Palmer LTER: Sea-ice coverage in the Long-Term Ecological Research region

SHARON E. STAMMERJOHN *and* RAYMOND C. SMITH, *Institute for Computational Earth System Science and Department of Geography, University of California at Santa Barbara, Santa Barbara, California 93106*

Spatial and temporal variability of ice coverage in the Long-Term Ecological Research (LTER) large-scale study region (Waters and Smith 1992) has been analyzed from 1973 to 1994 using surface sea-ice concentrations derived from passive microwave satellite data using the National Aeronautics and Space Administration (NASA) algorithm. The passive microwave satellite data have been made available by the National Snow and Ice Data Center (NSIDC) in Boulder, Colorado, and involve three datasets in conjunction with three passive microwave radiometers used to collect the data: the electrically scanned microwave radiometer (ESMR, 1973–1976), the scanning multichannel microwave radiometer (SMMR, 1978–1987), and the special sensor microwave/imagers (SSM/I, 1987 to the present). Efforts are being made to fill in data gaps in the earlier record between 1973–1978 using Navy/National Oceanic and Atmospheric Adminstration Joint Ice Data analyses. Higher resolution, visible and infrared satellite data [on the order of 1 kilometer (km) vs. 25–50 km for passive microwave] have also been analyzed when clear-sky conditions permit detection of the surface. A TeraScan system at Palmer Station captures advanced very high resolution radiometer (AVHRR), operational line scanner (OLS), and SSM/I 85-gigahertz (GHz) data of the Peninsula region, which are then archived and distributed by the Antarctic Research Center (ARC).

Seasonal and interannual variability in sea-ice coverage for the LTER study region have been compared with regionalized and total southern ocean sea-ice coverage (Stammerjohn 1993). This comparison revealed several distinguishing characteristics of LTER ice coverage. Using cross spectral analysis, it has been shown that the region west of the Antarctic Peninsula to about 97°W is fairly homogeneous with respect to variability in ice coverage. Hence, seasonal and interannual variability of ice coverage in the LTER and Bellingshausen Sea (270–300° longitude) regions are similar. Seasonal and interannual variability of ice coverage in the Amundsen Sea (230–270° longitude), Bellingshausen Sea, and east Antarctic Peninsula (300–320°) regions, however, are distinctly different. Cross spectral analysis also indicates that anomalous ice coverage in the Bellingshausen Sea lags the Amundsen Sea by approximately 1 year and that this west-to-east anomaly propagation is also prevalent within the Bellingshausen region. In addition, seasonal ice coverage in the LTER and Bellingshausen Sea regions is distinct from other southern ocean regions in that the period of ice advance (April to July) is relatively short in comparison to the period of ice retreat (August to January). The mean month of maximum ice coverage in the LTER and Bellingshausen Sea regions occurs in August, whereas for other southern ocean regions, maximum ice coverage usually occurs in September. Lastly, the LTER and Bellingshausen Sea regions are the only southern ocean regions that show long-term persistence in monthly anomalous ice coverage, so that 2–4 consecutive high-ice years are followed by 2–4 consecutive low-ice years, a pattern that repeats twice in the 1978–1994 ice record.

The 1973–1994 time series of monthly ice area (areal coverage of sea ice only) and extent (areal coverage inside the 10 percent ice-concentration contour including sea ice and open water) for the LTER region are shown in figure 1. The horizontal lines are the 17-year mean maximum and 19-year mean minimum sea area/extent. The difference in magnitude of ice area vs. ice extent is the amount of open water inside the ice-edge contour (i.e., 10 percent). Because the ice edge in normal to high-ice years lies north of the LTER study area, the time series of ice extent has an upper threshold that denotes the years that the entire grid is ice filled. The ice extent time series, however, does not illustrate the interannual variability in

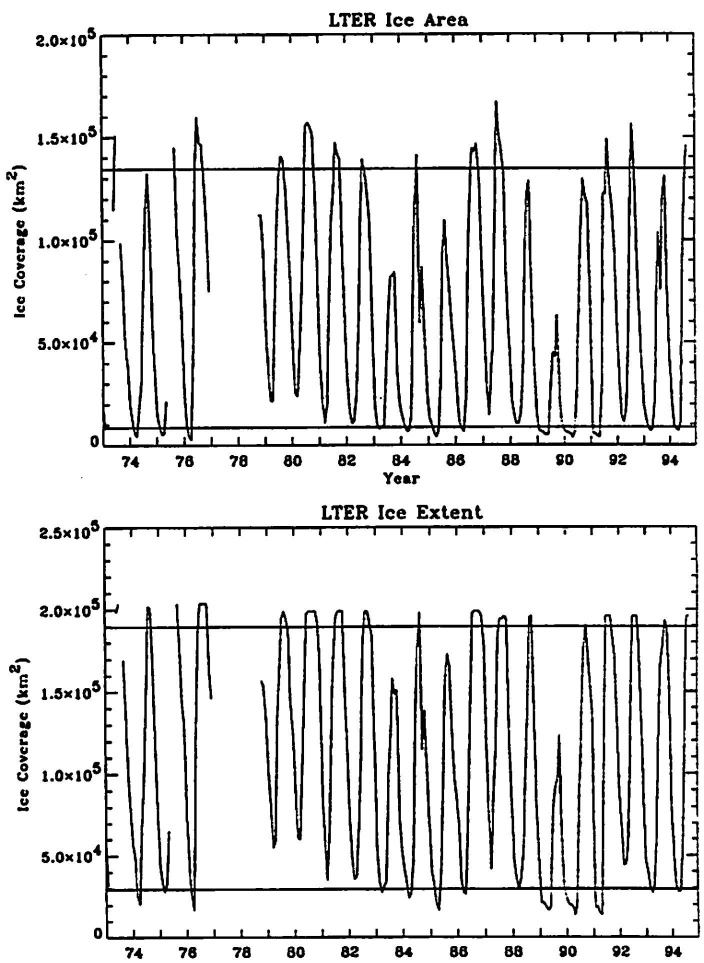

Figure 1. Monthly ice area and extent for the LTER large-scale study area. The time series begin January 1973 and end August 1994. Missing months are blank. The horizontal lines are 17-year mean maximum and 19-year mean minimum ice coverages.

actual ice amount in the LTER study area as does the ice area time series. Therefore, with respect to LTER seasons 1991–1992, 1992–1993, 1993–1994, and 1994–1995, we use ice area to characterize ice coverage.

For example, figure 2 summarizes yearly maximum/minimum ice area and month of maximum/minimum ice area for the LTER area. The 1991–1992 LTER season follows an above-mean winter ice maximum (in August 1991) and occurs during an above-mean summer ice minimum (in March 1992). This above-mean winter ice maximum is especially noteworthy, because a near record low summer ice minimum occurred in April 1991, just 3–4 months previous to the winter maximum. This illustrates one of the features that distinguishes seasonal progression in the LTER and Bellingshausen Sea regions: a short period of rapid ice advancement. The 1992–1993 LTER season follows an *early* above-mean winter ice maximum (in July 1992) and occurs during a below-mean summer ice minimum (in March 1993). The 1993–1994 LTER season follows a *late* mean winter ice maximum (in October 1993) and occurs during a below-mean summer ice minimum (in April 1994). The NSIDC ice record is updated only through August 1994, so a complete picture of the winter ice maximum preceding the 1994–1995 LTER season is not yet available. Ice area in August 1994, however, is already above mean, and again, this quickly follows a below-mean summer ice minimum in April 1994.

The overall ranking of ice years for the LTER seasons is (from high to low): 1992, 1991, 1993 (1994 is yet to be resolved). As illustrated by the 1991–1993 record described above and as is the general case for the 1973–1994 record, high-ice years have early maximums (June/July), and low-ice years have late maximums (September/October).

Acknowledgment and thanks are given to Michelle Holm for her many efforts and support at NSIDC. This work was supported by National Science Foundation grant OPP 90-11927 to Raymond C. Smith and is Palmer LTER contribution number 64.

References

Stammerjohn, S.E. 1993. Spatial and temporal variability in Southern Ocean sea ice coverage. (Master Thesis, University of California, Santa Barbara, Santa Barbara, California.)

Waters, K.J., and R.C. Smith. 1992. Palmer LTER: A sampling grid for the Palmer LTER program. *Antarctic Journal of the U.S.*, 27(5), 236–239.

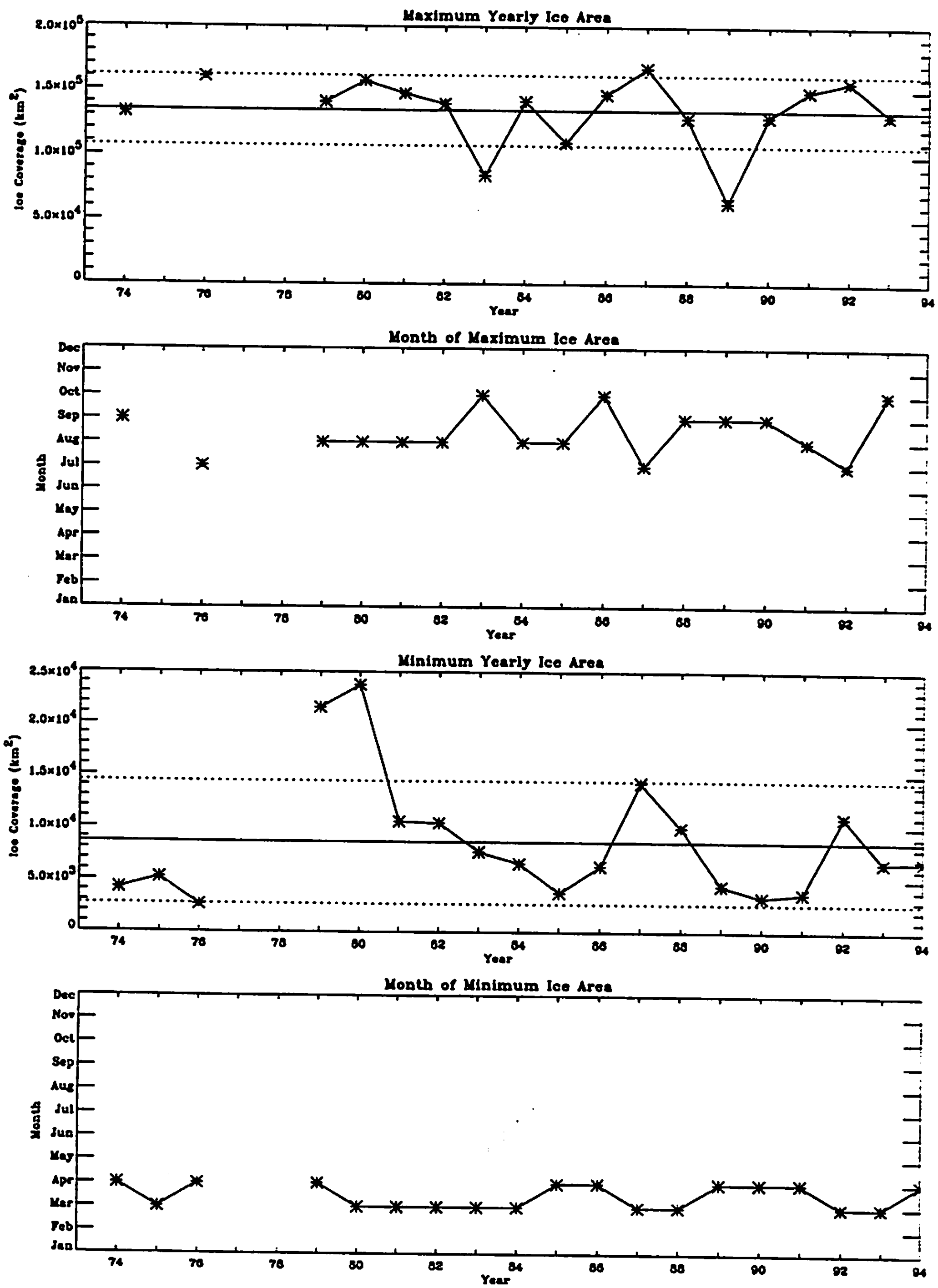

Figure 2. Maximum and minimum ice area attained each year (based on monthly averages) and the month of maximum and minimum occurrence for the LTER area. The solid lines in the maximum and minimum ice area plots denote the 17-year mean maximum and 19-year mean minimum, respectively, and the dotted lines are ±1 standard deviation.