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Palmer LTER: Palmer Station air temperature 1974 to 1996

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Climate variability is of central importance to long-term ecological studies in general and to bioclimatology in particular. As a consequence, the Palmer Long-Term Ecological Research (LTER) program has gathered historical meteorological data taken for Palmer Station as well as initiated the quality control and archiving of this data. The following is a preliminary report summarizing Palmer Station air temperature records from May 1974 to August 1996.

Meteorological measurements began after the first scientific occupation of Palmer Station in 1968. Over the years, the reporting of these data has undergone some change. Two separate records available from Palmer Station include

- monthly weather starting in 1974 and
- daily weather initiated in 1989.

Historical data in addition to the Palmer data provide the basis for this preliminary report.

Although early data is scarce, monthly measurements for Palmer Station beginning in 1974 have been published primarily in *Antarctic Journal of the United States.* Subsets have also been archived in other locations. For instance, the station holds some digital records for this early period whereas the National Climatic Data Center (NCDC) archives a subset of daily observations. A report of Palmer Station weather from 1975 to 1983 (Jacka, Christou, and Cook 1984) provides a few missing points in the *Antarctic Journal* series. Monthly maximum, minimum, and average temperatures available in *Antarctic Journal* were compared for consistency. Statistical outliers and obvious mistakes were corrected. For example, one average temperature reported was twice the reported maximum, and inspection showed that a negative sign had been dropped.

In April 1989, consistent daily weather records were begun (Oxton personal communication), and observations were made four times a day by Antarctic Support Associates personnel at Palmer Station. Daily measurements include maximum and minimum air temperature, wind speed, and wind direction. Daily mean air temperature is determined by taking the average of the daily maximum and minimum observed for that day. These daily air temperature observations were found to be well correlated with the higher frequency sampling of the automatic weather station at Bonaparte Point located roughly 750 meters west-southwest from the station (Baker and Stammerjohn 1995).

The daily temperature observations have been averaged into monthly values and combined with earlier data to create a 22-year composite record (May 1974 to August 1996) of monthly data. As a check of internal consistency for this combined data set, a subset of this series was compared with Faraday station temperature data (1974 to 1991).

As discussed elsewhere (Smith, Stammerjohn, and Baker in press), the Palmer Station air temperature data are well correlated with the Faraday data, and Faraday data can, when necessary, be used as a proxy for Palmer data. Palmer data outside two standard deviations from the Faraday regression were flagged and removed for the subsequent analysis.

The resultant monthly averages and standard deviations for Palmer Station are shown in figure 1 and summarized in table 1. A harmonic, known to describe seasonal variation (Lynn 1967; Van Loon 1967; Schwerdtfeger 1984) fit through these data, provides a simple method for calculation of the 22-year average value given julian day. Further, it provides an average against which one may view the variability of a single year's air temperature. For example, the Palmer Station 1995 daily temperature values are plotted along with the fit in figure 2.

The monthly data in the Faraday temperature record (1946–1991) have shown a warming trend, particularly in winter months (Smith et al. in press). A trend analysis for each month of the Palmer Station weather record (1974–1996) is summarized in table 2, and the January results are illustrated in figure 3. In agreement with previous reports (King 1994;

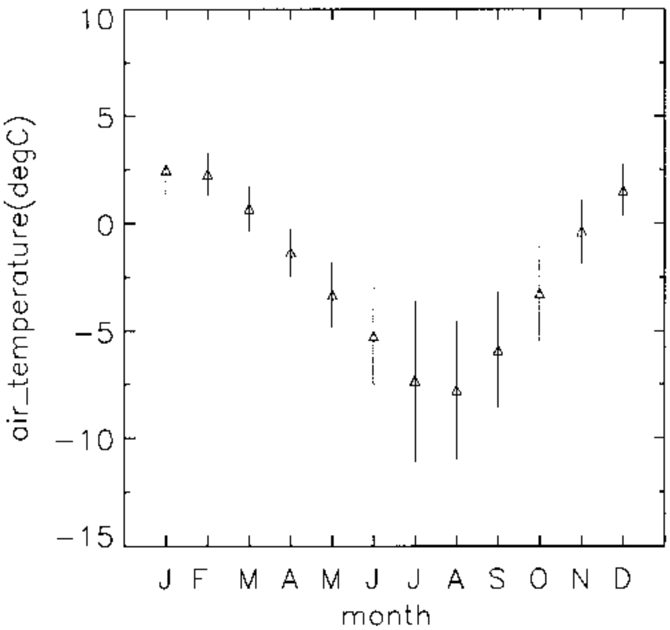

Figure 1. The Palmer Station 1974–1996 monthly average air temperatures and their standard deviations versus month.

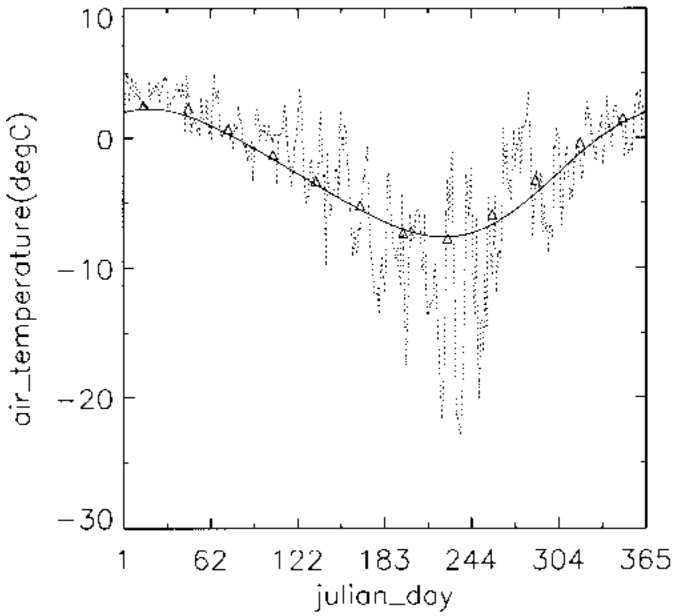

Figure 2. The Palmer Station 1995 daily air temperature (dotted line) and the 1974–1996 monthly average air temperatures (triangles) represented by a harmonic fit (solid line) versus the julian day where the harmonic fit takes the form

$$T = C + A1*\cos(\theta) + B1*\sin(\theta) + A2*\cos(2*\theta) + B2*\sin(2*\theta)$$

where the parameters are C = –2.710, A1 = –4.199, B1 = –2.406, A2 = 0.464, and B2 = –0.245, and θ is julian day converted to $\theta = (jd/365)*360° - 180°$).

Smith et al. in press), these data indicate a warming trend in the western Antarctic Peninsula region during the period that Palmer Station has been in operation. Although the statistical significance is less than that for the 44-year Faraday data, F-tests show the relationships are strong, and no serial correlation was indicated by Durbin-Watson tests.

Weather records are an integral component of any long-term study of an ecosystem. It is important to collect standardized, quality-assured weather measurements as well as to provide access to the data. The weather records discussed here have been placed in the Palmer LTER data system (*http://www.icess.ucsb.edu/lter*) as part of an ongoing effort to provide access to past and current meteorological data at Palmer Station.

Acknowledgment is given to the Antarctic Support Associates science technicians, who make the weather observations, and to Al Oxton, who initiated the development of the digital weather record at Palmer Station. Thanks to both Raymond Smith and Sharon Stammerjohn, who contributed to this work. This research was supported by National Science Foundation grant OPP 90-11927 and is Palmer LTER contribution number 102.

Table 1. Palmer Station 1974–1996 monthly average air temperatures and standard deviations

Month	Average	Standard deviation
January	2.51	1.21
February	2.29	0.96
March	0.68	1.04
April	–1.33	1.08
May	–3.32	1.50
June	–5.23	2.22
July	–7.33	3.74
August	–7.76	3.21
September	–5.90	2.68
October	–3.25	2.18
November	–0.37	1.46
December	1.53	1.19

Table 2. Palmer Station 1974–1996 monthly average air temperature trend analysis results

Month	Slope	Standard	f-test	Npoints
January	0.071	1.14	91.9	20
February	0.054	0.92	89.8	21
March	0.034	1.04	64.9	19
April	0.024	1.21	43.3	21
May	0.055	1.49	74.7	23
June	0.059	2.24	58.8	23
July	0.207	3.53	92.0	21
August	0.174	3.07	90.3	22
September	0.106	2.66	75.0	22
October	0.050	2.21	49.2	22
November	0.086	1.37	91.9	20
December	0.072	1.12	92.6	20

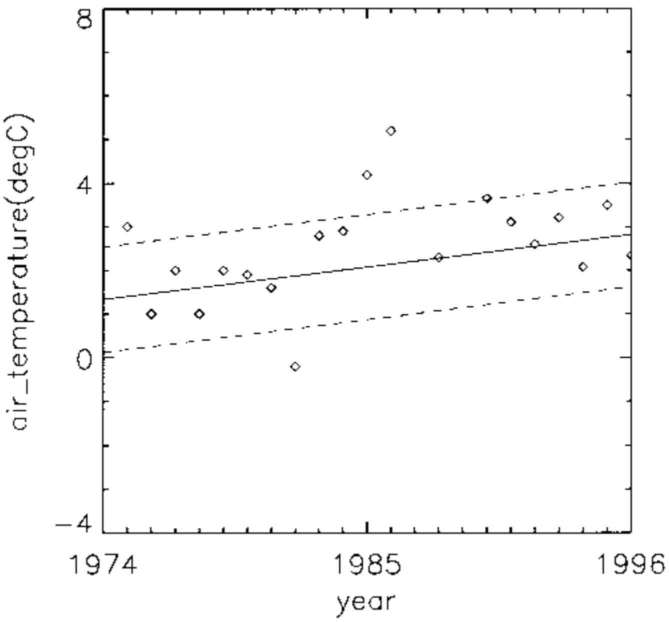

Figure 3. The Palmer Station January monthly average air temperatures versus year from 1975 to 1996 (N=20). The solid line is the least-squares regression line with a gradient of 0.071°C per year, and the dashed lines indicate ±1 standard deviation from this line.

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Palmer LTER: Annual season sampling on station

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The seasonal sampling program for the Palmer Long-Term Ecological Research (LTER) site (Smith et al. 1995) has developed over the past five seasons. Weekly observations from October through March at Palmer Station provide a time series that is enabling us

- to understand interannual variability in the seasonal timing and rates of lower trophic processes, which are reflected spatially and temporally in higher trophic levels,
- to place results from the regional scale annual cruises within a year's seasonal progression, and
- to place short-term experiments by LTER and other Palmer Station principal investigators in a seasonal/interannual context.

Observations include the seasonal progression of hydrography, nutrients, pigment biomass, and primary productivity; the near-shore abundance and distribution of antarctic krill and their larvae; and timing and success of the reproductive cycle of a major predator, Adélie penguins. The marine water column and seabird sampling schedule, summarized in the table, accommodates variability in weather.

The seasonal progression of seabird measurements follows the Adélie penguin breeding cycle. The seabird methods follow those developed and standardized by the Commission and Scientific Committee of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR 1992). Studies typically begin on Humble Island with censuses to determine the peak arrival periods of breeding adults (October) and end with chick weights at fledging (February). Additional measurements include censuses of breeding population size and the number of chicks creched per colony. These censuses encompass all colonies on each of the five island rookeries (figure; Humble, Torgersen, Litchfield, Christine, and Cormorant). Other information obtained includes data on adult Adélie breeding chronology and success (chicks creched per pair based on monitoring 300–500 nests annually) and foraging ecology (foraging trip durations and diet composition).

For marine water column sampling, each station activity is given a sequential event number. Transects from station A to E and from F to J (figure) each cover a few kilometers and are