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NOAA Technical Memorandum NOS NGS-51

THE NOAA GEOSAT GEOPHYSICAL DATA RECORDS:
SUMMARY OF THE THIRD YEAR OF THE EXACT REPEAT MISSION

Nancy S. Doyle
Robert E. Cheney
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Laury Miller
Edward L. Timmerman

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National Geodetic Survey, Charting and Geodetic Services
National Ocean Service, NOAA
Rockville, MD 20852

ABSTRACT. The GEOSAT radar altimeter provided approximately 80 million global observations of sea level, wind speed, and significant wave height between April 1985 and the end of the mission on January 5, 1990. Although sea level observations made by GEOSAT during the first 18 months of the mission are classified, data collected after November 8, 1986, are publicly available through NOAA. This portion of the GEOSAT mission is known as the Exact Repeat Mission (ERM) because the ground track repeated within approximately 1 km every 17 days.

The National Ocean Service of NOAA, in cooperation with the U.S. Navy and the Johns Hopkins University Applied Physics Laboratory (JHU APL), produced the GEOSAT Geophysical Data Records (GDRs). For background or ordering information, see the "GEOSAT Altimeter Geophysical Data Record User Handbook" (Cheney et al., 1987), which describes the data flow and NOAA processing. In this report we summarize GEOSAT ocean data collected during the third and final year of the ERM, November 1988-89. (A secondary set of ice/land GDRs was also produced, but will not be discussed in this summary.) For similar reports on the first 2 years of the ERM, see Cheney et al. (1988) and Doyle et al. (1989).

GLOBAL DATA DISTRIBUTION

Geophysical Data Records are produced by the Geodetic Research and Development Laboratory in Rockville, MD, by combining Sensor Data Records (SDRs), the satellite ephemeris, corrections for solid and fluid tides, and path length effects due to the troposphere and ionosphere. Figure 1 shows the total number of 1-second GDRs for each day of the third year of the ERM, and the limited portion of the fourth year prior to termination. No data were collected during a 1-week period in March 1989 (days 75 to 81) due to magnetic storms associated with solar disturbances. October 3, 1989 (day 296) is the final day on which global data were collected because of the failure of satellite tape recorders and other instrument-related problems. The nominal number of records per day was approximately 40,000 during the first half of the year and declined to less than 30,000 during the latter half. As during the previous 2 years, there is a tendency for the number of observations to be high in boreal winter and low in summer. However, superimposed on the seasonal variation is a low-frequency trend of data loss extending back to early 1988 when 50,000 records per day were typically obtained. This decline may be related to increased varibility of spacecraft attitude caused by added solar radiation pressure accompanying approach of the 1990 solar maximum.

The sequence of global ground track plots for each 17-day repeat cycle (see appendix) shows the changing areal coverage during the third year. In addition to the aforementioned gaps in global data, migratory regional gaps occurred similar to those during the first 2 years. These regional gaps are caused by systematic excursions in spacecraft attitude which adversely impact the altimeter's ability to track the reflected radar pulse.

NORTH ATLANTIC DATA

After the tape recorder malfunctioned in October 1989, GEOSAT data could be collected only by direct transmission to the ground station. This limited the data to a relatively small area of the North Atlantic and Gulf of Mexico where the satellite was in line of sight of the receiver at JHU APL. Although only 1 percent of the previous global data set in volume, these data showed no degradation in quality compared with those collected previously along these tracks.

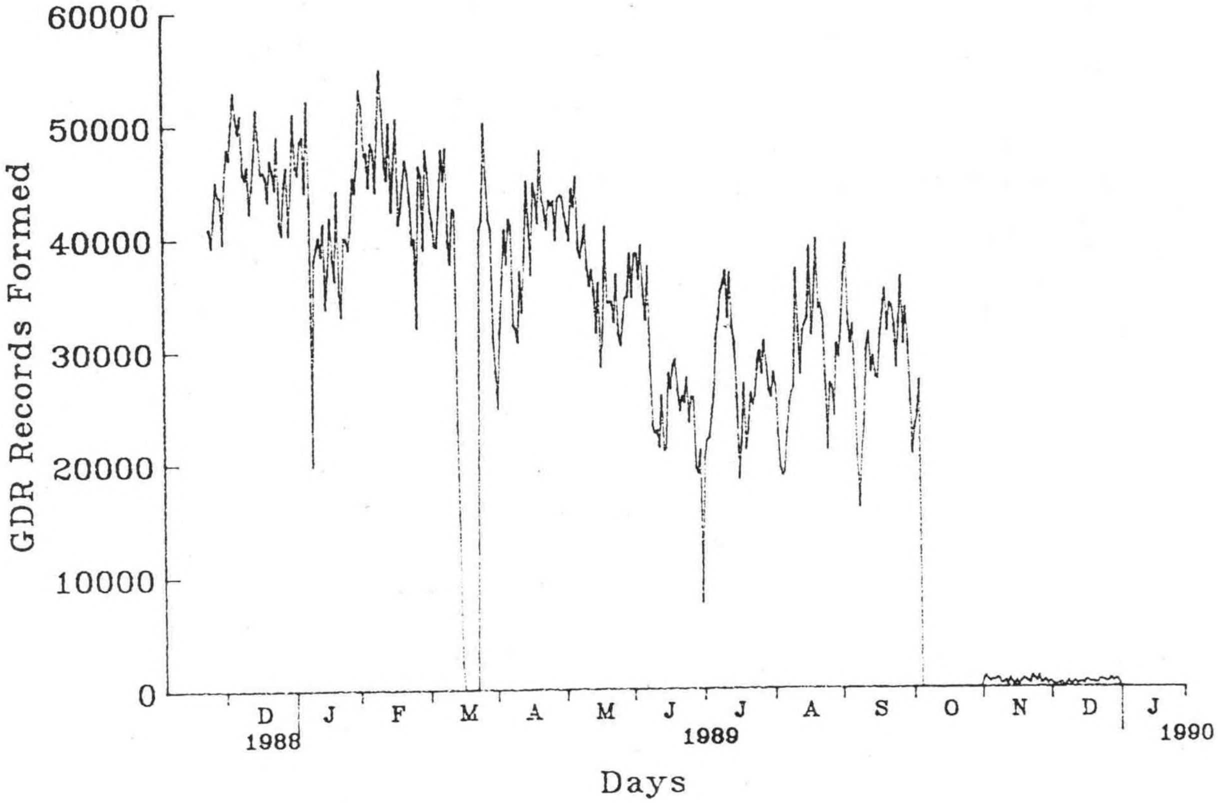


Figure 1.--Number of 1-second Geophysical Data Records for each day of the ERM third year.

GEOSAT BURN HISTORY

To maintain ground track collinearity, GEOSAT mission operations at JHU APL fired the thrusters onboard GEOSAT during the times listed in table 1. All times are universal time coordinated (UTC). The thruster vector identification (TV ID) is in relation to the direction of flight. A "+" burn is an increase in velocity in the same direction as the flight path vector. Burns are paired to reduce attitude disturbances caused by thruster misalignment with respect to the spacecraft center of mass. The offset is less than 1 cm.

Table 1.--Times at which GEOSAT thrusters were fired

Thruster ID Vector	Time on	Time off	Duration (seconds)
+	88-336/23:35:00	88-336/23:38:25	205
+	88-337/00:05:00	88-337/00:08:25	205
+	88-352/01:50:00	88-352/01:53:49	229
+	88-352/02:20:00	88-352/02:23:41	221
+	88-365/13:00:00	88-365/13:03:58	238
+	88-365/13:30:00	88-365/13:34:06	246
-	89-005/13:15:00	89-005/13:15:41	41
-	89-005/13:45:00	89-005/13:45:41	41
+	89-014/14:00:00	89-014/14:05:36	336
+	89-014/14:30:00	89-014/14:35:36	336
+	89-021/13:15:00	89-021/13:18:25	205
+	89-021/13:45:00	89-021/13:48:33	213
+	89-035/14:30:00	89-035/14:33:25	205
+	89-035/15:00:00	89-035/15:03:17	197
+	89-046/15:00:00	89-046/15:05:27	328
+	89-046/15:30:00	89-046/15:35:27	328
+	89-055/15:30:00	89-055/15:34:22	262
+	89-055/16:00:00	89-055/16:04:22	262
+	89-070/18:00:00	89-070/18:04:39	279
+	89-070/18:30:00	89-070/18:34:39	279
+	89-076/18:00:00	89-076/18:05:36	336
+	89-076/18:30:00	89-076/18:35:36	336
+	89-080/17:30:00	89-080/17:35:20	320
+	89-080/18:00:00	89-080/18:05:20	320
+	89-094/18:30:00	89-094/18:35:11	311
+	89-094/19:00:00	89-094/19:05:11	311

Table 1.--Times at which GEOSAT thrusters were fired (continued)

+	89-105/19:30:00	89-105/19:35:27	328
+	89-105/20:00:00	89-105/20:05:19	319
+	89-119/19:00:00	89-119/19:04:55	295
+	89-119/19:30:00	89-119/19:34:55	295
+	89-136/20:30:00	89-136/20:36:09	369
+	89-136/21:00:00	89-136/21:06:09	369
+	89-159/22:00:00	89-159/22:04:22	262
+	89-159/22:30:00	89-159/22:34:14	254
+	89-167/22:50:00	89-167/22:54:14	254
+	89-167/23:20:00	89-167/23:24:14	254
+	89-182/15:30:00	89-182/15:33:33	213
+	89-182/16:00:00	89-182/16:03:33	213
+	89-201/15:45:00	89-201/15:48:33	213
+	89-201/16:15:00	89-201/16:18:25	205
+	89-223/17:40:00	89-223/17:44:06	246
+	89-223/18:10:00	89-223/18:14:06	246
+	89-230/19:00:00	89-230/19:03:08	188
+	89-230/19:30:00	89-230/19:33:00	180
+	89-244/20:10:00	89-244/20:13:08	188
+	89-244/20:40:00	89-244/20:43:08	188
+	89-254/20:00:00	89-254/20:04:47	287
+	89-254/20:30:00	89-254/20:34:47	287
+	89-261/21:15:00	89-261/21:19:14	254
+	89-261/21:45:00	89-261/21:49:14	254
-	89-268/22:45:00	89-268/22:45:49	49
-	89-268/23:15:00	89-268/23:15:49	49
+	89-277/23:00:00	89-277/23:04:47	287
+	89-277/23:30:00	89-277/23:34:47	287
+	89-283/21:30:00	89-283/21:34:22	262
+	89-283/22:00:00	89-283/22:04:14	254
+	89-291/22:30:00	89-291/22:33:58	238
+	89-291/23:00:00	89-291/23:03:58	238
+	89-299/23:15:00	89-299/23:18:41	221
+	89-299/23:45:00	89-299/23:48:33	213
+	89-311/00:15:00	89-311/00:19:39	279
+	89-311/00:45:00	89-311/00:49:30	270

Table 1.--Times at which GEOSAT thrusters were fired (continued)

+	89-317/00:30:00	89-317/00:34:22	262
+	89-317/01:00:00	89-317/01:04:14	254
+	89-324/02:00:00	89-324/02:03:33	213
+	89-324/02:30:00	89-324/02:33:33	213
+	89-327/02:00:00	89-327/02:01:38	98
+	89-327/02:30:00	89-327/02:31:38	98
+	89-334/11:15:00	89-334/11:18:49	229
+	89-334/11:45:00	89-334/11:48:49	229
+	89-343/11:45:00	89-343/11:48:58	238
+	89-343/12:15:00	89-343/12:18:49	229
+	89-357/12:45:00	89-357/12:48:41	221
+	89-357/13:15:00	89-357/13:18:33	213
+	89-365/04:00:00	89-365/04:04:14	254
+	89-365/04:30:00	89-365/04:34:14	254

Figure 2 shows cross-track deviations from the nominal 17-day track. Positive values imply eastward deviations. Atmospheric drag during the first year of the ERM was relatively low, and orbit adjustments were performed at approximately monthly intervals. Maximum deviations were 1 km from the central track, and the standard deviation was 0.32 km based on daily values. Increased drag due to larger solar flux values during 1988 (see next section) required more frequent burns, and the standard deviation for the second year of the ERM increased to 0.66 km with maximum deviations increasing correspondingly to approximately 1.5 km. This remained constant during the third year, with a standard deviation of 0.65 km and maximum deviations of approximately 1.4 km. However, this collinearity was maintained only through increased frequency of burns. In the first year, burns were approximately 35 days apart, whereas in the second year the interval was about 25 days. A dramatic increase in atmospheric drag in the third year required burns at approximately 12-day intervals.

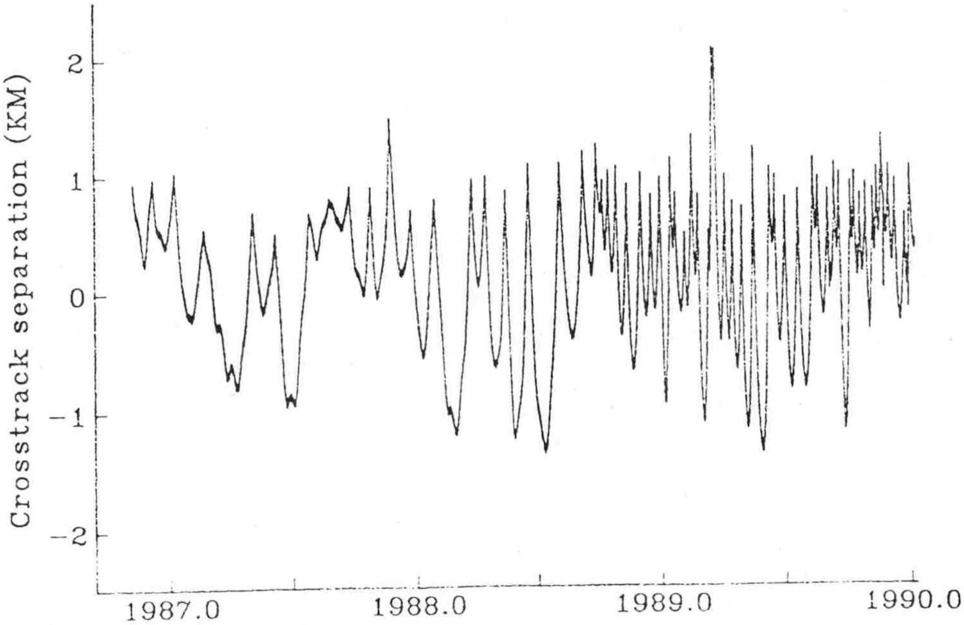


Figure 2.--Daily cross-track deviations from the nominal 17-day GEOSAT ground track.

TROPOSPHERIC CORRECTION

The wet and dry tropospheric corrections in the GDRs are interpolated from global grids at 12-hour intervals provided by the Fleet Numerical Oceanographic Center. Interpolation over a longer interval was required in only one case this year: 1988 Day 359 (0000 Z) to Day 360 (0000 Z).

IONOSPHERIC CORRECTION

GEOSAT was launched near solar minimum, and path delay due to the ionosphere had not been a serious concern because of its small amplitude and large geographic scale. However, solar flux values began increasing dramatically in late 1987 with approach of the 1990 maximum (fig. 3). A corresponding increase in GEOSAT altimeter noise might be expected, particularly in 1989 when large daily fluctuations were common.

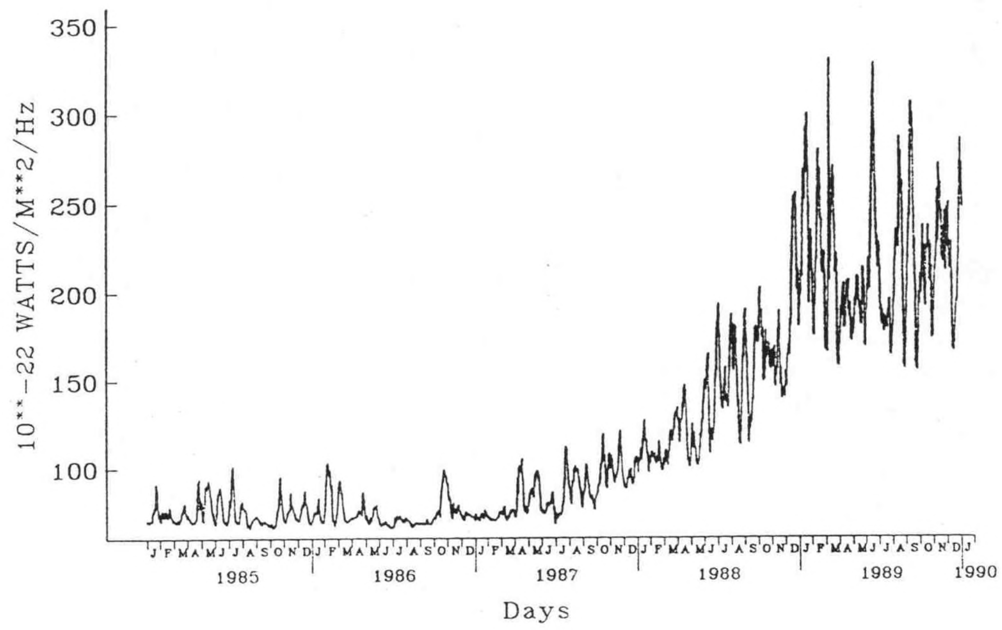


Figure 3.--Daily values of solar flux, 1985-89.

REFERENCES

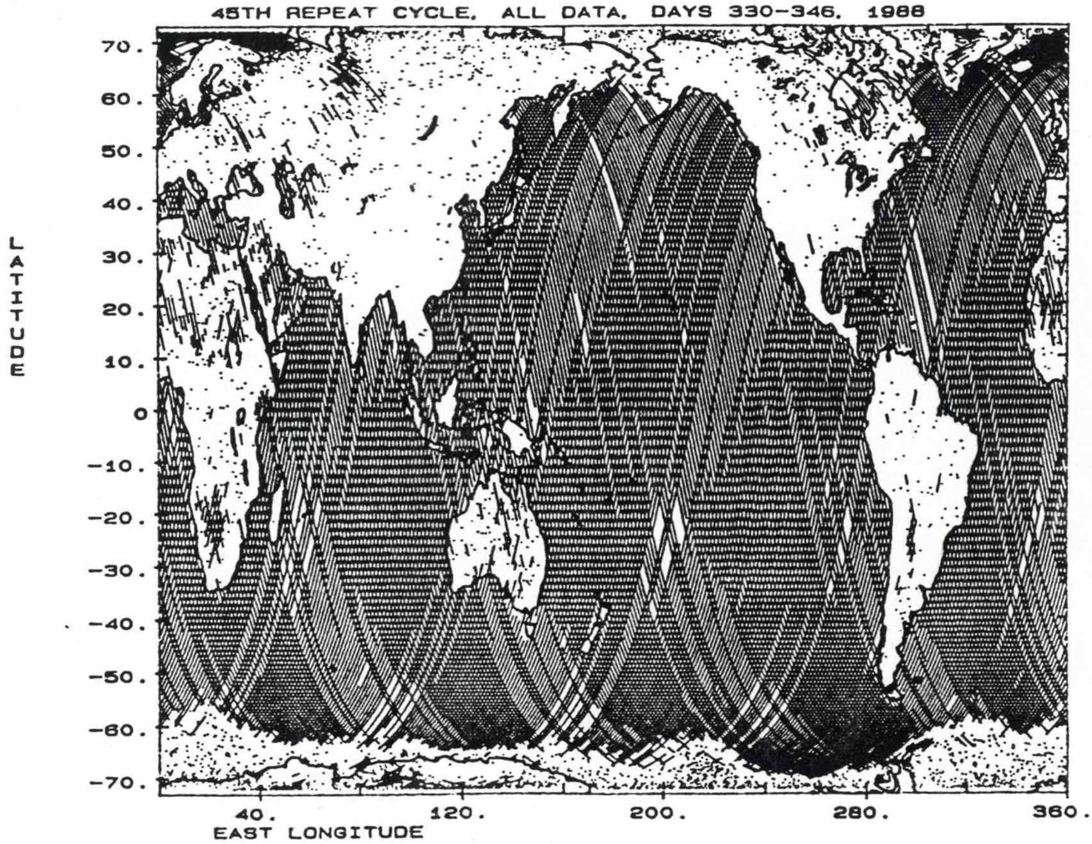
Cheney, R.E., Douglas, B.C., Agreen, R.W., Miller, and Doyle, N.S., 1988: The NOAA GEOSAT geophysical data records: Summary of the first year of the exact repeat mission. NOAA Technical Memorandum NOS NGS-48, 20 pp., National Geodetic Survey, N/CG112, NOAA, Rockville, MD 20852.

Cheney, R.E., Douglas, B.C., Agreen, R.W., Miller, L., Porter, D.L., and Doyle, N.S., 1987: GEOSAT altimeter geophysical data record user handbook. NOAA Technical Memorandum NOS NGS-46, 32 pp., National Geodetic Survey, N/CG112, NOAA, Rockville, MD 20852.

Doyle, N.S., Cheney, R.E., Douglas, B.C., Agreen, R.W., Miller, and Timmerman, E.L., 1989: The NOAA GEOSAT geophysical data records: Summary of the second year of the exact repeat mission. NOAA Technical Memorandum NOS NGS-49, 20 pp., National Geodetic Survey, N/CG112, NOAA, Rockville, MD 20852.

APPENDIX.--GEOSAT GEOPHYSICAL DATA RECORDS.
DATA DISTRIBUTION FOR 17-DAY CYCLES 45 TO 68 OF EXACT REPEAT MISSION.

(No data available for cycle 64)


45TH REPEAT CYCLE, ALL DATA, DAYS 330-346, 1988
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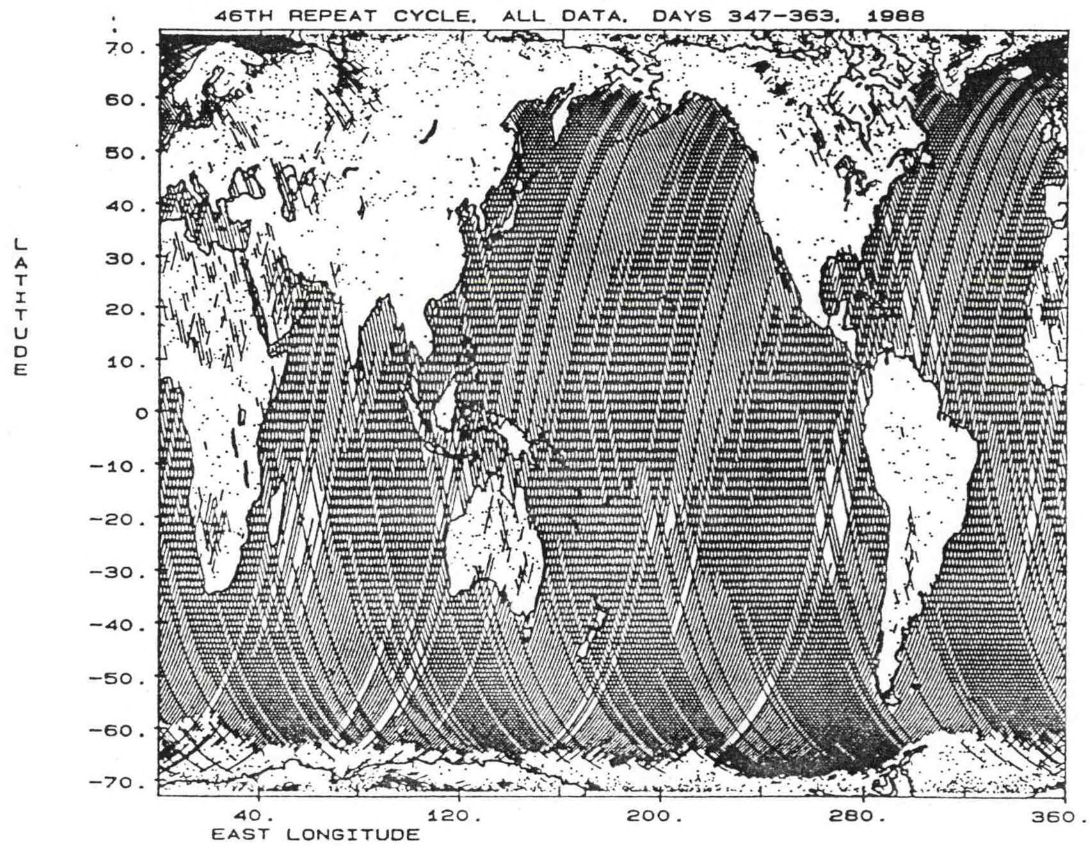
50.
40.
30.
20.
10.
0
-10.
-20.
-30.
-40.
-50.
-60.
-70.
40.
120.
200.
280.
360.
EAST LONGITUDE


46TH REPEAT CYCLE, ALL DATA, DAYS 347-363, 1988
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30.
20.
10.
0
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-60.
-70.
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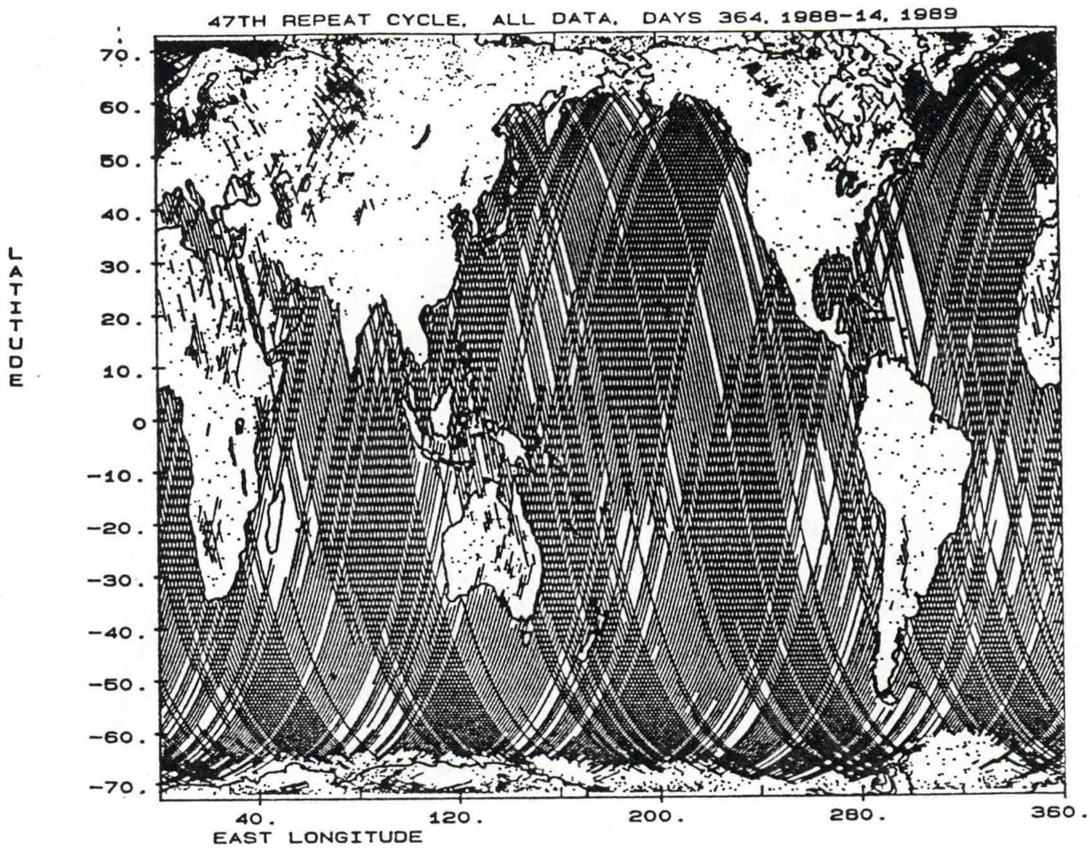
200.
280.
360.
EAST LONGITUDE


47TH REPEAT CYCLE. ALL DATA. DAYS 364, 1988-14, 1989
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30.
20.
10.
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-10.
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-70.
40.
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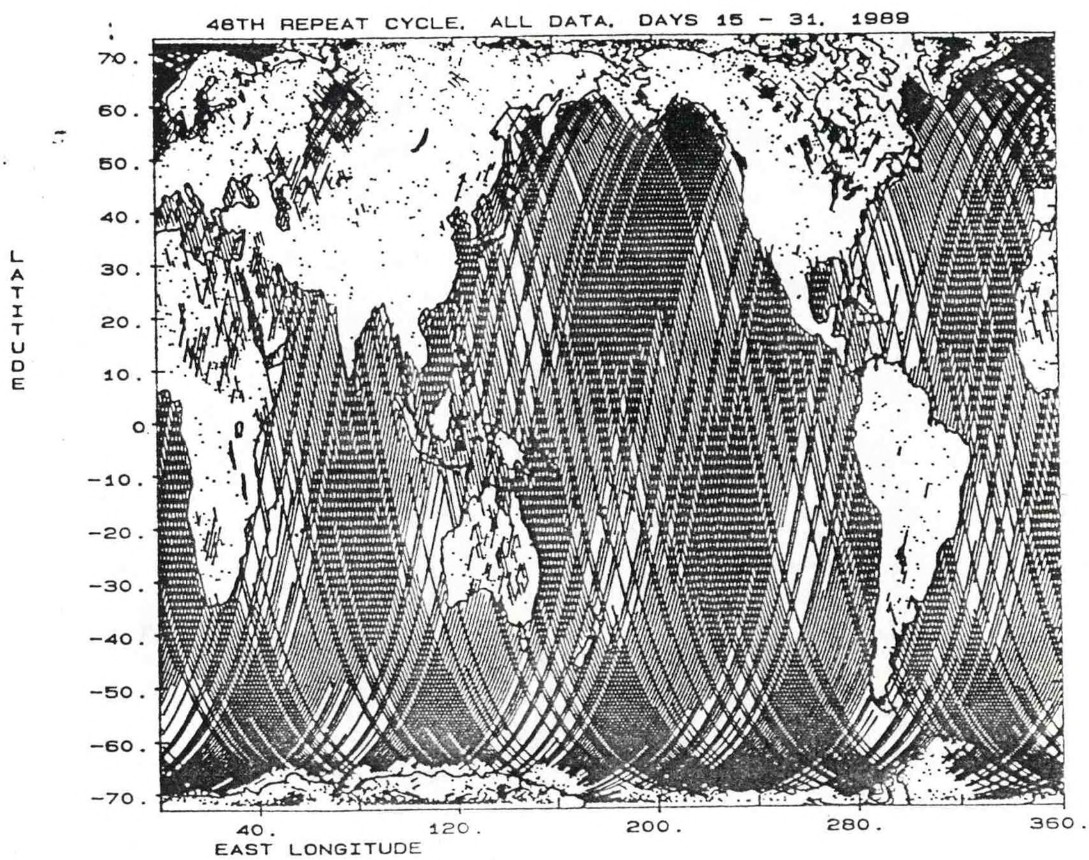
200.
280.
360.
EAST LONGITUDE


48TH REPEAT CYCLE. ALL DATA. DAYS 15 - 31. 1989
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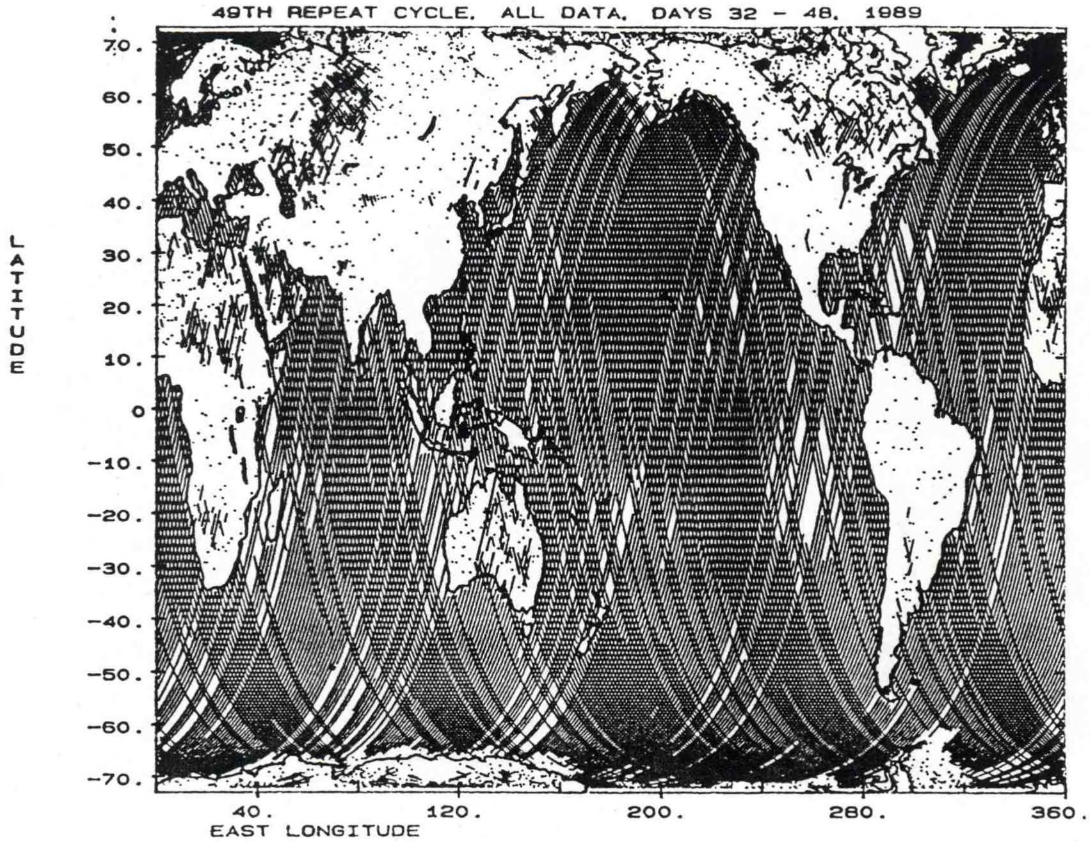
-40.
-50.
-60.
-70.
40.
120.
200.
280.
360.
EAST LONGITUDE


49TH REPEAT CYCLE. ALL DATA. DAYS 32 - 48. 1989
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20.
10.
0
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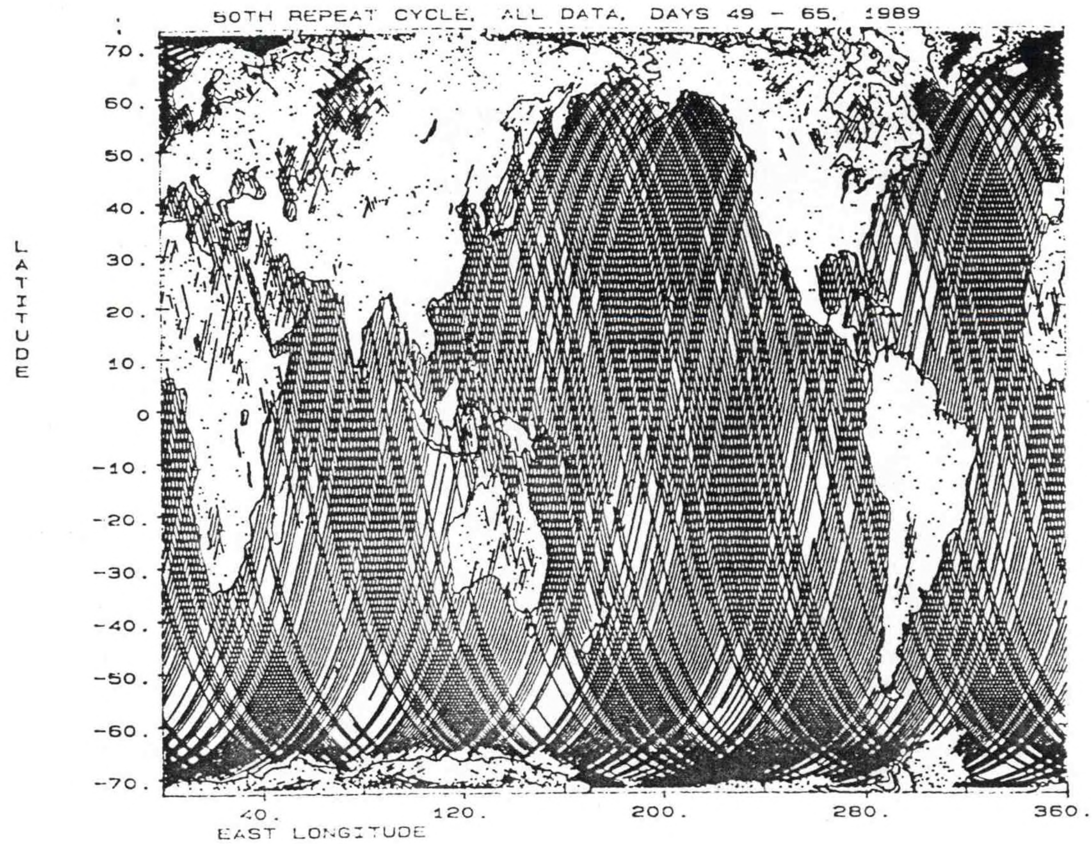
-60.
-70.
40.
120.
200.
280.
360.
EAST LONGITUDE


50TH REPEAT CYCLE. ALL DATA. DAYS 49 - 65. 1989
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10.
0
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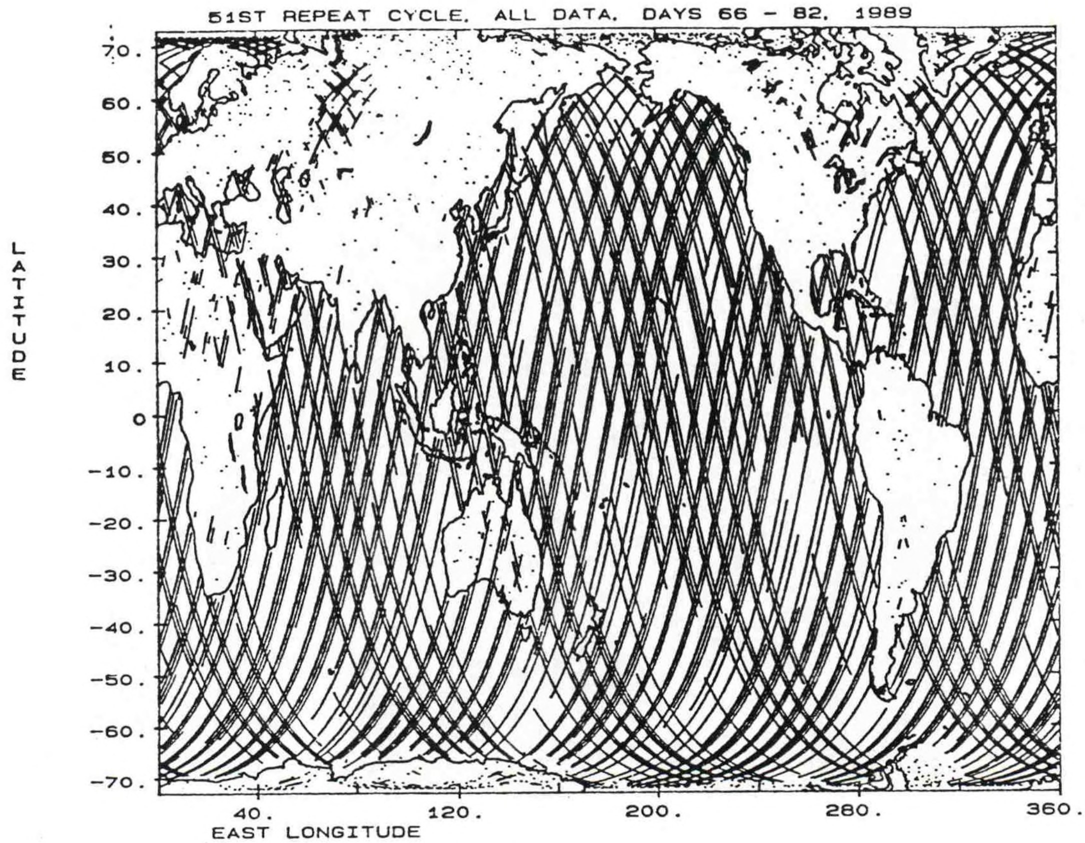
360.
EAST LONGITUDE


51ST REPEAT CYCLE. ALL DATA. DAYS 66 - 82. 1989
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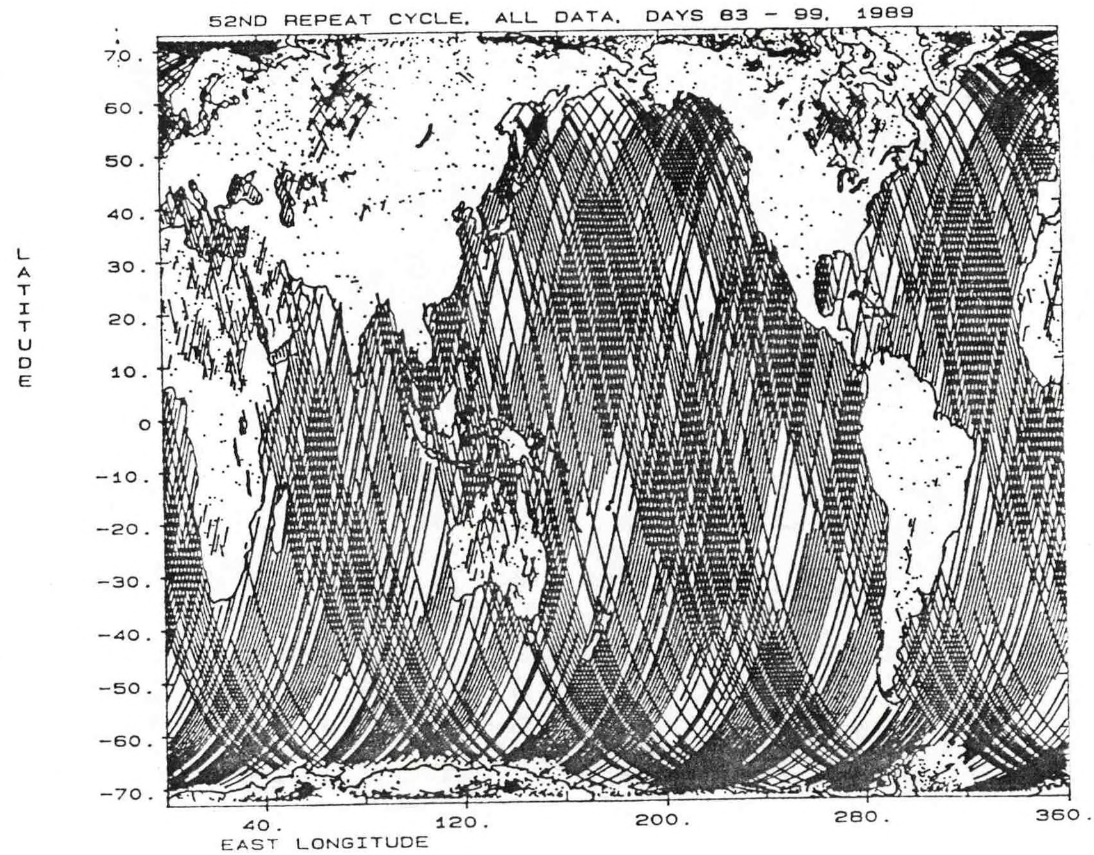
EAST LONGITUDE


52ND REPEAT CYCLE. ALL DATA. DAYS 83 - 99. 1989
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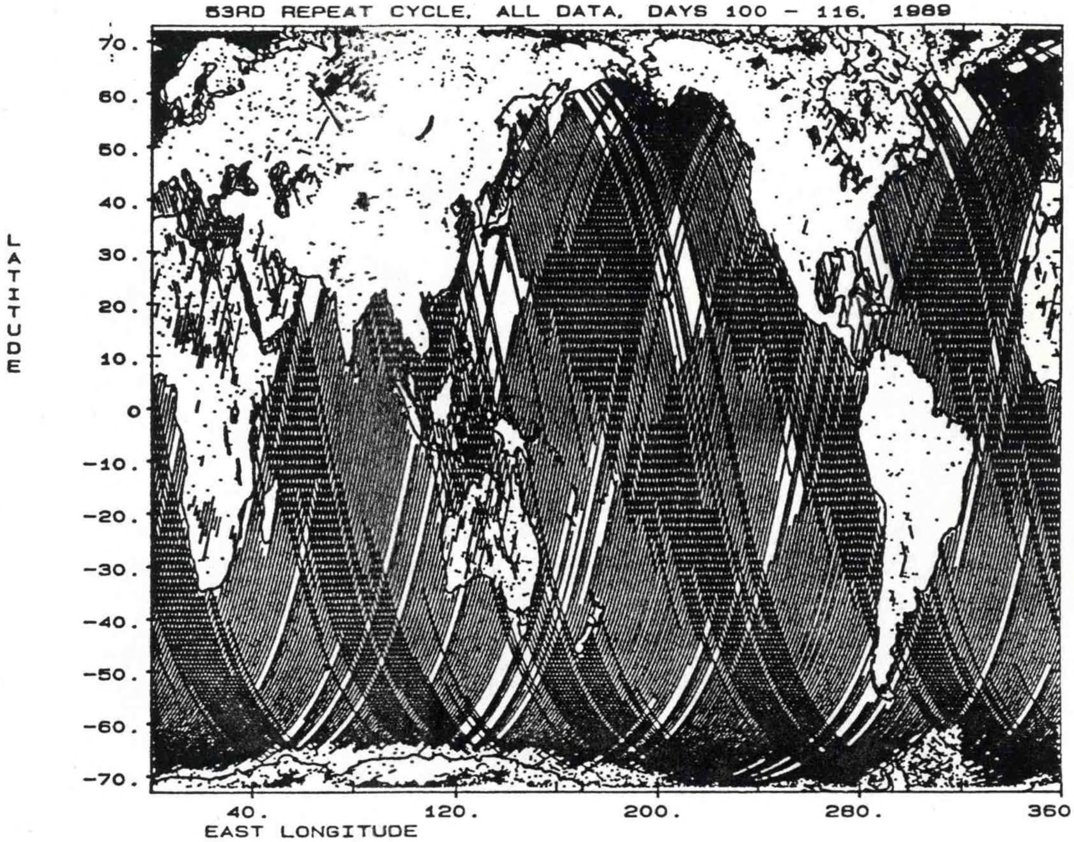
280.
360.
EAST LONGITUDE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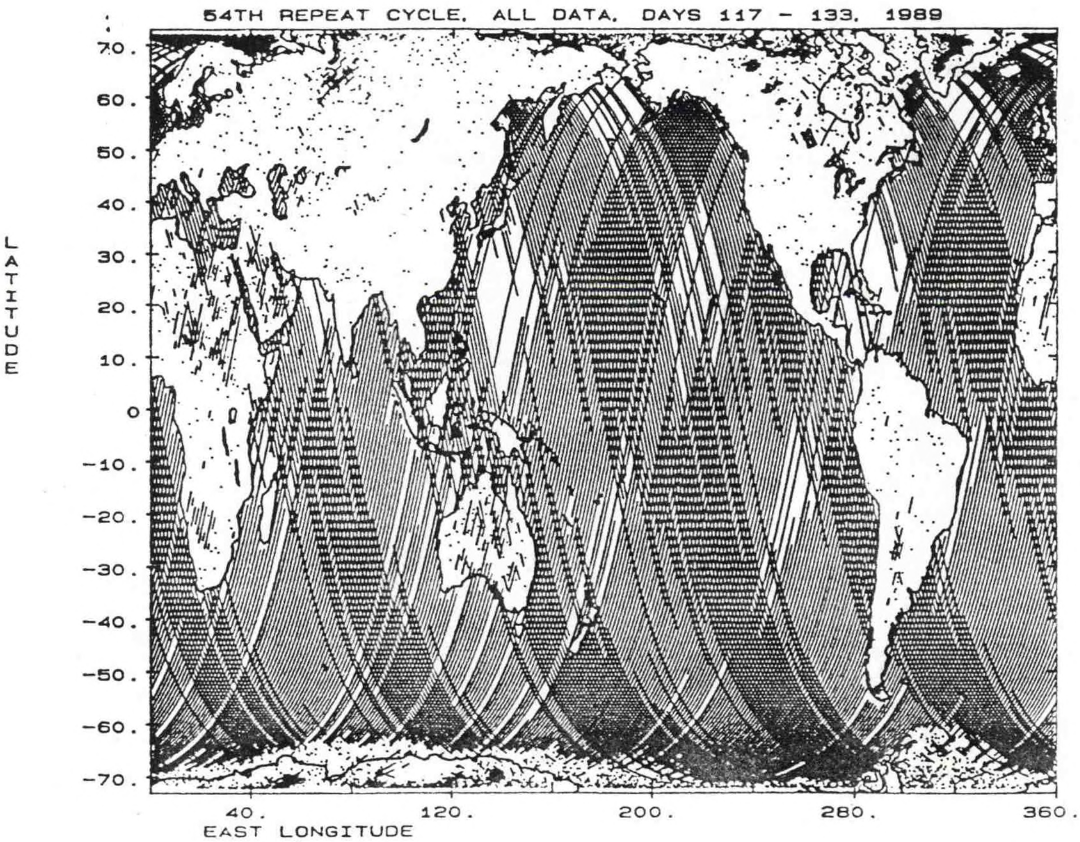
360
EAST LONGITUDE


54TH REPEAT CYCLE, ALL DATA, DAYS 117 - 133, 1989
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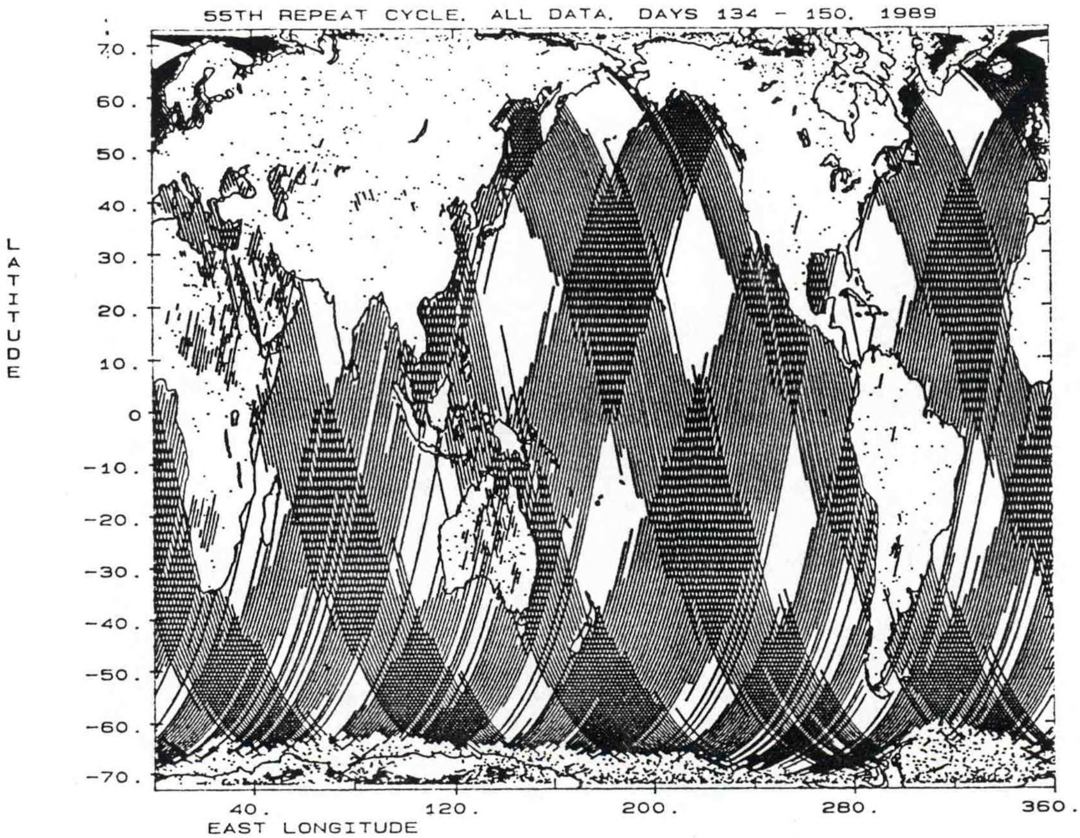
280.
360.
EAST LONGITUDE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20.
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0
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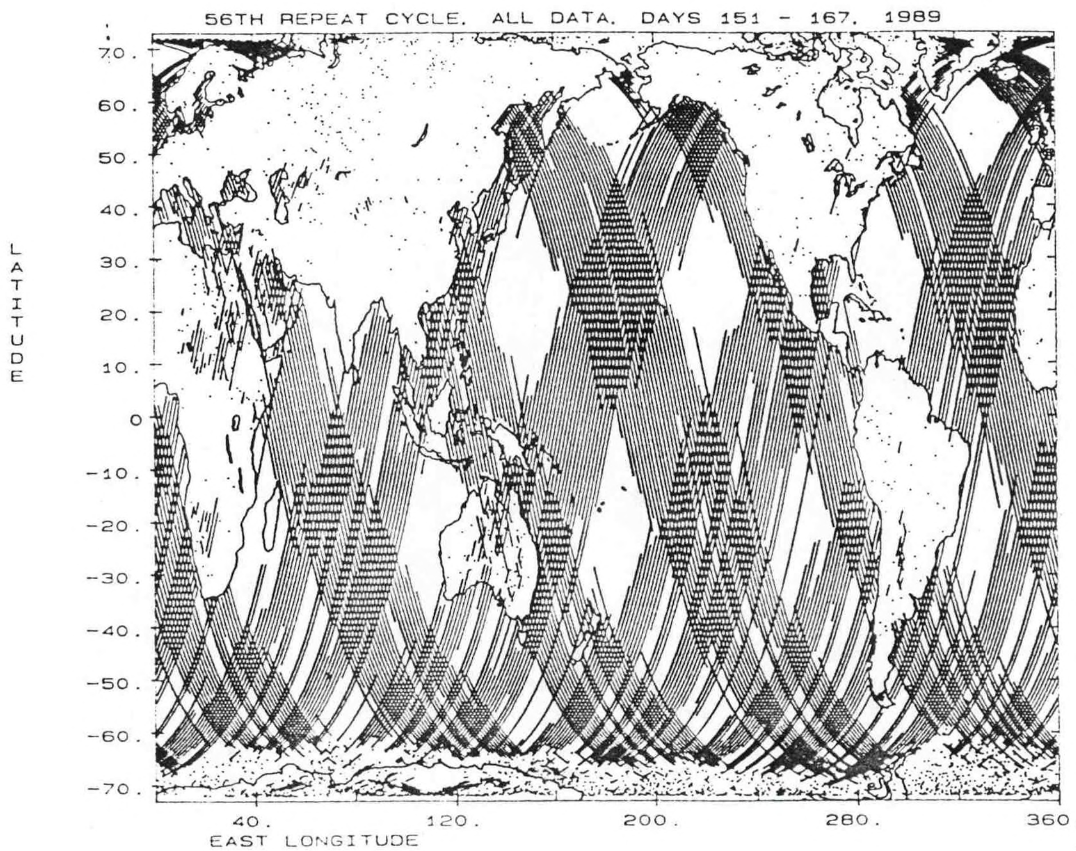
120.
200.
280.
360.
EAST LONGITUDE


56TH REPEAT CYCLE. ALL DATA. DAYS 151 - 167. 1989
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30.
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0
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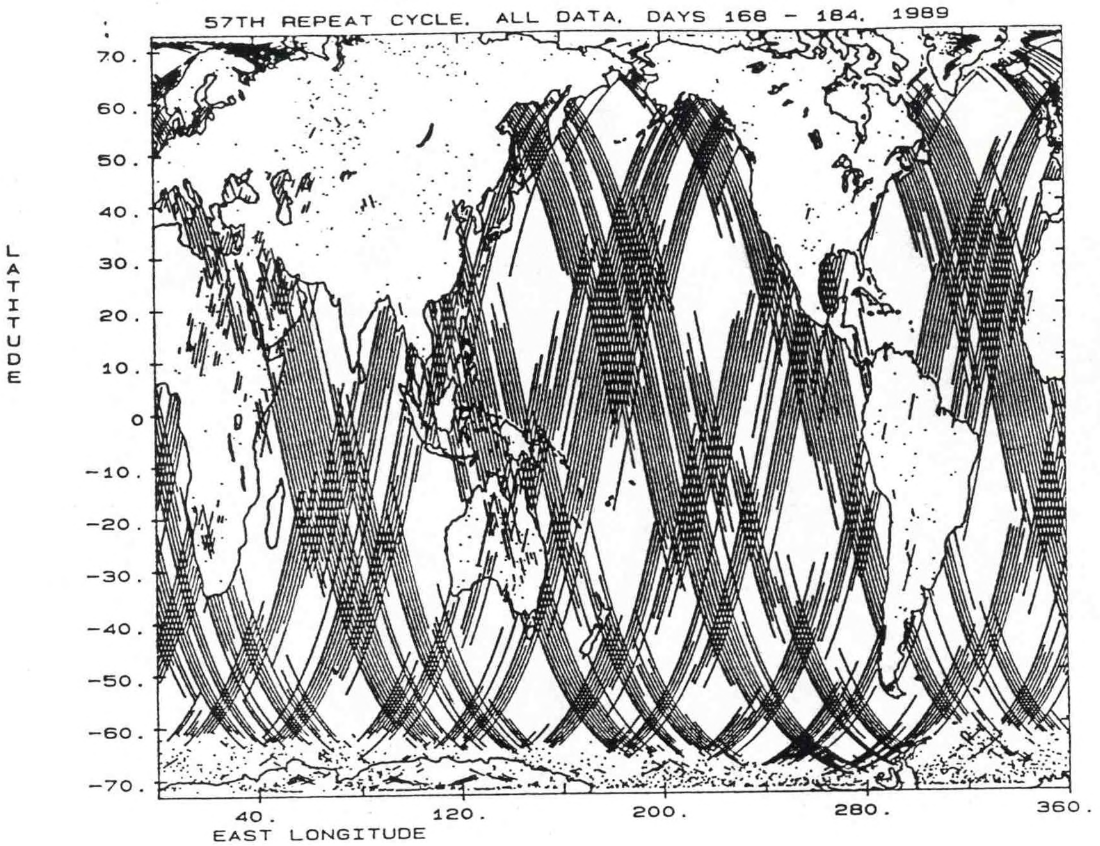
200.
280.
360.
EAST LONGITUDE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20.
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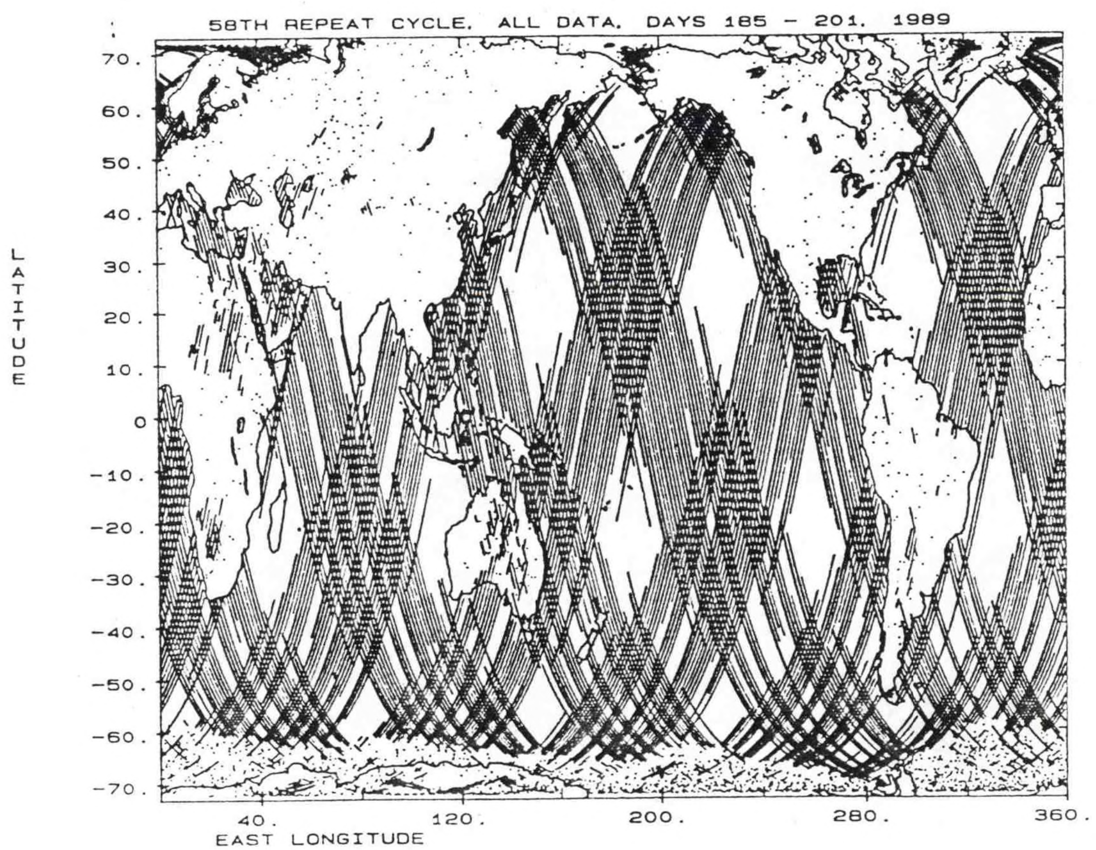
280.
360.
EAST LONGITUDE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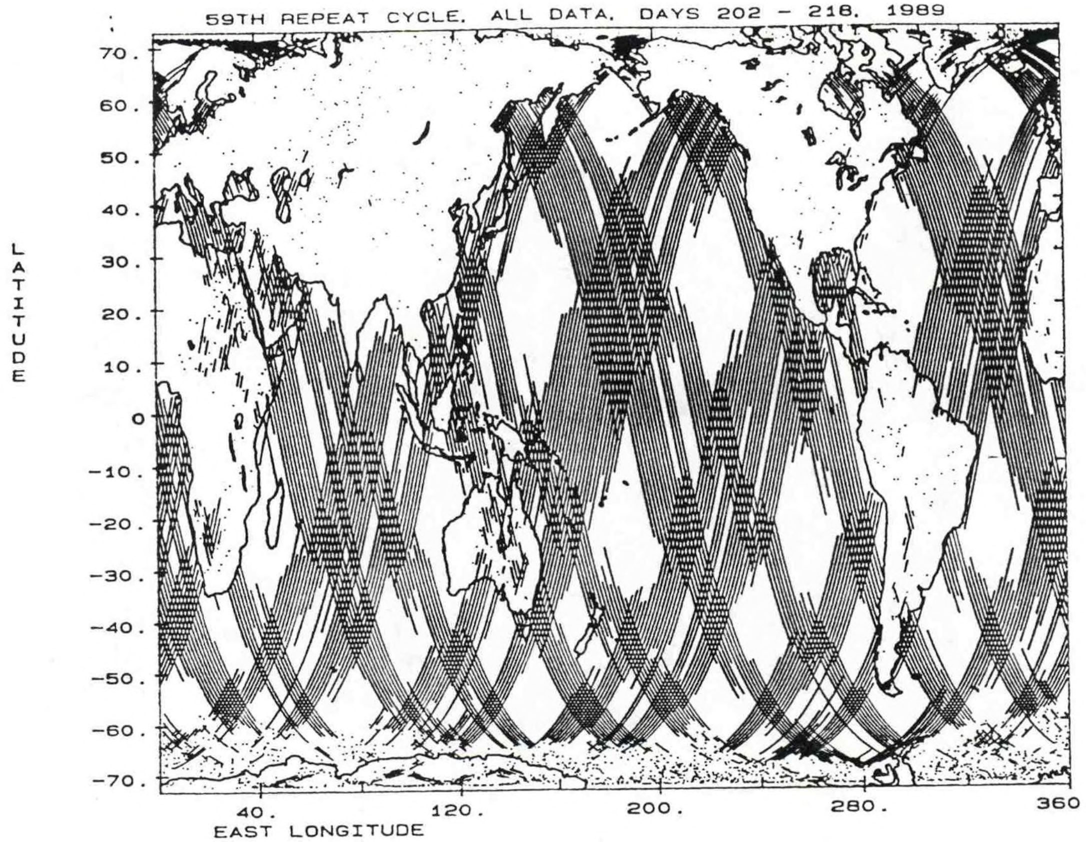
280.
360.
EAST LONGITUDE


59TH REPEAT CYCLE. ALL DATA. DAYS 202 - 218. 1989
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50.
40.
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20.
10.
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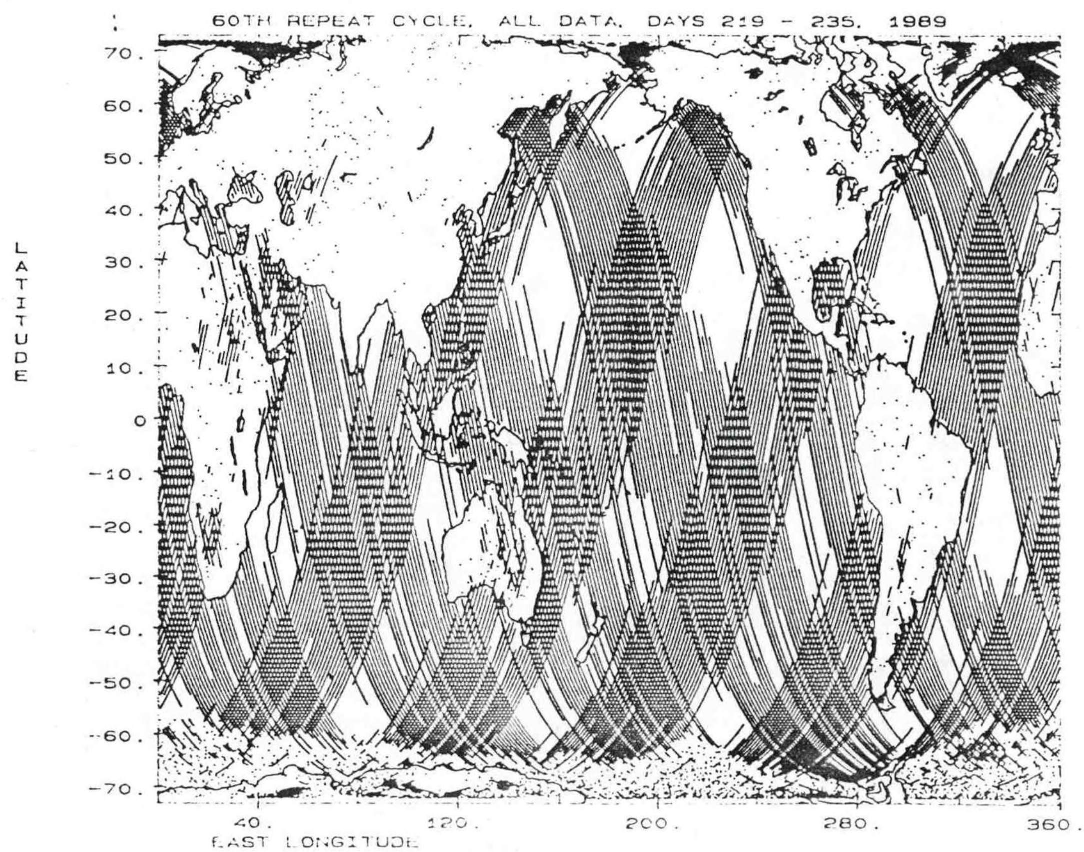
200.
280.
360.
EAST LONGITUDE


60TH REPEAT CYCLE. ALL DATA. DAYS 219 - 235. 1989
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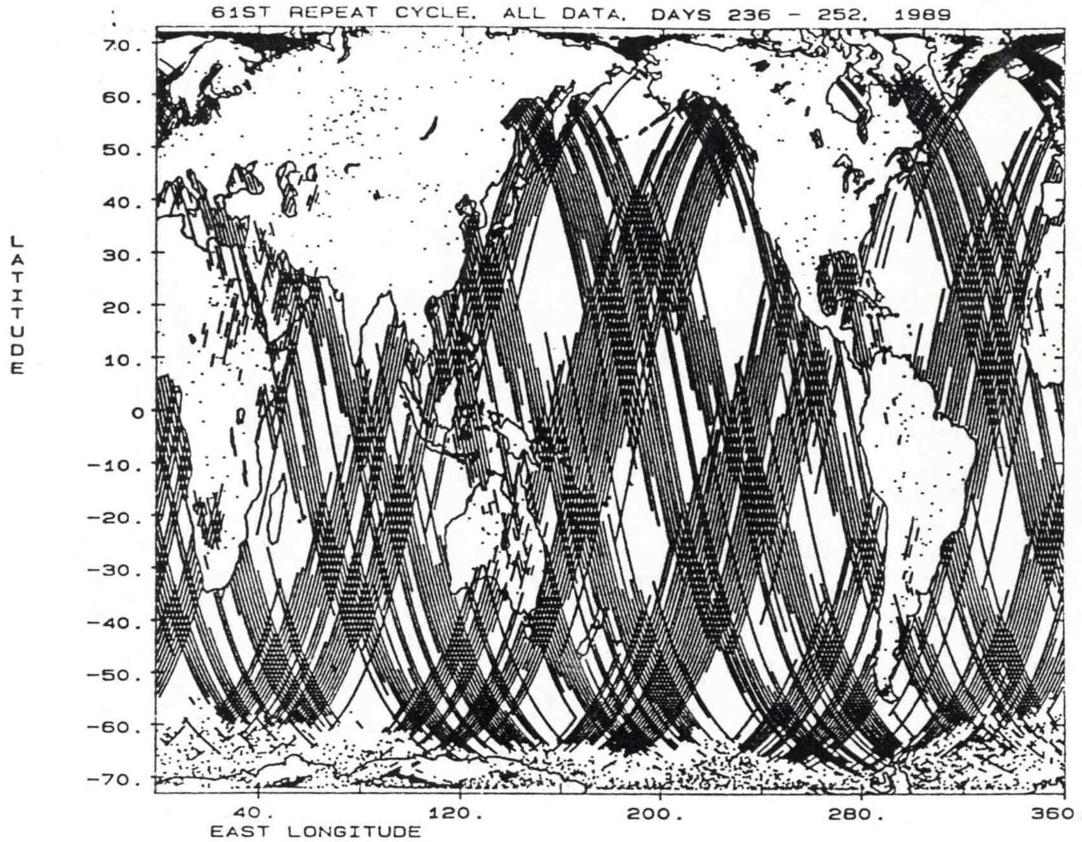
40.
120.
200.
280.
360.
EAST LONGITUDE


61ST REPEAT CYCLE. ALL DATA. DAYS 236 - 252. 1989
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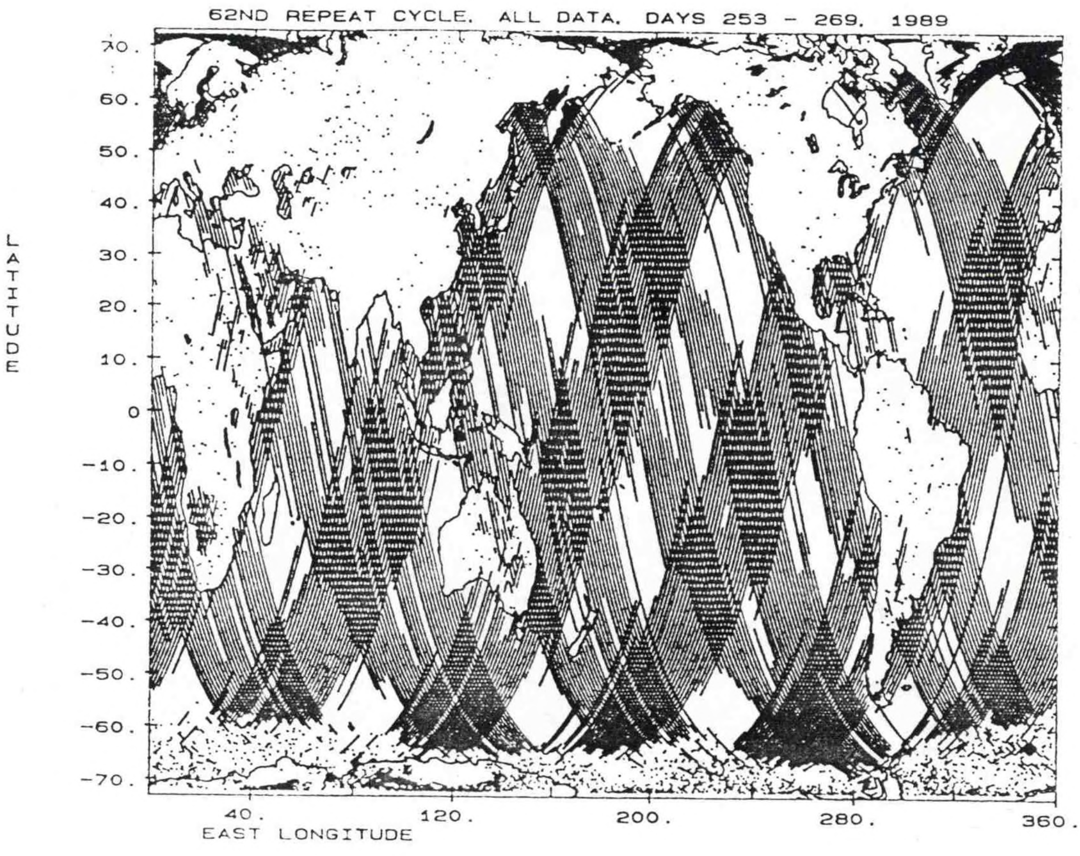
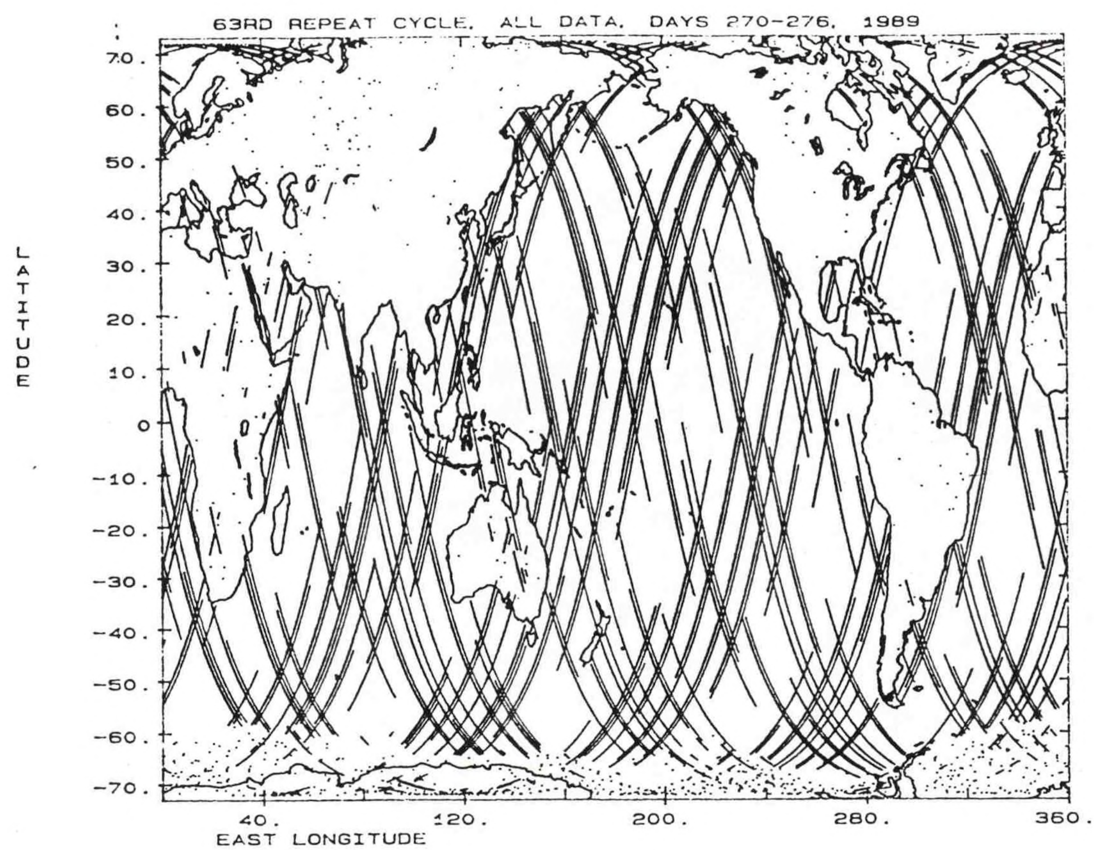
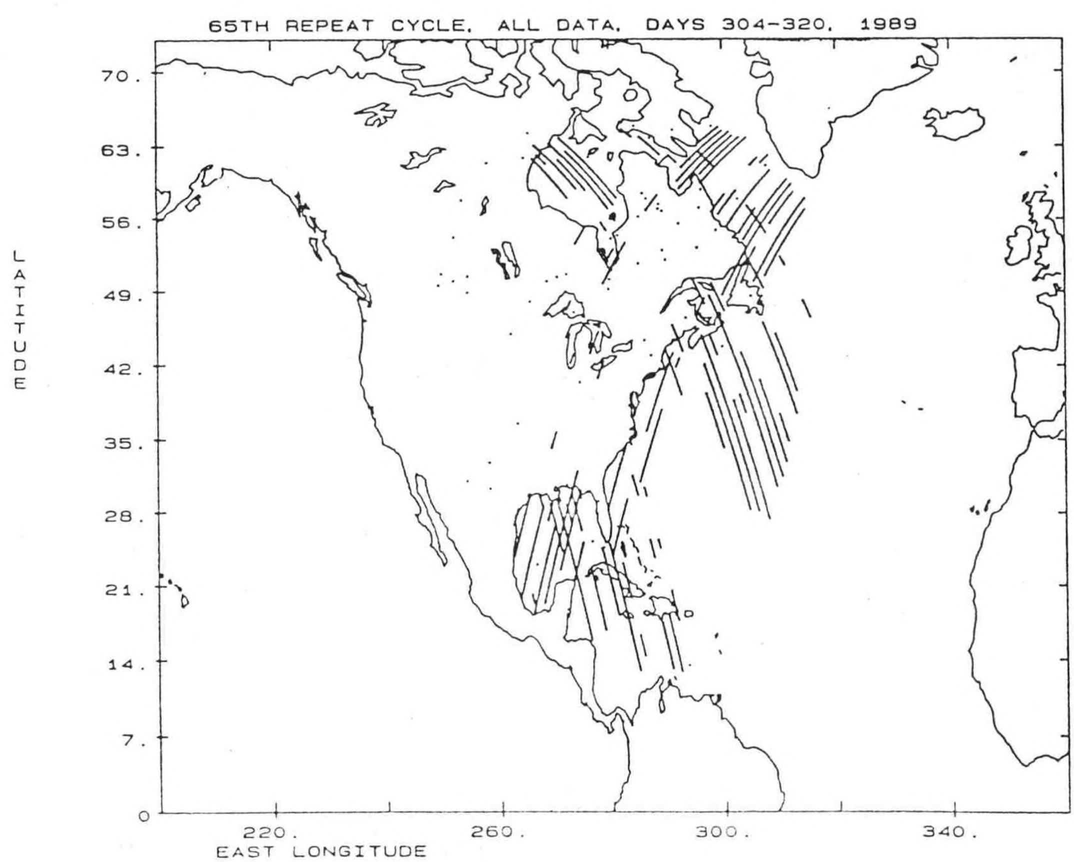
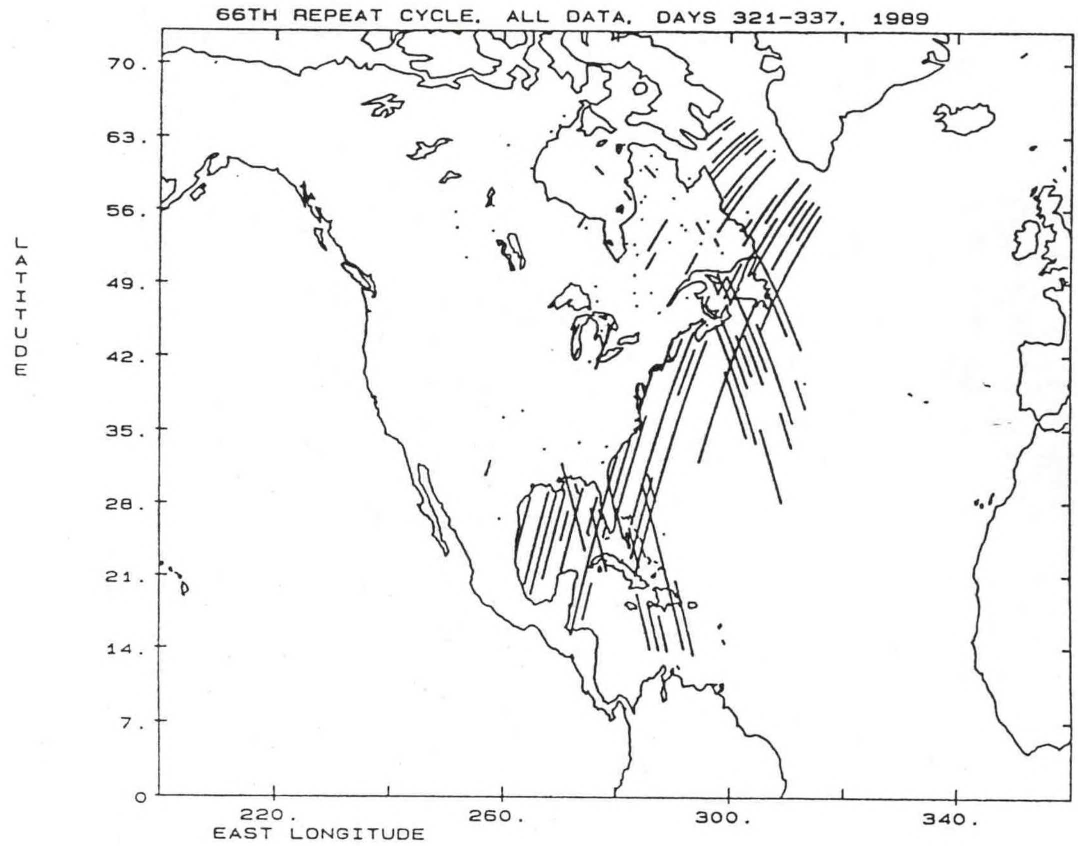
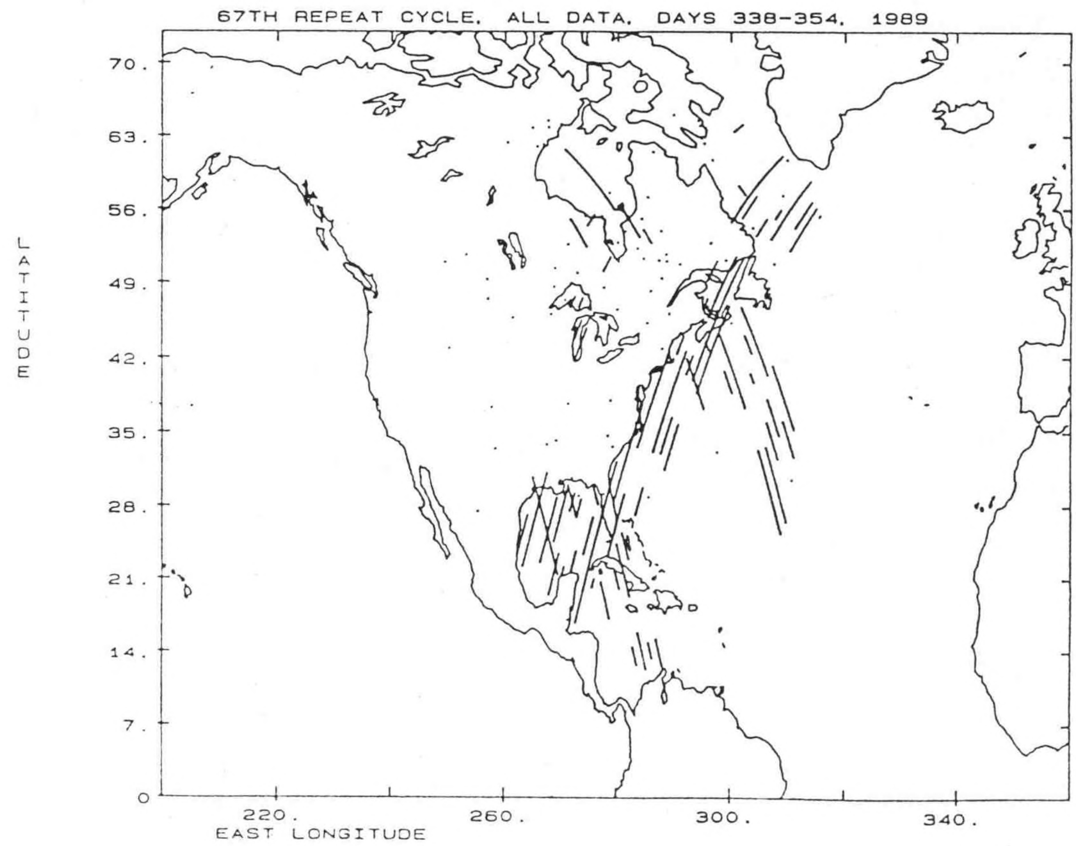
-10.
-20.
-30.
-40.
-50.
-60.
-70.
40.
120.
200.
280.
360.
EAST LONGITUDE

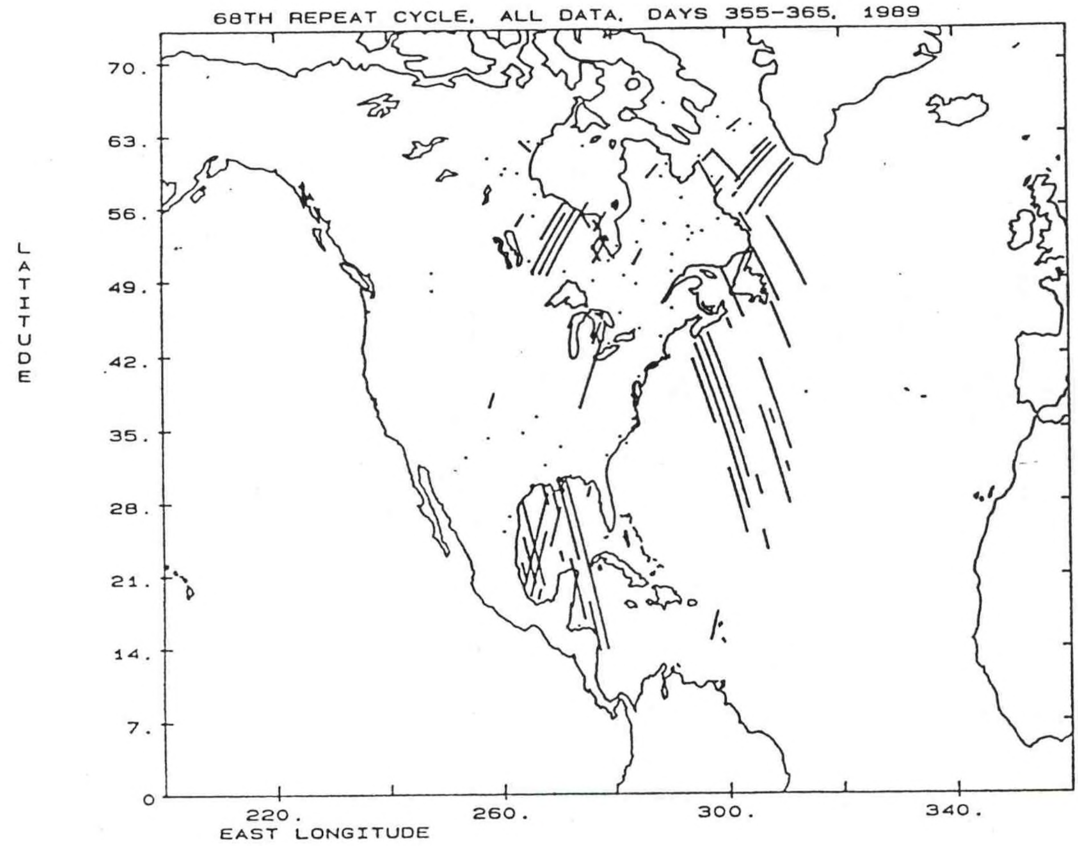

62ND REPEAT CYCLE. ALL DATA. DAYS 253 - 269. 1989
LATITUDE
70.
60.
50.
40.
30.
20.
10.
0
-10.
-20.
-30.
-40.
-50.
-60.
-70.
40.
120.
200.
280.
360.
EAST LONGITUDE


63RD REPEAT CYCLE. ALL DATA. DAYS 270-276. 1989
LATITUDE
70.
60.
50.
40.
30.
20.
10.
0
-10.
-20.
-30.
-40.
-50.
-60.
-70.
40.
120.
200.
280.
360.
EAST LONGITUDE


65TH REPEAT CYCLE. ALL DATA. DAYS 304-320. 1989
LATITUDE
70.
63.
56.
49.
42.
35.
28.
21.
14.
7.
0
220.
260.
300.
340.
EAST LONGITUDE


66TH REPEAT CYCLE, ALL DATA, DAYS 321-337, 1989
LATITUDE
70.
63.
56.
49.
42.
35.
28.
21.
14.
7.
0
220.
260.
300.
340.
EAST LONGITUDE


67TH REPEAT CYCLE, ALL DATA, DAYS 338-354, 1989
LATITUDE
70.
63.
56.
49.
42.
35.
28.
21.
14.
7.
0
220.
260.
300.
340.
EAST LONGITUDE


68TH REPEAT CYCLE, ALL DATA, DAYS 355-365, 1989
70.
63.
56.
49.
42.
35.
28.
21.
14.
7.
0
LATITUDE
220.
260.
300.
340.
EAST LONGITUDE