-	-	-	-	-	-	-	-	-	-
	Oct.	17.3	21.2	14.1	28.0	9.4	17.8	85.3	44.2	2.8	14.8	NNW(24)
	Nov.	11.5	16.9	6.9	23.9	1.1	12.9	73.1	37.1	-	-	-
	Dec.	7.2	11.8	3.2	17.2	-1.3	8.3	78.6	41.0	-	-	-
1999	Jan.	-	-	-	-	-	-	-	-	-	-	-
	Feb.	5.1	11.8	-0.4	20.6	-4.4	4.7	61.8	42.1	-	-	-
	Mar.	9.1	13.8	4.4	21.8	-1.3	8.0	72.9	43.2	-	-	-

"-" means no data.
Underlining of data means low accuracy.
The most prevailing wind direction represents sixteen azimuths.

the two levels in June was great probably due to cloudiness during the rainy season (Bai-u). Using the data from clear days only, the highest values on the ground level of daily total insolation and of instantaneous (actually hourly) global solar radiation occurred in June of 1997 and 1998.

Temperature

The annual mean temperature was 14.8 ℃. The highest values of monthly mean air temperatures (MMAT) and monthly mean soil temperatures (MMST) appeared in August, and the lowest values appeared in January as other weather stations in Japan (Arakawa and Taga 1969). They were one or two months behind those of net radiation and soil heat flux. The MMAT was higher than the MMST in summer while the MMST was larger than MMAT in winter. The monthly maximum of the daily range of air temperature was larger in summer

Table 2 (continued)

Daily Total Insolation		Solar Radiation			Net Radiation	Soil Heat Flux	Number of Days			
		Global		Direct						
[MJ/m^2/day]		[W/m^2]			[W/m^2]	[W/m^2]	[Days]			
Monthly Mean	Monthly Max.	Monthly Mean.	Monthly Max.	Monthly Mean.	Monthly Mean.	Monthly Mean.	Daily Min. Air Temp. < 0 ℃	Daily Min. Air Temp. >= 25℃	Daily Max. Air Temp. >= 30℃	All
15.7	25.8	181.2	921.5	133.8	83.2	2.5	0	0	0	27
15.2	28.1	175.7	970.1	95.9	84.3	2.9	0	0	1	31
15.3	27.2	177.7	973.5	95.2	90.3	3.5	0	0	4	30
15.6	27.0	180.8	923.7	111.5	84.5	2.6	0	1	15	31
15.1	25.1	174.7	896.7	-	81.6	1.6	0	4	18	31
9.8	19.2	113.7	801.7	-	53.5	-1.7	0	0	6	30
12.2	17.5	141.0	741.4	-	41.5	-3.8	0	0	0	31
7.7	13.9	89.6	620.2	-	-17.0	-4.0	0	0	0	30
7.8	12.1	90.7	547.7	-	-45.9	-5.6	9	0	0	28
9.2	15.4	106.1	652.6	-	-26.9	-4.8	20	0	0	30
10.5	16.4	121.1	765.7	-	9.1	-0.5	11	0	0	24
13.9	21.9	161.2	850.4	-	41.0	-1.0	6	0	0	20
12.3		142.8			39.9	-0.7				343
11.8	23.6	136.0	874.7	-	54.8	2.6	0	0	0	23
13.8	26.1	160.2	947.5	-	73.3	1.8	0	0	0	31
11.0	24.6	127.2	905.7	-	61.3	2.2	0	0	4	30
13.9	25.1	161.1	939.6	-	76.7	2.7	0	3	10	30
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
8.7	16.4	100.8	721.8	-	30.4	-3.3	0	0	0	15
9.6	14.1	111.2	636.9	-	10.6	-6.5	0	0	0	30
6.8	11.1	78.5	531.8	-	-2.1	-6.2	2	0	0	20
-	-	-	-	-	-	-	-	-	-	-
13.0	19.2	150.3	781.2	-	39.8	-2.4	10	0	0	18
10.5	21.4	121.2	868.8	-	-	0.1	0	0	0	29

Numbers in brackets mean relative frequency of the most prevailing wind direction.
'All' means the number of days for twenty-four observations.

than that in winter. However, the daily range of air temperature did not show a clear seasonal change.

Moisture condition

Annual mean relative humidity was 76.7 %. Relative humidity sometimes reached 100 % at night or on rainy days in every season. Daily mean relative humidity in winter was about 20 % lower than that in summer. Daily mean soil moisture did not have a clear seasonal variation and the values were about 40 %. However, daily mean soil moisture increased sharply about 10 % after rainfall and returned to the previous level within a few days.

Wind

The annual mean wind speed was about 3 m/s, which did not show particular seasonal change. The monthly prevailing wind direction was southerly in summer and northerly in

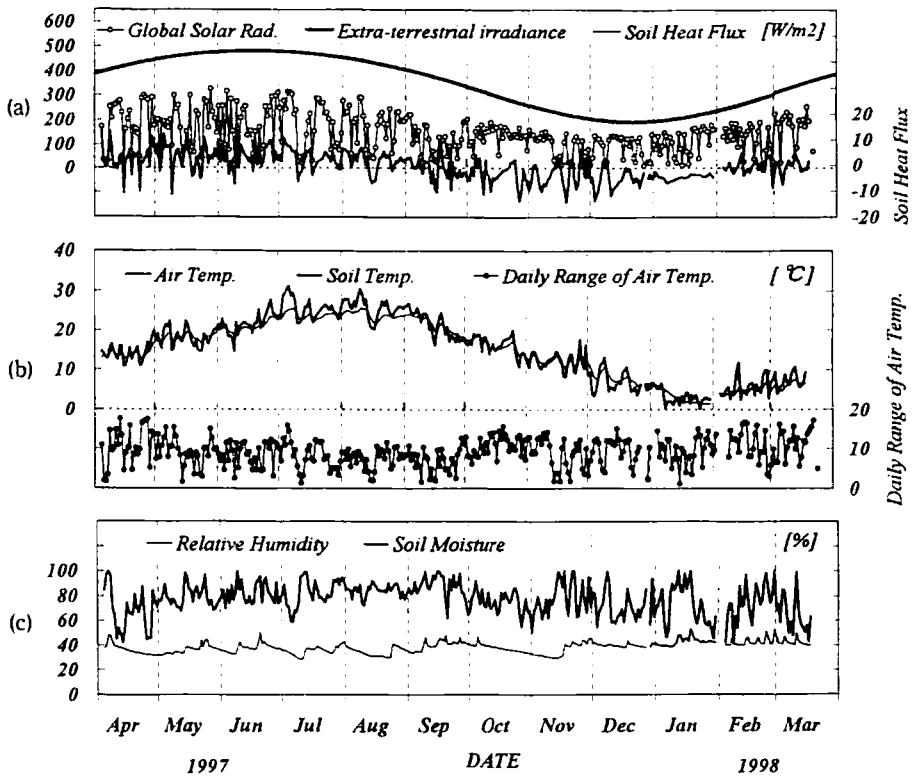

Fig. 3 Daily values at TMU from April 1997 to March 1998.
(a) Radiation [W/m^2], (b) Temperatures [℃], (c) Moisture Conditions [%].

winter. This was reflected in the seasonal characteristics of the land and sea breeze over the wide Kanto area (Fujibe 1981), but the fraction of the wind direction was about 20 % as shown in the round brackets.

Comparison with central Tokyo

In this section, we will compare the data measured at TMU (Table 2) with those measured at JMA described in Table 3.

Daily total solar radiation on both sites showed similar values throughout the year. MMAT and monthly minimum air temperatures at TMU were lower than those at JMA throughout the year. Annual mean air temperature at TMU was 1.7 ℃ lower than that at JMA, and 0.8 ℃ lower than normal value of that at JMA (Japan Meteorological Agency 1991). The difference of MMAT and monthly minimum air temperature between TMU and JMA was great (about 2 or 3 ℃) in winter and small (about 1 or 1.5 ℃) in summer. The differences of monthly mean daily maximum and the monthly extreme highest air temperatures were under 1 ℃ and seasonal changes were indistinct.

The number of days with 'winter day' (the daily minimum air temperature is below 0 ℃), the 'tropical night day' (the daily minimum air temperature is 25 ℃ or above), and the 'mid-

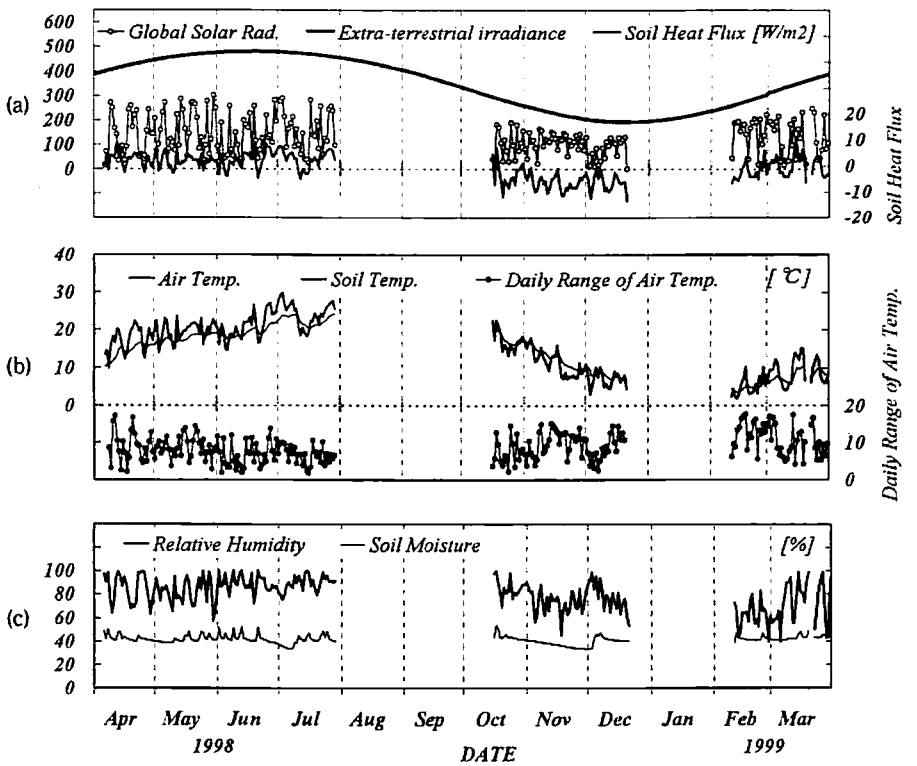

Fig. 4 Daily values at TMU from April 1998 to March 1999.
(a) Radiation [W/m^2], (b) Temperatures [℃], (c) Moisture Conditions [%].

Table 3 Monthly values at JMA from April 1997 to March 1998

ITEM		Air Temperature					Relative Humidity	Daily Total Insolation	Number of Days			
UNIT		[℃]					[%]	[MJ/m^2/day]	[Days]			
		Monthly Mean	Mean Daily Max.	Mean Daily Min.	Extremes Highest	Extremes Lowest	Monthly Mean	Monthly Mean	Daily Min. Air Temp. < 0 ℃	Daily Min. Air Temp. >= 25℃	Daily Max. Air Temp. >= 30℃	All
1997	Apr.	15.2	19.2	11.4	27.2	8.0	60	15.4	0	0	0	30
	May	19.2	23.2	15.6	27.9	11.3	69	15.7	0	0	0	31
	Jun.	22.7	26.6	19.3	32.8	13.4	72	16.1	0	0	6	30
	Jul.	26.6	30.7	23.4	37.7	19.4	72	16.9	0	9	22	31
	Aug.	27.0	30.7	23.9	34.5	19.4	73	14.7	0	8	23	31
	Sep.	22.9	26.4	20.1	32.9	15.4	75	9.8	0	2	7	30
	Oct.	18.7	22.8	14.8	27.1	9.6	60	11.9	0	0	0	31
	Nov.	14.3	18.1	11.0	24.4	6.9	63	7.7	0	0	0	30
	Dec.	9.2	12.4	5.8	17.6	2.5	56	7.1	0	0	0	31
1998	Jan.	5.3	9.3	1.9	13.6	-0.8	59	8.0	3	0	0	31
	Feb.	7.0	11.3	3.6	23.1	0.5	60	10.1	0	0	0	28
	Mar.	10.1	14.4	5.9	24.5	0.7	57	13.6	0	0	0	31
ANNUAL		16.5	20.4	13.1			65	12.3				365

summer day' (the daily maximum air temperature is 30 ℃ or above) in TMU were quite different from those at JMA, especially for 'winter day'. The number of 'winter days' in winter 1997 - 1998 was 46 days at TMU from December to March, while only 3 days at JMA in January. The number of 'tropical night days' in summer of 1997 was 5 days at TMU in July and August, and 19 days at JMA from July to September. The number of 'mid-summer days' at TMU was two weeks less than that at JMA.

Relative humidity at TMU was 8 ~ 15% higher than that at JMA. Water vapor pressure as calculated from relative humidity and air temperature was also higher at TMU than at JMA.

The original data (hourly values) from April 1997 to March 1999, daily mean and monthly mean values were all stored as digital information. To get or use these data, please contact the corresponding author by e-mail (mikami@comp.metro-u.ac.jp).

References

Arakawa, H. and Taga, S. 1969. Climate of Japan. In *Climates of Northern and Eastern Asia. (World Survey of Climatology vol.8)*. ed. H. Arakawa, 119-131. Amsterdam: Elsevier Publishing Company.

Linacre, E. 1992. *Climate Data and Resources*. London: Routledge.

Fujibe, F. 1981. Seasonal characteristics of a land and sea breeze. *Tenki* **28**: 367-375.*

Japan Meteorological Agency. 1991. *Climatic Tables of Japan volume 1*. Tokyo Japan Meteorological Association.**

Kondo, J. and Kuwagata, T. 1992. Hydrological climate in Japan (1): Radiation and evaporation from shallow lakes. *J. Japan Soc. Hydrol. and Water Resour.* **5** (2): 13-27.**

(* : in Japanese, ** : in Japanese with English abstract)