Palmer LTER: Comparison of meteorological observations from R/V *Nathaniel B. Palmer* to those at Palmer Station

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The Palmer Long-Term Ecological Research (LTER) program is focused on understanding the structure and function of the marine ecosystem on the western side of the Antarctic Peninsula. The major emphasis of the research is on the documented interannual changes in the ice cover in this region and the effect that these changes have on the physical, chemical, and biological processes that are important to the ecosystem.

A part of the LTER program considers hydrographic properties and circulation of the continental shelf. Exchanges between the surface ocean and the lower atmosphere have important effects on the processes that control the hydrography and circulation. These exchanges are based on air temperature, humidity, and wind speed as well as other factors, and control formation and melting of ice and heat exchange between the atmosphere and ocean as well as circulation of the ocean.

Estimating the atmospheric conditions over the ocean in antarctic coastal areas can be particularly challenging because of the small number of coastal meteorological stations and, more important, because of the strong effects from the continent on meteorological observations at coastal stations (Schwerdtfeger and Amaturo 1979). Two effects are topographic steering caused by mountain ranges and gaps and katabatic winds, which occur by dense air draining from the antarctic plateau or being pushed over a mountain range. The distance over which land influences meteorological conditions ranges from a few kilometers to perhaps 10 or more kilometers (Schwerdtfeger and Amaturo 1979).

The purpose of this study is to compare atmospheric conditions measured at Palmer Station with simultaneous measurements made on the R/V *Nathaniel B. Palmer* during a cruise in March through May 1993. Correspondence between the two measurements allows a predictive relationship to be developed.

The meteorological observations available from Palmer Station are the daily average temperature, surface barometric pressure, and wind speed and direction, all of which are the World Meteorological Organization (WMO) 6-hour observations. The data used in this study cover yeardays 102 to 132 (11 April to 11 May 1993), the time that the ship was sampling in the coastal waters west and south of Palmer Station (figure 1).

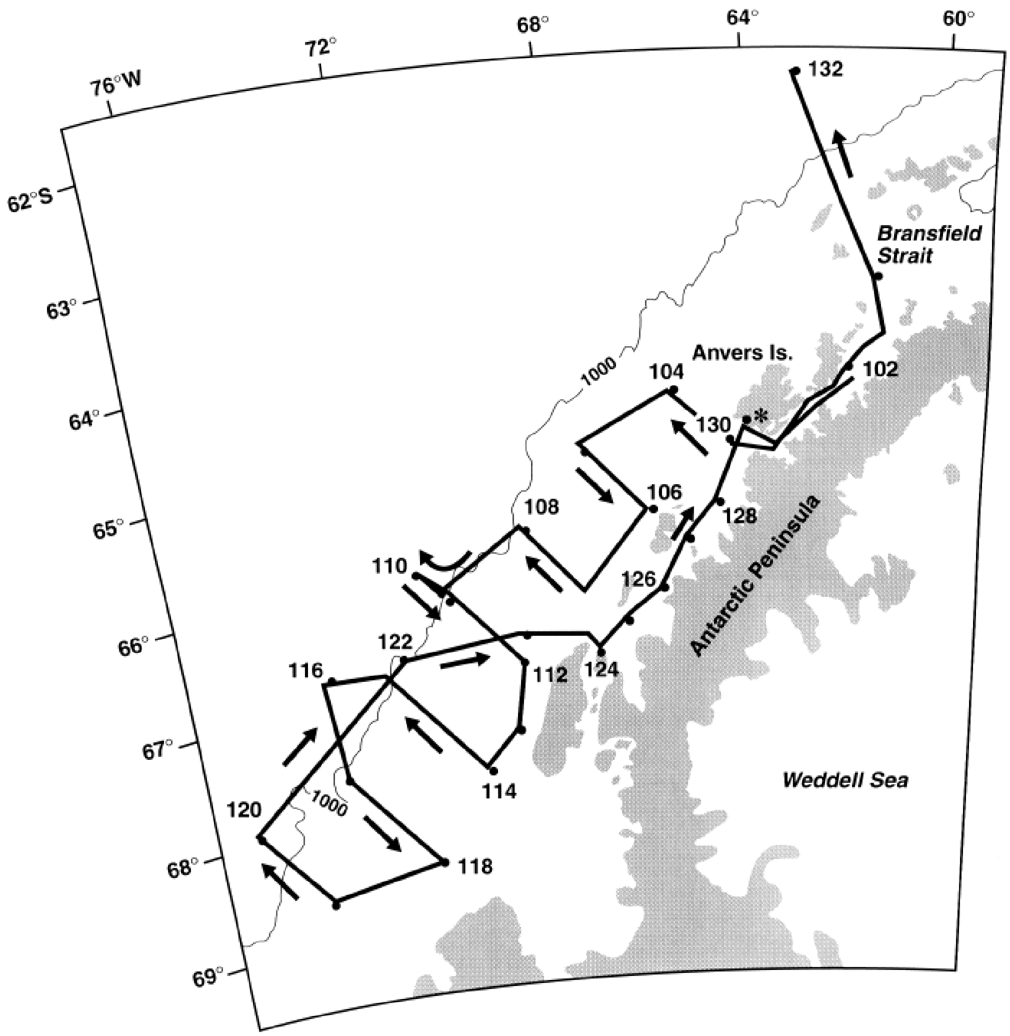

Figure 1. Cruise track for LTER cruise that occurred March to May 1993. The heavy line is the smoothed ship track (from daily values) with a solid dot every day. The numbers are the yearday for the indicated location. Shaded area is land. The line labeled 1,000 is the 1,000 m isobath, which approximately coincides with the edge of the continental shelf.

Meteorological conditions during the cruise were sampled every 6 seconds and averaged over 1 minute for logging (for details, *see* Smith et al. 1993). No corrections were applied to the temperature or surface pressure records. The wind readings were corrected for ship heading and motion, both of which were also included in the real-time logging system. All wind measurements are relative to magnetic north and indicate the direction toward which the wind is blowing (oceanographic convention). For the purpose of this study, ship observations were averaged to daily values to match the time interval of the station observations. Measurements were compared at yeardays 103 and 130 when the ship was near Palmer Station to give confidence that the various corrections were applied properly.

The comparison of the conditions on the ship and at the station is based on 30 daily measurements of surface pressure (figure 2*A*), air temperature (figure 2*B*), and the east-west (figure 2*C*) and north-south (figure 2*D*) wind components. A linear relationship (the simplest assumption) is assumed to exist between the station and the ship observations and a linear least-square technique was used to obtain the slope and intercept of the linear model for each pair of time series (table). The predicted meteorological conditions at the ship obtained from the station observations using the linear regression model are shown in figure 2.

The predicted surface pressure has the best correspondence with offshore observations: 92 percent of the variance is explained (figure 2*A*). The predicted values match well except between days 113 (ship near Adelaide Island) and 123 (ship returned to Adelaide Island). This fit is not surprising because of the large length scales (100s of kilometers) associated with atmospheric pressure variations.

The predicted air temperature has poorer agreement between conditions at the station and the ship; however, the linear relationship explains two-thirds of variance. At the beginning of the time interval (until day 110), the air is consistently warmer (2–3°C) over the shelf relative to the station. After day 115, the temperature is consistently colder on the ship, which has to do with the ship being south of the station, near Marguerite Bay. The predicted values are within 3°C of the ship values, but the predicted temperatures miss the warmer conditions over the shelf off Palmer Station (days 103–112). The model also underestimates peak values through the rest of the cruise. The slope parameter shows that the temperature variations over the shelf are about 60 percent of those observed at the station.

The predicted winds have a different character for each component. The station east-west wind is almost always weaker than winds over the shelf. At times, the east-west wind strengths at the station and offshore agree, but differences as large as 7 meters per second (m s^{-1}) occur. The agreement of the two wind time series does not seem to depend on separation distance. Although the two time series look different, the linear regression model produces a reasonable prediction.

The north-south component of the winds matches more closely, except when the ship is far to the south and offshore (days 120 to 125). The offshore winds are consistently stronger than the station winds but not by as much as the

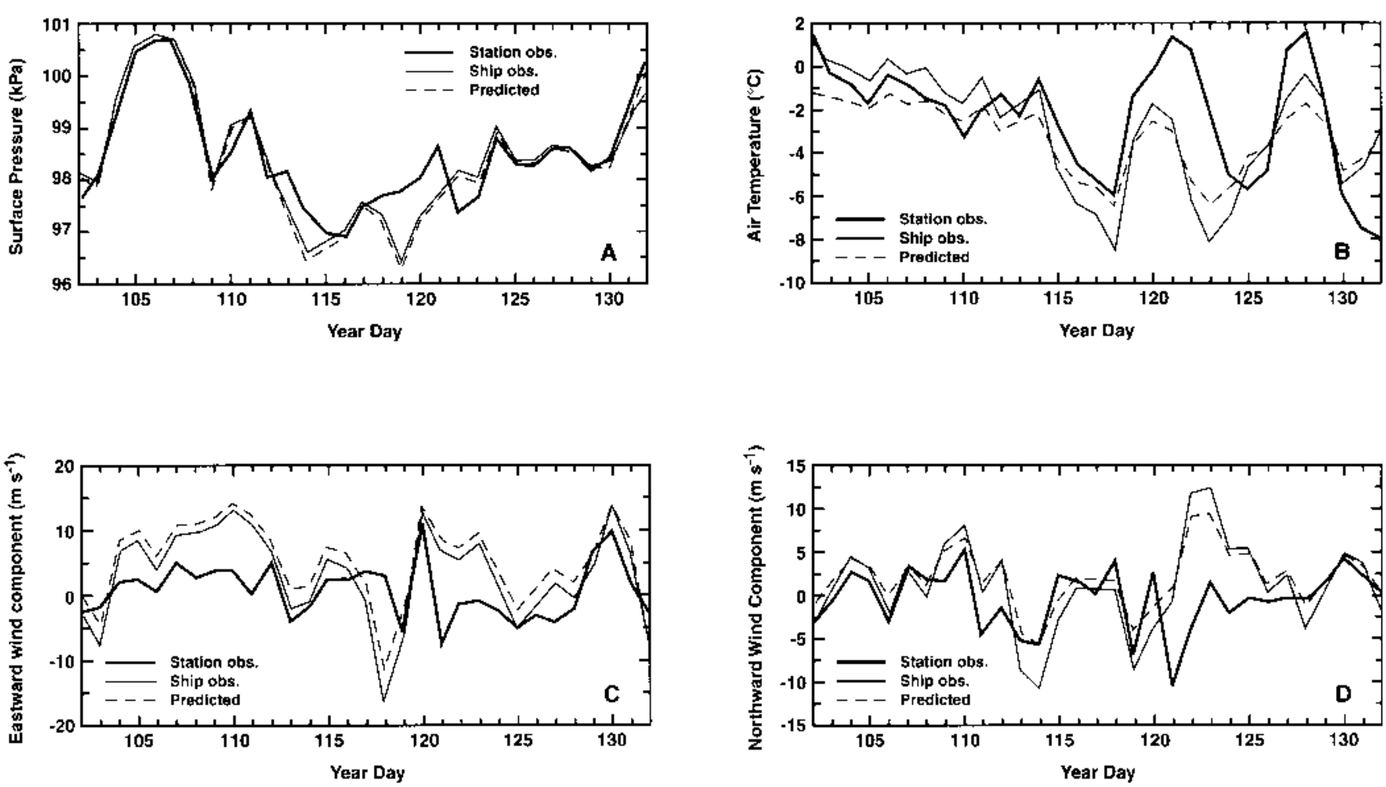

Figure 2. Daily values of four meteorological observations from Palmer station (heavy line) and from the R/V *Nathaniel B. Palmer* (thin line). The dashed line is the predicted values at the ship from the linear relationship. (*A*) Surface barometric pressure. (kPa denotes kilopascals) (*B*) Air temperature. (*C*) East component of surface winds. (*D*) North component of surface winds.

Parameters obtained for the linear model derived to predict offshore atmospheric conditions from those measured at Palmer Station

Parameter	Units	Intercept	Slope	r^2
Temperature	°C	–1.51	0.594	0.636
Surface pressure	Kilopascals	–3.15	1.030	0.918
North-south wind speed	Meters per second	1.28	0.653	0.446
East-west wind speed	Meters per second	2.53	0.880	0.520

east-west winds. Once again, the linear model produces a reasonable prediction of the observed ship winds, but it underestimates the amplitude of some of the peaks.

Overall, the offshore winds are well represented by the linear model. The largest misfit is in the range of 1.3 m s^{-1}, which is not small but is within acceptable limits for many studies. This study demonstrates that it is possible to use station observations of atmospheric conditions to estimate conditions over the ocean. The values predicted from the station observations have similar amplitude and time variation as the values measured on the ship over a wide area of the shelf. The relationship must be used with caution because it would be valid only over the austral fall and may not apply to all years without additional testing. This work could be extended with longer data records and more sophisticated models. It would also be useful to have independent observation to test the quality of the prediction formulas.

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References

Schwerdtfeger, W., and L.R. Amaturo. 1979. *Wind and weather around the Antarctic Peninsula* (Technical Report 79.00.S1). Madison: Department of Meteorology, University of Wisconsin.

Smith, D.A., R.A. Locarnini, B.L. Lipphardt, Jr., and E.E. Hofmann. 1993. *Hydrographic data collected aboard R/V* Nathaniel B. Palmer *March–May 1993* (CCPO Technical Report No. 93-04). Norfolk, Virginia: Old Dominion University.

Palmer LTER: Temporal variability in primary production in Arthur Harbor during the 1995–1996 growth season

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An understanding of spatial and temporal variability in primary production and its relationship to physical and biological factors is necessary to model carbon cycling in the antarctic ecosystem. The Palmer Long-Term Ecological Research (LTER) program is testing the hypothesis that the magnitude and distribution in carbon uptake by phytoplankton are linked to the extent of ice cover during the preceding winter months. This temporal variability is studied at a coastal station near Arthur Harbor on Anvers Island for 5 months to show the extent and timing of productivity in the area. The sampling represents the growth season in coastal waters of the Antarctic Peninsula, which on the average, extends from November to March in this region (Tokarczyk 1986; Smith, Dierssen, and Vernet in press).

Water samples were obtained biweekly from two stations (stations B and E in Palmer LTER inshore grid): one off Bonaparte Point, Anvers Island, and the other offshore and to the south (64°48.9'S 64°02.4'W) (Waters and Smith 1992). Samples were taken with a Go-Flo bottle at the surface and depths corresponding to 50 percent, 24 percent, 14 percent, 4 percent, and 2 percent of incident radiation. Depths were established by measuring photosynthetically available radiation with a LICOR 193-SA Quantum Sensor. Water was stored in a cooler and transported back to the station. Duplicate samples were inoculated with 5 microcuries of carbon-14–bicarbonate and incubated outside the station. Neutral nickel screens were used to simulate the corresponding light levels. Running sea water through the incubator kept the samples at *in situ* temperature. After 24 hours, samples were filtered onto a Whatman GF/F filter, acidified with 0.4 milliliters of 15 percent glacial acetic acid, and counted after addition of Universol ES. Production rates are expressed as milligrams carbon per cubic meter per day.

The major pulses in primary production in this area occur in late spring (December and January) as well as later in the summer (February and March) (Prézelin et al. 1992). The first event is generally larger and can last for a few weeks whereas the second pulse is of secondary magnitude. The 1995–1996 season blooms followed this general pattern, though the first pulse in productivity in late November and early December was slightly smaller than the second, which occurred in early February (figure). Maximum rates were observed below the surface layer (24