Chapter 16
Palmer Station

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Site Description

The Palmer LTER study area is located to the west of the Antarctic Peninsula and centered on the region which surrounds Palmer Station (64° 40'S, 64° 03'W). Palmer Station is located in a protected harbor on the southwest side of Anvers Island midway down the Antarctic Peninsula. This study area is representative of a polar marine biome and research is focused on the Antarctic pelagic marine ecosystem, inclusive of marine sea ice habitats, regional oceanography and terrestrial nesting sites of sea bird predators. A sampling grid, motivated by the need for station locations that could be visited repeatedly over time scales of many years, has been established along the west coast of the peninsula. This grid, which is 200 km on/offshore and 900 km along shore roughly parallel to the peninsula, reflects the regional scale of atmospheric, oceanic and sea ice interactions with populations in the marine ecosystem. Embedded within this grid are smaller scale grids addressing local hydrography, near shore primary and secondary production and the foraging ranges of the predators (seabirds) nesting near Palmer Station.

Quality meteorological data records for the Antarctic are relatively short, most dating from the International Geophysical Year of 1957-58. Prior to the 1950s few data were collected south of 45° S. A consistent digital weather record is available for Palmer Station beginning in 1989 including daily maximum and minimum air temperature, wind speed and wind direction (Baker and Stammerjohn, 1995). Measurements are made four times per day. Monthly temperature data summaries for Palmer are available, with some gaps, back to 1974. British Antarctic Survey (BAS) data from Faraday Station (Jones, 1987), located 35 nautical miles (65 km) south of Palmer Station, provide high quality continuous data from the early 1940's. These data are highly correlated with the shorter Palmer record, and can be used to provide a climatology for the western Antarctic Peninsula (WAP) area (Smith et al, 1996).

Two Automatic Weather Station (AWS) sites (Bromwich and Stearns, 1993) near sea level were designated at the request of the Palmer LTER program. AWS Bonaparte (64° 46'S, 64° 04'W) was installed in January 1992 on a rocky point at the entrance to Arthur Harbor about 750 m WSW of Palmer Station. AWS Hugo (64° 58'S, 65° 40'W) was installed in December 1994 on an island in the Victor Hugo archipelago, a small group of low lying islands and rocks, approximately 90 km northwest of the Peninsula and roughly this same distance WSW of Palmer Station. AWS Hugo, being 90 km seaward of the peninsula, is an especially important addition since there is a sharp on/offshore gradient in maritime versus continental regimes. Data from AWS Hugo illustrate the distinction between data from coastal stations, which comprise our only historical records, and data from oceanic stations, which are more closely coupled to the marine environment.

Vegetation

Phytoplankton production plays a key role in this so-called high-nutrient, low-chlorophyll marine environment. Factors that regulate production include those that control cell growth (light, temperature, and nutrients) and those that control cell accumulation rate and hence population growth (water column stability, grazing, and sinking). Climatic factors and sea ice mediate several of these factors and frequently condition the water column for a spring bloom which is characterized by a pulse of production restricted in both time and space. The abundance and distribution of terrestrial vegetation (predominately lichens and mosses) is sensitive to climatic conditions and is limited by the short growing season and the limited area of soil/rock substrate. Terrestrial plant vegetation is thought to have relatively little influence on the marine environment.

Synoptic Climatology

The western Antarctic Peninsula (WAP) area is distinguished by a weather system that displays extreme seasonal and interannual variability. The Antarctic Peninsula is a physical barrier to tropospheric circulation which is reflected in the sharp contrasts between the relatively mild maritime climate to the west and north of the peninsula and the harsher more continental climate to the east and south. Further, the Peninsula is one place on the continent where the axis of the circumpolar low-pressure trough or atmospheric convergence line (ACL) crosses over land. The variability of the mean position of cyclones, as the ACL seasonally and interannually shifts along the Antarctic Peninsula, strongly influences winds, temperature and the distribution of sea ice. Weather patterns at Palmer are strongly influenced by the linkages between cyclones, temperature and sea ice extent and these patterns continually shift between the influence of maritime as contrasted with continental climatic regimes.

The climate is typically maritime Antarctic, relatively warm and moist compared to other locations in Antarctica yet cold and dry compared to lower latitude sites. The temperature at Palmer is relatively mild for the Antarctic, averaging about -10° C in July/Aug and 2° C in January, with temperature extremes recorded at -31° C and 9° C. Snow and rain are common any time of year with total annual precipitation (as water equivalent) about 383 mm (Table 16.1).

In polar regions wind is a dominant meteorological variable. Storms are evaluated in terms of wind speed and direction. Surface wind is decisive for the chill factor along with temperature, the drift and compaction of sea ice, and the depth of the ocean upper mixed layer. Further, wind greatly influences the overall conditions for human activity. The WAP experiences the mildest and wettest climate of the Antarctic influenced both by relatively warm winds from the northwest quadrant and cold dry continental conditions with winds from the southern quadrants.

A predominant and distinguishing characteristic of the Southern Ocean is sea ice, with a range of minimum to maximum sea ice cover that represents the largest seasonal surface change (roughly 16x10^6 km^2) on earth. The LTER region is distinguished by an annual sea ice cycle showing a relatively short period of ice advance (about 5 months) followed by a longer period of ice retreat (7 months) and a long-term persistence, wherein two to four high- ice years are followed by one to three low-ice years. An oscillation of high and low-ice years has been linked to the Southern Oscillation Index (Stammerjohn and Smith, 1996).

Water Balance

In spite of their importance for completion of water, salt and heat budgets of the ocean, values for evaporation and precipitation over the ocean are not well determined. Typically their estimation depends upon various extrapolative schemes using data from islands and coastal areas. To the best of our knowledge there are few, if any, reliable data for the WAP area. The water balance in the following tables refers to a terrestrial area that is naturally dominated by water being held in a snowpack for most of the year.

Climatic Factors Affecting Flora and Fauna

Factors strongly influencing the flora and fauna of this site include: low temperatures, a short growing season, high winds influencing the depth of the mixed layer, proximity to land with the potential for input of micronutrients, and the presence or absence of sea ice and snow cover. Increased UV-B associated with the "ozone hole" has also been shown to have a variety of effects (Weiler and Penhale, 1994). Sea ice is associated with a range of predator and prey habitats and is hypothesized to play a key role in various trophic level couplings. The high variability in ice coverage in the vicinity of Palmer Station provides the LTER with an ideal study site in which to conduct "natural experiments" associated with high interannual sea ice variability and hypothesized consequences to the marine ecology of the area.

Notes on the Climate Data

The climate record at Palmer Station itself is too short for developing a 30 year climatology. Meteorological data from the British Antarctic Survey (BAS) is available for Faraday Station since the mid 1940's. Comparison for the period overlapping data from 1974 to 1991, shows the Palmer record has a similar seasonal pattern but is on average 1° to 3° C higher than the Faraday temperature record (Smith et al, 1996). Taking into account the serial correlation present in the data, there is a significant correlation between monthly mean air temperatures from 1974 to 1991 where

$$\text{Temperature(Palmer)}=1.15+0.96*\text{Temperature(Faraday)} \quad \text{(Eq. 1)}$$

with N=188 and R-sq=0.94 so that, within the limits of this correlation, the Faraday temperature data may be used as a proxy for Palmer Station.

Mean temperature data from Faraday were used for the summary statistics and water balance analysis (Tables 16.1 and 16.2) but the short record observed at Palmer Station were utilized for mean maximum and mean minimum temperature and total precipitation summaries.

Water Budget

Accurate precipitation data for the WAP region, lacking both temporal and spatial coverage, are virtually non-existent. In particular, there are virtually no accurate or systematic data on soil warmth and/or availability of free water for terrestrial ecosystems. Summary statistics (temperature and precipitation) for Faraday Station as well as derived products are given in Table 16.2. These derived products (based on results from temperate latitudes) may have little significance for Antarctic terrestrial biotic communities where meltwater from snow and glaciers and the dessicating effects of strong cold and dry winds create a complexity of ecological niches. Similar comments hold for Fig. 16.3. A review of the biota and functional processes of the terrestrial and freshwater ecosystems of the WAP is given by R. I. L. Smith (1996).

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Table 16.1

SUMMARY STATISTICS PALMER STATION 1961-1990

	MMEAN	MMAX*	MMIN*	PPT*	WETTEST YEAR (1982)	DRIEST YEAR (1981)
JAN	0.7	3.5	-0.5	50	74	34
FEB	0.6	3.3	-0.5	31	35	36
MAR	-0.4	2.2	-1.4	35	34	26
APR	-2.3	0.0	-3.7	52	106	49
MAY	-4.3	-1.5	-5.4	22	32	16
JUN	-6.3	-2.5	-7.6	27	20	34
JUL	-9.0	-4.4	-10.9	18	19	10
AUG	-9.8	-4.4	-11.6	18	10	21
SEP	-7.4	-3.6	-11.3	29	17	6
OCT	-5.0	-2.0	-8.1	26	26	15
NOV	-2.3	1.1	-4.6	37	19	46
DEC	-0.2	2.4	-2.1	37	19	33
ANNUAL	-3.8	-0.5	-5.6	383	411	324
STDEV	1.34	0.94	1.83			

		STDEV
Mean Temp Warmest Month	0.7	0.80
Mean Max Temp Warmest Month	3.5	0.67
Mean Temp Coldest Month	-9.8	3.61
Mean Min Temp Coldest Month	-11.6	3.91
Annual Range of Monthly Mean Temps	10.5	
No Months with Temp >0	2	
No Months with Temp >15	0	
Total Precip in Months with Temp >0	81	

		YEAR
Highest Monthly Mean Temp	2.3	Jan-85
Overall Maximum	4.9	Jan-85
Lowest Monthly Mean Temp	-20.1	Jul-87
Overall Minimum	-25.8	Jul-87

* Mean maximum and mean minimum temperature statistics calculated for the period 1981-1990 making use of Faraday Station data and Eq 1.; Monthly precipitation data from Faraday Station for the period 1981-1985 (B.A.S. Meteorological Unit).

Table 16.2

Water Budget for Faraday Station used as proxy for Palmer Station at: Latitude -65.3 Longitude 64.3
Field Capacity 150.0 mm Resistance curve c

MON	TEMP	UPE	APE	PREC	DIFF	ST	DST	AE	DEF	SURP	SMT	SST
JAN	0.7	135	184	50	-135	83	0	184	0	1	136	32
FEB	0.6	125	139	31	-108	48	-35	94	46	4	32	0
MAR	-0.4	0	0	35	35	83	35	0	0	0	0	0
APR	-2.3	0	0	52	0	83	0	0	0	0	0	52
MAY	-4.3	0	0	22	0	83	0	0	0	0	0	74
JUN	-6.3	0	0	27	0	83	0	0	0	0	0	101
JUL	-9	0	0	18	0	83	0	0	0	0	0	119
AUG	-9.8	0	0	18	0	83	0	0	0	0	0	138
SEP	-7.4	0	0	29	0	83	0	0	0	0	0	167
OCT	-5	0	0	26	0	83	0	0	0	0	0	193
NOV	-2.3	0	0	37	0	83	0	0	0	0	0	230
DEC	-0.2	0	0	37	37	83	0	0	0	100	63	167
Yearly Totals:			324	383				278	46	105		

Explanation for water balance columns (all units are millimeters depth of water unless otherwise specified).

MON	Month of the year
TEMP	Mean monthly air temperature in degrees Celsius
UPE	Unadjusted potential evapotranspiration
APE	Adjusted potential evapotranspiration
PREC	Precipitation
DIFF	PREC minus APE
ST	Soil moisture storage
DST	Change in storage from preceding month
AE	Actual evapotranspiration
DEF	Soil moisture deficit
SURP	Soil moisture surplus
SMT	Snowmelt
SST	Water equivalent held in snowpack

Charts

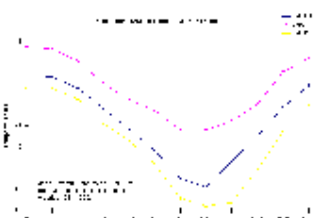

Figure 16.1

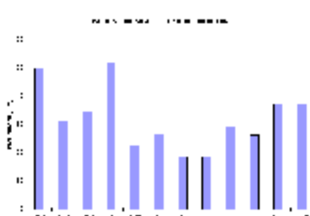

Figure 16.2

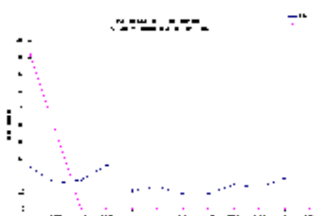

Figure 16.3

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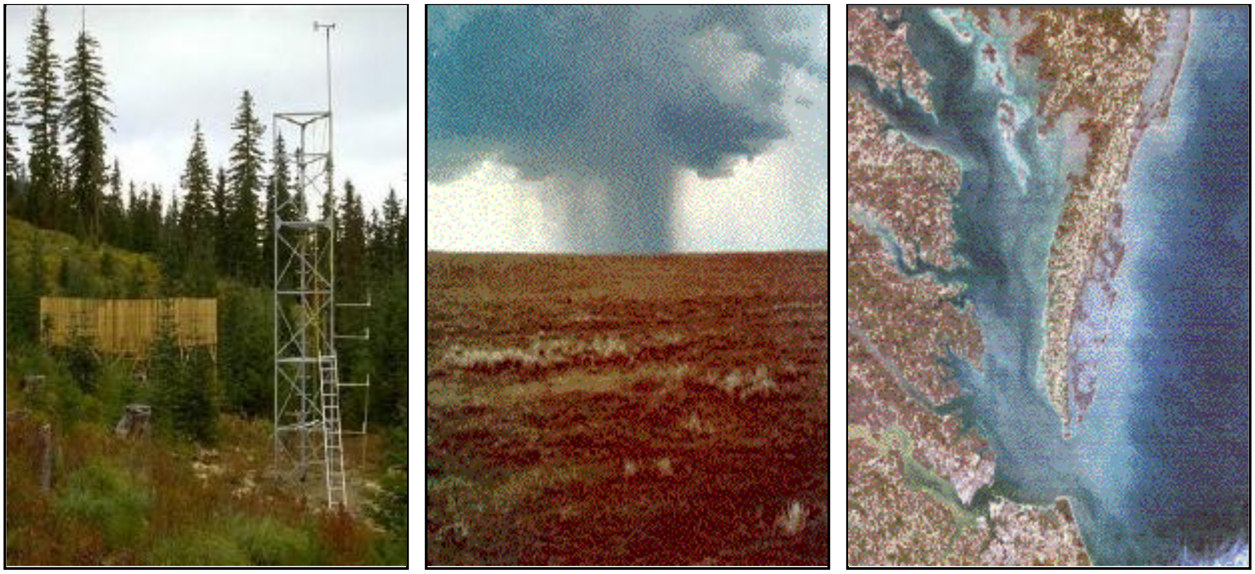
A Climatic Analysis Of Long-Term Ecological Research Sites



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Division of Biotic Systems, is mandated to pursue ecological research over long time periods at a variety of sites throughout the United States. Climate research is recognized by both ecologists and climatologists as having a key role in long-term ecological research. Each LTER site maintains its own climate program and at many sites climate data represent the longest data set available.

Increasing attention to possible ecological consequences of global change requires that we understand how climate varies and what the potential is for rapid directional climate change. This research presented here describes climatic variability, climatic change scenarios, and individual climate and water budget analyses performed at all 18 LTER sites.

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