SIMULATION OF GLOBAL LAND COVERAGE
BY MODIS-T
(W. GREGG AND G. RIGGS, RDC)

We have initiated a simulation of global coverage by MODIS-T in an effort to examine the effects of conflicting land/ocean gain mode. According to the "dual-mode" MODIS-T operational scenario, gain may be switched to be useful for land observations or ocean observations, but not both simultaneously. This gain-switching is required because of the different irradiance reflectances typical of land and ocean; land reflectance is typically ≈50% while ocean may be < 10%. It is our understanding that these modes may be switched between scans, but not within scans.

The questions addressed here is: what will be the land coverage if for any scan containing ocean the sensor is ocean mode? The answers to these questions will provide extrema in land/ocean coverage and help to assess the sometimes conflicting needs of the land and ocean sciences.

We developed computer code to simulate the EOS orbit, and scan characteristics of MODIS-T, as given by T. Magner, Jan. 31, 1990 (MODIS-T Instrument Status Report). Important EOS orbital parameters and MODIS-T instrument characteristics used in the code are summarized in Table 1.

Table 1. EOS orbital simulation parameters and MODIS-T instrument characteristics.

<u>EOS Orbital Parameters</u>	
Altitude	705 km
Orbital Repeat Time	16 days (233 orbits)
Period	98.9 minutes
Inclination	98.25 degrees
Equatorial Crossing Time	1:30 local time
<u>MODIS-T Instrument Characteristics</u>	
Scan Width	$\pm$ 45°
IFOV	1.56 mrad (0.089°)
Ground IFOV at nadir	1.1 km
Scan time	4.75 secs
Pixels Along Scan	1007
Ground Coverage Along Scan	1500 km (at nadir; no tilt)
Tilt	$\pm$ 50°
Pixels Along Track	30 pixels
Ground Coverage Along Track	32.6 km (at nadir; no tilt)
Successive Orbit Equatorial Crossing Longitude	-24.721°

Earth Data Set

We obtained the Elaine Matthews Global Vegetation Data Set (GVDS) from the National Climate Data System (NCDS), which is a global map of vegetation types on a 1° by 1° latitude/longitude grid. We are only interested in land vs. ocean, which is designated index 0 in the GVDS.

Single Day Simulation

We developed computer code on the NASA IBM 3081 to plot the scan coverage by MODIS-T, and can generate plots where the scan coverage includes only land. An example of Earth coverage by MODIS-T is shown in Fig. 1 for Day 1, which begins with an equatorial crossing longitude at the Greenwich Meridian. This example is for an untilted sensor.

It is noteworthy that inland lakes, such as Lake Baikal in Asia and Lake Victoria in Africa, are denoted by index 0 in the GVDS. In this simulation, any scan containing an inland lake will thus be considered an ocean scan.

This coverage required 82 total gain changes (land-to-ocean or ocean-to-land). If this day is representative, we may expect 1312 total gain changes in 16 days.

Simulated Land Coverage

We simulated global land coverage for a "CZCS tilt strategy", i.e., 0 tilt for sub-satellite ground points $> \pm 32.5^\circ$ from the solar declination sub-solar point, -20° tilt (aft) for a sub-satellite point southward of the sub-solar point to -32.5°, and $+20^\circ$ tilt (fore) northward to $+32.5^\circ$ of the sub-solar point. This tilt strategy was suggested by Wayne Esaias as a possible reasonable simulation of MODIS for ocean coverage to avoid sun glint.

Examination of the land coverage by this tilt strategy requires three simulations to be representative: one for the equinox, and one each for the Northern Hemisphere summer and winter solstices. The results for these three scenarios are plotted in Figs. 2-4, as land coverage composites for 16 days (the orbital repeat time for Eos).

Land coverage was determined by comparing the areas viewed by individual pixels with the (GVDS). Plotted on the figures are 1° x 1° grid boxes of land coverage. This coverage is derived from the actual simulated scan coverage, but the horizontal lines do not depict the scan pattern, rather the Earth coverage at GVDS spatial resolution.

One may immediately note the large land coverage for the composite figure (Fig. 2). At a computed global land area of 1.48×10^8 km^2 by the GVDS, in 16 days Modis-T observed 1.15×10^8 km^2, or 78%, even under ocean priority.

However, it is clear that some land areas of the Earth are never covered if ocean coverage is to be maximized in dual mode. Some notable areas are Spain, Scandinavia, the southern tips of South America and Africa, Central America, and the southeast Asian archipelago. Note also the gap in coverage at the Equator; this is due to the tilt strategy, whereby the tilt was changed from -20° to +20° at the Equator for this equinox simulation. This coverage gap moves to the solstices for the summer and winter solstice simulations (Figs. 3 and 4). This coverage gap will also apply to ocean coverage, suggesting the need for MODIS-N imagery for these regions.

The composites reveal substantial land coverage, even under ocean coverage maximization, including many coastal features. Interestingly, land coastal coverage is extensive. It should be noted, however, that under the stipulations of the simulation, that if any ocean lies under the scan the entire scan is in ocean mode, that coastal coverage is entirely due to scan edges. However, since the primary purpose of MODIS-T for land observations is to investigate bi-directional reflectance, this may not be deleterious to land objectives; such scan-edge views may be of use to bi-directional reflectance studies.

Coverages for each day in the 16-day simulation are also provided as Figs. 5-20 to allow observation of daily coverages and overlaps. These simulations were performed for the Equinox case.

Ocean Coverage

The converse question was also addressed: what will the ocean coverage be if, for any scan containing land, the entire scan is in land mode? This simulation was run at a tilt of +50° in anticipation of maximizing bi-directional reflectance. Thus, at a +50° tilt, if any area under the scan contained land, the entire scan was considered land.

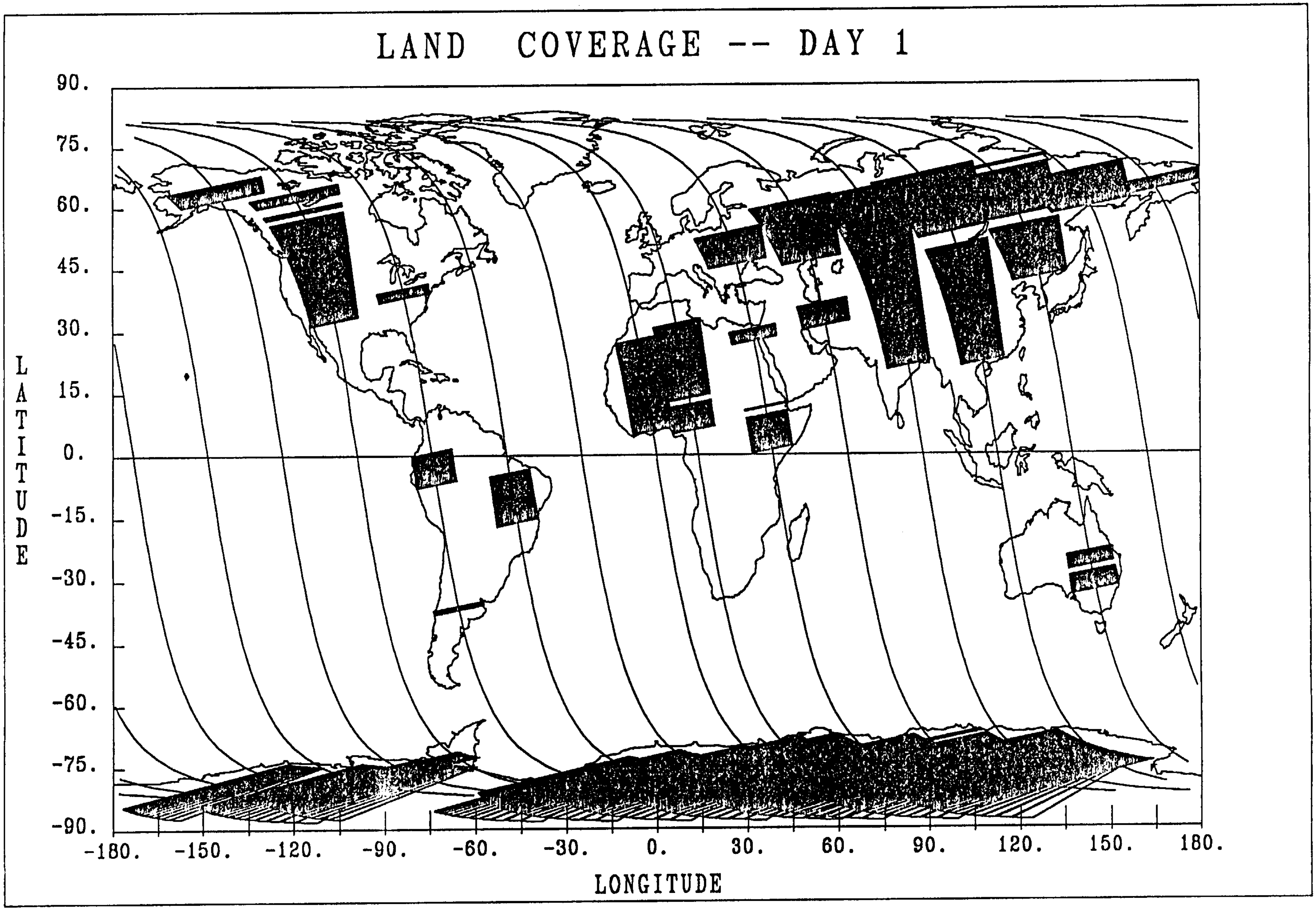
The resulting ocean coverage is depicted in Fig. 21 for a single day. First, it should be noted that the scan coverage is much greater than under the 0° and 20° tilts shown before, nearly extending to the previous and successive sub-satellite ground track at the Equator.

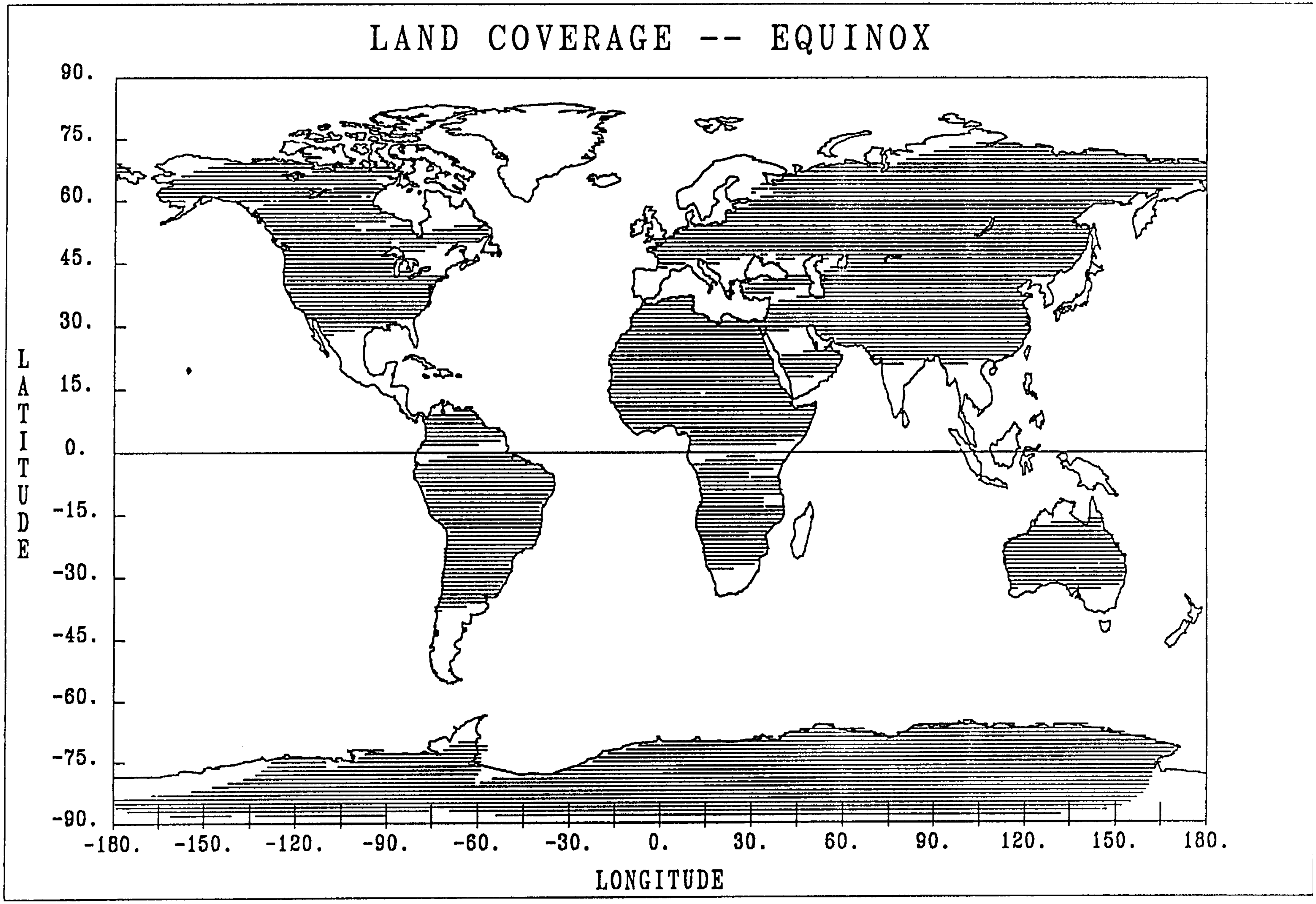
A full 16 day simulation (Fig. 22) revealed substantial ocean coverage, despite land priority. At a computed ocean area by the GVDS of 3.58×10^8 km^2, 3.17×10^8 km^2 was covered, or 88.6%.

Note the lack of coverage of the North Atlantic, Arabian Sea, and Bay of Bengal, and the sparse coverage of the Gulf of Mexico.

However, it is important to note that the ocean coverage is exaggerated by the 50° tilt. This tilt is likely too extreme for most ocean applications since it produces a large atmospheric path length that will reduce the effectiveness of the atmospheric corrections. A smaller tilt will result in much less ocean coverage.

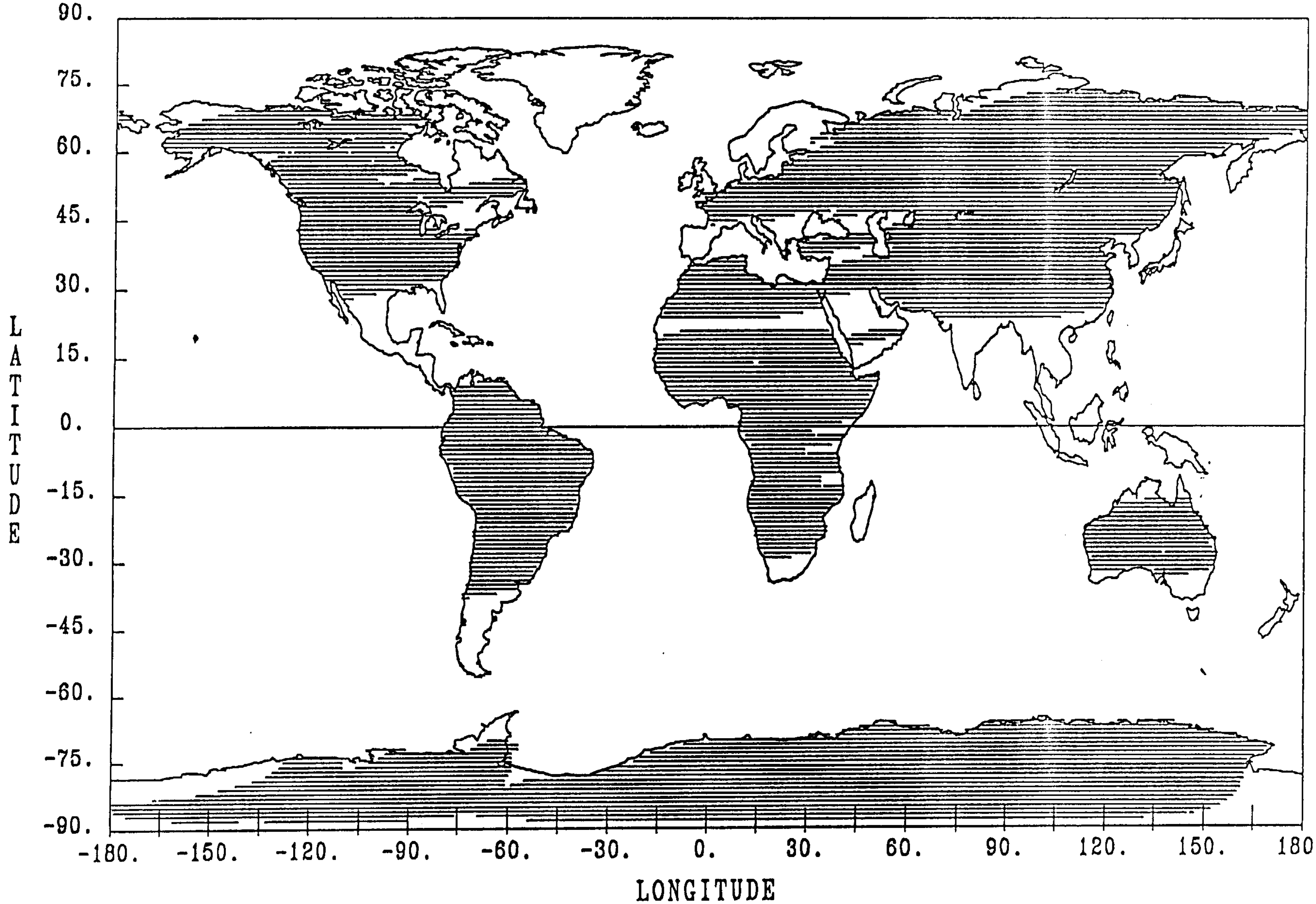
Secondly, as with land coverage under ocean priority, coastal areas are covered exclusively by scan edges. Unlike the previous case, this is an extremely disadvantageous result since the atmospheric path length is very large. We estimated a spacecraft zenith angle of over 80° at the scan edge. Thus useable coastal ocean coverage under this scenario is likely to be much reduced than one might expect given the results of Fig. 22.


LAND COVERAGE -- DAY 1
90.
75.
60.
45.
30.
15.
0.
-15.
-30.
-45.
-60.
-75.
-90.
LATITUDE
-180.
-150.
-120.
-90.
-60.
-30.
0.
30.
60.
90.
120.
150.
180.
LONGITUDE



LAND COVERAGE -- EQUINOX
90.
75.
60.
45.
30.
15.
0.
-15.
-30.
-45.
-60.
-75.
-90.
LATITUDE
-180.
-150.
-120.
-90.
-60.
-30.
0.
30.
60.
90.
120.
150.
180.
LONGITUDE

LAND COVERAGE -- NH SUMMER



LAND COVERAGE -- NH WINTER

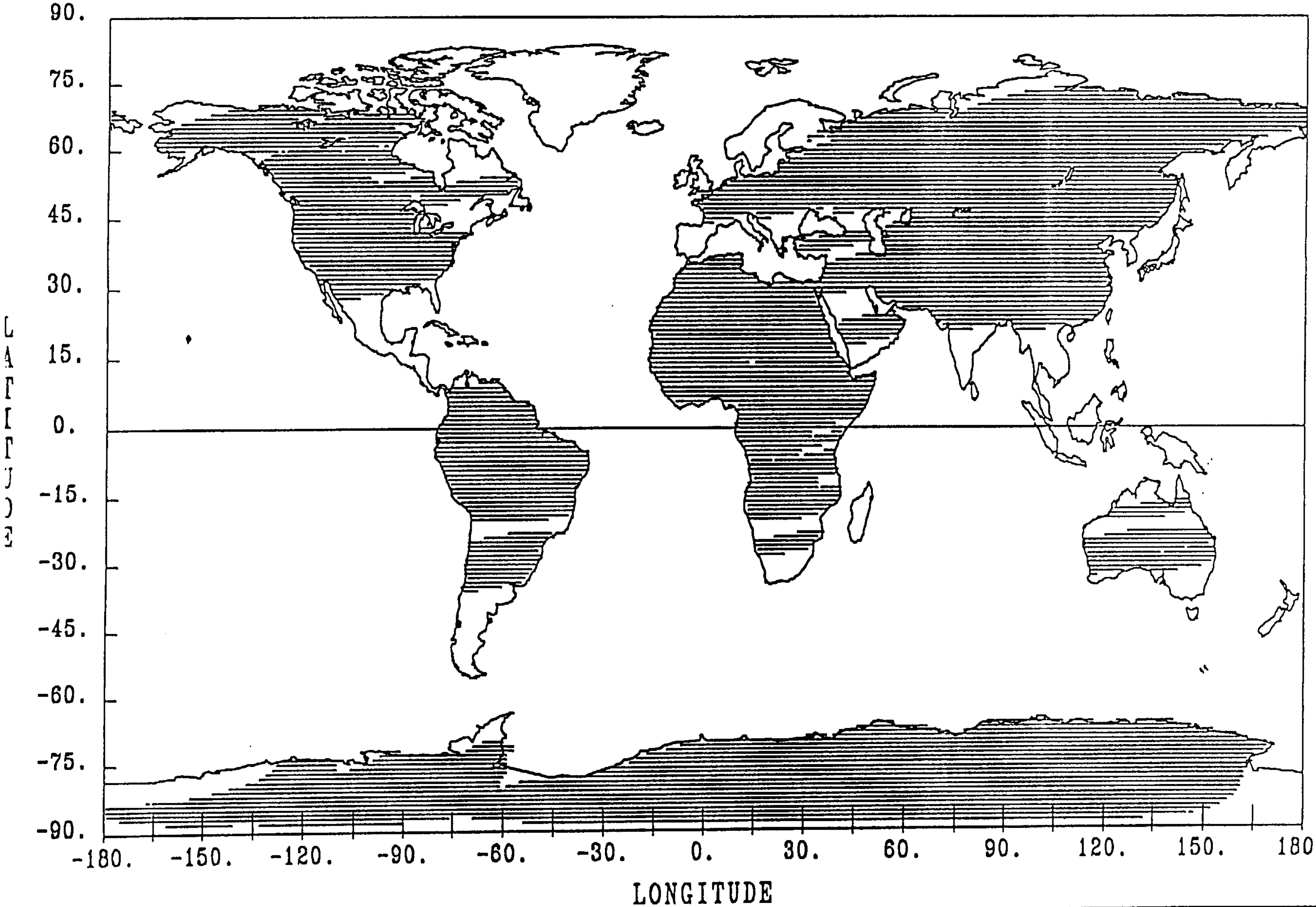


Fig. 4

CRCS Tilt

LAND COVERAGE -- DAY 1

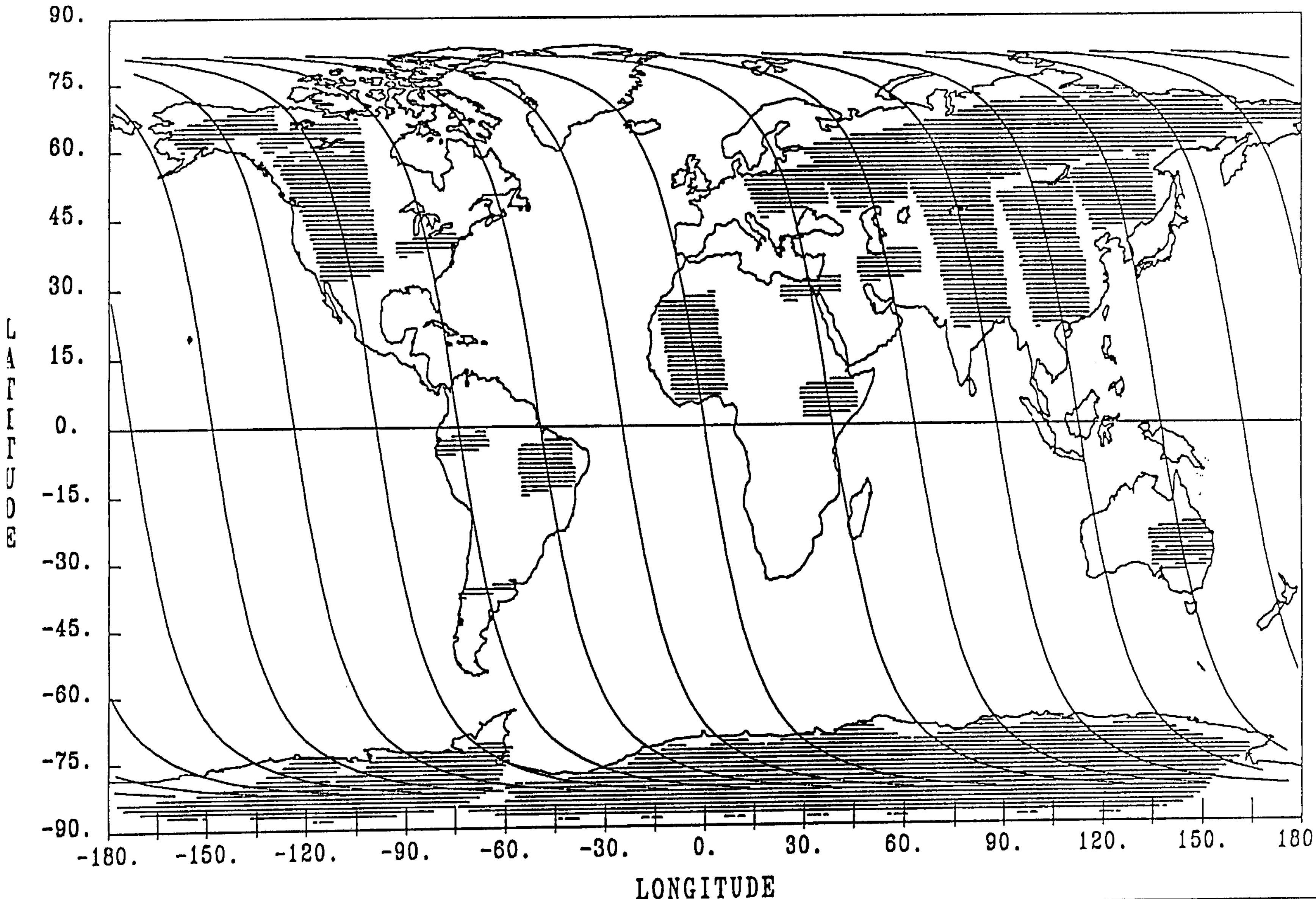
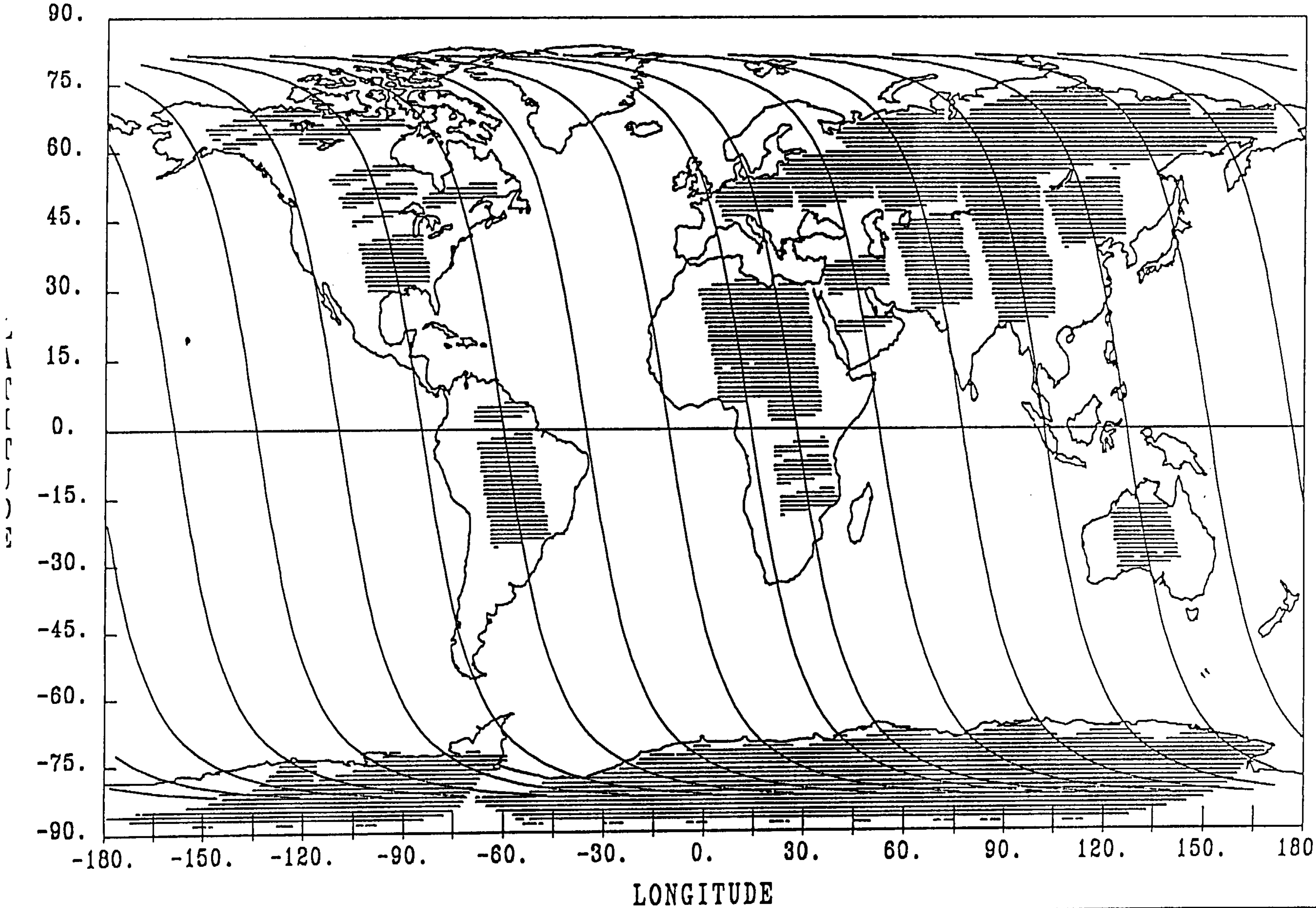
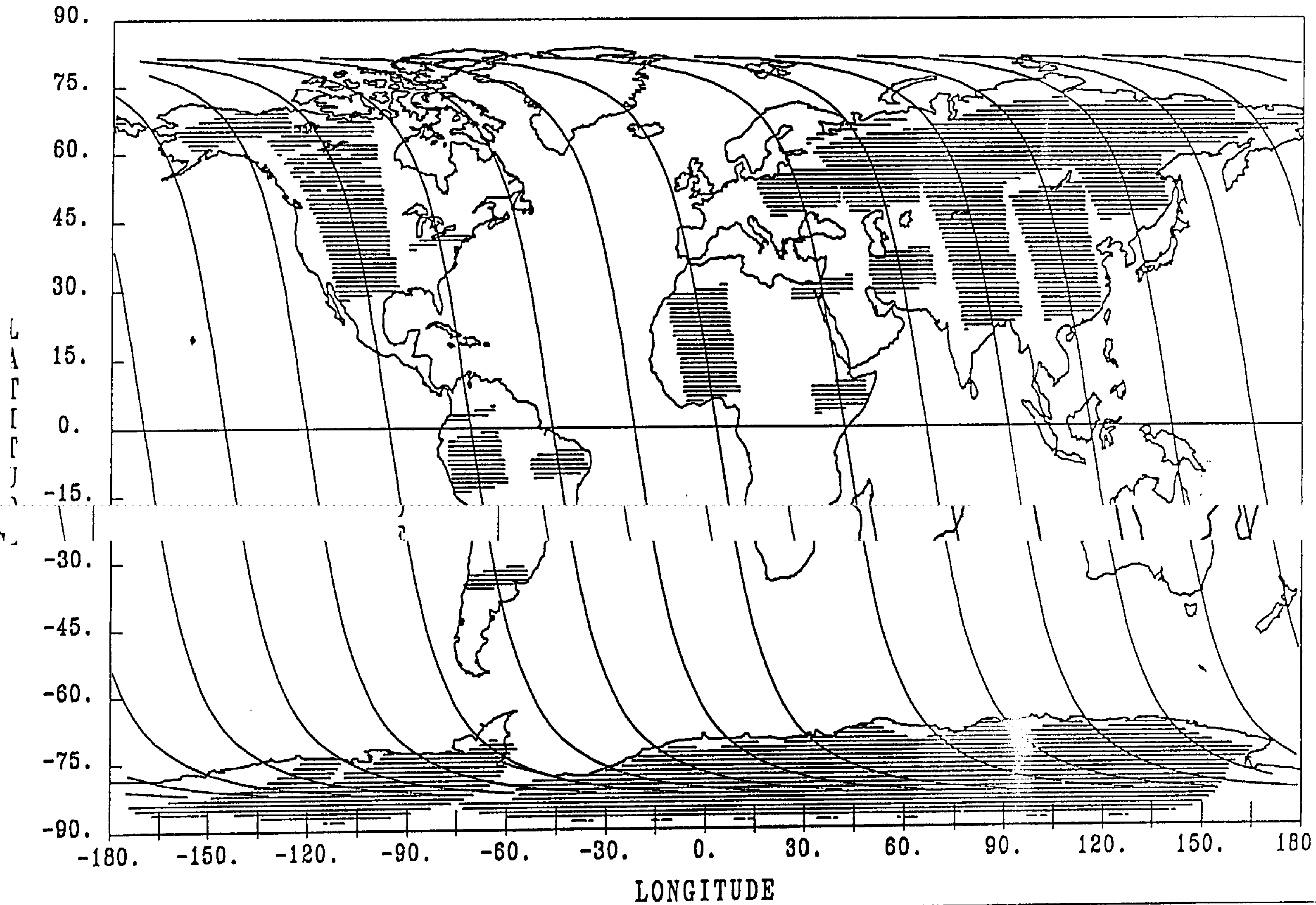


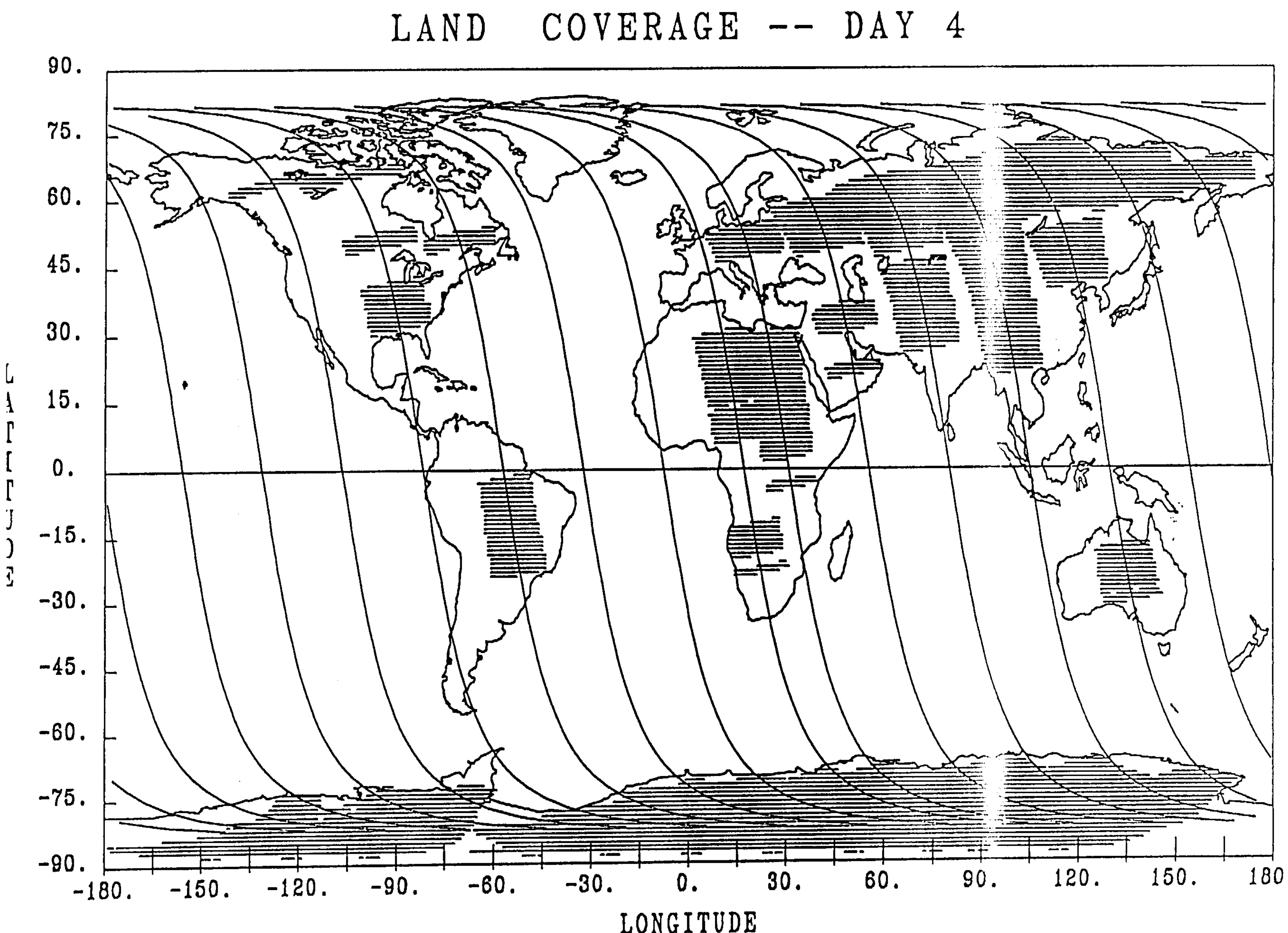
Fig 5

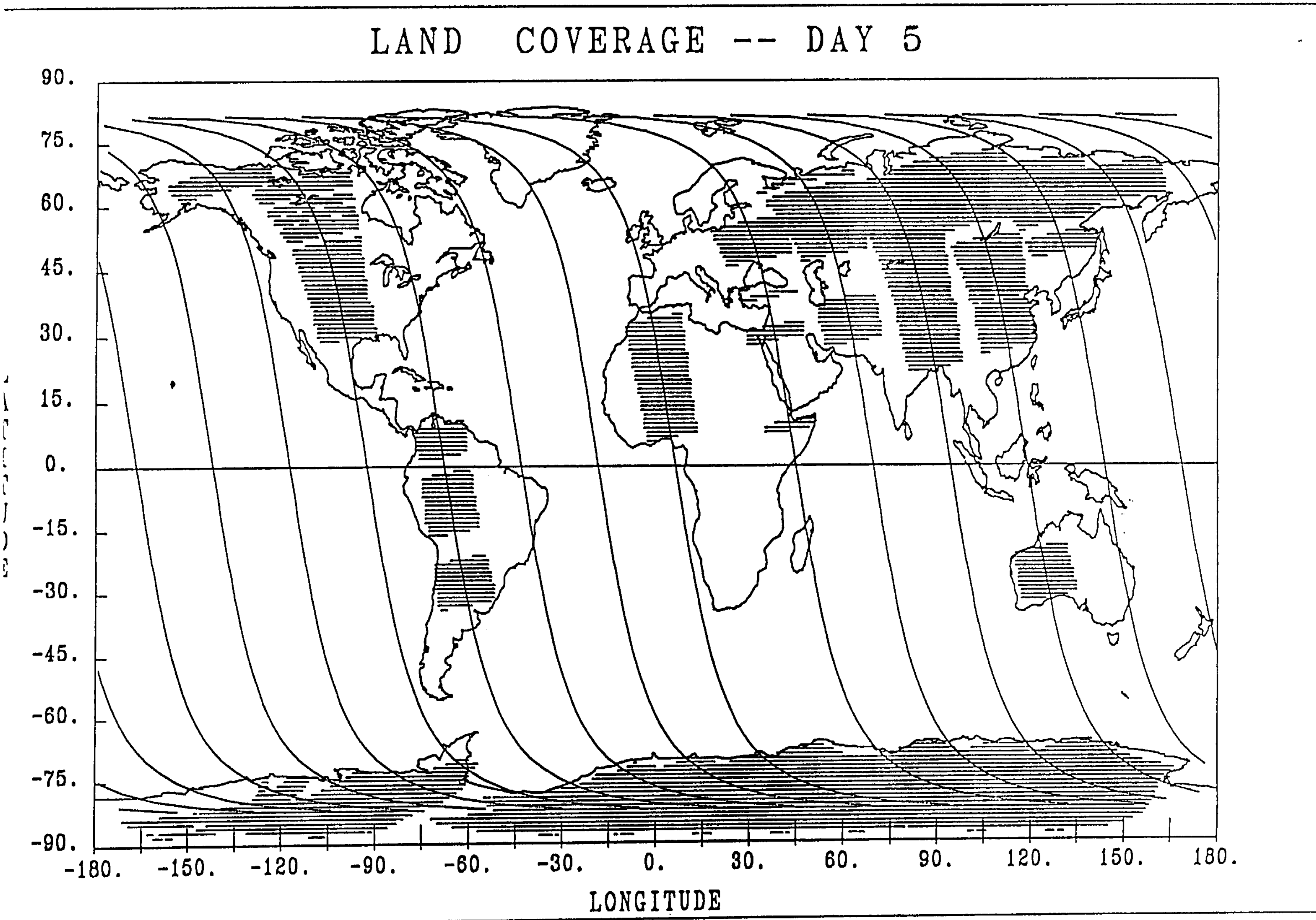
LAND COVERAGE -- DAY 2



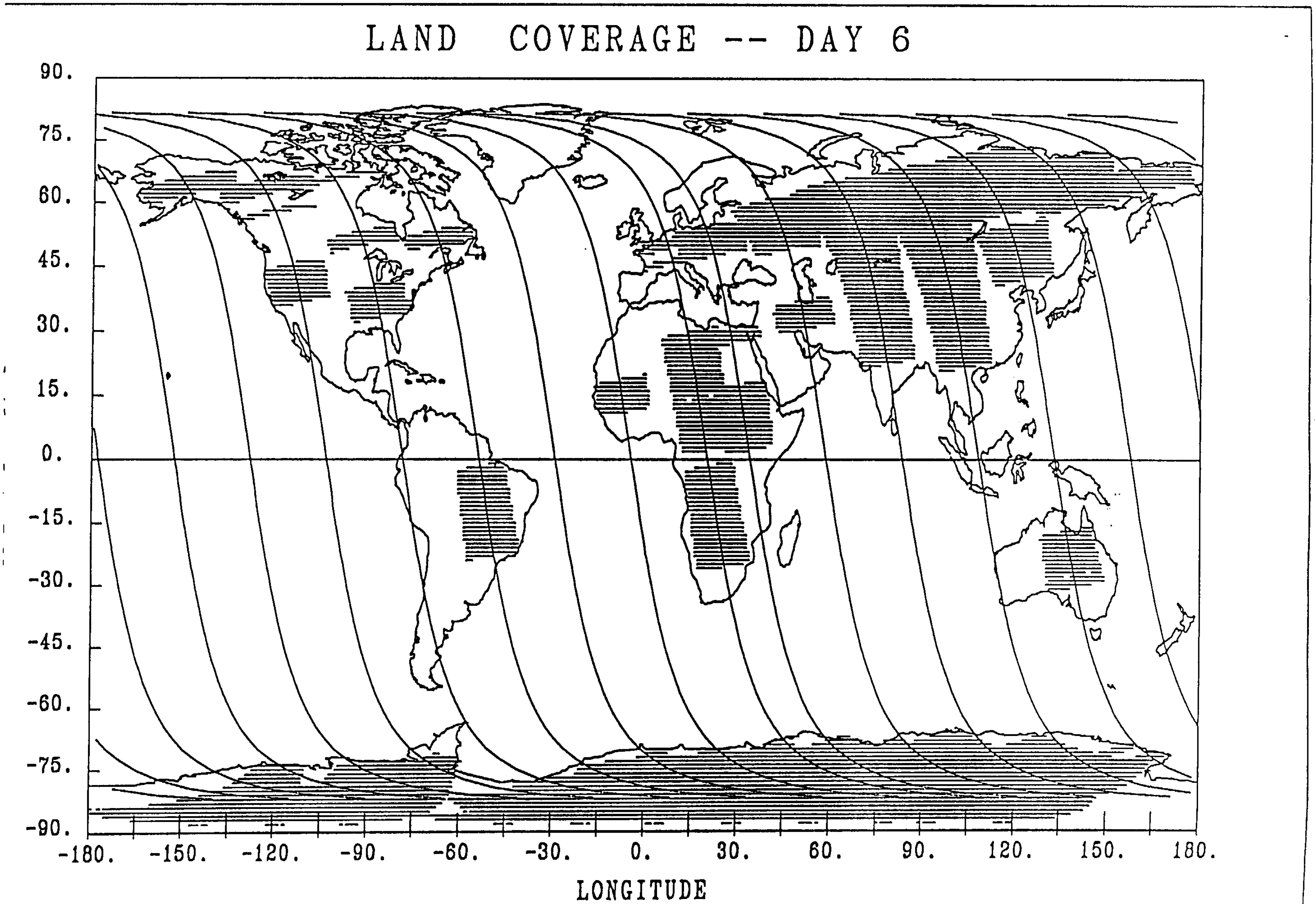
LAND COVERAGE -- DAY 3

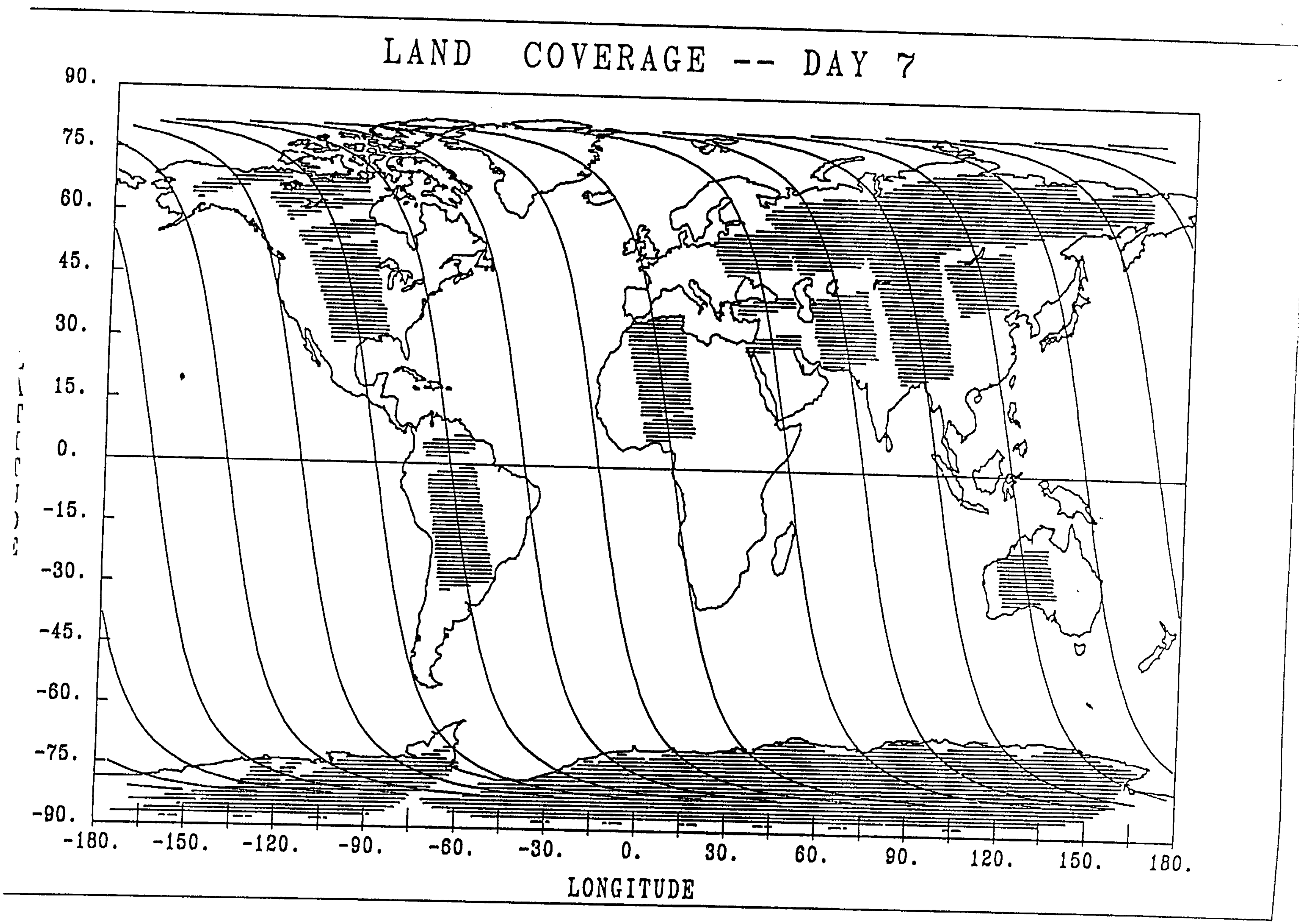



LAND COVERAGE -- DAY 4
90.
75.
60.
45.
30.
15.
0.
-15.
-30.
-45.
-60.
-75.
-90.
LATITUDE
-180.
-150.
-120.
-90.
-60.
-30.
0.
30.
60.
90.
120.
150.
180.
LONGITUDE



LAND COVERAGE -- DAY 5
90.
75.
60.
45.
30.
15.
0.
-15.
-30.
-45.
-60.
-75.
-90.
-180.
-150.
-120.
-90.
-60.
-30.
0.
30.
60.
90.
120.
150.
180.
LONGITUDE


LAND COVERAGE -- DAY 6
90.
75.
60.
45.
30.
15.
0.
-15.
-30.
-45.
-60.
-75.
-90.
-180.
-150.
-120.
-90.
-60.
-30.
0.
30.
60.
90.
120.
150.
180.
LONGITUDE


LAND COVERAGE -- DAY 7
90.
75.
60.
45.
30.
15.
0.
-15.
-30.
-45.
-60.
-75.
-90.
-180.
-150.
-120.
-90.
-60.
-30.
0.
30.
60.
90.
120.
150.
180.
LONGITUDE

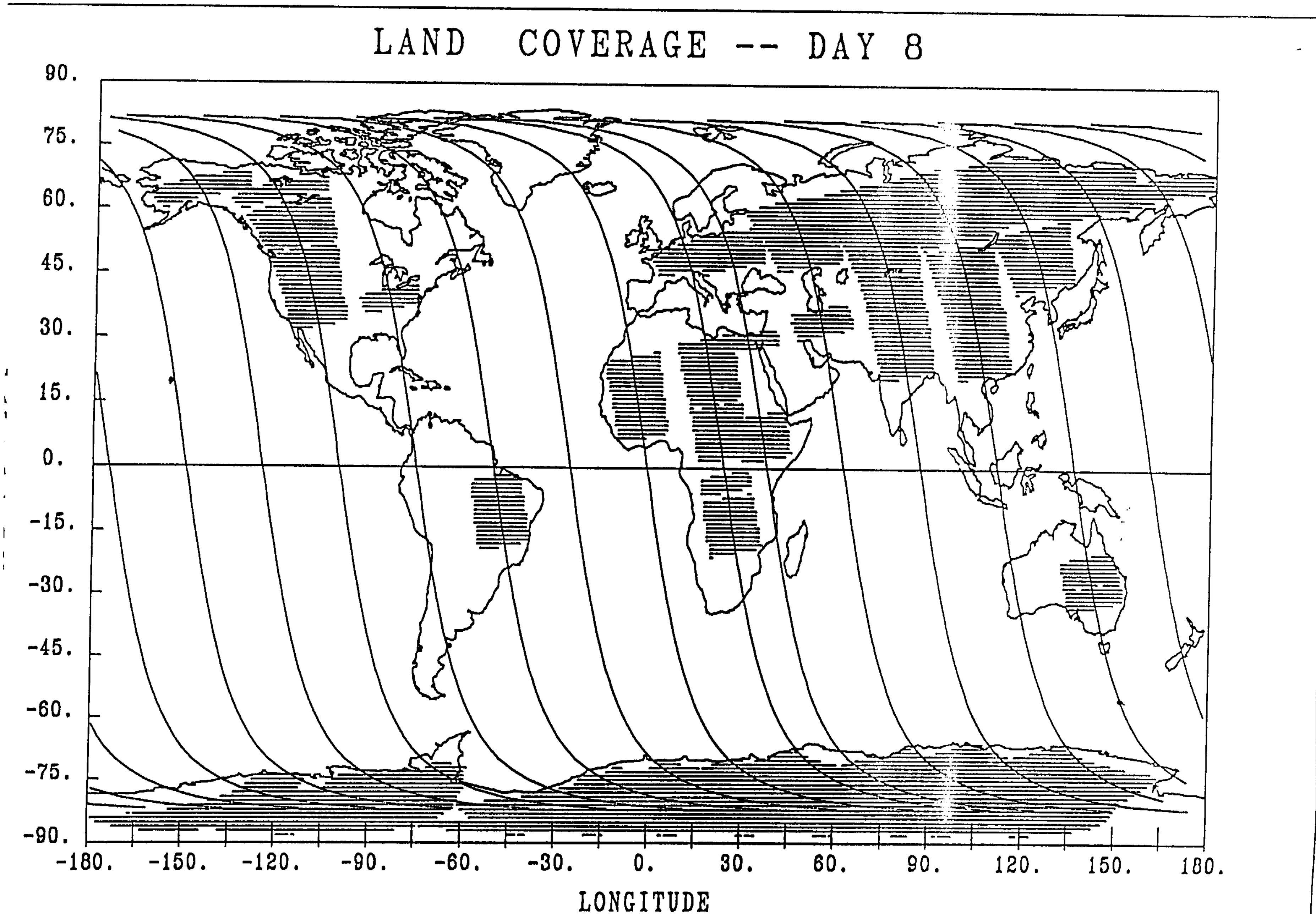
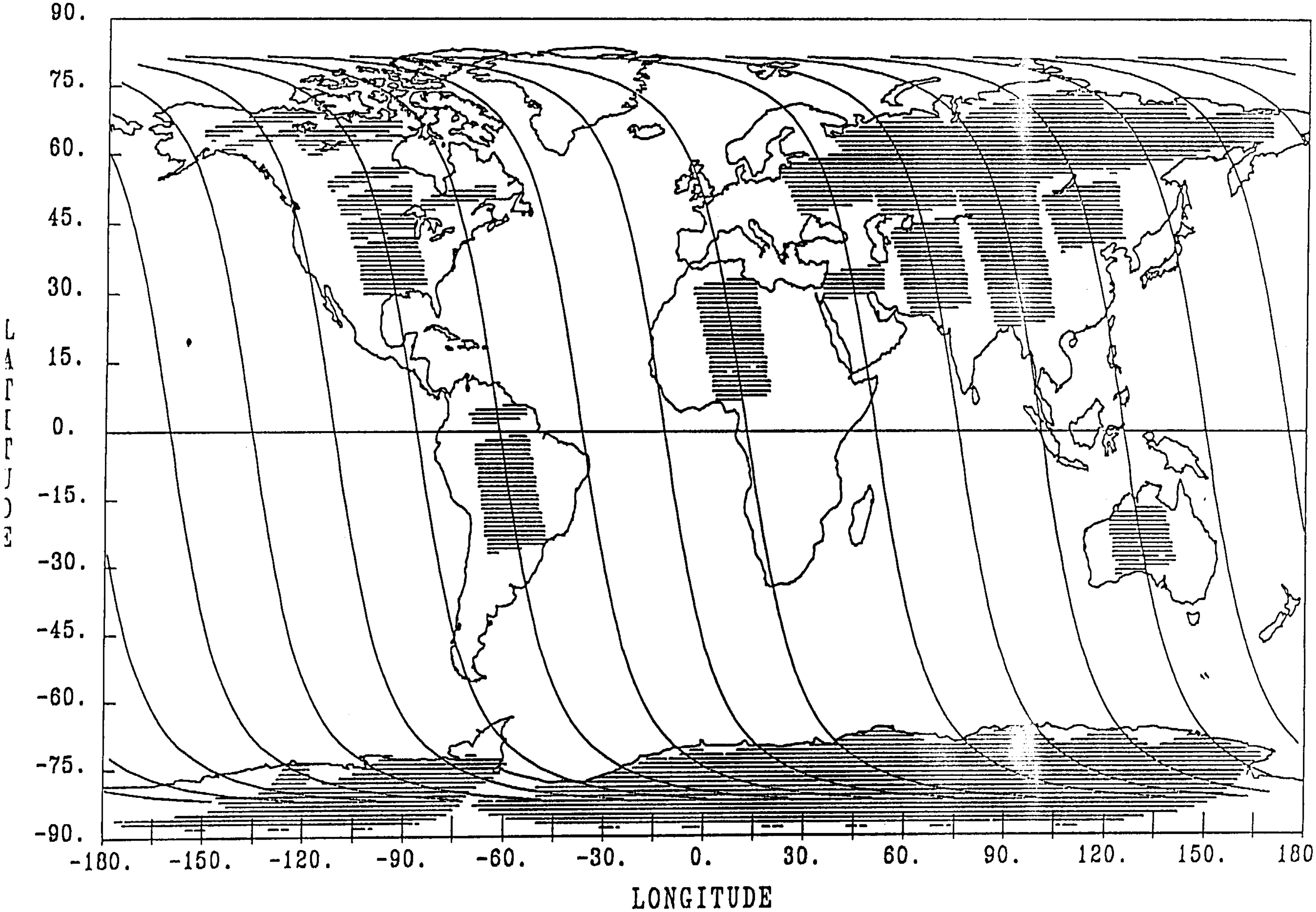
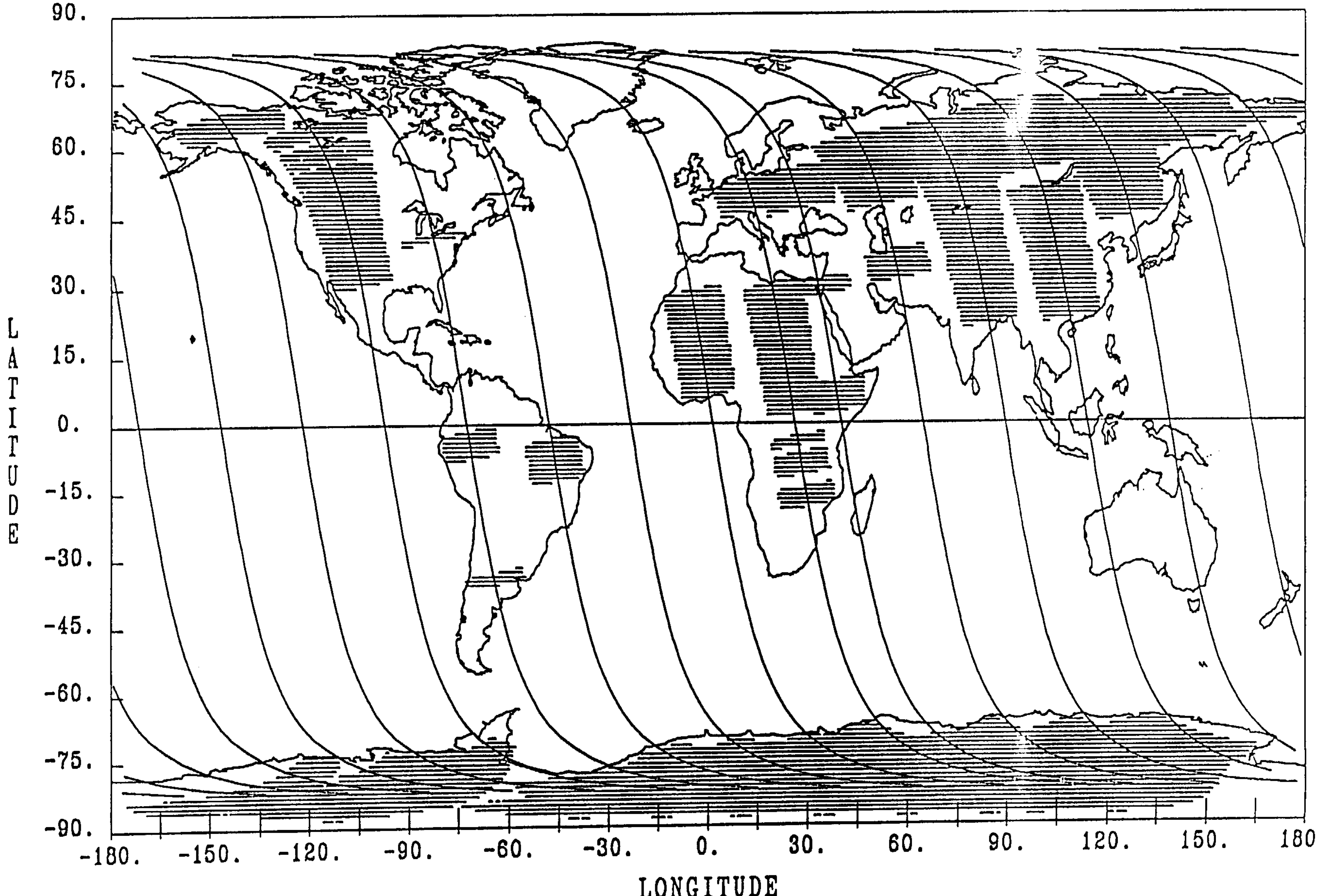

LAND COVERAGE -- DAY 8
90.
75.
60.
45.
30.
15.
0.
-15.
-30.
-45.
-60.
-75.
-90.
-180.
-150.
-120.
-90.
-60.
-30.
0.
30.
60.
90.
120.
150.
180.
LONGITUDE

Fig. 12

LAND COVERAGE -- DAY 9



LAND COVERAGE -- DAY 10



LAND COVERAGE -- DAY 11

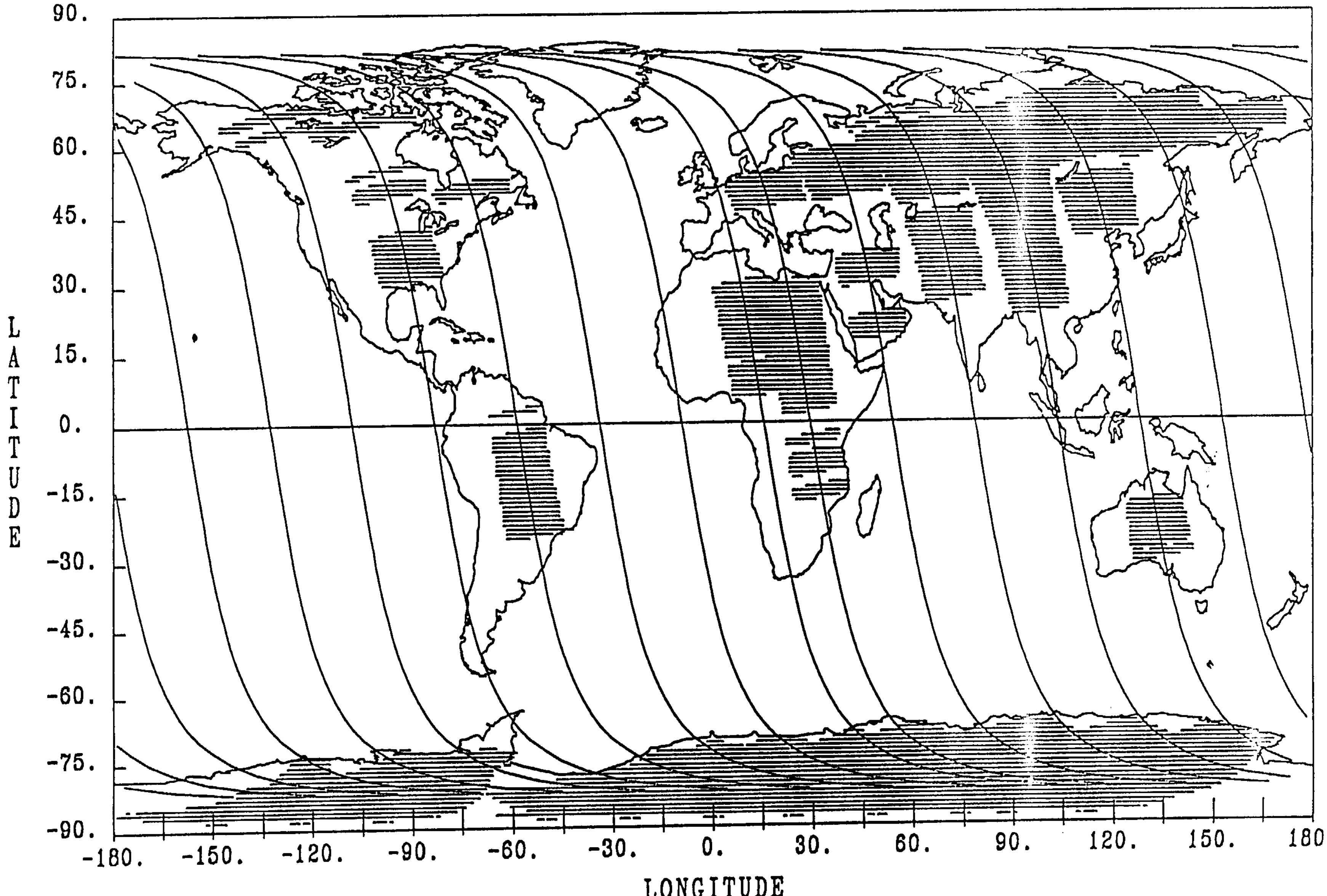
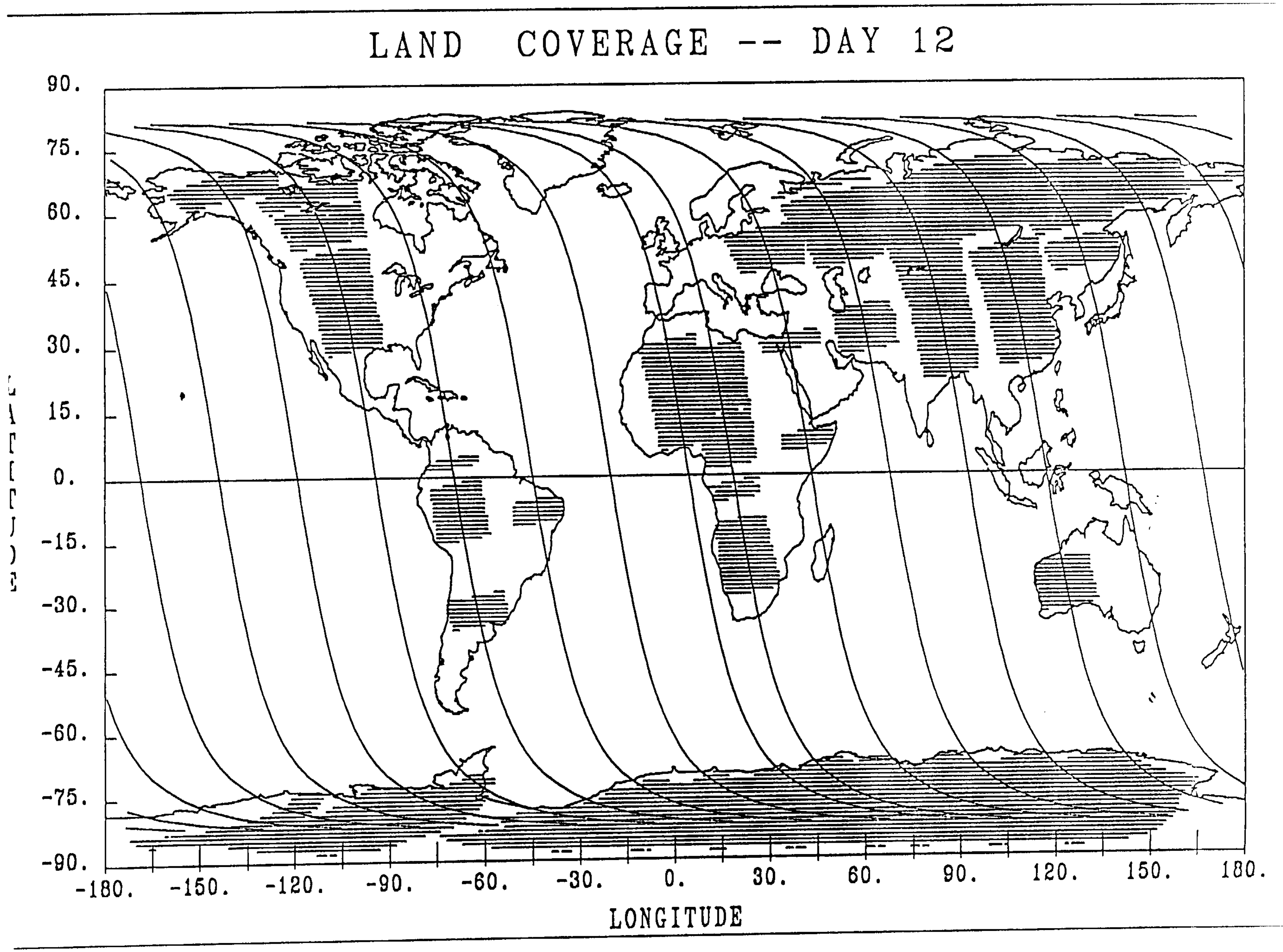
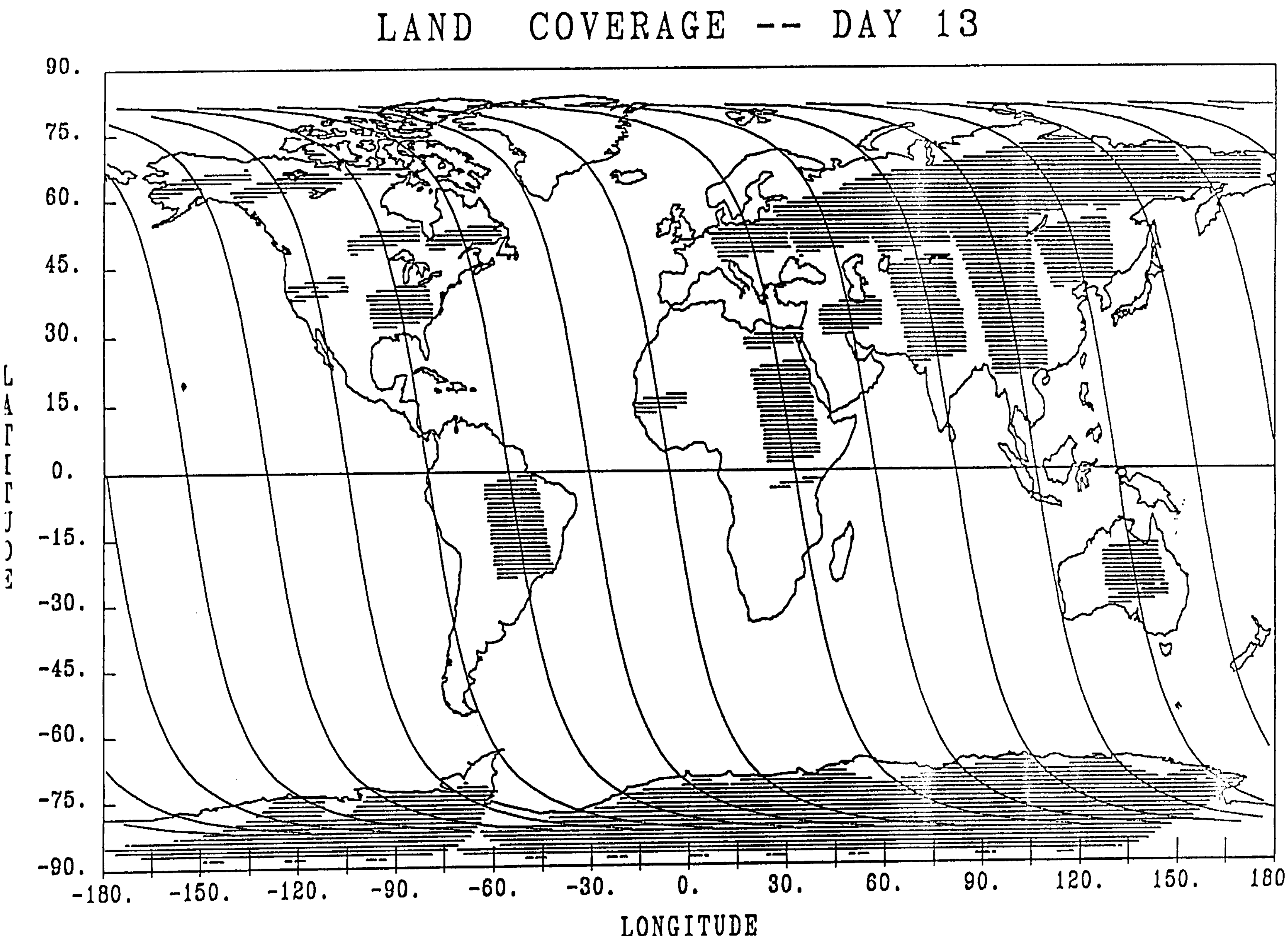


Fig 5


LAND COVERAGE -- DAY 12
90.
75.
60.
45.
30.
15.
0.
-15.
-30.
-45.
-60.
-75.
-90.
-180.
-150.
-120.
-90.
-60.
-30.
0.
30.
60.
90.
120.
150.
180.
LONGITUDE


LAND COVERAGE -- DAY 13
90.
75.
60.
45.
30.
15.
0.
-15.
-30.
-45.
-60.
-75.
-90.
LATITUDE
-180.
-150.
-120.
-90.
-60.
-30.
0.
30.
60.
90.
120.
150.
180.
LONGITUDE

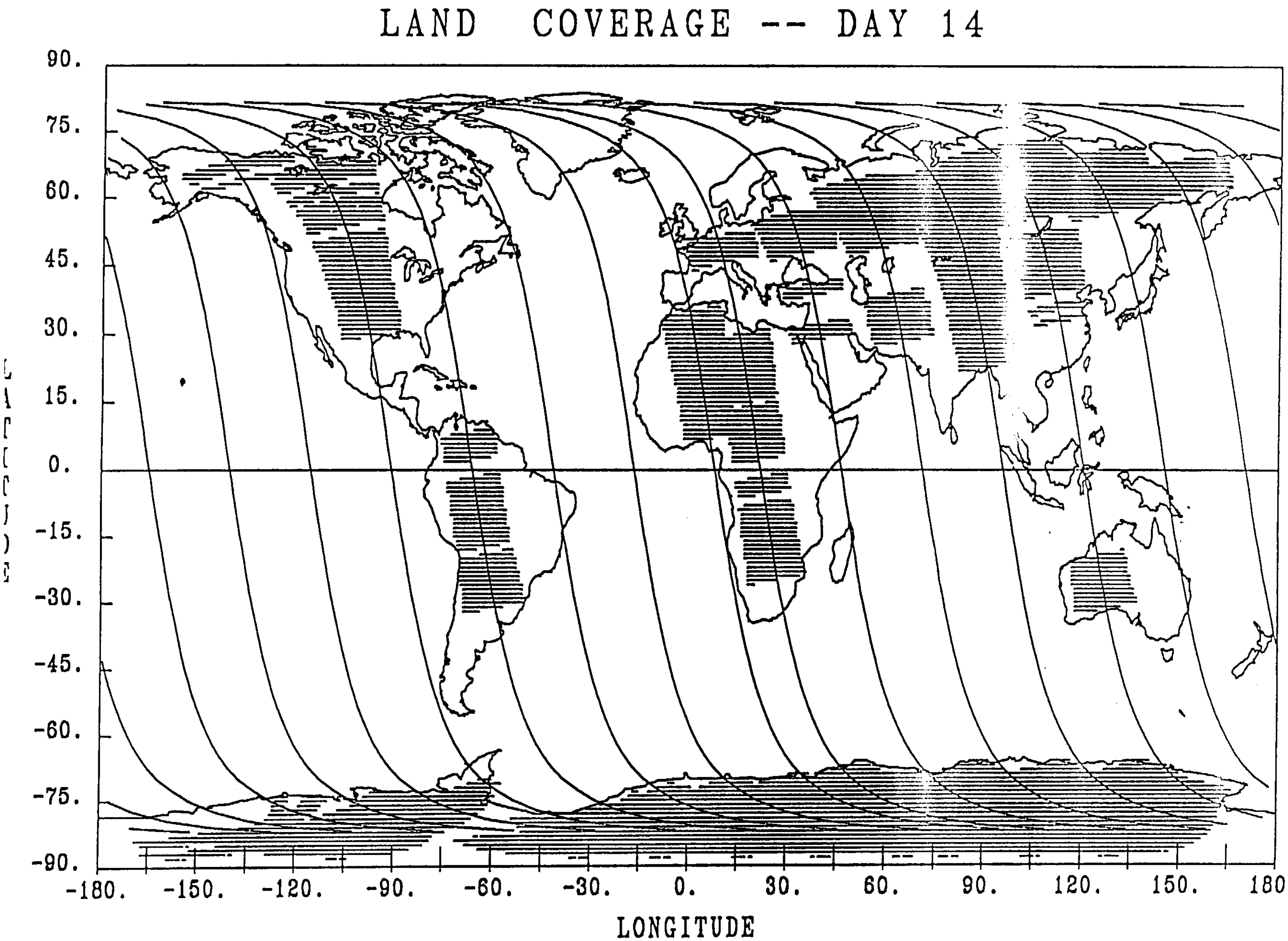
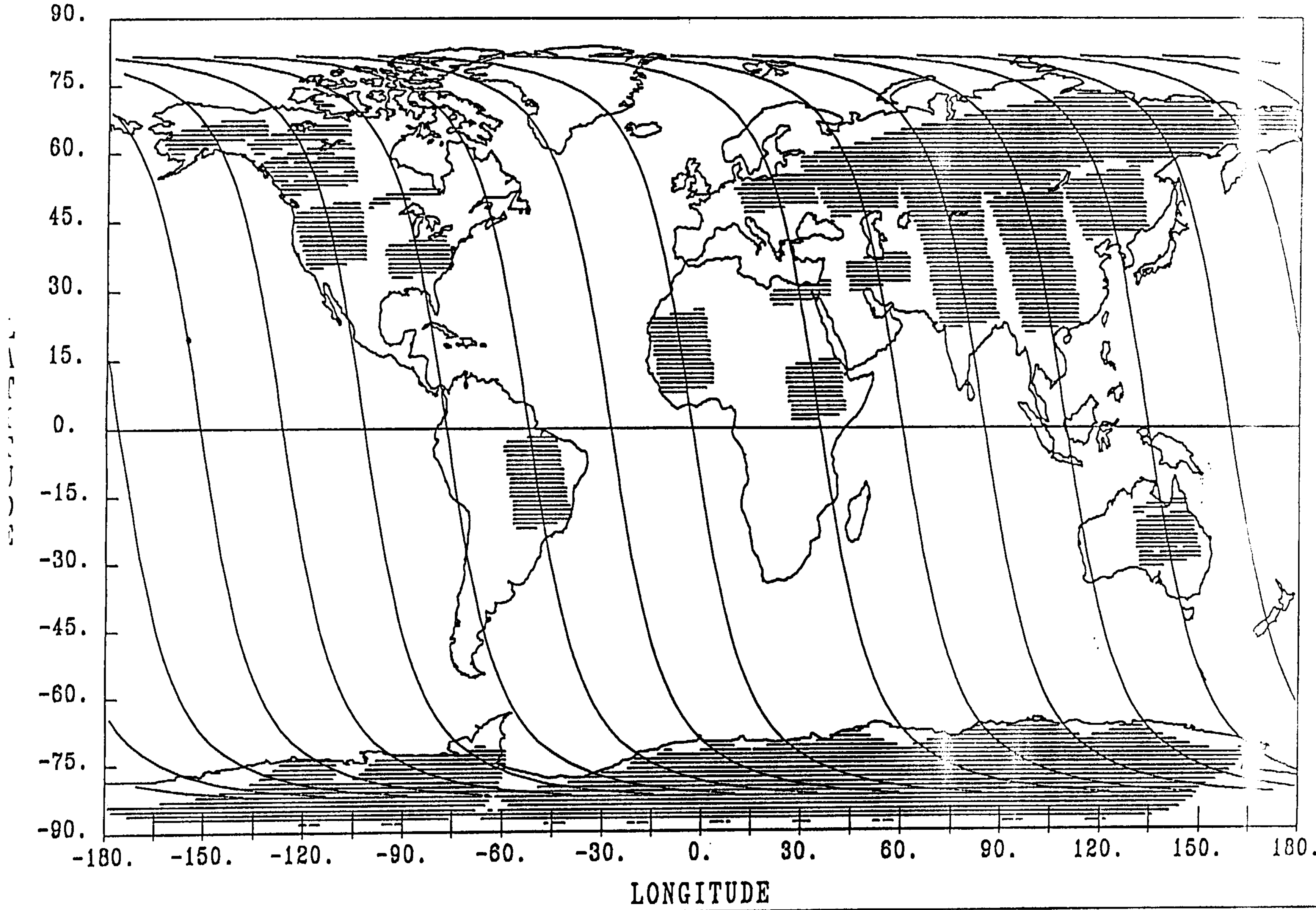

LAND COVERAGE -- DAY 14
90.
75.
60.
45.
30.
15.
0.
-15.
-30.
-45.
-60.
-75.
-90.
LATITUDE
-180.
-150.
-120.
-90.
-60.
-30.
0.
30.
60.
90.
120.
150.
180.
LONGITUDE

Fig. 12

LAND COVERAGE -- DAY 15



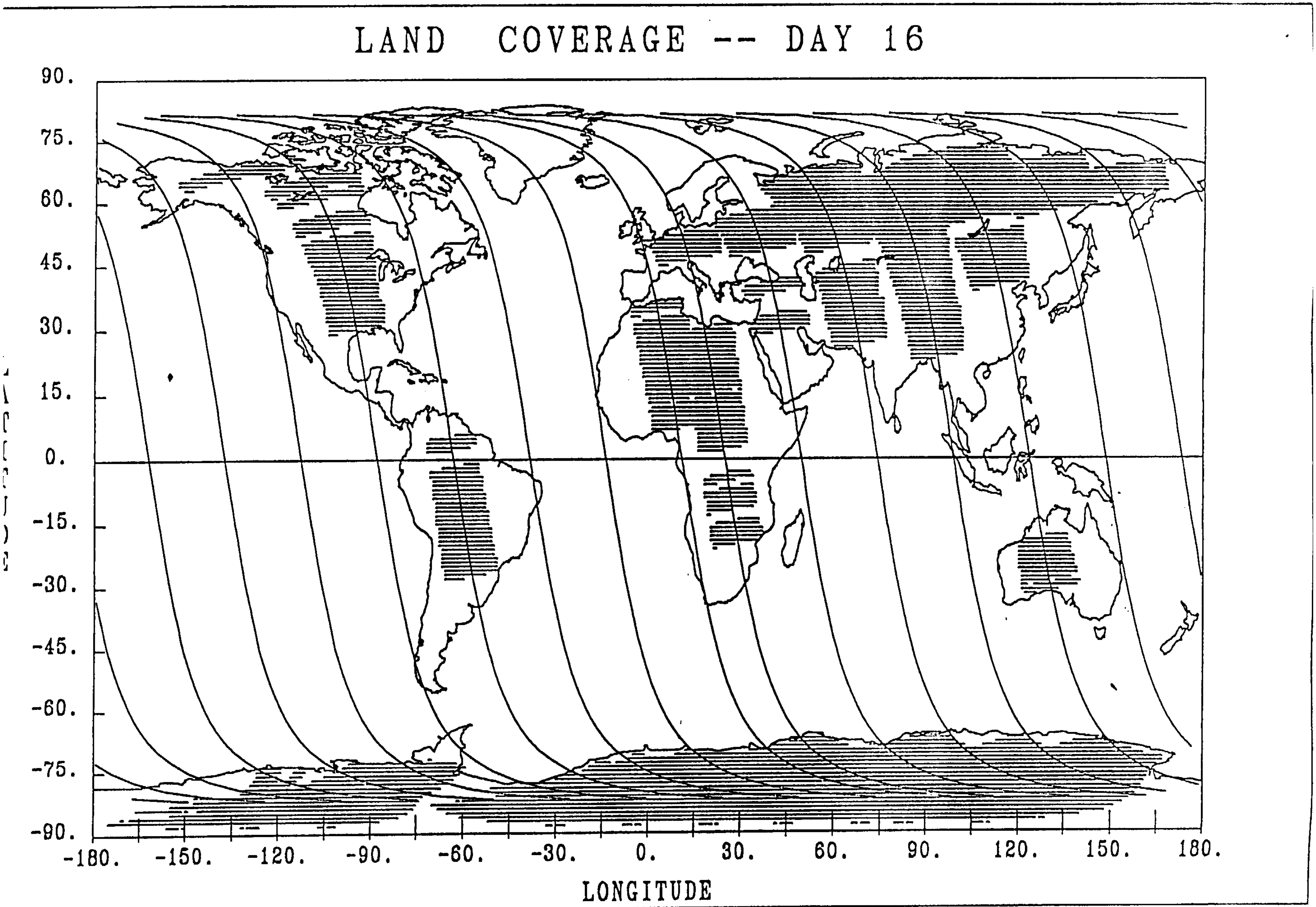
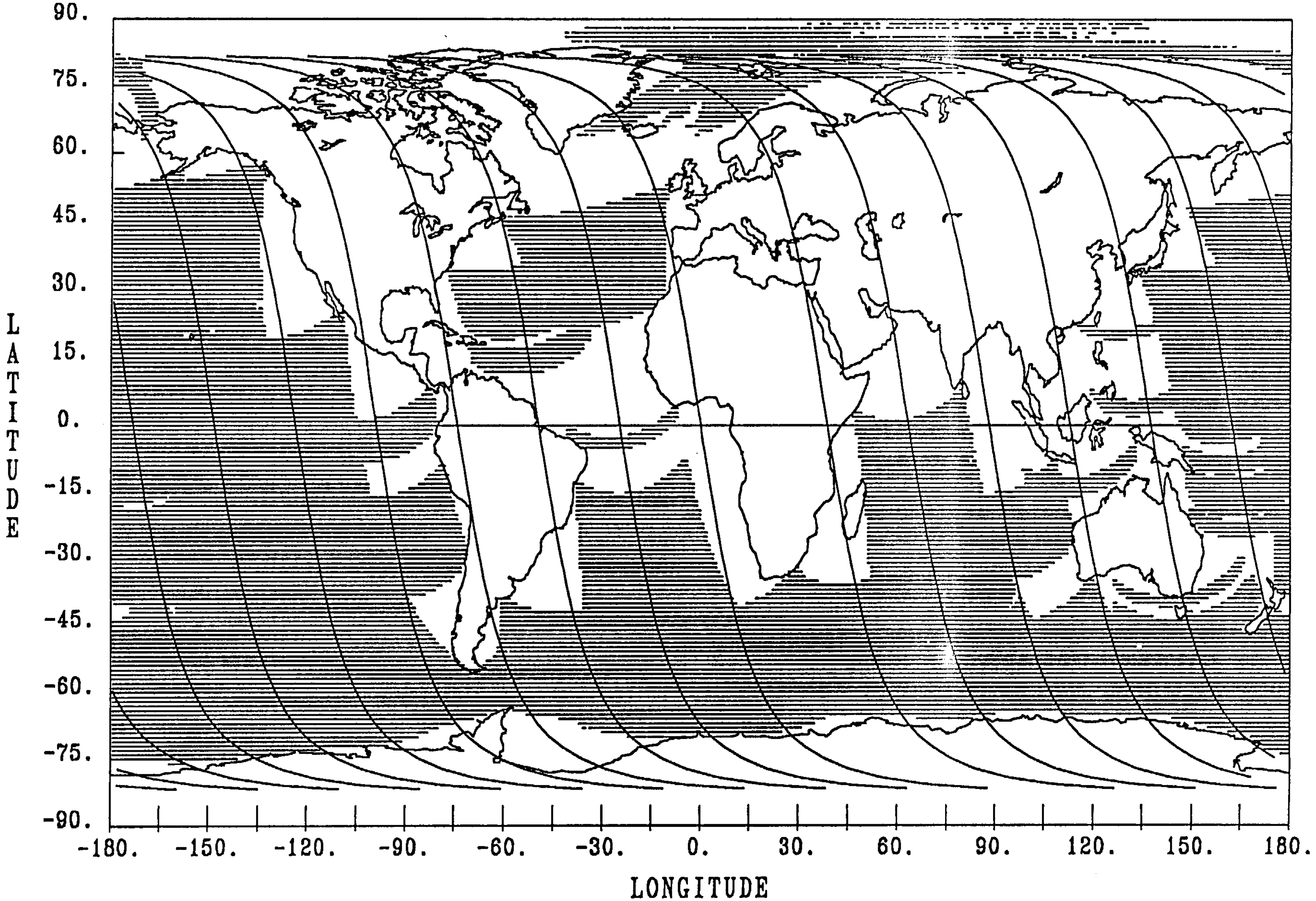

LAND COVERAGE -- DAY 16
90.
75.
60.
45.
30.
15.
0.
-15.
-30.
-45.
-60.
-75.
-90.
-180.
-150.
-120.
-90.
-60.
-30.
0.
30.
60.
90.
120.
150.
180.
LONGITUDE

Fig. 2

OCEAN COVERAGE -- DAY 1



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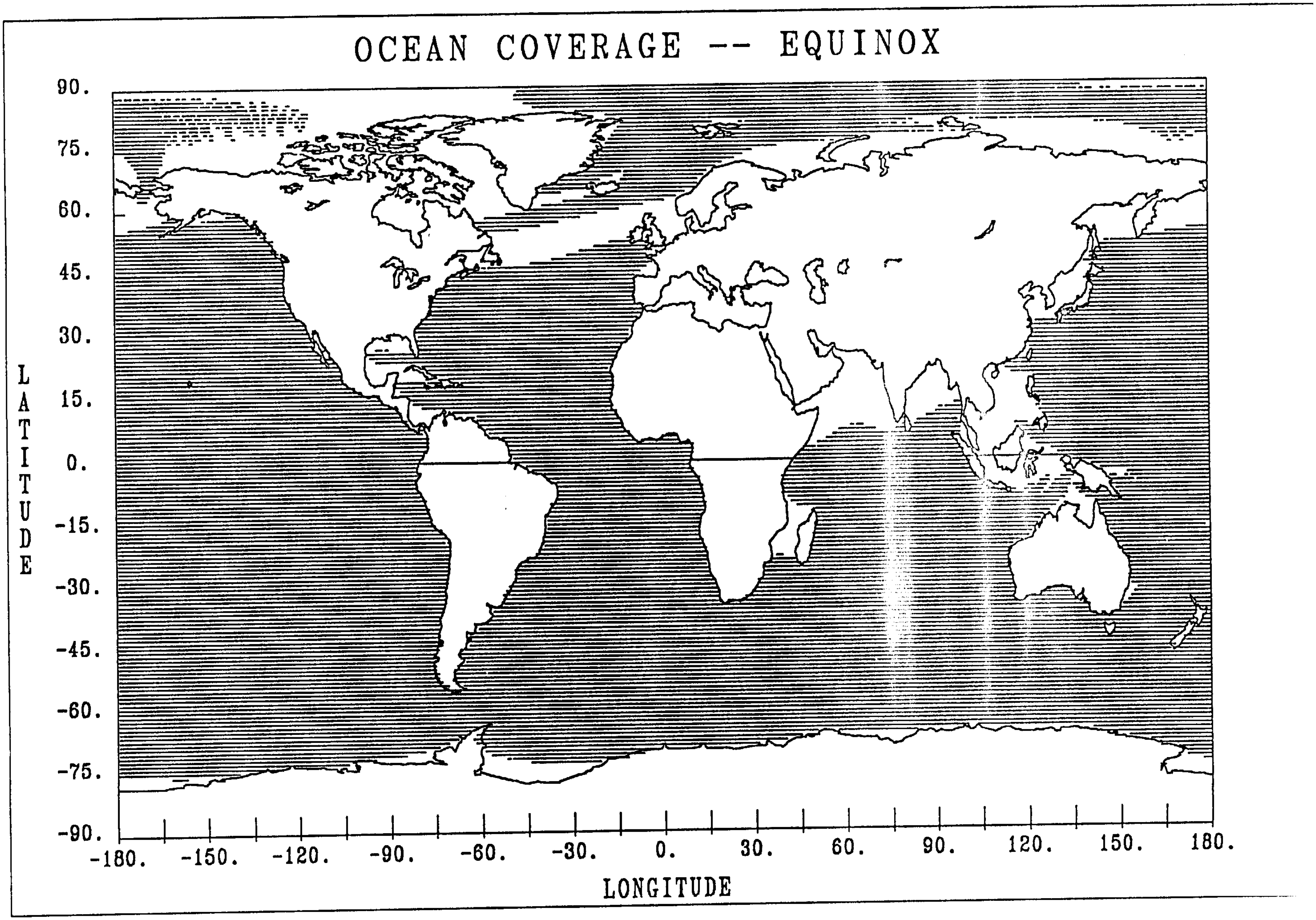
OCEAN COVERAGE -- EQUINOX
90.
75.
60.
45.
30.
15.
0.
-15.
-30.
-45.
-60.
-75.
-90.
LATITUDE
-180.
-150.
-120.
-90.
-60.
-30.
0.
30.
60.
90.
120.
150.
180.
LONGITUDE

Fig. 22