Pedology

Soil Temperature Regimes from Different Latitudes on a Subtropical Island (Tenerife, Spain)

M. Rodríguez
J. Neris
M. Tejedor
C. Jiménez*
Dep. Edafología y Geología
Facultad de Biología
Avda. Astrofísico Francisco Sánchez s/n
Univ. de La Laguna
38206 La Laguna, Tenerife (Canary Islands, Spain)

We studied the soil temperature regimes of the volcanic island of Tenerife (Canary Islands, Spain), which is situated in the Atlantic Ocean between 27 and 28° N. The island is 2034 km^2 in size and its highest point is 3718 m above sea level. Direct temperature measurements were taken during a 4-yr period at 103 sites, at a depth of 50 cm, in altitudinal sequences from the north and south slopes of the island. In contrast to continental situations, soil temperature regimes from all latitudes are found within a small area of the island. Seven of the nine regimes considered by Soil Taxonomy have been identified—hyperthermic, thermic, mesic, isohyperthermic, isothermic, isomesic, and cryic—and are widely distributed according to elevation and orientation. In the mid-altitude zone on the north face, which is influenced by the trade winds, regimes typical of tropical regions were found, while above 3000-m elevation, a high-latitude regime was also described. The wide diversity of soil temperatures in such a small area is explained by the variability of a range of factors, including elevation, the orientation of the mountain systems, and the influence of the trade winds. In addition to recording the presence of temperature regimes from different latitudes in a subtropical island, we documented a cryic regime at this latitude for the first time.

Abbreviations: MAST, mean annual soil temperature; MST, mean summer soil temperature; MWT, mean winter soil temperature.

Soil temperature is a necessary parameter for classifying soils in Soil Taxonomy (Soil Survey Staff, 1999, 2006) given the practical nature of the system and its influence on use and management. Until recently, soil temperature was estimated using air temperature data, an approach that–as has been shown since–did not always produce good results. The work by Smith et al. (1964) relating direct soil temperature data with air temperature data has been followed up by many other researchers (Bocock et al., 1977; Billaux, 1981; Ikawa and Kourouma, 1985; Taimeh, 1987; Yin and Arp, 1993). Today, an ever-increasing number of articles based on comprehensive direct field data is now available.

Soil temperature regimes are defined in Soil Taxonomy using measurements taken at a depth of 50 cm. A distinction is drawn between the soils of tropical regions, located between the Tropics of Cancer and Capricorn, and those of other latitudes. In the former, the mean summer and mean winter soil temperatures differ by <6°C. The prefix *iso* is used to denote these soil temperature regimes (isofrigid, isomesic, isothermic, and isohyperthermic). There are also temperature regimes associated with the cold conditions typical of high latitudes or high mountain zones (frigid and cryic). Other regimes tend to be associated with mid-latitudes. At the continental level, it is rare to find a large number of temperature classes occurring across short distances, a phenomenon more frequently seen in mountainous island ecosystems. To date, we have found no references concerning the presence of soil temperature regimes from all the world's climatic regions in an area as small as the island of Tenerife. Altitudinal sequences are often used to illustrate the spatial variability of soil temperature regimes (Kyuma, 1985; Chen, 1994; Mount and Paetzold, 2002; Hikmatullah and Prasetyo, 2003).

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*Corresponding author (cacojime@ull.es).

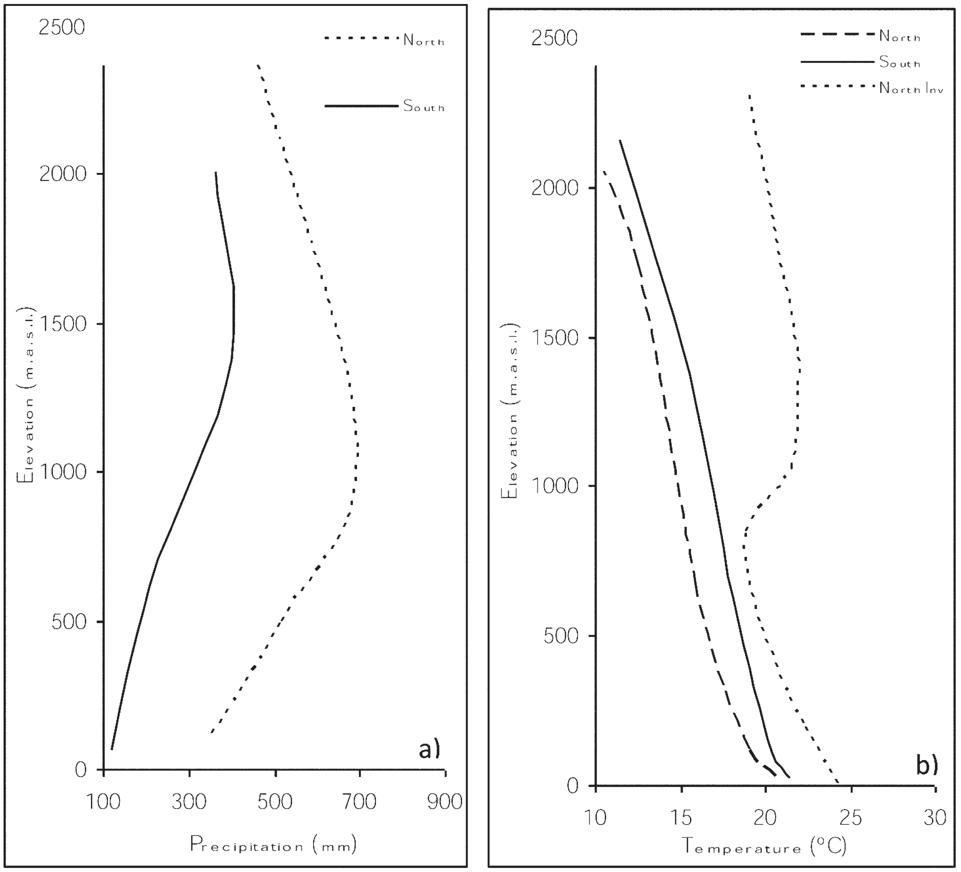

Fig. 1. Annual (a) precipitation distribution and (b) mean air temperature distribution according to elevation (m above sea level) for the north and south slopes; North, north slope; South, south slope; North Inv, air temperature distribution for a day with temperature inversion.

The Atlantic island of Tenerife (Canary Islands, Spain), which is situated outside the Tropics, is a mere 2034 km^2 in size and has its highest point at 3718 m above sea level; Mt. Teide is the highest peak of any island in the Atlantic Ocean. The island offers a wide climatic diversity. Whereas on the continent one needs to travel long distances to change from one ecosystem to another, only a few kilometers are required on the island. Until recently the soil temperature regimes of Tenerife were estimated using atmospheric data, but a project was commenced in 2000 to measure the temperature directly. We measured the soil temperature for 4 yr at a depth of 50 cm at 103 sites that reflect the island's different climatic zones. We also examined the relationship between soil temperature and elevation using altitudinal sequences. The soil temperature regimes were determined according to Soil Taxonomy, as well as the spatial variability. The results were compared with those from other world regions.

MATERIALS AND METHODS

Study Zone

Tenerife, which is located in the Atlantic Ocean at 28°35′ to 27°60′ N and 16°05′ to 16°55′ W, is the biggest (2034 km^2) of the seven islands making up the archipelago of the Canary Islands, as well as being the one with the highest point (the Mt. Teide volcano). Within a subtropical location, it offers a wide range of mesoclimates, which are produced by the following factors: its island characteristics, the marked variations in elevation, the east–west orientation of the mountain systems that give the island its two faces (north and south), the cold Canary Current, and the influence of the trade winds. In the center of the triangular-shaped island stands Mt. Teide, from which the main mountain system emerges eastward (the dorsal range), gradually decreasing in height. Two massifs (Anaga and Teno), with maximum heights of 1024 and 1342 m, respectively, occupy the eastern and western tips.

On contact with the island, the moisture-rich north–northeast trade winds cause a layer of stratocumuli (known locally as the *sea of clouds*) to form and hang between 800 and 1400 m above sea level on the north side. The clouds are prevented from rising farther upward by the presence of warm winds at higher altitudes, leading to a thermal inversion layer. The upper and lower limits of the cloud cover vary according to the season, with the lowest levels seen in summer and the highest in winter (Marzol, 2003). The thickness of the layer varies also, from <1000 to >1500 m. The north side of the island is cooler and more humid than the south, which is not affected by these winds. Only on the Anaga and Teno massifs and at occasional points along the central mountain range does the elevation allow the clouds to spill over to the other side. Figure 1a shows the annual precipitation of the different altitudinal levels on both sides of the island. It is worth noting that normal precipitation in the zone influenced by the cloud layer is supplemented by condensation water, which, according to some researchers, can double or triple the precipitation (Kämmer, 1974; Marzol, 2003). Figure 1b depicts the mean annual air temperature dependence on altitude for the north and south slopes. This average trend does not reflect the inversion situations already mentioned, as reflected also in Fig. 1b for a summer day in which inversion occurred.

Tenerife is a volcanic island with a wide variety of materials both in terms of age (Myocene to the present day: the last eruption took place in 1909) and type, with a predominance of basalts and phonolytic materials in the form of pyroclasts and outcrops. This situation is reflected in the presence of soils presenting varying characteristics and degrees of evolution. In the north, Vertisols, Alfisols, and Ultisols are found on old materials and Andisols and Inceptisols on recent ones. In the south, Aridisols, Mollisols, and Inceptisols are present, together with Entisols, which are found on both sides of the island (Fernández Caldas et al., 1982; Tejedor et al., 2007).

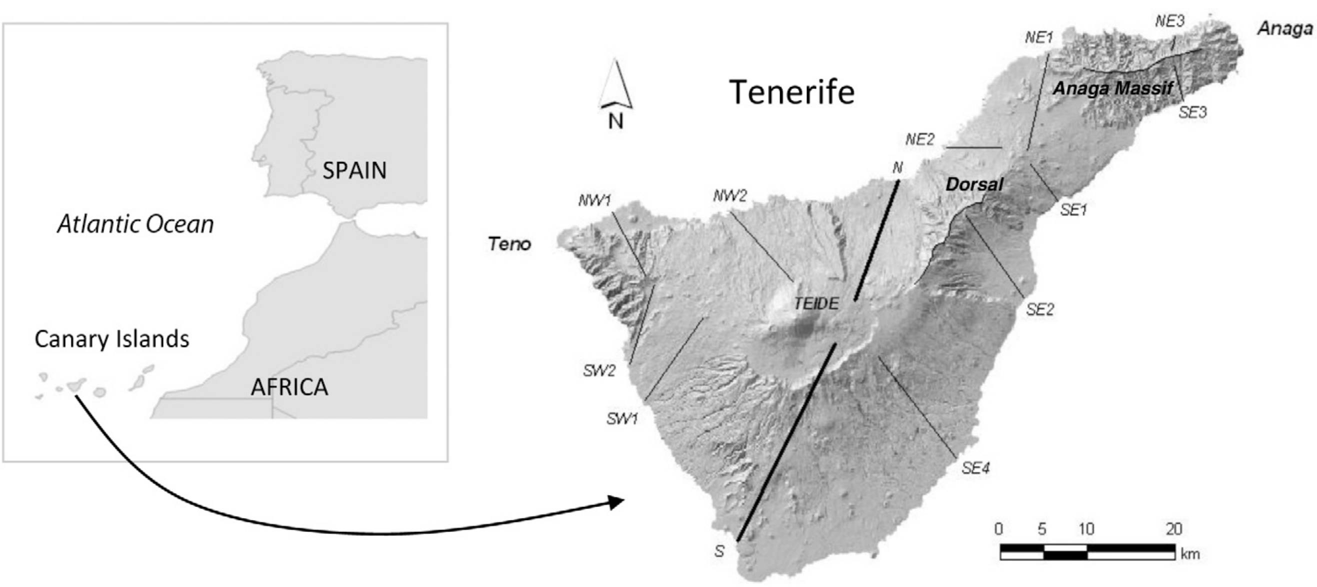

Fig. 2. Location of altitudinal sequences studied.

Site Selection and Temperature Measurements

The study sites were selected to ensure representation of possible variants, particularly elevation and aspect. In each of the 15 altitudinal sequences defined (Fig. 2), the sites were chosen approximately every 200 m up to the base of the Mt. Teide volcano (2100–2400 m) or to the maximum elevation of the sequence. In some sequences, only sites were selected at elevations where doubts existed with respect to the altitudinal limits between soil temperature regimes. In each of the 103 sites selected, the temperature was measured monthly in quadruplicate at a depth of 50 cm during a 4-yr period (2001–2004) using T-bar digital multistem temperature sensors. Only for Mt. Teide did the results correspond to just 1 yr (2003–2004) and were obtained from measurements taken with a HOBO H8 Temp sensor (Onset Computer Corp., Pocasset, MA) at one site (3345 m) on the north face.

Although the temperature data for the 15 studied sequences are given, we will focus primarily on the two most complete sequences, which cover the maximum of elevations in the central section of the two faces (one in the north and one in the south). Table 1 gives the elevation, vegetation, and soil information for the study sites for these two sequences.

Map Development

Based on empirical data obtained in the selected study zones in the altitudinal sequences, geostatistical techniques were used to analyze and predict soil temperature values at the 50-cm depth across the island.

To produce the final map, three predictive maps were prepared using the soil temperature data at 50 cm. The first map reflected the mean summer temperature (mean of June, July, and August), the second the mean winter temperature (mean of December, January, and February) and the difference between the two temperatures was calculated to obtain the isotivity map. Another map predicting the mean annual temperature was compiled and combined with the isotivity map to obtain the final soil temperature regime map.

The interpolation technique chosen was the ordinary cokriging method, which is a very flexible spatial interpolation method capable of working simultaneously with several variables. The main variable was the mean soil temperature at 50 cm in each of the selected zones. Raster 75- by 75-m elevation and orientation maps for the island were used as secondary variables. Also used were air temperature data from weather stations located throughout the island. Of the variables, elevation showed the greatest correlation with the soil temperature at 50 cm.

Table 1. Site information: north and south sequences.

North sequence				South sequence			
Site	Elevation	Vegetation	Soils	Site	Elevation	Vegetation	Soils
	m				m		
1	60	grassland	Haplocambids	12	30	coastal scrub	Haplocalcids
2	280	grassland	Dystrustepts	13	160	scrub	Haplocalcids
3	440	grassland	Dystrustepts	14	280	scrub	Haplocalcids
4	610	grassland	Dystrustepts	15	440	scrub	Haplocambids
5	800	grassland	Hapludands	16	600	scrub	Haplocambids
6	1180	pine and wax-myrtle/tree heath	Hapludands	17	800	grassland	Haploxererts
7	1340	pine	Hapludands	18	1130	scrub-grassland	Haploxerepts
8	1630	pine	Haplustands	19	1370	grassland	Haploxerepts
9	1820	pine	Haplustands	20	1800	pine	Haploxerepts
10	2100	high mountain scrub	Udivitrands	21	2240	pine/broom/Teide broom	Haploxerepts
11	3345	*Viola cheiranthifolia* Humb. & Bonpl.	Cryorthents	22	2330	high mountain scrub	Haplustepts
				23	2400	high mountain scrub	Udorthents

Table 2. Mean annual soil temperature and isotivity at the 50-cm depth for all the studied sequences on the north face.

NW1			NW2			N			NE2			NE1			NE3		
Elev.†	MAST‡	ISO§	Elev.	MAST	ISO	Elev.	MAST	ISO	Elev.	MAST	ISO	Elev.	MAST	ISO	Elev.	MAST	ISO
m	—— °C ——		m	— °C —		m	— °C —		m	— °C —		m	— °C —		m	— °C —	
60	24.6	6.6	50	23.7	6.5	60	24.4	7.0	110	23.1	7.5	40	24.7	7.6	100	23.0	7.6
330	21.2	5.8	550	16.6	2.7	280	19.9	4.5	739	17.8	6.9	250	22.7	7.8	430	19.7	8.1
450	20.0	6.0	840	14.7	5.2	440	19.6	5.9	910	14.4	2.2	420	20.0	6.4			
650	19.0	6.1	1040	13.3	7.4	610	17.5	3.7				530	18.0	3.8	Anaga Massif		
780	15.6	2.4	1700	13.8	14.8	800	16.0	5.1	Dorsal			617	19.1	7.0	785	14.2	5.8
800	13.9	2.2				1180	12.9	3.5	1370	11.7	4.1	840			810	14.2	2.3
1240	13.0	4.0				1340	12.5	4.8	1430	12.2	6.4	1000			860	14.2	1.9
						1630	13.3	7.2	1640	12.1	7.8				880	13.6	2.7
						1820	12.7	10.1	1850	11.7	8.2						
						2100	14.0	10.2									
						3345	5.1	13.2									

† Elevation.

‡ Mean annual soil temperature.

§ Isotivity (mean soil summer temperature minus mean soil winter temperature).

RESULTS

Parameters Defining Soil Temperature Regimes

The soil temperature regimes were defined using the parameters established by Soil Taxonomy (Soil Survey Staff, 1999, 2006), namely, the mean annual soil temperature (MAST), the mean summer soil temperature (MST, mean of June, July, and August), and the mean winter soil temperature (MWT, mean of December, January, and February). The *iso* prefix is used to distinguish soils where the mean summer and mean winter temperatures (ΔT) differ by <6°C at a depth of 50 cm. Moreover, as Mount and Paetzold (2002) noted, "Soil Taxonomy defines each soil temperature regime and temperature class to the nearest whole unit. Thus, because of rounding, a temperature described as less than 8° is actually less than 7.5°C. It can be argued that soil temperature should be defined to the nearest tenth of a degree C." In this study, the Soil Taxonomy rounding criterion was followed. Tables 2 and 3 give the mean annual temperatures and isotivity for all the studied sequences. Table 4 gives separate and fuller data for the two main central sequences in the north and south, which are referred to further below. The altitudinal variations in the other sequences are explained below where the soil temperature regimes are defined.

On the north side (Table 4), significant changes with altitude were observed at 280, 1180, 2100, and 3345 m. The MAST reduction was not uniform across the sequence (Fig. 3); a 5°C drop occurred above the coastal strip (around 200 m). The MAST gradually decreased by 4°C across a 520-m vertical distance between 280 and 800 m and decreased by 3°C between 800 and 1180 m. Temperatures were similar across a 640-m vertical distance between 1180 and 1820 m, and then increased by 1.3°C between 1820 and 2100 m. The MST also decreased with elevation, although in this case the temperature rise occurred between 1340 and 1630 m. In the case of the MWT, except in the lower part of the sequence where the reduction was very noticeable, the temperature fall with elevation was more gradual than for MAST and MST. The increase in MWT occurred at the same elevation as for MAST (between 1820 and 2100 m). The isotivity value was >6°C on the coastal strip but was lower

Table 3. Mean annual soil temperature and isotivity at the 50-cm depth for all the studied sequences on the south face.

SW2			SW1			S			SE4			SE2			SE1			SE3		
Elev.†	MAST‡	ISO§	Elev.	MAST	ISO	Elev.	MAST	ISO	Elev.	MAST	ISO	Elev.	MAST	ISO	Elev.	MAST	ISO	Elev.	MAST	ISO
m	—— °C ——		m	—— °C ——		m	—— °C ——		m	—— °C ——		m	—— °C ——		m	—— °C ——		m	—— °C ——	
240	23.9	7.0	100	27.4	7.4	30	26.1	7.3	230	23.4	7.9	60	26.5	8.0	40	25.3	5.8	30	25.2	8.7
400	24.4	9.4	250	24.6	7.4	160	25.9	6.0	534	20.1	6.7	200	24.2	7.1	190	25.0	7.8	260	22.1	6.8
720	23.0	13.4	420	22.8	9.2	280	24.1	6.5	817	19.3	8.9	400	21.9	7.8	240	25.4	7.5	430	21.2	6.1
990	21.1	9.6	670	21.6	8.6	440	24.4	6.3	1520	18.2	10.5	700	20.0	7.3	420	23.7	8.4	630	17.1	0.6
1060	19.3	13.1	960	20.7	9.6	600	24.6	8.9	1622	17.4	7.7	910	17.5	5.7	590	22.2	8.6	640	17.5	4.1
1130	16.9	8.2	1340	18.2	8.9	800	22.8	9.2	1880	16.7	11.0	1030	17.4	6.2	820	18.7	8.7	680	18.7	5.0
1260	14.7	4.2	1500	17.1	9.0	1130	20.5	11.4				1320	15.7	7.0						
			1600	15.6	9.4	1370	20.5	12.9				1530	12.7	7.3						
			1900	16.1	10.6	1800	17.4	13.2				1650	12.0	5.9						
						2240	15.8	12.4												
						2330	14.7	11.6												
						2400	14.2	10.3												

† Elevation.

‡ Mean annual soil temperature.

§ Isotivity (mean soil summer temperature minus mean soil winter temperature).

Table 4. Seasonal and annual soil temperature (°C) at 50 cm, isotivity, and soil temperature regime for the north and south sequences.

North sequence							South sequence						
Site	Elev.†	MAST‡	MST§	MWT¶	ISO#	Soil temp. regime	Site	Elev.	MAST	MST	MWT	ISO	Soil temp. regime
	m	°C						m	°C				
1	60	24.4	27.7	20.7	7.0	hyperthermic	12	30	26.1	29.3	22.0	7.3	hyperthermic
2	280	19.9	21.8	17.3	4.5	isothermic	13	160	25.9	28.6	22.6	6.0	hyperthermic
3	440	19.6	22.5	16.6	5.9	thermic/isothermic	14	280	24.1	27.0	20.5	6.5	hyperthermic
4	610	17.5	19.3	15.6	3.7	isothermic	15	440	24.4	27.3	21.0	6.3	hyperthermic
5	800	16.0	18.3	13.2	5.1	isothermic	16	600	24.6	28.9	20.0	8.9	hyperthermic
6	1180	12.9	14.5	11.0	3.5	isomesic	17	800	22.8	27.5	18.3	9.2	hyperthermic
7	1340	12.5	14.9	10.1	4.8	isomesic	18	1130	20.5	26.3	14.9	11.4	thermic
8	1630	13.3	17.1	9.9	7.2	mesic	19	1370	20.5	26.9	14.0	12.9	thermic
9	1820	12.7	17.8	7.7	10.1	mesic	20	1800	17.4	24.2	11.0	13.2	thermic
10	2100	14.0	19.2	9.0	10.2	mesic	21	2240	15.8	22.1	9.7	12.4	thermic
11	3345	5.1	12.9	−0.3	13.2	cryic	22	2330	14.7	20.7	9.1	11.6	thermic/mesic
							23	2400	14.2	19.3	9.0	10.3	mesic

† Elevation.

‡ Mean annual soil temperature.

§ Mean summer soil temperature.

¶ Mean winter soil temperature.

\# Isotivity (mean summer soil temperature minus mean winter soil temperature).

than or bordered on 6°C between 280 and 1340 m, becoming greater once more at the latter height. Above 2100 or 2400 m, on the slopes of Mt. Teide, the temperature began to fall again: at 3345 m, the MAST was 5.1°C, the MST was 12.9°C, and the MWT was −0.3°C, while the isotivity increased to 13.2°C.

On the south side (Table 4; Fig. 3) the MAST also decreased with elevation, although, unlike in the north, no temperature inversion occurred. The MAST on this south face was very similar in the 280- to 600- and 1130- to 1370-m strips. Other differences compared with the north face are that there was no sharp fall in temperature in the first 200 m and the MAST was always higher than in the north regardless of elevation, with the smallest differences recorded in the coastal strip and at heights above 2000 m corresponding to the central part of the island where the temperatures were very similar. When the MST is considered, the difference between the north and south slopes was most pronounced (9–12°C) in the mid-altitudes (610–1340 m). This is the strip on the north face that is most heavily influenced by the trade winds, which keep the temperatures homogenous in summer. In contrast, on the south face, which is not influenced by these winds, the MST increases considerably. The MWT differences were smaller, however. Differences were also seen in isotivity: on the southern face, ΔT exceeded 6°C at all heights, with the lowest values (6–7°C) recorded below 440 m.

Soil Temperature Regimes and their Distribution on the Island

The temperature regimes identified on the north face and the altitudes at which they are located in the central sequence are as follows (Table 4): hyperthermic on the lowest strip up to approximately 200 m, isothermic from 200 to 800 m, isomesic between 800 and 1340 m, mesic up to approximately 3000 m, and cryic above this height (MST < 15°C, the soil is not saturated with water in summer and has no O horizon). In the 200- to 800-m strip, some thermic zones bordered on isothermic (Site 3, $\Delta T = 5.9$°C). The soil temperature of the coastal strip was isohyperthermic during some of the study years.

The soil temperature regimes defined for the south face, with their altitudinal limits in the central sequence, are as follows (Table 4): hyperthermic up to 800 m, thermic to 2240 m, and

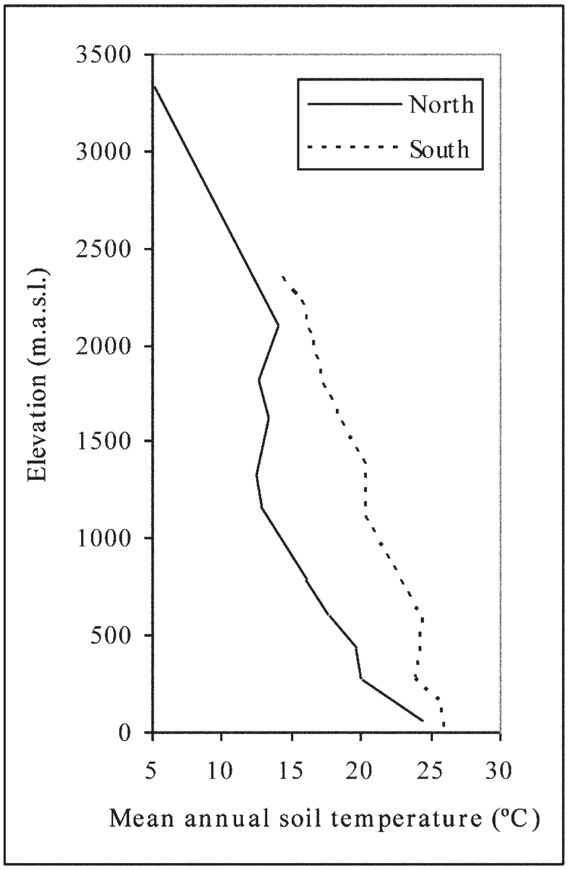

Fig. 3. Mean annual soil temperature at 50-cm depth vs. elevation (m above sea level) of the north and south sequences.

Table 5. Soil temperature regime (ST) of all the studied sequences on the north face.

NW1		NW2		N		NE2		NE1		NE3	
Elev.†	ST‡	Elev.	ST	Elev.	ST	Elev.	ST	Elev.	ST	Elev.	ST
m		m		m		m		m		m	
60	H	50	H	60	H	110	H	40	H	100	H
330	T	550	IT	280	IT	739	T	250	H	430	T
450	T	840	IT	440	T/IT	910	IM	420	T		
650	T	1040	M	610	IT			530	IT	Anaga Massif	
780	IT	1700	M	800	IT			617	T	785	M/IM
800	IM			1180	IM	Dorsal		840	IT	810	IM
1240	IM			1340	IM	1370	IM	1000	IT	860	IM
				1630	M	1430	M			880	IM
				1820	M	1640	M				
				2100	M	1850	M				
				3345	C						

† Elevation.

‡ H, hyperthermic; T, thermic; IT, isothermic; IM, isomesic; M, mesic; C, cryic.

mesic in the central part (2400 m) of the island, where the soil temperature regime of both faces merges at these upper parts.

The altitudinal limits between the different regimes defined above changed as we moved away from the two studied sequences (which were located centrally on their respective faces) toward the northeast–northwest and southeast–southwest tips of the island (Tables 5 and 6). Accordingly, on the north face the hyperthermic strip widened at the tips, reaching heights of 300 to 350 m. There was an altitudinal difference between thermic and isothermic, with the former always seen at lower elevations than the latter. In the sequences in which it was found, the isomesic regime was maintained at similar heights, with its most typical zones located in ridge zones where the effect of the sea of clouds is the greatest (Tejedor et al., 2009).

The most significant variations on the south side as we moved southeast and southwest (Table 6) were that the hyperthermic strip narrowed toward the east, with a minimum height of 350 to 400 m at the easternmost tip, but was maintained at similar heights in the west. The mesic regime, which was present on the south side only at the highest elevations where north and south converged, appeared gradually as we moved eastward at the limits of the central mountain range (around 1500–1600 m), although it did not occur frequently, given that these elevations are unusual on the southeast of the island. In the southeast and southwest, the elevation of the two massifs (1024 and 1342 m) allows the sea of clouds on the northern face to spill over and cross to the south. The only *iso* regime identified on the south face (isothermic) was located here.

The map of the spatial distribution of soil temperature regimes is shown in Fig. 4.

DISCUSSION

The island of Tenerife, which is situated in subtropical latitudes, is a transition zone between the temperate and tropical climatic regions, a circumstance reflected in its soil temperature regimes. The fact that seven different regimes of the nine considered in Soil Taxonomy have been described in an area as small as Tenerife can be explained by a combination of factors, including aspect, elevation, and (on the northern face in particular) the influence of the trade winds that form a layer of stratocumuli, which exerts an important buffering effect on soil temperature, reducing seasonal differences to <6°C. This effect is detected not only in the altitudinal strip where the clouds hang almost permanently and produce an isomesic soil temperature regime, but also on the strip immediately below, which is isothermic. The presence of warm winds above the cloud deck accounts for the local increase in temperature with elevation and the change from an isomesic to a mesic soil temperature regime. This is the regime present where the two sides meet in the central part of the island, at the base of Mt. Teide. The soil temperature then fell gradually as elevation increased and, at approximately 3000 m, temperatures became cold enough for a cryic temperature regime.

Some of the regimes present on this north face (isothermic and isomesic) are typical of tropical regions in that they have a $\Delta T < 6°C$ (Tejedor et al., 2009). Other tropical islands presenting, at least in part, similar altitudinal sequences include

Table 6. Soil temperature regime (ST) of all the studied sequences on the south face.

SW2		SW1		S		SE4		SE2		SE1		SE3	
Elev.†	ST‡	Elev.	ST	Elev.	ST	Elev.	ST	Elev.	ST	Elev.	ST	Elev.	ST
m		m		m		m		m		m		m	
240	H	100	H	30	H	230	H	60	H	40	H	30	H
400	H	250	H	160	H	534	T	200	H	190	H	260	H
720	H	420	H	280	H	817	T	400	H	240	H	430	T
990	T	670	H	440	H	1520	T	700	T	420	H	630	IT
1060	T	960	T	600	H	1622	T	910	T	590	H	640	IT
1130	T	1340	T	800	H	1880	T	1030	T	820	T	680	IT
1260	IT	1500	T	1130	T			1320	T				
		1600	T	1370	T			1530	M				
		1900	T	1800	T			1650	M				
				2240	T								
				2330	T/M								
				2400	M								

† Elevation.

‡ H, hyperthermic; T, thermic; IT, isothermic; M, mesic.

the mountainous island of Maui in Hawaii, whose soil temperature regimes were described by Nullet et al. (1990) as follows: hyperthermic or isohyperthermic at low elevations, isothermic between 500 and 1650 m, and isomesic as of the latter height. Mount et al. (1992) defined three temperature regimes for Puerto Rico: isohyperthermic below 610 m, isothermic between 610 and 1067 m, and isomesic at higher elevations.

Although not a frequent occurrence, the presence of tropical soil temperature regimes outside the Tropics has been recorded by some researchers. Meeder described an isohyperthermic regime in the subtropical zone of South Florida at 25°31′N (Mount and Paetzold, 2002). Newton cited an isomesic regime on a north aspect in the Great Smoky Mountains of Tennessee at 35°45′ N (1158-m elevation) and noted that this is the first soil east of the Mississippi River to be documented with this soil temperature regime (Mount and Paetzold, 2002).

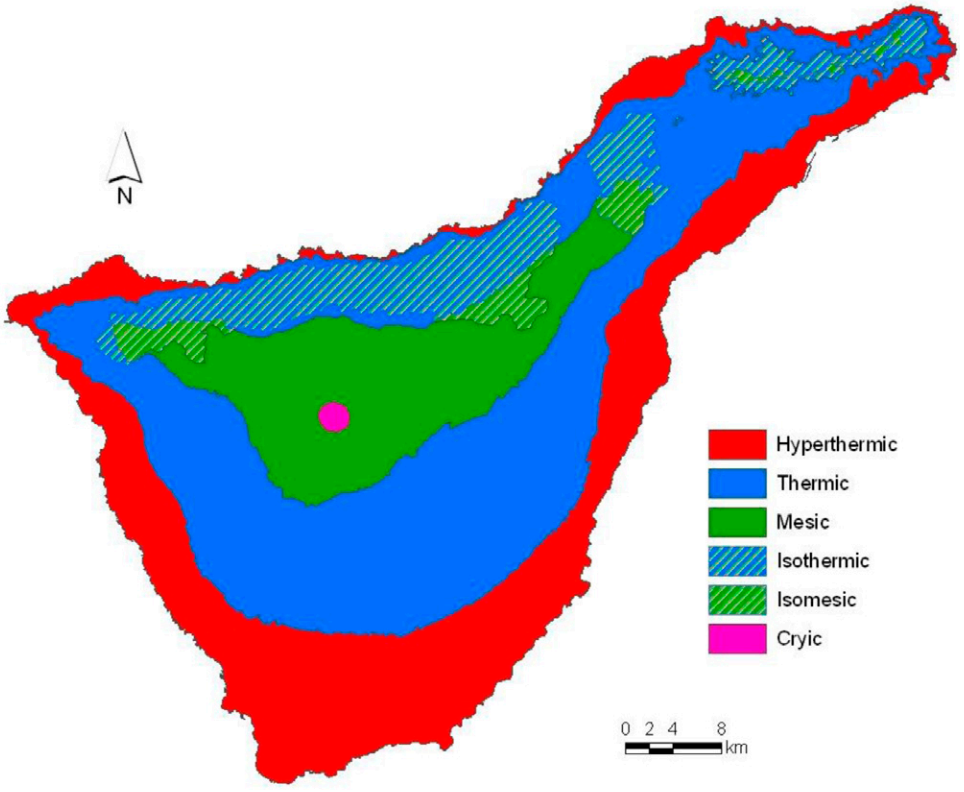

Fig. 4. Soil temperature regime distribution map.

The soil temperature regimes on the south face of Tenerife, which is free from the influence of the sea of clouds, are more in keeping with Mediterranean conditions and offer greater seasonal contrasts, although the influence of the ocean is noticeable at low levels (Arrue et al., 1984; Kiliç et al., 2004). The cryic zone is typical of high latitudes, where it is found at all elevations (Ping, 1987; Hartshorn et al., 2003). It has also been defined in high mountain parts in other latitudes. The elevation at which it is found increases with proximity to the equator. According to Poulenard and Podwojewski (2006), alpine soils are located approximately between 3500 and 5000 m in latitudes between 0 and 20° N, and between 3250 and 4750 m in latitudes between 20 and 30° N. Elevation thresholds for cryic conditions decrease as latitude increases. To our knowledge, the cryic zone on Tenerife is the lowest latitude ever reported for a cryic regime.

Regarding the variability of soil temperature regimes in other island territories, it is worth noting that, for example, five regimes have been defined in the Hawaiian Islands, which are situated in the Tropics near the Tropic of Cancer and occupy a total area of 16,409 km^2 with a highest point of 4205 m: hyperthermic/isohyperthermic, isothermic, and isomesic (Nullet et al., 1990; Soil Survey Quality Assurance Staff, 1994). At 3566 m, the regime documented was mesic, with a MAST of 12.3°C and ΔT of 6.4°C (Gavenda in Mount and Paetzold, 2002). Japan occupies an extensive range of latitudes from 45 to 24° N and most of the country enjoys a temperate climate, although the south is subtropical (Ryuku Islands). The island nation of Japan is 377,815 km^2 in size and has a highest point of 3776 m. Four temperature regimes have been defined (Kyuma, 1985). As is appropriate for a predominantly temperate climate, the two most commonly found regimes are mesic in the northern regions and thermic in the center and south of the country. A frigid regime has been recorded in a small area in the northeast and a hyperthermic regime in the subtropical region only, although no *iso* regimes have been defined there.

CONCLUSIONS

Four years of soil temperature monitoring at a depth of 50 cm in different parts of Tenerife illustrate the high degree of variability of the existing regimes. Regimes from all latitudes–low, middle and high–are present on the island. Seven of the nine soil temperature regimes defined in Soil Taxonomy have been described thus far on an island that is a mere 2034 km^2 in size: hyperthermic, thermic, mesic, isohyperthermic, isothermic, isomesic, and cryic. Changes occur within very short distances and at times a slight difference in elevation or a change in aspect can suffice. The island can be considered a miniature continent. The diversity is largely the result of differences in elevation, the aspect of the mountain systems, and, in the case of the north side, the presence of moist winds at mid-altitude. A cryic soil temperature regime was documented at this latitude for the first time.

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