Hydroclimatic conditions that affect the subtropical dry scrub of Ani-jima Island

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ABSTRACT

Subtropical dry scrub is widely distributed on Ani-jima (Ani-jima Island) and includes rare endemic plant species of the Ogasawara Islands, northwestern Pacific. In this study, we evaluated the hydroclimatic conditions that affect the establishment of subtropical dry scrub on Ani-jima. We have conducted continuous meteorological observations at Ani-jima Point (180 m a.s.l.) at the center of Ani-jima since December 2006. Annual mean air temperature and precipitation at Ani-jima Point were 22.0°C and 1508.0 mm in 2007, and 21.5°C and 1609.3 mm in 2008, respectively. These annual precipitation values are 376 mm and 308 mm larger, respectively, than those recorded at the observatory on nearby Chichi-jima (Chichi-jima Island) in 2007 and 2008. In contrast, the potential evaporation calculated from meteorological observations at Ani-jima Point was less than that at Chichi-jima Observatory (1409.2 mm vs. 1507.6 mm in 2007, 1428.2 mm vs. 1558.3 mm in 2008). Thus the annual water balance between precipitation and potential evaporation suggests that hydroclimatic conditions at Ani-jima are relatively wet, contrary to expectation based on the structure and composition of subtropical dry scrub. Precipitation and potential evaporation varied seasonally, with an obvious water deficit developing during summer just after the rainy season. Consequently, the soil moisture content markedly decreased, and the subtropical dry scrub species would have been exposed to severe drought conditions in this period. We concluded that such seasonal drought strongly affects the establishment of subtropical dry scrub on Ani-jima.

Keywords: Ani-jima Island, hydroclimatic condition, potential evaporation, subtropical dry scrubs, drought

INTRODUCTION

Hydroclimatic conditions determined by water resources are a major limiting factor in the structure and species composition of a terrestrial ecosystem. The significance of water availability should increase on a remote oceanic island far from continents (Vitousek and Benning 1995; Whittaker 1998). However, surprisingly few studies have examined the hydroclimatic conditions of oceanic islands, compared with the more numerous ecological investigations of unique island ecosystems.

The Ogasawara Islands are typical oceanic islands, located approximately 1,000 km south of Tokyo, Japan. Almost all the Ogasawara Islands have been severely disturbed by human impacts, including cultivation and deforestation (Katahira 1981; Yoshida and Oka 2001). Ani-jima (Ani-jima Island) is exceptionally undisturbed, and the terrestrial ecosystems on this island remain relatively intact (Funakoshi 1992a). A number of studies have examined the flora and fauna of Ani-jima, which have high biological and ecological value (e.g., Yasui 1988; Shimizu 1990; Tomiyama 1992). However, very few studies have investigated the physical environments of Ani-jima, particularly the hydroclimatic conditions that affect the establishment of the island's terrestrial ecosystem.

Previous studies have substituted data observed at the Chichi-jima (Chichi-jima Island) Observatory, located just south of Ani-jima, to estimate the local climate conditions. However, researchers have also inferred that Ani-jima has drier hydroclimatic conditions than Chichi-jima, given that Ani-jima is dominated by subtropical dry scrub vegetation, consisting of plants exhibiting morphological adaptations to dry conditions (Shimizu 1989; Mishio 1992). Therefore, data from Chichi-jima Observatory are not necessarily satisfactory for evaluating the physical environments on Ani-jima. On-site meteorological data are needed to clarify the effects of hydroclimatic conditions on the formation of the subtropical dry scrub of Ani-jima.

We have conducted continuous meteorological observations at a subtropical dry scrub site on Ani-jima since December 2006. In this study, we present the data observed in 2007 and 2008 and related hydroclimatic conditions. We also used the meteorological data to calculate the potential evaporation (E_P) and water balance to clarify the hydroclimatic conditions of the subtropical dry scrub on Ani-jima. In particular, by comparing the potential evaporation with that at the Chichi-jima Observatory, we examine whether subtropical dry scrub should naturally dominate in relatively dry habitats of the Ogasawara Islands.

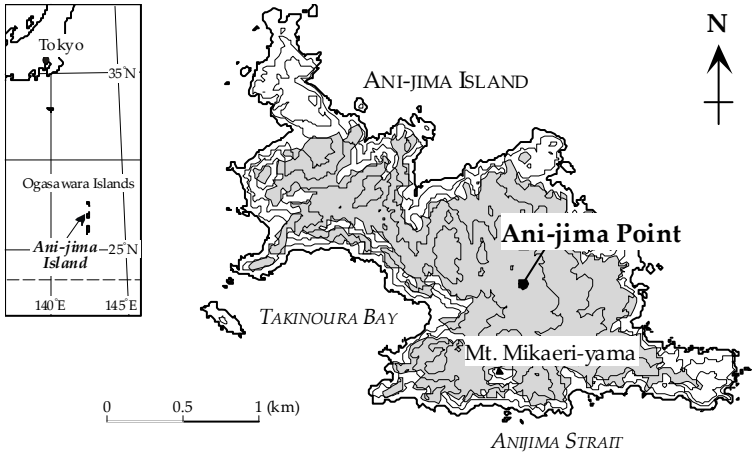

Fig. 1 Location of Ani-jima Point. The gray areas on the map depict the distribution of subtropical dry scrub (Shimizu 1992). The contour interval is 50 m

STUDY AREA AND METHODS

The study area was Ani-jima, an island that is located north of Chichi-jima in the Ogasawara Islands (Fig. 1). Low-relief surfaces surrounded by steep sea cliffs are broadly distributed at elevations of 150 to 200 m on Ani-jima (Kaizuka et al. 2000). Geologically, the island consists of boninite and orthopyroxene andesite pillow lava and tuff breccias (Umino and Nakano 2007). The climate is maritime and subtropical (Oka 1989). Data from the Chichi-jima Observatory provide a mean annual temperature of 23.0°C and mean annual precipitation (1971–2000) of 1276.7 mm.

Subtropical dry scrub vegetation is widely distributed throughout Ani-jima (Shimizu 1992). Scrub forests are dominated mainly by endemic tree species such as *Distylium lepidotum* and *Rhaphiolepis wrightiana* and include rare endemic plants such as *Callicarpa nishimurae*. Because of its valuable and unique ecosystems (Funakoshi 1992b), Ani-jima was designated as part of the Ogasawara National Park in October 1972 and subsequently added to the Ogasawara Forest Ecosystem Reserve in April 2007.

Although Ani-jima is geographically contiguous with Chichi-jima, the two islands differ in both topography and vegetation type. Because of such differences, differences in hydroclimatic conditions between the two islands have been predicted. However, on-site meteorological data have been needed to accurately evaluate the actual hydroclimatic conditions of the subtropical dry scrub on Ani-jima.

Photo 1 The meteorological equipment at Ani-jima Point on Ani-jima Island.

We established a meteorological observation station at Ani-jima Point in 2006 (Fig. 1, Photo 1), and hourly meteorological data have been continuously obtained from this station since December 2006. Ani-jima Point is located at the center of the island's low-relief plain at 180 m in elevation. Subtropical dry scrub with tree heights of 0.5–1.0 m is distributed around Ani-jima Point. Soils are not well developed and have depths of only 20–40 cm. This study used observations of air temperature and relative humidity at a height of 1.8-m, precipitation, solar radiation, wind direction and speed at a height of 2.5-m, air pressure, ground temperature (surface, 5 cm depth, and 10 cm depth), and soil moisture content at 10 cm depth at Ani-jima Point, as shown in Table 1.

Potential evaporation E_P was estimated to elucidate the hydrological properties at Ani-jima and Chichi-jima. Here, E_P is defined as "evaporation from a hypothetical black wet surface where soil heat flux is zero, and when surface temperature is equal to the equilibrium temperature which is determined by daily heat balance" (Kondo and Xu 1997). The potential evaporation was calculated by the following equations:

$$R^{\downarrow} = \varepsilon \sigma T_{SE}^4 + H + \iota E_P \quad (1)$$

$$H = c_P \rho C_H U (T_{SE} - T_A) \quad (2)$$

$$\iota E_P = \iota \rho \beta C_H U (q_{SE} - q_A) \quad (3)$$

$$R^{\downarrow} = (1 - ref) S^{\downarrow} + \varepsilon L^{\downarrow} \quad (4)$$

where $R^{\downarrow}$ is the input radiation at the ground surface, σ is the Stefan-Boltzmann constant, H is latent heat flux, ι is the latent heat of vaporization, c_P is the specific heat of air, ρ is the air density, T_{SE} is the calculated surface temperature that satisfies the heat balance equations (1)–(4), T_A is the air temperature, q_{SE} is the saturation specific humidity of T_{SE}, q_A is the specific humidity, $S^{\downarrow}$ is the solar radiation, and $L^{\downarrow}$ is longwave radiation. The parameters of the imaginary surface include a surface roughness of 0.005 m, albedo $ref = 0.06$ (water surface), surface emissivity $\varepsilon = 0.98$, and

Table 1 The observed meteorological parameters and specifications of sensors

Parameters	Height or Depth	Sensor type	Resolution
Air temperature	1.8 m	Platinum resistance thermometer	0.1 °C
Relative humidity	1.8 m	Hygrometer*	0.1 %
Wind speed	2.5 m	Propeller wind vane and anemometer	0.1 m/s
Wind direction	2.5 m	Propeller wind vane and anemometer	0.1 °C
Solar radiation	2.1 m	Pyranometer	0.1 W/m^2
Air pressure	1.5 m	Piezoresistive diaphragm barometer	1 hPa
Precipitation	0.8 m	Tipping bucket rain gauge	0.25 mm
Ground temperature	0, 5, 10 cm depth	Thermistor temperature sensor	0.1 °C
Soil moisture content	10 cm depth	Time domain reflectometer	0.1 %

* A condenser, the dielectric of which is a hygroscopic polymer

evaporation efficiency $\beta = 1$.

The exchange speed, $C_H U$, is given as

$$C_H U = \max (a + b \times U, c \times (T_{SE} - T_A)^{1/3}) \quad (5)$$

$a = 0.0027$ ms^{-1}, $b = 0.0031$, $c = 0.0036$ ms^{-1}K$^{-1/3}$

where U is the wind speed at 1 m above the imaginary surface and $c \times (T_{SE} - T_A)^{1/3}$ corresponds to the heat transfer by natural convection (in $T_{SE} - T_A > 0.5$°C). The potential evaporation was estimated from daily air-temperature data, relative humidity, wind speed, and solar radiation at Ani-jima Point and Chichi-jima Observatory in 2007 and 2008.

Potential evaporation is a useful index for discussing the climatic conditions of water and energy balances (Yamazaki et al. 2004). The potential evaporation estimated from the above equations can represent the hydroclimatic characteristics of Ani-jima. The differences in the hydroclimatic conditions between Ani-jima and Chichi-jima can also be determined by comparison of potential evaporation.

Air-temperature data at Ani-jima Point are missing from 1 January to 20 February 2007, 23 April to 26 July 2007, and 1 June to 8 December 2008 because of sensor problems. Relative humidity data are also missing from 1 January to 25 July 2007, 4 September 2007 to 8 March 2008, and 1 June to 8 December 2008. In these cases, missing data were substituted from a linear regression of hourly data from Chichi-jima Observatory. Air temperature was accurately estimated by linear regression ($r^2 = 0.913$, $p < 0.001$ in 2007, $r^2 = 0.963$, $p < 0.001$ in 2008), but the estimation of relative humidity was not as accurate as that of air temperature ($r^2 = 0.604$, $p < 0.001$

in 2007, $r^2 = 0.826$, $p < 0.001$ in 2008). Thus the estimation accuracy of the potential evaporation based on the predicted relative humidity was also evaluated by the root mean-square error (RMSE).

On the basis of vegetation physiognomy and the morphological characteristics of the tree species of the subtropical dry scrub, Ani-jima was predicted to be drier than Chichi-jima. The daily mean air temperature, specific humidity, wind speed, solar radiation, and potential evaporation on Ani-jima were compared with those on Chichi-jima to examine whether the hydroclimates actually differed. We also investigated the seasonal variation of water balance and soil moisture content, and discuss the hydroclimatic conditions of the subtropical dry scrub of Ani-jima.

RESULTS

Figures 2 and 3 present the daily air temperature, specific humidity, wind speed, and solar radiation, and Table 2 lists the annual values of meteorological parameters in 2007 and 2008. The daily temperature varied in cold periods (January to May and November to December), but was stable at around 25°C in warm periods (June to October). The annual mean temperatures in 2007 and 2008 were 22.0°C and 21.5°C, respectively. The air temperature at Ani-jima was usually lower than that at Chichi-jima (Fig. 2a, 3a), and the lapse rate was 0.85°C per 100 m. The seasonal variation of specific humidity was similar to that of air temperature (Fig. 2b, 3b). The specific humidity was stable at 18–20 gkg^{-1} in warm periods. Annual mean wind speed was 4.2 ms^{-1} in 2007 and 3.6 ms^{-1} in 2008. Although the wind speed was weak at 2–3 ms^{-1} in warm periods, it was relatively strong, at about 5 ms^{-1}, in cold periods (Fig. 2c, 3c). The wind speed at Ani-jima Point was about 1 ms^{-1} stronger throughout the year, but the differences tended to be small in warm periods. The solar radiation was higher in summer, at nearly 30 MJm^{-2}, and lower in winter, at 10 MJm^{-2} (Fig. 2d, 3d). Solar radiation was significantly small in the rainy season from

Table 2 Annual climatological elements for Ani-jima Point in 2007 and 2008

Year	Wind (ms^{-1})	Air temperature (°C)	Precipitation (mm)	Potential evaporation (mm)
2007	4.2	22.0	1508.0 (1132)	1409.2 (1508)
2008	3.6	21.5	1609.3 (1301)	1428.2 (1558)

* Data from Chichi-jima Observatory are shown in parentheses

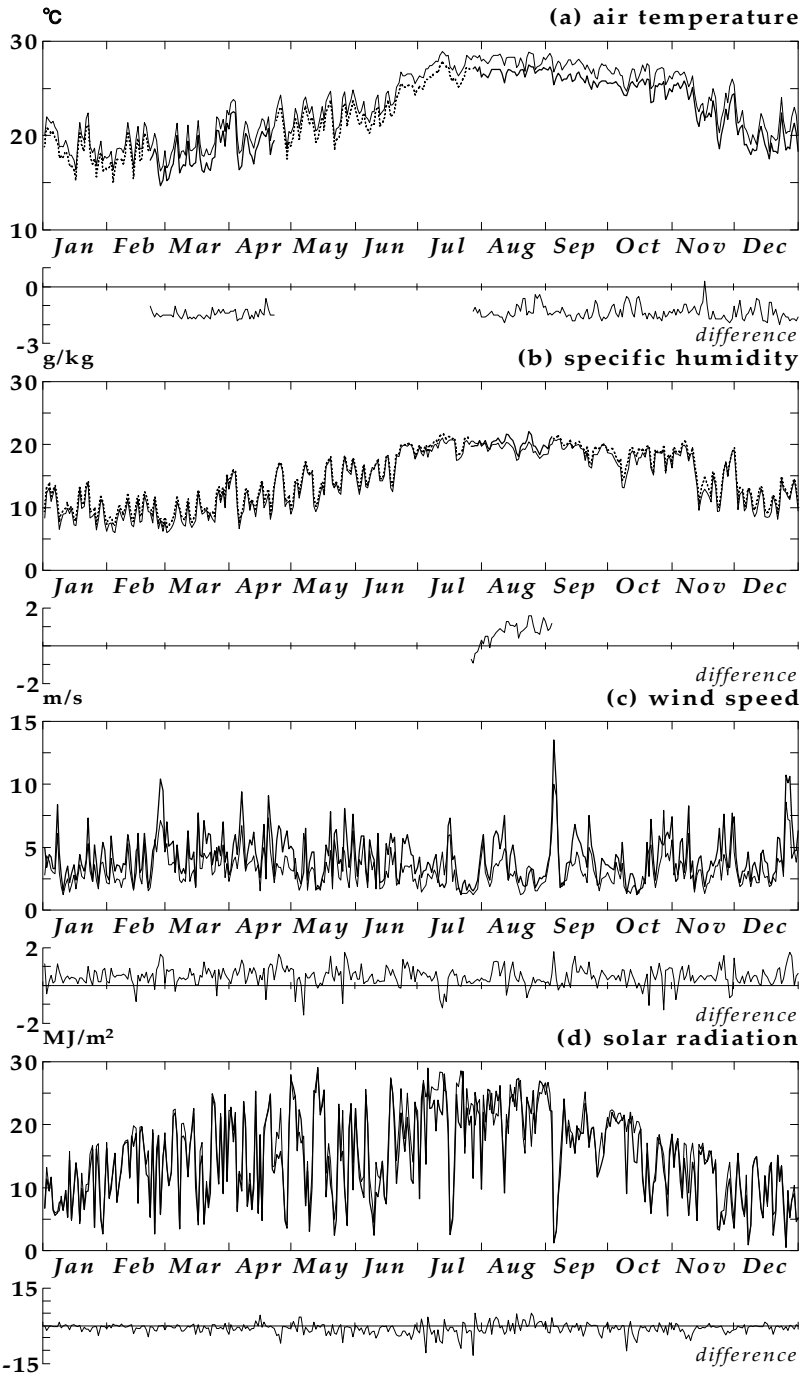

Fig. 2 Daily time series of (a) air temperature, (b) specific humidity, (c) wind speed, and (d) solar radiation, and differences between Ani-jima Point (bold line) and Chichi-jima Observatory (solid line) during 2007. The broken line in (a) and (b) shows the estimated data from Chichi-jima Observatory.

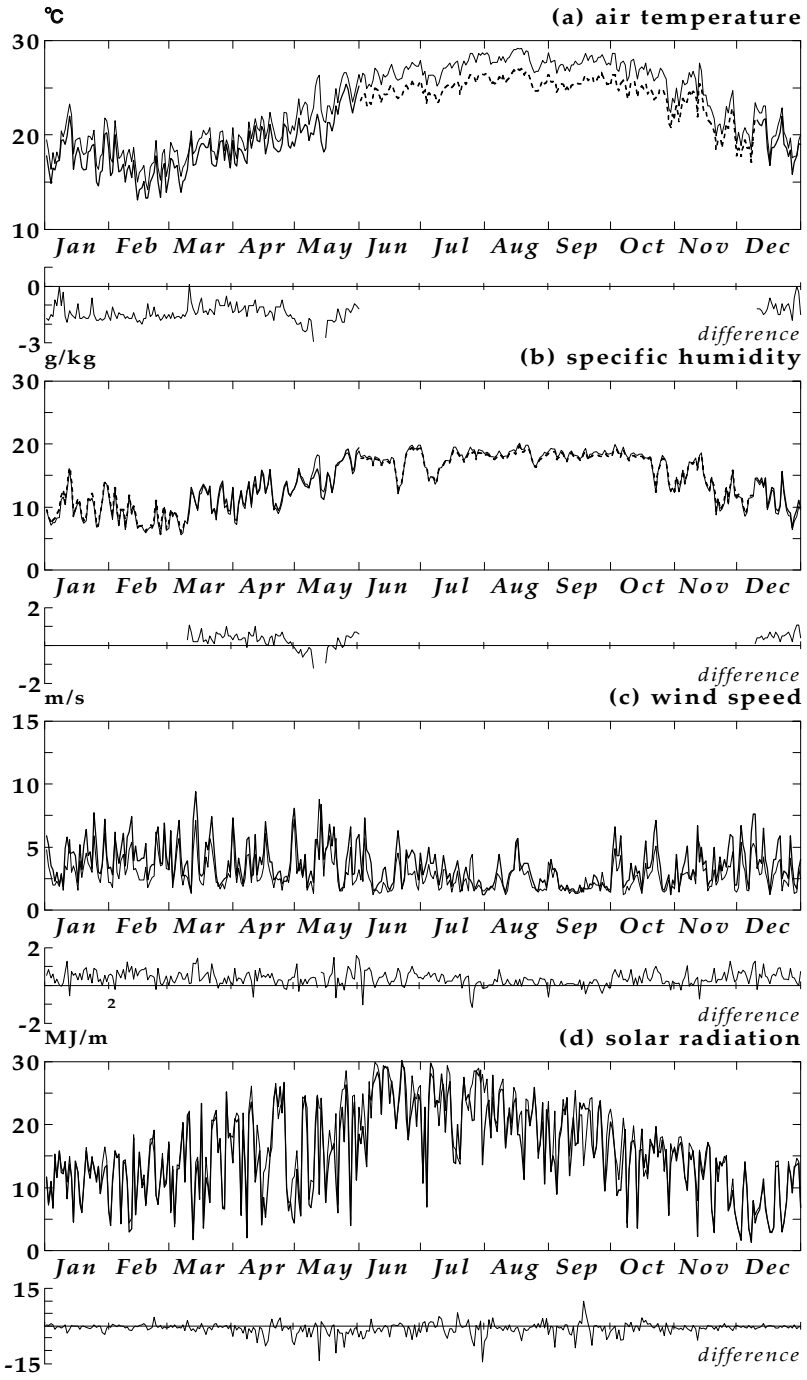

Fig. 3 Daily time series of (a) air temperature, (b) specific humidity, (c) wind speed, and (d) solar radiation, and differences between Ani-jima Point (bold line) and Chichi-jima Observatory (solid line) during 2008. The broken line in (a) and (b) shows the estimated data from Chichi-jima Observatory.

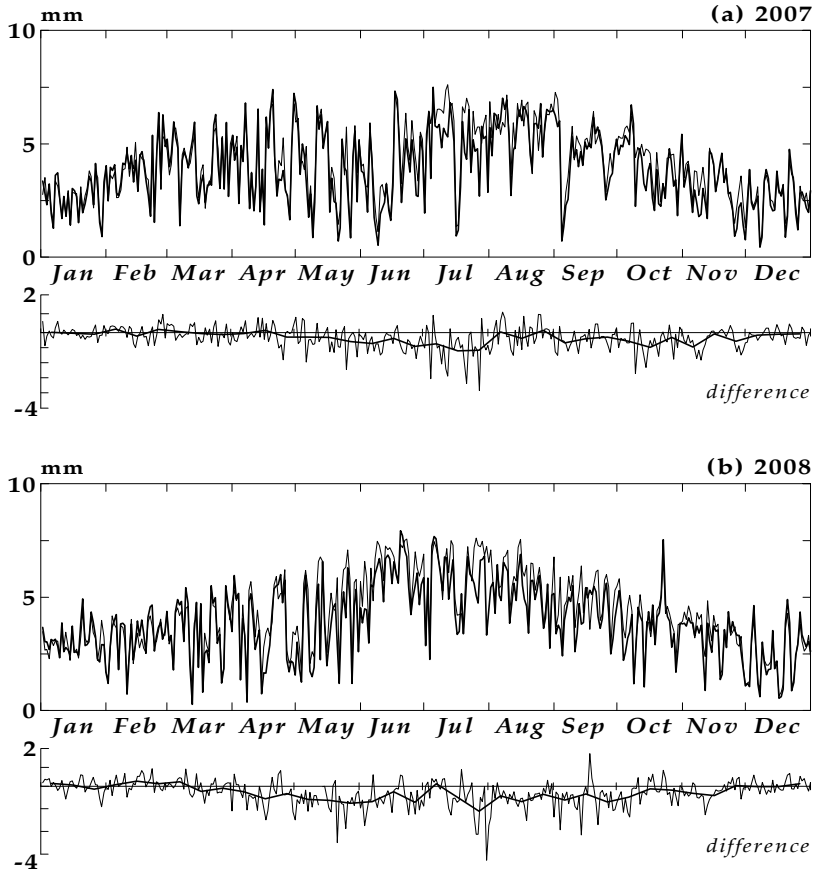

Fig. 4 Time series of daily total potential evaporation and differences between Ani-jima Point (bold line) and Chichi-jima Observatory (solid line) in 2007 and 2008.

March to early June, with large fluctuation. During warm periods, solar radiation at Ani-jima Point was smaller than that at Chichi-jima Observatory.

The annual potential evaporation at Ani-jima was 1409 mm in 2007 and 1428 mm in 2008 (Table 2). Since the RMSEs of the estimates of annual potential evaporation from the predicted relative humidity were significantly small, 14.3 mm (1.0%) in 2007 and 11.2 mm (0.8%) in 2008, these data can be considered to represent the hydroclimatic conditions at Ani-jima. Daily potential evaporation was 2–4 mm in cold periods and increased to 5–7 mm in warm periods (Fig. 4). The daily potential evaporation decreased in the rainy season when there was less solar radiation. The annual potential evaporation at Ani-jima Point was 100–130 mm less than that at Chichi-jima Observatory. Although the daily potential evaporation at the two stations was similar in the cold period, it was 1–2 mm greater at Ani-jima Point than

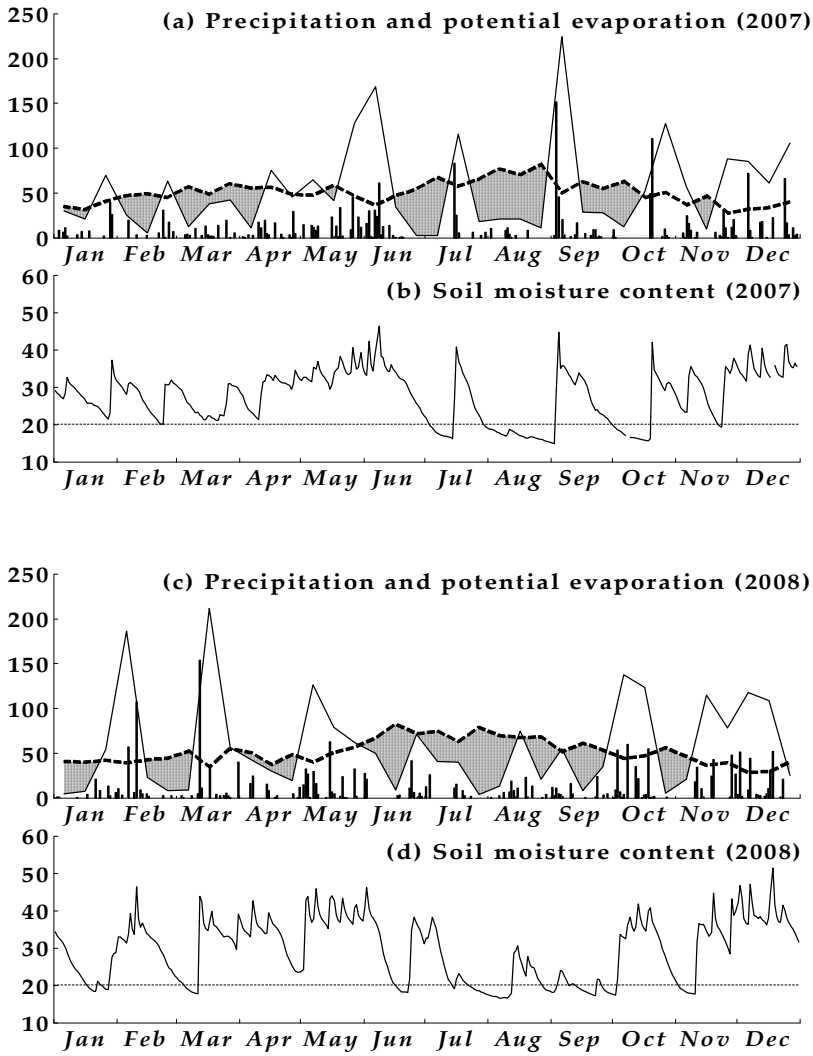

Fig. 5 Daily (bar) and 10-day total of precipitation (solid line), 10-day total of potential evaporation (broken line), and daily averaged soil moisture (at 10 cm depth) at Ani-jima Point during 2007 and 2008. Hatched areas in (a) and (c) denote dry periods (potential evaporation > precipitation). The dotted line in (b) and (d) shows 20% of soil moisture.

at Chichi-jima Observatory (Fig. 4). On the other hand, the annual precipitation at Ani-jima Point was 300–400 mm larger than that recorded at Chichi-jima (Table 2).

Figure 5 shows the seasonal variations of the water balances between precipitation and potential evaporation in 10-day periods and daily soil water content at Ani-jima Point. Precipitation was abundant from March to early June, but much lower in summer (late June to September), just after the rainy season. The 10-day total of potential evaporation greatly exceeded the 10-day total of precipitation in most periods during summer, leading to the development of a severe water deficit at Ani-jima Point. Soil water content decreased in periods when potential evaporation exceeded precipitation. In particular, soil water content strikingly decreased to less than 20% in volume in summer, just after rainy season.

DISCUSSION

The results of this study contradict the prediction of relatively drier hydroclimatic conditions on Ani-jima than on Chichi-jima. Subtropical dry scrub has been characterized as vegetation that establishes under dry hydroclimatic conditions (e.g., Shimizu and Tabata 1991). Although few studies had examined the physical environments of Ani-jima, it was assumed that dry conditions predominated, given the wide distribution of subtropical dry scrub on the island. However, our on-site meteorological observations show that annual precipitation was larger and potential evaporation was smaller at Ani-jima Point than at Chichi-jima Observatory. Consequently, the annual water balance between the potential evaporation and precipitation during the study period indicate water surplus on Ani-jima and water deficit on Chichi-jima. The hydroclimatic conditions of Ani-jima were, therefore, relatively wetter than those of Chichi-jima.

Potential evaporation is related to air temperature, humidity, solar radiation, and wind speed (Xu et al. 2005). During warm periods, the daily potential evaporation on Ani-jima was about 1 mm less than that on Chichi-jima, reflecting lower air temperatures, higher specific humidity, and less solar radiation on Ani-jima. In contrast, during cold periods there was less difference in potential evaporation between the two islands because of higher wind speeds. In general, air temperature and specific humidity depend mainly on altitude. The spatial pattern and seasonal variations in solar radiation and wind speed appear to be caused by the local topography of Ani-jima, although further study is needed.

The subtropical dry scrub on Ani-jima was exposed to severe seasonal drought. The seasonal water deficit between high potential evaporation and low precipitation

led to soil water depletion at Ani-jima Point. In particular, the soil moisture content rapidly decreased to below 20% during the period of water deficit in summer, just after the rainy season. Although the annual water balance was relatively wet, the subtropical dry scrub tree species have physiological characteristics that are adapted to drought (Mishio 1992, Ishida et al. 2008). Moreover, Yoshida et al. (2002) reported that subtropical dry scrub was distributed in areas of extremely low soil water content. Our results, showing seasonal variability of water balance and soil water content, also suggest that the seasonal depletion of soil water during summer drought periods affects the establishment of the subtropical dry scrub on Ani-jima.

Our current hydroclimate research suggests that climate change may pose a serious threat to the terrestrial ecosystems of the Ogasawara Islands in the near future. The hydroclimatic environment during the 20th century tended to be drier (Oka et al. 2001), and continuation of this drying trend could trigger abrupt changes in ecosystems on the Ogasawara (Bonin) Islands (Yoshida and Iijima 2009). In particular, long-term change in the hydroclimatic environment was found to produce longer and drier summer droughts (Yoshida et al. 2006). Thus, recent changes in hydroclimatic environments will probably affect the structure and composition of subtropical dry scrub ecosystems. Unfortunately, at present only limited data are available for predicting how climate change may affect the subtropical dry scrub (Yoshida et al. 2006). Much more research, especially on hydroclimatic conditions, will be needed.

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ABSTRACT IN JAPANESE

兄島の乾性低木林における水文気候条件

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小笠原諸島兄島には固有種を多く含む貴重な乾性低木林が広く分布する．兄島の乾性低木林における水文気候条件について明らかするため，本研究では兄島観測点（180 m a.s.l.）において詳細な気候観測を実施し，そこで得られた2007年と2008年のデータを用いて，ポテンシャル蒸発量を算出した．兄島の年平均気温と年降水量は2007年が22.0℃と1508.0 mm，2008年が21.5℃と1609.3 mmであった．兄島観測点の年降水量は父島気象観測所に比べ，2007年と2008年で376 mmと308 mmそれぞれ多かった．その一方で，兄島のポテンシャル蒸発量は父島気象観測所と比べ100 mm程度小さかった．降水量とポテンシャル蒸発量により算出した水収支は，兄島の方が父島に比べ湿潤であることを示した．降水量とポテンシャル蒸発量の季節変化から，兄島観測点では梅雨明け直後に降水量よりもポテンシャル蒸発量が上回っており，水不足が生じていた．そのため，その期間には土壌水分量が急速に低下して，乾性低木林の構成種は季節的な乾燥環境に晒されていた．これらの結果から，季節的に卓越する水文気候条件の乾燥環境が兄島の乾性低木林の成立に影響すると考えられた．

キーワード：兄島，水文気候条件，ポテンシャル蒸発量，乾性低木林，乾燥

Appendix 1a Monthly climatological elements for Ani-jima Point during 2007.

Month	Wind (ms^{-1})	Temp. (℃)	RH (%)	Precpitation (mm)	E_P (mm)	Soil moisture (%)	Ground temperature (℃)
1	3.8	19.7	-	91.8	81.5	27.6	18.4
2	4.6	18.6	-	70.5	108.5	27.4	19.0
3	4.7	17.8	-	69.5	128.6	25.4	19.7
4	5.3	19.7	-	101.3	124.3	29.2	22.1
5	4.1	22.8	-	183.8	117.4	34.2	24.9
6	4.2	23.7	-	161.0	106.0	33.4	26.4
7	3.1	-	-	104.5	148.2	23.6	31.9
8	3.6	26.8	90.2	37.5	179.6	17.3	32.9
9	4.7	26.0	-	221.8	129.5	28.1	29.4
10	3.8	25.1	-	149.0	122.1	22.8	29.1
11	4.2	23.1	-	119.0	83.9	28.3	24.4
12	4.5	19.4	-	198.5	79.6	35.5	18.8

- : missing data

Appendix 1b Monthly climatological elements for Ani-jima Point during 2008.

Month	Wind (ms^{-1})	Temp. (℃)	RH (%)	Precpitation (mm)	E_P (mm)	Soil moisture (%)	Ground temperature (℃)
1	4.2	17.8	-	48.5	93.7	24.5	18.5
2	4.5	15.6	-	170.0	96.1	32.0	16.4
3	4.2	17.6	-	218.0	107.9	29.8	19.4
4	3.9	19.0	86.0	69.0	105.0	33.0	22.3
5	4.2	21.8	94.4	210.3	113.5	38.5	25.1
6	3.4	-	-	99.8	172.5	29.7	31.6
7	2.8	-	-	63.3	169.3	24.1	32.1
8	2.8	-	-	82.0	160.1	21.2	31.3
9	2.0	-	-	74.0	128.2	19.6	29.9
10	3.4	-	-	209.8	114.2	31.8	26.5
11	3.6	-	-	167.3	93.7	29.9	23.2
12	4.0	-	-	197.5	74.0	39.1	18.6

- : missing data

Appendix 2 Daily averaged data of air temperature, relative humid, wind speed, soil moisture, and ground surface temperature, and daily total data of precipitation.

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
January, 2007						
1	22.9	-	0.0	5.0	29.2	17.9
2	22.1	-	0.0	3.4	28.4	21.8
3	22.7	-	6.75	4.4	28.1	20.6
4	22.1	-	0.0	4.2	27.5	19.6
5	-	-	5.25	3.3	26.9	19.4
6	-	-	8.75	3.3	28.4	19.7
7	21.4	-	1.5	8.4	32.6	16.9
8	18.2	-	0.0	4.5	31.3	15.1
9	17.8	-	0.0	2.8	30.6	17.0
10	18.2	-	0.0	1.5	30.2	18.3
11	18.4	-	0.0	2.9	29.7	19.3
12	17.9	-	3.0	3.5	29.0	18.3
13	18.1	-	0.0	2.2	28.4	18.8
14	20.0	-	5.75	2.9	27.5	16.5
15	19.2	-	0.0	3.6	27.2	15.9
16	18.5	-	0.0	2.4	26.4	16.5
17	19.6	-	0.0	3.0	25.7	18.2
18	20.2	-	6.25	4.4	25.7	19.4
19	19.5	-	0.0	3.6	25.8	18.7
20	19.9	-	0.0	3.1	25.2	17.6
21	22.3	-	0.0	4.0	25.1	21.2
22	23.7	-	0.25	7.3	24.9	21.2
23	19.9	-	0.0	3.9	24.2	19.2
24	20.2	-	0.0	2.3	23.5	20.4
25	19.7	-	1.75	5.2	22.9	16.7
26	17.2	-	0.0	3.8	22.1	17.4
27	18.9	-	0.0	2.1	21.6	19.2
28	19.2	-	31.5	4.0	23.3	18.3
29	16.9	-	20.75	5.4	37.2	16.6
30	18.3	-	0.25	4.8	33.9	15.8
31	19.2	-	0.0	2.8	32.2	17.2

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
February, 2007						
1	20.5	-	0.0	2.4	31.2	16.7
2	21.0	-	0.0	5.9	30.6	17.5
3	18.9	-	0.0	4.1	29.9	17.6
4	19.9	-	0.0	3.1	29.2	18.8
5	21.6	-	0.0	3.6	28.2	18.4
6	19.7	-	15.75	3.5	31.0	17.8
7	20.1	-	0.0	3.0	31.4	18.1
8	19.0	-	0.0	3.7	30.8	18.7
9	19.0	-	0.0	3.6	30.4	19.5
10	21.0	-	2.75	6.0	29.9	21.8
11	19.4	-	0.25	5.1	29.2	18.7
12	17.7	-	0.0	3.0	28.1	20.3
13	17.4	-	0.0	1.7	26.8	19.6
14	19.7	-	0.0	3.0	25.7	21.6
15	19.8	-	2.25	6.1	24.9	19.6
16	17.2	-	0.0	3.0	24.1	20.0
17	17.6	-	0.0	3.3	23.3	22.2
18	19.9	-	0.0	6.1	22.6	22.1
19	19.5	-	0.0	4.3	22.0	22.3
20	18.6	-	0.0	1.8	21.3	21.7
21	17.3	-	4.5	2.6	20.6	18.0
22	17.9	-	0.0	4.7	20.1	19.7
23	18.7	-	24.75	5.2	20.1	17.9
24	17.9	-	0.5	6.3	30.9	18.2
25	15.9	-	0.0	8.3	30.6	17.7
26	14.6	-	14.25	10.4	30.7	14.3
27	15.3	-	0.0	9.5	32.0	14.6
28	16.9	-	5.5	5.0	31.2	18.0

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
March, 2007						
1	15.2	-	0.0	7.0	30.8	14.9
2	15.4	-	0.0	5.1	30.3	16.1
3	16.6	-	0.0	5.3	29.8	18.0
4	17.0	-	0.0	5.5	29.2	20.4
5	18.8	-	0.0	3.0	28.3	22.8
6	19.9	-	3.0	5.2	27.0	22.9
7	15.9	-	3.5	3.3	25.9	16.9
8	16.6	-	2.0	2.9	25.4	19.2
9	16.9	-	0.0	3.3	24.6	19.6
10	16.7	-	0.0	2.9	23.9	20.6
11	19.4	-	8.5	6.3	23.3	19.9
12	16.9	-	0.0	4.1	23.4	18.4
13	16.7	-	0.0	4.0	22.6	19.6
14	17.0	-	2.0	4.6	22.1	21.5
15	17.2	-	0.0	1.9	21.4	19.1
16	20.0	-	11.0	7.7	21.4	19.0
17	17.6	-	3.0	4.4	22.4	18.8
18	16.3	-	1.75	4.2	22.3	17.7
19	16.1	-	1.5	7.1	21.8	15.0
20	17.0	-	1.0	5.3	21.6	17.1
21	16.4	-	0.0	6.1	21.2	15.7
22	16.3	-	11.25	6.0	21.1	16.5
23	17.6	-	0.0	3.6	22.7	20.4
24	17.7	-	0.0	4.7	22.6	21.0
25	20.6	-	0.0	3.9	22.4	22.9
26	20.4	-	15.75	5.1	25.8	21.3
27	19.4	-	0.0	4.3	31.0	21.3
28	20.4	-	0.5	7.0	30.9	21.1
29	19.0	-	0.0	3.8	30.5	24.7
30	21.3	-	4.75	4.6	30.3	22.2
31	20.7	-	0.0	2.8	30.2	24.7

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
April, 2007						
1	22.2	-	0.0	3.2	29.6	27.8
2	22.5	-	0.0	5.3	28.7	26.3
3	22.3	-	1.25	6.0	27.7	26.9
4	18.1	-	0.75	4.4	26.3	19.7
5	16.4	-	0.0	6.0	25.0	19.1
6	16.8	-	2.75	9.4	24.0	17.4
7	18.8	-	0.0	6.8	23.6	24.0
8	20.2	-	2.0	3.3	23.0	23.8
9	19.9	-	0.25	4.4	22.4	20.6
10	18.1	-	0.0	5.6	21.9	21.5
11	17.7	-	14.0	5.2	21.4	19.3
12	17.0	-	9.0	6.2	28.1	17.2
13	18.4	-	0.0	4.5	31.4	20.9
14	19.0	-	15.75	3.6	31.7	19.1
15	19.8	-	3.75	2.6	33.4	23.3
16	20.4	-	3.0	4.6	33.2	20.3
17	20.0	-	0.25	6.8	32.7	20.4
18	20.0	-	0.0	2.5	31.8	23.1
19	20.8	-	13.5	9.1	33.2	21.9
20	18.0	-	0.0	7.1	32.5	23.2
21	19.1	-	0.0	5.6	31.6	21.9
22	19.6	-	3.25	2.7	31.4	22.2
23	21.9	-	0.75	5.6	31.2	24.0
24	23.1	-	0.0	6.7	31.1	25.8
25	23.2	-	0.0	6.4	30.9	26.6
26	22.0	-	3.0	4.6	30.4	25.4
27	19.2	-	0.75	5.7	29.4	18.7
28	17.6	-	23.5	6.3	30.9	17.2
29	19.4	-	3.75	4.9	34.6	20.9
30	19.2	-	0.0	5.1	33.0	23.3

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
May, 2007						
1	20.4	-	0.0	4.8	32.2	26.0
2	22.4	-	0.0	2.5	31.8	28.8
3	22.0	-	11.75	3.0	32.7	24.6
4	21.0	-	0.0	2.5	32.8	24.8
5	22.0	-	0.0	2.1	32.2	26.9
6	23.5	-	0.0	3.0	31.8	26.6
7	24.6	-	11.25	6.5	31.6	24.3
8	22.9	-	9.75	2.4	35.4	24.8
9	22.1	-	7.0	3.8	35.0	21.6
10	22.8	-	10.5	4.6	37.0	22.6
11	21.2	-	0.0	4.6	34.8	23.0
12	20.9	-	0.0	1.8	33.5	25.5
13	21.7	-	0.0	1.7	32.7	27.6
14	22.7	-	0.0	1.9	31.9	28.3
15	23.1	-	0.0	2.6	31.1	30.7
16	22.1	-	0.0	3.1	29.5	30.0
17	23.9	-	18.5	5.2	30.7	23.4
18	24.8	-	1.0	4.3	34.0	25.0
19	25.7	-	11.0	7.8	34.7	24.6
20	22.7	-	1.0	2.7	35.2	23.2
21	19.5	-	27.0	6.1	38.2	19.1
22	20.7	-	1.75	6.4	36.8	20.3
23	21.3	-	0.0	3.7	35.1	22.5
24	22.1	-	0.0	4.0	33.8	21.3
25	23.9	-	0.0	3.1	33.3	25.7
26	25.8	-	7.5	8.1	33.8	24.9
27	23.2	-	36.75	5.4	40.6	22.6
28	23.4	-	0.25	3.4	37.5	25.0
29	23.9	-	0.25	4.6	34.9	26.4
30	25.1	-	18.75	7.6	35.4	24.4
31	24.0	-	9.75	4.2	39.3	26.3

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
June, 2007						
1	23.5	-	0.0	2.7	35.4	24.1
2	22.0	-	0.0	4.7	33.8	22.1
3	22.2	-	13.0	5.9	33.2	22.2
4	23.8	-	24.25	5.9	42.4	23.3
5	21.8	-	1.0	3.4	36.0	25.5
6	21.6	-	0.5	2.3	34.4	25.4
7	20.9	-	24.75	5.6	38.6	21.6
8	22.7	-	19.0	4.4	42.0	22.9
9	22.5	-	49.25	4.0	46.3	22.3
10	23.4	-	2.75	2.0	38.3	24.9
11	24.1	-	10.0	6.1	37.9	24.2
12	21.9	-	0.0	2.2	35.7	23.3
13	22.2	-	0.0	2.3	34.4	24.1
14	22.5	-	11.5	2.5	34.3	22.7
15	24.6	-	0.0	5.3	36.1	24.7
16	-	-	2.0	4.4	34.9	26.4
17	22.0	-	0.75	6.1	34.1	26.6
18	22.2	-	0.0	5.4	33.2	27.3
19	22.6	-	0.5	5.8	32.4	27.0
20	24.1	-	1.25	2.6	32.1	26.1
21	24.5	-	0.5	2.1	32.0	28.9
22	26.1	-	0.0	3.4	31.4	31.5
23	26.0	-	0.0	5.7	30.2	30.4
24	25.9	-	0.0	5.3	29.0	30.0
25	26.1	-	0.0	6.0	27.9	31.0
26	25.9	-	0.0	5.2	26.8	31.0
27	25.8	-	0.0	4.4	25.9	29.5
28	25.2	-	0.0	4.3	25.2	28.7
29	24.9	-	0.0	2.9	24.5	33.1
30	25.6	-	0.0	3.4	23.4	32.0

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
July, 2007						
1	26.1	-	0.0	4.2	22.4	28.4
2	26.5	-	0.0	2.6	21.8	34.7
3	26.2	-	0.0	3.1	20.8	33.6
4	27.0	-	0.0	3.2	19.8	30.1
5	27.3	-	0.0	3.8	19.2	32.9
6	27.8	-	0.0	3.6	18.5	32.1
7	28.0	-	0.0	3.0	18.0	32.0
8	-	-	0.0	4.0	17.6	32.9
9	-	-	0.0	4.4	17.3	31.7
10	-	-	0.0	2.7	17.1	33.4
11	-	-	0.0	1.9	17.0	34.9
12	-	-	0.0	2.1	16.9	34.9
13	-	-	0.0	1.8	16.8	36.9
14	-	-	0.0	2.2	16.6	35.2
15	-	-	0.25	6.7	16.2	30.8
16	-	-	66.75	7.3	26.4	26.2
17	-	-	20.25	4.0	40.8	26.8
18	-	-	4.5	4.3	36.7	27.9
19	-	-	0.0	2.9	35.6	28.7
20	-	-	0.0	1.9	33.9	28.4
21	-	-	0.0	1.2	32.8	30.0
22	-	-	0.0	2.1	31.9	34.8
23	-	-	0.0	2.4	30.1	32.3
24	-	-	0.0	1.6	28.3	35.9
25	-	-	5.25	2.1	26.2	34.0
26	27.8	79.6	0.25	1.7	24.6	31.0
27	27.1	86.2	0.0	1.5	23.4	30.0
28	27.2	85.8	0.25	1.8	22.6	35.1
29	26.8	88.1	2.0	2.4	21.5	35.0
30	27.2	89.4	0.0	3.7	20.3	31.9
31	26.2	91.6	5.0	5.1	19.5	27.0

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
August, 2007						
1	26.5	91.2	0.0	6.0	19.1	29.7
2	26.4	94.4	0.0	3.7	18.9	31.2
3	26.1	90.8	8.5	2.8	18.8	31.2
4	26.6	87.3	0.0	2.4	18.6	33.5
5	27.0	89.8	0.0	3.6	18.4	33.5
6	27.0	91.0	0.0	5.8	18.0	32.7
7	27.0	91.5	0.0	6.3	17.7	33.5
8	26.9	93.5	0.0	6.0	17.4	33.1
9	27.0	90.5	0.0	4.9	17.2	34.3
10	26.4	91.3	6.75	5.7	16.9	32.0
11	25.6	97.9	9.25	7.5	17.5	26.5
12	26.6	96.8	3.25	3.6	18.9	28.9
13	27.0	94.6	0.5	2.4	18.5	29.8
14	26.8	93.1	0.25	4.3	18.2	32.9
15	26.7	92.4	2.0	5.2	17.8	31.2
16	26.7	88.8	0.0	4.2	17.4	32.6
17	26.2	85.7	0.0	2.9	17.2	34.6
18	26.5	82.7	0.0	2.2	16.9	35.8
19	26.8	87.6	0.0	2.7	16.7	35.2
20	26.9	89.1	0.0	2.0	16.5	34.1
21	26.2	93.0	6.75	1.9	16.5	30.7
22	26.8	92.8	0.0	2.0	16.7	30.3
23	27.5	94.3	0.0	2.9	16.7	33.1
24	27.4	93.3	0.0	3.3	16.6	32.9
25	27.2	86.8	0.0	3.2	16.5	35.4
26	26.6	88.8	0.25	1.8	16.3	32.9
27	26.7	86.1	0.0	2.1	16.1	34.5
28	27.0	81.5	0.0	2.6	16.0	35.8
29	26.9	85.0	0.0	2.5	15.8	35.8
30	27.2	86.9	0.0	2.7	15.6	35.6
31	27.2	86.1	0.0	2.7	15.5	35.7

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
September, 2007						
1	26.8	85.7	0.0	3.8	15.2	34.0
2	27.3	89.5	0.0	4.4	15.1	33.8
3	26.8	93.4	2.25	7.5	14.9	32.2
4	25.3	-	121.25	13.5	28.9	25.3
5	26.2	-	36.5	9.8	44.7	26.3
6	26.6	-	0.0	4.6	35.1	27.3
7	26.3	-	16.25	1.8	35.9	28.3
8	25.7	-	3.0	2.2	35.5	29.0
9	26.1	-	0.25	2.0	34.4	29.3
10	26.1	-	0.0	3.7	33.3	29.7
11	26.4	-	1.25	3.8	32.6	30.5
12	26.5	-	0.0	3.8	31.7	30.6
13	25.8	-	2.75	5.5	30.7	28.9
14	25.9	-	13.5	6.8	32.2	27.9
15	26.5	-	0.0	6.0	33.9	28.3
16	26.7	-	0.0	5.6	33.1	29.7
17	26.2	-	0.25	5.3	32.4	30.4
18	25.9	-	3.75	4.3	31.5	28.8
19	25.5	-	0.0	4.2	30.3	31.1
20	26.4	-	0.0	3.4	28.5	33.6
21	25.4	-	2.5	7.5	26.5	27.8
22	24.9	-	7.25	5.1	25.0	29.6
23	25.8	-	7.25	4.4	23.9	27.2
24	25.4	-	0.75	3.5	24.1	26.9
25	25.2	-	1.75	2.0	23.2	25.9
26	25.6	-	1.25	2.1	22.8	27.1
27	25.7	-	0.0	4.1	22.5	28.0
28	25.8	-	0.0	3.9	22.1	29.6
29	25.7	-	0.0	3.6	21.7	32.2
30	25.6	-	0.0	3.6	21.0	32.1

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
October, 2007						
1	25.6	-	0.0	3.4	20.1	32.7
2	25.5	-	7.5	3.3	19.7	29.1
3	25.5	-	0.75	3.2	19.1	30.8
4	25.7	-	0.0	4.4	18.7	30.8
5	25.3	-	0.0	4.1	18.2	31.2
6	25.2	-	0.25	3.1	17.9	32.0
7	24.7	-	0.0	5.4	17.5	30.8
8	24.3	-	0.0	3.4	17.1	31.2
9	24.2	-	0.0	1.3	-	26.5
10	24.8	-	0.0	2.1	16.7	31.3
11	25.5	-	0.0	2.9	16.7	33.0
12	25.7	-	0.0	2.9	16.5	32.0
13	25.4	-	0.0	2.5	16.4	31.1
14	25.1	-	0.0	1.2	16.2	29.6
15	25.7	-	0.0	1.6	16.1	32.0
16	25.9	-	0.0	1.7	16.0	32.1
17	26.0	-	0.0	1.8	15.9	29.6
18	25.4	-	0.0	2.6	15.7	28.3
19	26.0	-	0.0	5.4	15.7	31.2
20	25.9	-	39.5	2.7	16.3	28.6
21	23.5	-	88.75	7.2	42.1	23.6
22	23.7	-	0.0	3.9	34.8	24.2
23	25.3	-	0.0	2.4	33.4	26.5
24	25.3	-	0.0	3.8	32.5	26.8
25	25.5	-	0.0	5.9	31.5	28.3
26	25.4	-	1.25	5.3	30.3	27.9
27	25.7	-	7.75	5.2	29.1	27.7
28	23.8	-	2.5	5.9	31.1	24.3
29	24.3	-	0.75	6.2	31.3	24.5
30	25.0	-	0.0	5.7	30.9	26.5
31	24.6	-	0.0	7.4	29.8	27.9

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
November, 2007						
1	25.4	-	0.0	3.5	28.5	28.8
2	25.3	-	0.0	2.3	27.3	29.3
3	25.6	-	0.0	2.5	25.9	30.1
4	25.0	-	0.0	5.4	24.6	28.3
5	25.2	-	4.5	5.7	23.9	26.6
6	25.8	-	0.5	3.0	23.4	27.6
7	25.2	-	19.75	4.2	23.4	26.7
8	23.8	-	12.75	8.3	33.1	24.2
9	24.3	-	6.75	3.0	35.6	25.6
10	25.1	-	0.0	3.9	34.2	25.8
11	23.5	-	0.5	1.7	33.1	25.3
12	21.5	-	5.25	3.4	32.9	21.7
13	21.0	-	0.0	4.1	32.0	20.0
14	22.3	-	0.0	4.3	31.0	22.3
15	22.6	-	0.0	2.9	29.8	24.3
16	21.9	-	0.0	1.9	28.2	23.5
17	22.0	-	0.0	3.0	26.3	23.9
18	22.3	-	0.0	3.2	24.8	25.4
19	21.9	-	0.0	3.9	23.4	24.9
20	23.8	-	0.0	3.5	22.2	25.7
21	22.3	-	5.25	4.0	21.3	23.1
22	19.6	-	0.0	4.8	20.3	18.2
23	18.6	-	2.0	6.5	19.6	17.2
24	20.1	-	1.0	3.9	19.3	20.1
25	21.3	-	25.25	7.6	27.9	21.8
26	22.8	-	9.25	4.6	35.5	23.3
27	21.8	-	0.5	3.4	34.7	23.3
28	23.4	-	0.0	3.4	33.7	24.3
29	24.3	-	9.5	6.7	35.0	24.5
30	24.4	-	16.25	7.4	37.7	24.7

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
December, 2007						
1	21.3	-	2.0	4.2	36.8	23.2
2	20.1	-	0.0	2.9	35.0	20.1
3	20.9	-	0.0	2.2	33.9	20.1
4	21.0	-	0.0	3.1	33.4	21.1
5	19.0	-	0.0	3.1	32.7	18.5
6	19.1	-	0.0	3.5	31.7	19.2
7	18.6	-	57.75	4.6	38.9	18.9
8	18.0	-	6.75	2.3	41.3	18.7
9	18.6	-	0.5	3.5	38.1	18.2
10	18.5	-	0.0	3.8	35.1	17.3
11	18.5	-	0.0	3.2	33.8	17.7
12	20.3	-	0.0	2.4	33.1	18.9
13	20.9	-	14.25	4.4	32.6	20.2
14	20.0	-	14.75	4.8	40.4	19.1
15	19.1	-	0.0	3.9	35.8	17.3
16	18.4	-	0.5	3.7	34.2	16.2
17	17.5	-	0.0	2.3	33.4	16.9
18	19.2	-	0.0	2.1	32.6	18.1
19	18.3	-	18.25	2.8	-	18.3
20	18.3	-	0.0	3.1	35.9	17.7
21	18.0	-	0.0	5.8	34.4	16.3
22	19.8	-	0.0	5.7	33.4	18.1
23	22.3	-	0.0	4.1	33.1	22.5
24	20.3	-	0.0	3.4	32.7	21.3
25	18.5	-	53.25	10.7	41.0	18.1
26	18.8	-	13.75	10.1	41.6	18.6
27	18.6	-	2.75	10.6	36.9	17.6
28	20.2	-	0.0	7.2	35.6	19.0
29	21.2	-	8.75	4.7	35.2	20.5
30	20.3	-	2.0	4.7	36.4	19.2
31	18.2	-	3.25	6.3	35.6	16.6

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
January, 2008						
1	17.8	-	0.25	5.9	34.3	16.6
2	16.5	-	1.0	5.2	33.4	15.2
3	14.9	-	1.0	3.5	32.7	14.4
4	16.5	-	0.0	3.2	32.0	15.2
5	16.3	-	0.0	2.3	31.3	16.5
6	17.2	-	0.0	3.0	30.3	17.3
7	17.3	-	0.0	2.0	28.8	17.3
8	19.4	-	0.0	2.8	27.5	19.8
9	19.5	-	0.0	1.9	26.4	20.0
10	19.0	-	0.0	4.9	25.3	20.5
11	19.9	-	0.0	5.8	24.3	20.9
12	22.1	-	0.75	4.5	23.8	24.1
13	20.5	-	0.0	4.5	23.2	22.4
14	16.3	-	0.0	4.6	22.1	17.8
15	17.7	-	0.0	4.3	21.3	20.5
16	18.7	-	0.0	2.2	20.6	21.4
17	18.0	-	3.5	5.2	20.0	17.8
18	16.6	-	0.0	3.2	19.3	16.2
19	16.4	-	0.0	5.1	18.8	16.6
20	16.4	-	0.0	6.4	18.4	18.2
21	18.3	-	16.75	4.3	18.6	19.6
22	18.3	-	0.25	4.6	21.2	18.7
23	18.9	-	6.5	3.3	20.3	18.5
24	18.9	-	0.0	7.7	20.0	18.0
25	14.9	-	0.0	5.2	19.4	15.4
26	14.6	-	0.0	3.0	19.0	16.4
27	16.1	-	11.0	2.9	19.0	17.6
28	16.2	-	2.25	3.6	23.3	18.0
29	20.1	-	0.25	7.2	27.6	20.4
30	20.2	-	0.0	4.3	28.7	21.9
31	18.5	-	5.0	3.3	28.8	19.6

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
February, 2008						
1	15.8		8.25	3.4	33.0	16.7
2	16.0		0.0	2.8	33.1	16.4
3	20.0		3.0	5.8	32.5	19.7
4	17.8		0.0	4.6	32.2	18.5
5	16.1		0.0	3.7	31.3	17.1
6	16.3		46.0	4.7	33.7	15.5
7	16.8		0.25	6.1	39.3	17.7
8	15.1		0.0	3.5	35.1	15.9
9	16.3		5.0	5.8	33.7	15.6
10	16.8		85.75	6.2	46.4	17.3
11	15.5		0.25	7.4	37.8	14.7
12	17.4		7.25	3.9	35.5	18.0
13	14.9		3.75	5.1	36.7	14.8
14	13.1		0.25	3.9	35.0	13.8
15	14.2		3.75	3.9	33.9	14.7
16	14.4		1.5	4.1	33.6	14.0
17	15.0		0.0	4.1	32.9	13.9
18	13.2		0.0	5.3	32.3	12.3
19	13.3		0.0	2.4	31.8	14.0
20	14.9		0.0	3.4	31.3	17.2
21	15.5		0.0	3.6	30.6	17.9
22	16.0		0.0	3.6	29.5	19.2
23	17.8		2.25	5.8	28.2	18.5
24	15.0		0.25	6.6	27.1	15.5
25	13.5		0.0	3.7	25.7	15.7
26	16.3		0.0	3.7	24.8	18.7
27	16.9		2.5	6.9	24.1	17.9
28	13.9		0.0	4.3	23.3	15.1
29	15.5		0.0	3.2	22.6	19.1

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
March, 2008						
1	17.5	-	0.0	6.3	21.9	18.1
2	17.4	-	0.0	2.3	21.4	20.7
3	16.5	-	2.25	3.2	20.8	16.5
4	16.8	-	0.5	5.8	20.3	17.6
5	15.1	-	0.25	7.1	19.6	16.6
6	13.9	-	0.0	4.2	19.1	18.2
7	15.1	-	0.0	2.7	18.7	21.1
8	15.2	-	2.5	3.5	18.3	16.4
9	16.3	59.9	0.0	3.9	18.1	20.4
10	18.6	64.3	0.0	2.1	18.0	22.9
11	19.6	85.6	4.0	1.6	17.8	22.1
12	16.8	99.5	123.0	7.1	43.8	17.3
13	16.9	87.1	8.75	9.4	42.4	17.3
14	17.8	72.8	0.0	7.1	36.7	16.6
15	18.8	87.8	0.0	2.9	35.3	18.4
16	19.1	89.3	0.0	2.7	34.7	21.6
17	19.1	96.4	29.5	2.9	37.5	19.1
18	18.7	93.5	0.25	5.4	39.7	20.3
19	18.8	86.2	0.0	4.8	36.3	19.0
20	19.5	87.0	3.5	6.0	35.7	18.6
21	17.0	72.3	0.0	7.4	35.1	17.6
22	16.7	81.0	2.0	4.6	34.3	19.6
23	16.7	65.7	0.0	2.8	33.7	21.1
24	18.1	81.1	2.25	1.9	33.0	20.8
25	19.4	88.6	4.5	2.0	33.3	22.2
26	19.3	98.0	2.0	2.3	33.2	21.0
27	17.3	79.8	0.75	2.5	32.9	17.8
28	19.0	71.9	0.0	2.6	32.3	21.1
29	17.7	70.0	0.0	3.9	31.2	21.0
30	16.6	70.9	0.0	3.0	29.7	20.7
31	19.5	88.7	32.0	7.3	39.1	19.8

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
April, 2008						
1	17.0	60.7	0.0	5.3	37.6	18.1
2	16.8	59.3	0.0	2.7	35.5	19.1
3	18.7	73.3	0.0	4.1	34.6	21.3
4	18.4	92.1	0.0	2.9	34.3	20.1
5	18.0	79.0	0.0	2.1	33.8	23.5
6	17.3	79.7	13.0	3.3	33.0	21.4
7	17.1	99.7	19.5	5.6	42.6	17.4
8	20.4	88.7	0.0	5.8	39.2	21.8
9	18.5	74.1	0.0	2.7	36.7	22.1
10	19.7	88.2	0.0	2.8	35.7	23.5
11	21.0	89.3	0.25	6.0	35.2	22.1
12	19.4	86.0	0.0	2.8	34.5	22.6
13	19.3	91.6	0.0	4.2	33.9	23.1
14	21.0	99.8	12.5	3.6	34.1	21.4
15	20.3	98.1	7.0	4.5	39.5	22.4
16	18.0	94.5	0.0	7.0	37.5	18.8
17	19.2	98.3	0.0	4.9	36.4	20.8
18	21.2	97.6	0.5	3.8	35.9	22.9
19	19.8	84.7	2.25	3.8	35.4	22.4
20	18.7	69.6	0.0	2.4	34.3	23.5
21	18.5	76.0	0.0	2.6	33.4	25.8
22	18.1	74.8	0.0	3.0	31.8	25.3
23	18.3	79.5	0.0	3.1	30.0	27.5
24	19.1	83.8	0.0	2.1	28.2	26.3
25	21.2	85.2	0.0	2.3	26.8	29.1
26	20.8	94.5	0.0	2.3	25.5	25.0
27	18.8	94.4	3.75	2.8	24.7	21.0
28	18.6	91.8	0.25	3.8	23.9	20.0
29	19.3	95.7	0.5	6.9	23.5	20.2
30	18.9	99.2	9.5	8.1	23.5	19.5

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
May, 2008						
1	20.1	100.0	0.0	5.2	23.9	22.4
2	21.8	98.7	12.0	3.1	24.3	23.2
3	20.2	98.2	26.0	4.0	42.8	21.5
4	20.6	92.6	21.25	2.7	43.9	25.2
5	21.1	86.7	0.5	4.4	38.7	24.3
6	20.9	90.8	0.0	1.8	37.0	25.4
7	19.4	95.2	23.75	2.6	37.7	21.4
8	20.2	100.0	13.0	3.1	45.9	21.9
9	20.0	99.4	3.5	2.2	41.2	23.5
10	21.1	95.7	0.25	5.6	39.0	25.3
11	22.2	92.0	0.0	5.6	37.7	28.1
12	21.3	98.3	0.0	4.0	37.0	25.9
13	19.2	84.0	0.75	8.4	36.2	26.4
14	18.3	90.1	0.25	4.0	35.3	24.9
15	18.5	98.0	50.0	4.7	43.2	21.7
16	21.4	96.9	5.5	5.1	44.0	23.4
17	21.4	93.5	3.75	6.8	42.7	23.2
18	20.4	83.6	0.0	5.1	38.8	22.6
19	21.4	88.6	0.0	6.6	37.4	22.6
20	23.0	94.0	1.5	4.4	36.9	24.3
21	22.2	99.9	19.25	3.1	43.4	24.1
22	23.5	97.0	0.5	1.5	40.7	27.2
23	24.2	97.8	0.75	1.8	39.0	29.1
24	24.8	94.7	0.25	1.8	38.0	27.9
25	25.4	91.2	0.0	3.9	37.1	30.6
26	24.8	96.1	0.0	4.8	36.4	30.5
27	23.3	98.1	25.75	6.6	40.9	24.4
28	22.3	92.8	1.5	2.8	41.6	26.6
29	23.3	90.2	0.25	2.9	38.8	26.5
30	24.3	97.2	0.0	5.6	37.8	26.1
31	25.1	95.5	0.0	6.0	37.3	28.9

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
June, 2008						
1	-	-	21.75	3.8	40.8	29.2
2	-	-	17.0	2.3	46.2	27.9
3	-	-	0.0	7.3	40.4	26.0
4	-	-	0.0	4.8	38.8	26.2
5	-	-	0.0	4.4	38.0	30.0
6	-	-	0.0	3.7	37.3	31.8
7	-	-	0.0	1.6	36.2	33.5
8	-	-	0.0	1.5	34.3	34.2
9	-	-	0.0	2.0	31.7	34.9
10	-	-	0.0	2.2	29.1	35.1
11	-	-	0.0	2.3	26.9	31.9
12	-	-	0.0	3.2	25.0	34.0
13	-	-	0.0	3.4	23.3	34.9
14	-	-	0.0	1.9	21.8	35.9
15	-	-	0.0	1.6	20.7	35.4
16	-	-	0.0	2.0	19.9	35.6
17	-	-	2.5	2.2	19.4	35.6
18	-	-	3.0	4.7	18.8	29.7
19	-	-	0.0	6.3	18.3	28.0
20	-	-	0.0	4.9	18.3	32.2
21	-	-	0.0	1.7	18.2	35.1
22	-	-	0.0	2.4	18.1	35.1
23	-	-	9.25	4.8	21.9	27.9
24	-	-	33.5	4.1	34.9	27.2
25	-	-	5.25	4.4	38.4	27.9
26	-	-	0.0	4.8	37.1	29.1
27	-	-	1.25	4.4	35.9	30.6
28	-	-	4.5	3.2	35.0	29.1
29	-	-	1.5	2.4	33.5	30.8
30	-	-	0.25	4.5	31.2	31.9

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
July, 2008						
1	-	-	10.25	2.8	32.6	27.6
2	-	-	0.0	3.3	32.7	28.4
3	-	-	21.0	3.9	34.8	24.8
4	-	-	0.0	5.0	38.4	26.6
5	-	-	0.0	3.7	36.8	30.9
6	-	-	0.0	3.7	35.3	33.2
7	-	-	0.0	4.4	32.5	31.2
8	-	-	0.0	3.1	29.4	32.3
9	-	-	0.0	2.0	27.2	32.7
10	-	-	0.0	3.0	25.3	35.4
11	-	-	0.25	4.3	23.3	34.3
12	-	-	0.0	3.4	21.7	32.2
13	-	-	0.0	2.5	20.6	35.1
14	-	-	0.0	2.9	19.8	36.0
15	-	-	8.75	1.9	19.2	29.5
16	-	-	12.5	2.9	21.7	28.1
17	-	-	0.0	3.3	23.2	28.2
18	-	-	0.0	3.9	22.3	30.3
19	-	-	6.75	2.6	21.5	28.2
20	-	-	2.25	1.5	21.0	28.7
21	-	-	0.0	2.8	20.6	31.2
22	-	-	0.0	3.4	20.1	33.8
23	-	-	1.5	2.5	19.7	34.0
24	-	-	0.0	2.4	19.3	33.8
25	-	-	0.0	2.1	18.9	33.2
26	-	-	0.0	1.5	18.7	33.9
27	-	-	0.0	1.9	18.6	37.5
28	-	-	0.0	2.4	18.4	38.0
29	-	-	0.0	2.2	18.1	38.9
30	-	-	0.0	1.2	17.7	32.1
31	-	-	0.0	1.2	17.6	34.6

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
August, 2008						
1	-	-	0.0	1.6	17.5	35.7
2	-	-	0.5	1.7	17.3	35.8
3	-	-	0.25	1.9	17.1	33.2
4	-	-	0.0	1.9	17.1	36.7
5	-	-	0.0	2.3	16.9	33.9
6	-	-	2.5	3.3	16.6	29.9
7	-	-	0.0	4.4	16.6	33.6
8	-	-	5.0	3.3	16.7	35.8
9	-	-	0.25	2.0	16.7	32.1
10	-	-	0.25	1.4	16.6	28.8
11	-	-	5.75	2.2	17.3	29.7
12	-	-	15.25	2.9	18.0	29.3
13	-	-	7.0	3.1	28.6	27.9
14	-	-	1.25	3.2	29.2	29.1
15	-	-	9.25	5.4	30.7	28.5
16	-	-	0.25	5.7	27.7	29.4
17	-	-	0.0	3.8	25.6	31.9
18	-	-	0.0	3.3	23.9	31.4
19	-	-	18.5	3.7	22.5	30.0
20	-	-	1.0	3.7	27.8	29.9
21	-	-	0.0	3.7	25.5	31.5
22	-	-	11.0	3.1	25.0	30.5
23	-	-	0.0	2.4	24.7	28.8
24	-	-	0.0	2.0	23.2	31.7
25	-	-	0.0	1.6	21.9	31.2
26	-	-	0.0	1.6	20.8	30.6
27	-	-	0.75	2.5	20.0	30.1
28	-	-	0.0	2.2	19.4	33.0
29	-	-	3.25	2.4	18.8	27.8
30	-	-	0.0	1.8	18.7	31.5
31	-	-	0.0	2.6	18.4	32.2

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
September, 2008						
1	-	-	9.5	4.0	18.2	27.6
2	-	-	2.0	3.2	18.4	27.9
3	-	-	9.0	3.3	19.3	27.9
4	-	-	4.0	3.0	21.8	25.4
5	-	-	3.5	1.7	24.1	27.8
6	-	-	1.5	2.0	23.7	29.3
7	-	-	0.0	1.8	22.5	30.3
8	-	-	0.0	1.6	21.2	30.8
9	-	-	0.0	2.0	20.1	33.1
10	-	-	13.0	1.5	20.2	27.8
11	-	-	3.75	1.7	20.5	28.3
12	-	-	0.0	1.7	20.2	29.3
13	-	-	0.0	1.4	19.7	29.3
14	-	-	0.0	1.4	19.3	30.0
15	-	-	0.0	2.0	19.0	32.2
16	-	-	0.0	1.4	18.7	32.8
17	-	-	0.75	1.8	18.4	33.8
18	-	-	0.25	1.7	18.2	32.8
19	-	-	0.0	1.7	18.0	32.9
20	-	-	0.0	2.1	17.8	33.9
21	-	-	0.0	2.0	17.5	31.8
22	-	-	1.25	2.8	17.2	28.6
23	-	-	19.0	2.6	21.7	28.4
24	-	-	0.0	2.2	21.7	29.8
25	-	-	0.0	1.5	20.4	31.7
26	-	-	2.75	2.2	19.2	28.4
27	-	-	0.0	1.8	18.5	27.7
28	-	-	3.75	1.9	18.2	27.9
29	-	-	0.0	1.5	18.0	28.8
30	-	-	0.0	1.4	17.9	31.1

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
October, 2008						
1	-	-	0.75	4.4	17.6	29.8
2	-	-	7.25	6.6	17.4	28.5
3	-	-	43.0	4.3	21.6	27.2
4	-	-	5.75	4.3	33.7	26.6
5	-	-	0.75	5.9	33.2	26.5
6	-	-	3.5	1.8	32.8	28.6
7	-	-	0.25	2.0	32.5	28.7
8	-	-	47.75	2.3	36.2	25.2
9	-	-	0.0	2.4	38.3	25.8
10	-	-	0.0	3.7	35.7	27.1
11	-	-	0.0	2.4	34.5	27.6
12	-	-	28.25	3.5	35.6	27.1
13	-	-	17.75	2.9	41.8	25.2
14	-	-	0.0	3.1	38.2	26.6
15	-	-	0.5	1.6	36.2	27.9
16	-	-	2.75	3.8	35.3	27.2
17	-	-	3.25	5.5	34.6	26.7
18	-	-	44.0	3.3	40.0	26.3
19	-	-	0.5	3.4	40.8	26.9
20	-	-	1.0	4.0	37.2	26.2
21	-	-	1.5	6.1	35.9	24.4
22	-	-	0.0	7.1	34.4	23.6
23	-	-	0.0	4.7	33.3	25.7
24	-	-	0.0	3.4	31.8	27.3
25	-	-	0.0	1.7	29.9	28.5
26	-	-	0.0	1.6	28.0	27.9
27	-	-	1.0	2.1	26.6	27.2
28	-	-	0.25	2.8	25.3	23.3
29	-	-	0.0	1.2	24.1	23.4
30	-	-	0.0	2.4	22.9	24.9
31	-	-	0.0	2.0	21.7	24.8

- : no data

Appendix 2 continued

Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
November, 2008						
1	-	-	0.0	4.4	20.7	25.5
2	-	-	0.0	1.7	19.9	25.1
3	-	-	0.0	2.4	19.1	25.3
4	-	-	0.25	3.3	18.8	26.6
5	-	-	0.0	3.8	18.4	26.0
6	-	-	0.25	5.1	18.2	25.2
7	-	-	0.0	2.5	18.0	27.2
8	-	-	0.0	2.7	17.9	27.3
9	-	-	0.0	3.2	17.8	27.4
10	-	-	14.75	2.7	17.8	25.6
11	-	-	27.75	6.7	31.6	22.6
12	-	-	0.0	3.8	36.6	25.8
13	-	-	8.25	5.0	36.2	25.6
14	-	-	1.0	3.6	36.4	24.4
15	-	-	0.0	3.9	35.3	23.7
16	-	-	0.0	1.9	34.3	23.0
17	-	-	0.0	2.3	33.2	22.3
18	-	-	19.5	2.4	34.2	22.3
19	-	-	34.5	5.0	44.7	20.3
20	-	-	0.0	2.3	37.9	19.3
21	-	-	0.0	3.0	36.0	20.2
22	-	-	0.0	4.2	34.9	19.4
23	-	-	0.0	3.1	33.9	19.0
24	-	-	0.0	4.0	32.9	20.0
25	-	-	0.0	3.4	31.7	22.1
26	-	-	0.0	4.9	30.0	21.0
27	-	-	1.25	6.0	28.4	21.5
28	-	-	38.25	5.8	43.3	23.2
29	-	-	0.0	2.0	38.8	20.8
30	-	-	21.5	2.0	39.8	19.2

- : no data

Appendix 2 continued

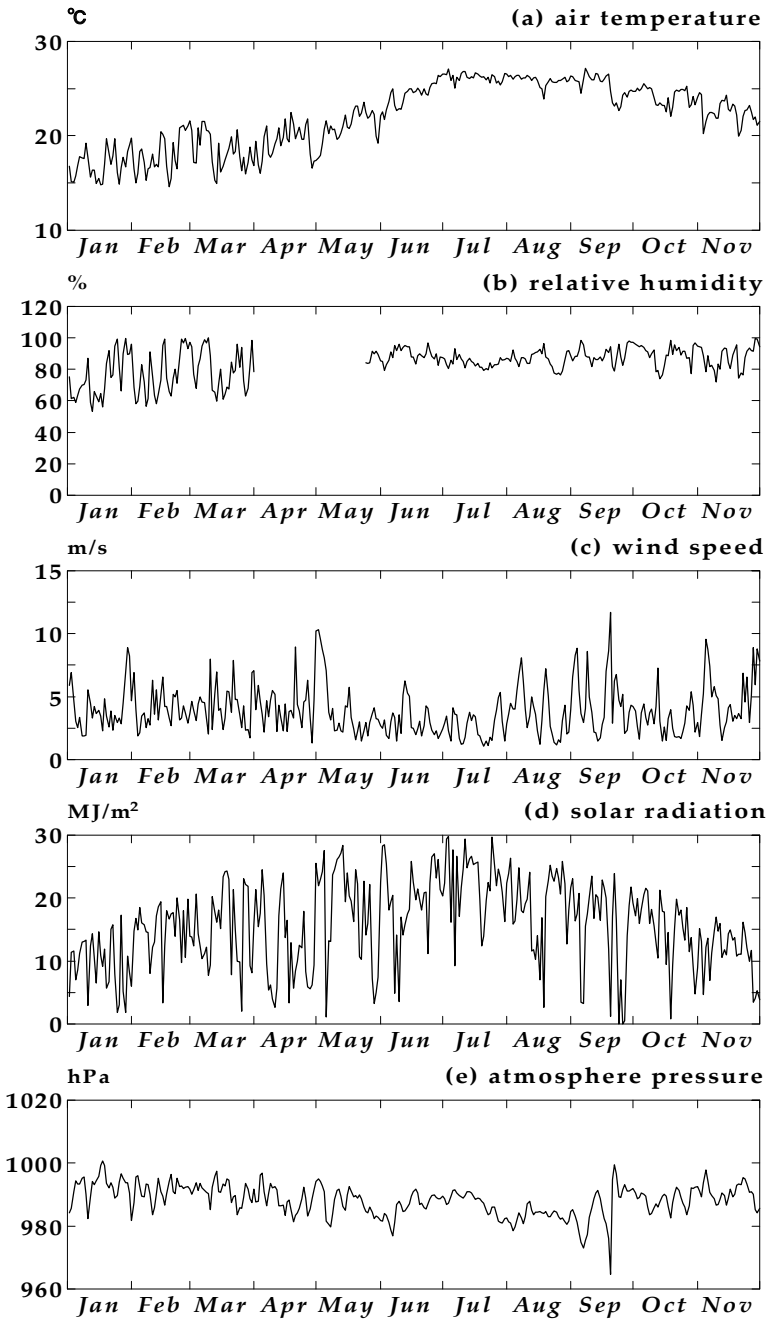
Day	Temp. (℃)	RH (%)	Precpitation (mm)	Wind (ms^{-1})	Soil moisture (%)	Ground temp. (℃)
December, 2008						
1	-	-	3.25	3.3	42.1	18.8
2	-	-	41.25	6.7	46.7	17.7
3	-	-	1.75	5.2	43.4	17.8
4	-	-	0.0	4.5	38.0	17.6
5	-	-	0.0	2.5	36.6	17.8
6	-	-	7.25	1.7	36.3	18.5
7	-	-	35.75	6.2	47.1	17.6
8	-	-	0.25	7.6	42.4	19.0
9	-	-	0.25	7.6	38.8	21.0
10	21.5	93.2	3.25	3.3	38.4	21.6
11	21.0	90.6	2.75	4.0	37.9	21.0
12	21.0	95.6	2.0	3.7	38.5	21.8
13	21.7	84.7	0.25	6.5	37.7	20.6
14	21.7	92.3	1.5	4.0	37.1	21.6
15	18.5	74.3	4.0	3.3	36.3	18.3
16	16.8	90.9	8.5	1.4	37.9	17.6
17	18.7	98.1	25.0	2.9	44.4	18.8
18	18.8	96.6	42.0	4.0	51.4	19.2
19	19.0	71.0	0.0	4.0	41.7	17.8
20	19.6	65.3	0.0	5.6	38.4	17.2
21	20.3	71.2	0.0	5.9	37.1	18.2
22	22.0	97.7	1.0	2.5	36.9	21.2
23	19.0	94.0	17.0	3.1	41.6	19.6
24	18.6	73.9	0.0	2.9	40.2	18.2
25	17.7	70.9	0.0	2.5	38.1	17.1
26	18.3	67.2	0.0	5.9	36.9	16.6
27	15.9	58.7	0.0	3.5	35.8	15.3
28	17.1	63.9	0.0	2.1	35.0	16.6
29	17.8	68.5	0.0	1.7	34.1	17.3
30	19.1	75.4	0.25	3.3	32.9	18.3
31	18.5	74.6	0.25	4.0	31.6	18.3

- : no data

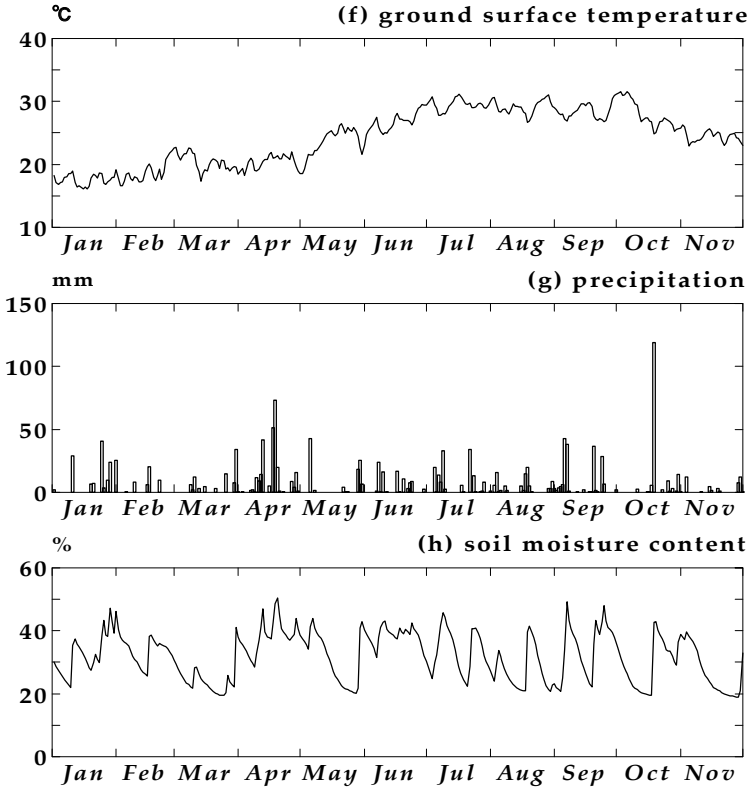
Appendix 3 Monthly climatological elements for Ani-jima Point from January to November 2009.

Month	Wind (ms^{-1})	Temp. (℃)	RH (%)	Precpitation (mm)	Soil moisture (%)	Ground temperature (℃)
1	4.1	17.0	74.5	149.0	32.7	17.5
2	4.0	18.0	76.8	45.8	33.6	18.7
3	4.3	18.3	79.6	89.5	24.5	20.3
4	4.3	19.3	-	262.0	38.4	20.3
5	3.9	21.1	-	100.3	31.1	23.7
6	3.0	24.4	89.2	93.5	38.2	26.8
7	2.6	26.2	84.2	143.5	33.5	29.5
8	3.7	25.9	86.1	96.5	27.2	29.1
9	4.8	25.2	89.3	177.5	34.8	28.4
10	3.2	24.2	89.5	161.0	29.3	27.9
11	5.0	22.4	87.3	44.5	26.5	24.4

- : missing data



Appendix 4a Daily time series of (a) air temperature, (b) relative humidity, (c) wind speed, (d) solar radiation, and (e) atmosphere pressure at Ani-jima Point from January to November 2009.



Appendix 4b Daily time series of (f) ground surface temperature, (g) precipitation, and (c) soil moisture content at Ani-jima Point from January to November 2009.