Palmer LTER: A sampling grid for the Palmer LTER program

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The antarctic long-term ecological research (LTER) program will focus on the palegic marine ecosystem and the ecological processes which link the extent of annual pack ice to the biological dynamics of different trophic levels. The Palmer LTER site is centered near Palmer Station, Anvers Island midway down the Antarctic Peninsula (64°40' S 64°03' W) and will include a long-term comprehensive measurement program of this ice dominated system. Like other LTERs the Palmer LTER will investigate phenomena that occur on time scales of years to decades in order to separate long-term (decadal) systematic trends from interannual variability in physical conditions and populations. In order to structure our long-term monitoring we created a sampling grid analogous to the well-known CalCOFI grid along the west coast of North America. The PalLTER grid is west of the Antarctic Peninsula and covers an area of 900 kilometers (roughly parallel to the peninsula) by 200 kilometers (on- to offshore) (figure 1). Within this grid, cardinal lines spaced every 100 kilometers along the peninsula and cardinal points spaced every 20 kilometers on to offshore will comprise basic sampling stations (table 1). Imbedded within this large-scale or peninsula grid is a finer-scale grid specific to the immediate area of Palmer Station (figure 2, table 2). It is anticipated that other investigators working in this area may wish to reference their work to this PalLTER grid as a long-term data base is developed for this region.

The need for fixed geographic station locations that could be visited repeatedly over time scales of many years and the desire for a regularly spaced grid to simplify modeling computations motivated our effort. The difficulty in laying out such a grid in a polar region where lines of longitude rapidly converge complicated the problem. The recognition that increased use of Geographical Position Systems (GPS) would lead to outdated navigation charts leads us to base the grid on GPS positions.

We defined the PalLTER grid using a universal transverse Mercator (UTM) projection for zone minus 20 with the Geodetic Reference System 1980 (GRS80) spheriod (cf. Maling 1992). A UTM grid provides a coordinate system that is roughly Cartesian near the center point. By rotating the UTM grid by 50 degrees counterclockwise about a point near Palmer Station at 64°56' S 64°24' W), we obtain a grid that is approximately parallel to the peninsula in this region. Designating X as the axis running parallel to the peninsula for the rotated grid, and Y as the axis running perpendicular to the peninsula, we define LTER coordinates/stations as xxx.yyy where xxx is the distance along the X axis in kilometers and yyy is the distance along the Y axis in kilometers. We set the center point of the UTM grid (64°56' S 64°24' W) as station 600.040, thus completely defining all stations.

The conversion from UTM coordinates to latitude-longitude is done with the program PLANE-PC developed for interactive grid coordinates conversion by Jack Waananen, U.S. Geological

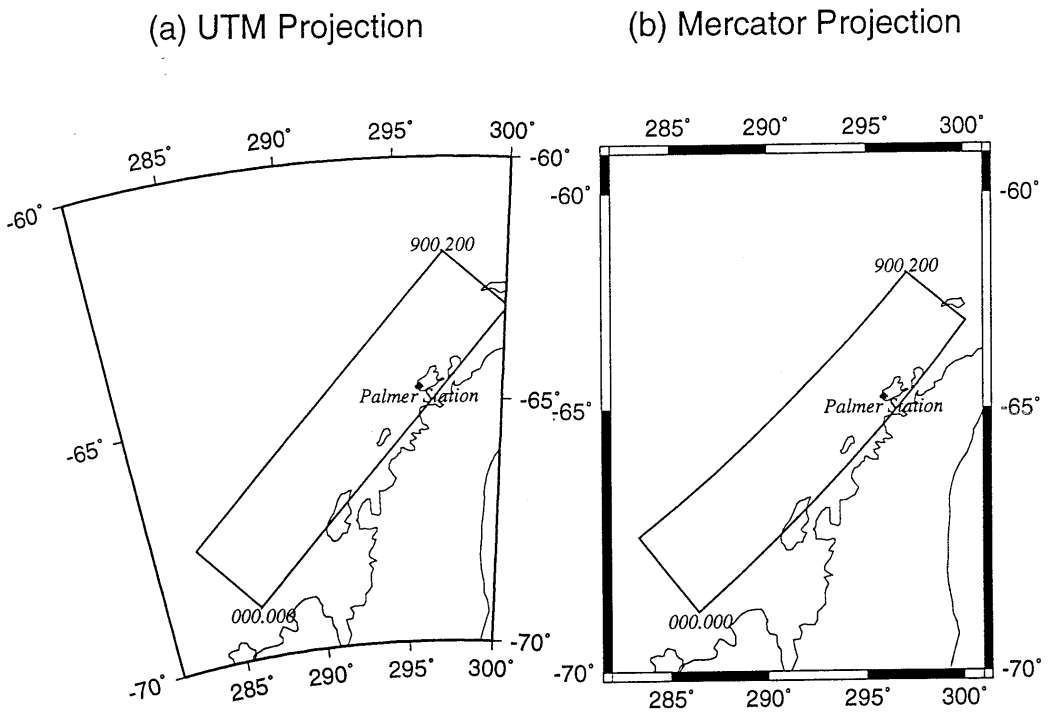

Figure 1. The Palmer peninsular area is shown on both UTM and Mercator projections. The PalLTER grid region is outlined.

Survey (USGS), Reston, Virginia (version of 6/17/86 program available from USGS). Additional programs were written to perform the coordinate rotation and provide input files for the PLANE-PC program. All programs were recompiled in a UNIX environment and piped together so that an input LTER station number gives an output latitude-longitude.

Thus defined, the PalLTER grid has coordinates, for our interests, from 000.000 to 900.200. Figure 1 illustrates the difference between the UTM projection used for the grid layout and a standard Mercator projection typically used for nautical charts where we show the PalLTER grid boundaries on both projections. The curvature of the boundary shown on the Mercator projection shows the difficulty of laying out a regularly spaced grid using a standard nautical chart. A finer grid, consistent with the cardinal lines and points given in table 1, is easily produced via the computer programs and is available upon request.

Fine-scale sampling positions near Palmer Station were selected to provide a set of fixed station locations within the Zodiac boating range of the station and with some selected to be along the normal in/out access route of research vessels visiting the station. These stations are not on a regular grid and are designated alphabetically (figure 2). Sampling of stations A-J by a Zodiac is done weekly from Palmer Station; stations K-O are sampled by Zodiac if a potential rescue ship is at the station; stations E1-E4 are sampled infrequently from a ship of opportunity. We designate this set of stations near Palmer station as the Palmer grid.

We found the nautical charts for this area (Defense Mapping Agency Stock #29AHA29123, last update 1977) to be systematically offset compared to GPS satellite positions. GPS positions are 51 seconds of longitude (690 meters) west of charted positions. The chart in figure 2 has been redrawn from the original so that landmarks, sampling stations, and GPS positions are consistent. Palmer grid stations locations shown on this chart and their GPS coordinates are listed in table 2. This chart is unofficial and should not be used for navigation purposes. We use a Trimble Pathfinder GPS to locate the stations from the Zodiac. We also give the LTER grid coordinates for the Palmer grid stations in table 2.

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Reference

Maling, D. H. 1992. *Coordinate Systems and Map Projections*, 2nd edition. New York: Pergamon Press.

Table 1. LTER grid coordinates/stations

Grid number	Latitude S	Longitude W	Grid number	Latitude S	Longitude W
000.000	68°58.047'	73°33.648'	500.080	65°21.409'	66°27.834'
000.020	68°49.820'	73°52.797'	500.100	65°14.029'	66°46.558'
000.040	68°41.559'	74°11.711'	500.120	65°06.611'	67°05.107'
000.060	68°33.265'	74°30.393'	500.140	64°59.156'	67°23.485'
000.080	68°24.939'	74°48.847'	500.160	64°51.665'	67°41.692'
000.100	68°16.583'	75°07.077'	500.180	64°44.138'	67°59.730'
000.120	68°08.196'	75°25.086'	500.200	64°36.576'	68°17.601'
000.140	67°59.779'	75°42.877'	600.000	65°10.122'	63°45.505'
000.160	67°51.333'	76°00.455'	600.020	65°03.081'	64°04.837'
000.180	67°42.859'	76°17.822'	600.040	64°56.000'	64°24.000'
000.200	67°34.358'	76°34.982'	600.060	64°48.878'	64°42.994'
100.000	68°22.795'	71°42.302'	600.080	64°41.717'	65°01.821'
100.020	68°14.778'	72°01.648'	600.100	64°34.516'	65°20.483'
100.040	68°06.727'	72°20.768'	600.120	64°27.277'	65°38.981'
100.060	67°58.641'	72°39.667'	600.140	64°20.000'	65°57.315'
100.080	67°50.521'	72°58.347'	600.160	64°12.685'	66°15.489'
100.100	67°42.368'	73°16.811'	600.180	64°05.334'	66°33.503'
100.120	67°34.183'	73°35.063'	600.200	63°57.947'	66°51.358'
100.140	67°25.966'	73°53.105'	700.000	64°28.921'	62°24.124'
100.160	67°17.718'	74°10.941'	700.020	64°22.057'	62°43.318'
100.180	67°09.441'	74°28.573'	700.040	64°15.150'	63°02.353
100.200	67°01.133'	74°46.005'	700.060	64°08.203'	63°21.230
200.000	67°46.319'	69°56.667'	700.080	64°01.215'	63°39.949
200.020	67°38.510'	70°16.130'	700.100	63°54.188'	63°58.513'
200.040	67°30.664'	70°35.377'	700.120	63°47.121'	64°16.922'
200.060	67°22.781'	70°54.414'	700.140	63°40.016'	64°35.178'
200.080	67°14.863'	71°13.242'	700.160	63°32.872'	64°53.281'
200.100	67°06.911'	71°31.863'	700.180	63°25.692'	65°11.234'
200.120	66°58.924'	71°50.281'	700.200	63°18.474'	65°29.037'
200.140	66°50.905'	72°08.499'	800.000	63°47.008'	61°06.757'
200.160	66°42.852'	72°26.518'	800.020	63°40.312'	61°25.784'
200.180	66°34.768'	72°44.343'	800.040	63°33.574'	61°44.662'
200.200	66°26.652'	73°01.974'	800.060	63°26.794'	62°03.391'
300.000	67°08.723'	68°16.460'	800.080	63°19.974'	62°21.973'
300.020	67°01.115'	68°35.970'	800.100	63°13.113'	62°40.409'
300.040	66°53.469'	68°55.276'	800.120	63°06.212'	62°58.699'
300.060	66°45.785'	69°14.382'	800.140	62°59.273'	63°16.845'
300.080	66°38.065'	69°33.289'	800.160	62°52.294'	63°34.847'
300.100	66°30.309'	69°52.001'	800.180	62°45.278'	63°52.708'
300.120	66°22.517'	70°10.518'	800.200	62°38.225'	64°10.427'
300.140	66°14.690'	70°28.844'	900.000	63°04.445'	59°53.146'
300.160	66°06.829'	70°46.982'	900.020	62°57.910'	60°11.983'
300.180	65°58.935'	71°04.932'	900.040	62°51.333'	60°30.680'
300.200	65°51.008'	71°22.698'	900.060	62°44.715'	60°49.238'
400.000	66°30.100'	66°41.390'	900.080	62°38.055'	61°07.658'
400.020	66°22.688'	67°00.888'	900.100	62°31.354'	61°25.941'
400.040	66°15.237'	67°20.194'	900.120	62°24.614'	61°44.087'
400.060	66°07.747'	67°39.310'	900.140	62°17.833'	62°02.097'
400.080	66°00.218'	67°58.239'	900.160	62°11.014'	62°19.972'
400.100	65°52.653'	68°16.981'	900.180	62°04.157'	62°37.714'
400.120	65°45.051'	68°35.540'	900.200	61°57.261'	62°55.322'
400.140	65°37.413'	68°53.917'			
400.160	65°29.739'	69°12.114'			
400.180	65°22.031'	69°30.133'			
400.200	65°14.289'	69°47.976'			
500.000	65°50.540'	65°11.167'			
500.020	65°43.317'	65°30.603'			
500.040	65°36.054'	65°49.859'			
500.060	65°28.751'	66°08.935'			

Cardinal lines (every 100 kilometers along the peninsula) and points (every 20 kilometers on- or offshore) are shown for the PalLTER grid. The locations of the Palmer grid stations are given in terms of latitude-longitude and LTER grid coordinates.

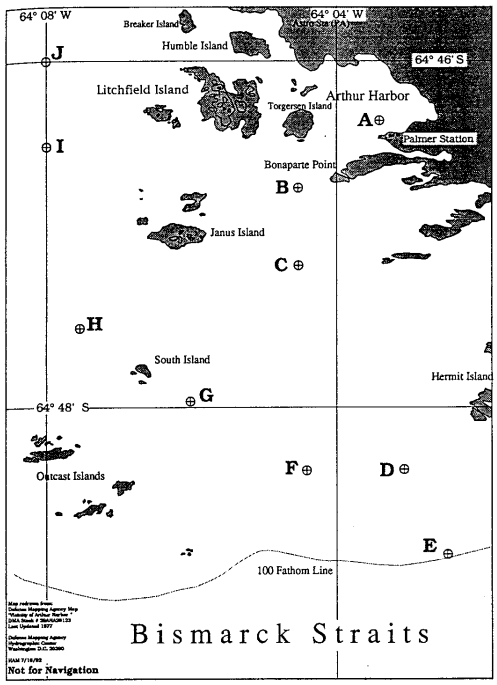

Figure 2. The PalLTER grid in relation to Palmer Station. The chart latitude-longitude marks have been redrawn so as to agree with GPS positions. The GPS and USGS benchmark at the tip of Bonaparte Point agree. The GPS readings are 51 seconds west (roughly 690 meters) with respect to the chart. This chart is unofficial and should NOT be used for navigation.

Table 2. LTER Palmer grid stations

Station ID	Latitude S	Longitude W	LTER grid
A	64° 46.45'	64° 03.27'	624.039
B	64° 46.77'	64° 04.35'	624.040
C	64° 47.30'	64° 04.35'	622.039
D	64° 48.40'	64° 03.06'	622.037
E	64° 48.90'	64° 02.43'	622.036
F	64° 48.40'	64° 04.35'	621.037
G	64° 48.00'	64° 06.00'	622.039
H	64° 47.3()'	64° 07.60'	621.040
I	64° 46.50'	64° 08.00'	622.042
J	64° 46.00'	64° 08.00'	622.042
K	64° 50.51'	64° 02.94'	619.034
L	64° 51.97'	64° 03.07'	617.033
M	64° 53.01'	64° 03.14'	615.031
N	64° 53.91'	64° 06.0()'	614.032
0	64° 52.60'	64° 08.30'	613.035
E1	64° 53.00'	64° 09.71'	613.035
E2	64° 52.92'	64° 39.16'	597.053
E4	64° 56.00'	64° 24.00'	600.040