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Washington, D.C.

October 1968

Meso-Scale Archive and Products of Digitized Video Data from ESSA Satellites

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NESCTM 8 Operational Utilization of Upper Tropospheric Wind Estimates Based on Meteorological Satellite Photographs. Gilbert Jager, Walton A. Follansbee, and Vincent J. Oliver, October 1968.

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Environmental Science Services Administration
U. S. National Environmental Satellite Center, Washington, D.C.

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MESO-SCALE ARCHIVE AND PRODUCTS OF DIGITIZED VIDEO DATA FROM ESSA SATELLITES

Arthur L. Booth and V. Ray Taylor

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National Oceanic and Atmospheric Administration
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MESO-SCALE ARCHIVE AND PRODUCTS OF DIGITIZED VIDEO DATA FROM ESSA SATELLITES

Arthur L. Booth and V. Ray Taylor

ABSTRACT

Data received from the optical sensors of the ESSA satellites (video data) are digitized and various products produced. The mode of processing described here is of less than full-scale resolution, hence is termed meso-scale. The meso-scale archival data tape is described. Computer-derived products of the meso-scale archive are shown and discussed.

I. INTRODUCTION

Since January 1967, an archive has been maintained of digitized video data from the ESSA series of meteorological satellites. These data, which represent an almost complete once-a-day view of the earth are now being made available on magnetic tape through the National Weather Records Center, Asheville, N. C. At the National Environmental Satellite Center (NESC) basic archival tapes are produced routinely, and investigations to develop useful operational computer-derived products are continuing. The intent of this memorandum is to provide information on the existence, content, and format (see Appendix) of the basic archival tapes, to show sample products, and to discuss briefly the various uses of these products.

II. DATA SOURCE AND COMPRESSION

Digitized video data from the ESSA satellites are resolved each day into two 4096 x 4096, or full resolution matrices, which present polar stereographic views of both northern and southern hemispheres. Each 64 x 64 submatrix of full resolution data corresponds to one Numerical Weather Prediction (NWP) grid square. Four thousand and ninety six (64 x 64) NWP grid squares cover each hemisphere and contain the familiar octagon grid as a subset. Each spot (datum point) of the full resolution array has one of 16 integral values from 0 (darkest) to 14 (brightest) or 15 (missing data). Each of these values is a measure of the brightness of clouds, background, or both at that particular time and geographic location. Further details concerning the preliminary processing of data and production of the full resolution arrays can be found in Bristor et. al. (1966), Bradford and Gross (1967), and Bristor (1968).

The meso-scale array is made from the full resolution by an eight-fold reduction in each dimension of the number of spots. This results in a 512 x 512 array to cover each hemisphere. Each meso-scale spot represents an 8 x 8 block of full resolution data and constitutes 1/64 of an NWP grid square. The original relative brightness range of 0-14 is divided into 5 equal

categories, and for each meso-scale spot (64 full resolution spots), the full resolution population falling into each category is determined. The five population numbers for each meso-scale spot constitute an individual byte which is stored on magnetic tape. Each day of data contains a grid of 512 x 1024 bytes covering both hemispheres. A more detailed description of the tape format is given in the Appendix.

III. PRODUCTS OBTAINED FROM THE MESO-SCALE ARCHIVE

1. Averages

One of the more easily derived data products, at least in principle, is a straightforward time average of brightness. Kornfield (1967) has used a photographic multi-exposure technique to obtain averages from the daily photographs which are routinely produced from the full resolution data tapes. If problems, such as lack of precise registration, non-uniformity of the daily photographs, and non-linear film sensitivity to multi-exposures, can be minimized, such techniques might have the advantage of retaining the original resolution of the daily photographs in average charts. For the study of small scale orographic effects or some semi-permanent features such resolution will probably be desirable. However, for the study of large-scale phenomena and for global averaging, the meso-scale should be quite sufficient. Accordingly a variety of experimental products have been computer-produced through multi-day combinations of meso-scale image tapes.

Taylor and Winston (1968) used digital averaging and display for a full year of data (Feb. 1967 - Feb. 1968) in constructing monthly and seasonal global averages. Here the data were averaged into 5 degree latitude by 5 degree longitude areas and displayed on a Mercator projection. An attempt was also made to adjust the average brightness for various time periods in order to compensate for instrumental changes and to eliminate obviously erroneous data.

In the present case, data are time averaged digitally while retaining the meso-scale resolution, recorded on magnetic tape, and displayed by means of a cathode ray film device. Mapped video averages for 5-day periods have been produced on an operational test basis since November, 1967. Sample Northern Hemisphere charts for two consecutive 5-day periods are shown in Figures 1 and 2. Southern Hemisphere 5-day averages have also been produced experimentally (Figure 3). More recently, averaged charts have been prepared for longer periods. Figure 4 is a sample 10-day averaged image. Figures 5 - 10 contain a sequence of six 30-day averages; 90-day seasonal averages are shown in Figures 11 and 12. Grey scaling of the brightness values can be easily adjusted in the production of these charts, and was changed to enhance the contrast on the longer-term averages (Figures 11 and 12) as well as to compensate for changes in camera response between ESSA 5 and 3 (Figures 8-10).

The major features obvious on the average brightness charts presented here will not be pointed out on the individual figures. As important as the existence of these features may be, their variations from week to week or

season to season are equally important. Examples of the various features are clearly discernable in these charts. A few of the more noticeable features are: the intertropical convergence zone(s), subtropical high pressure regions, the Antarctic continent and surrounding ice cover, the north polar ice cap and Greenland, the polar front regions, the Sahara and Arabian deserts, monsoon cloudiness over India and southeast Asia, and snow or cloudiness associated with major mountain ranges. An apparent stepwise progression of rapidly moving features appears occasionally on the short-term (5-day) averages. This is because these features are photographed only once per day, so the intermediate positions of the features are not available for averaging. This effect is minimized on longer term averages.

2. Composites

On almost any time-average chart, land features or semi-permanent cloud systems are well defined because their brightness is contributed to the same spots on all days. Transient features, on the other hand, tend to be smoothed out in proportion both to their speed and the number of samples (days of data) used.

For some studies it is desirable to minimize the effects of transient features even more than is done by simple averaging. The minimum composites shown in Figures 13 and 14 are designed for this purpose. By saving only the minimum response of each spot for a selected number of days, any relatively bright feature which did not show up over a spot on all days of the period would not show up at all on the minimum composite chart. The Antarctic continent with its overlying and surrounding ice cover is shown clearly on any minimum composite of the region. This suggests an immediate application as a convenient way to chart the extent of semi-permanent pack ice. Dr. E. Paul McClain, Director of the Environmental Sciences Group, NESC, has used minimum composites and digital averages to establish the snow line over the North American continent. These results have compared favorably with snow lines established by conventional snow-guage reports and satellite data using photographic averaging techniques. Other possible applications of the minimum composite include background and terrain studies.

Maximum composites (Figures 15 and 16), as the name implies, are constructed by saving only the maximum response over each spot for the selected period. Dark areas of this display represent regions over which no relatively bright phenomena occurred during the period involved; in temperate latitudes these dark areas may represent regions of high pressure blocking. The brighter areas, on the other hand, may be related to areas of significant precipitation. The apparent step-wise progression of persistent but rapidly moving systems which was mentioned previously is especially noticeable in this product and suggests a possible means for recording the tracks, development, and dissipation of individual cloud systems.

Figures 14 and 15, both for the same time period, present a contrast between minimum and maximum compositing.

IV. CURRENT AND FUTURE EFFORTS

Several projects are currently underway at the Data Processing and Analysis Division (DAPAD), NESC to develop other useful computer products. Among these are the specifications of wind fields by means of objective computer analysis of certain cloud features, construction of computer-produced nephanalysis, support for hydrological research, and cloud type specification by measurement of statistical parameters over a sufficient population of full resolution spots.

Future efforts will include experiments with intermediate resolutions (between full and meso-scale), especially over polar regions as an aid in ice surveillance, and the use of partially eroded cloud images for constructing multi-day composites. Planning is also underway for use of multi-channel radiometer data from the future Improved TIROS Operational Satellite (ITOS) series. With a trend toward sensors of the scanning radiometer type, more reliable calibration of image data is expected. Availability of these more reliable data should increase the quantitative significance of interpretive products. Multi-day composites of the warmest response from the IR window channel, for example, may well provide sea surface temperature information for direct input to NWP operations.

The development of many additional interpretive products derived from satellite data awaits or will parallel the development of pattern recognition schemes in computers. This development will necessarily be laborious due to conflicting requirements. These schemes must be both sophisticated in order to recognize the myriad of patterns which clouds may assume, and yet simple enough to handle the enormous volume of satellite data which is processed for operational use.

The present archive of meso-scale satellite data offers material for use in many areas of study. It is hoped that this sample of meso-scale products currently available will not only lead to additional uses, but will suggest other basic products that might be derived from the satellite data. Direct communications with the authors, or the NESC, are invited.

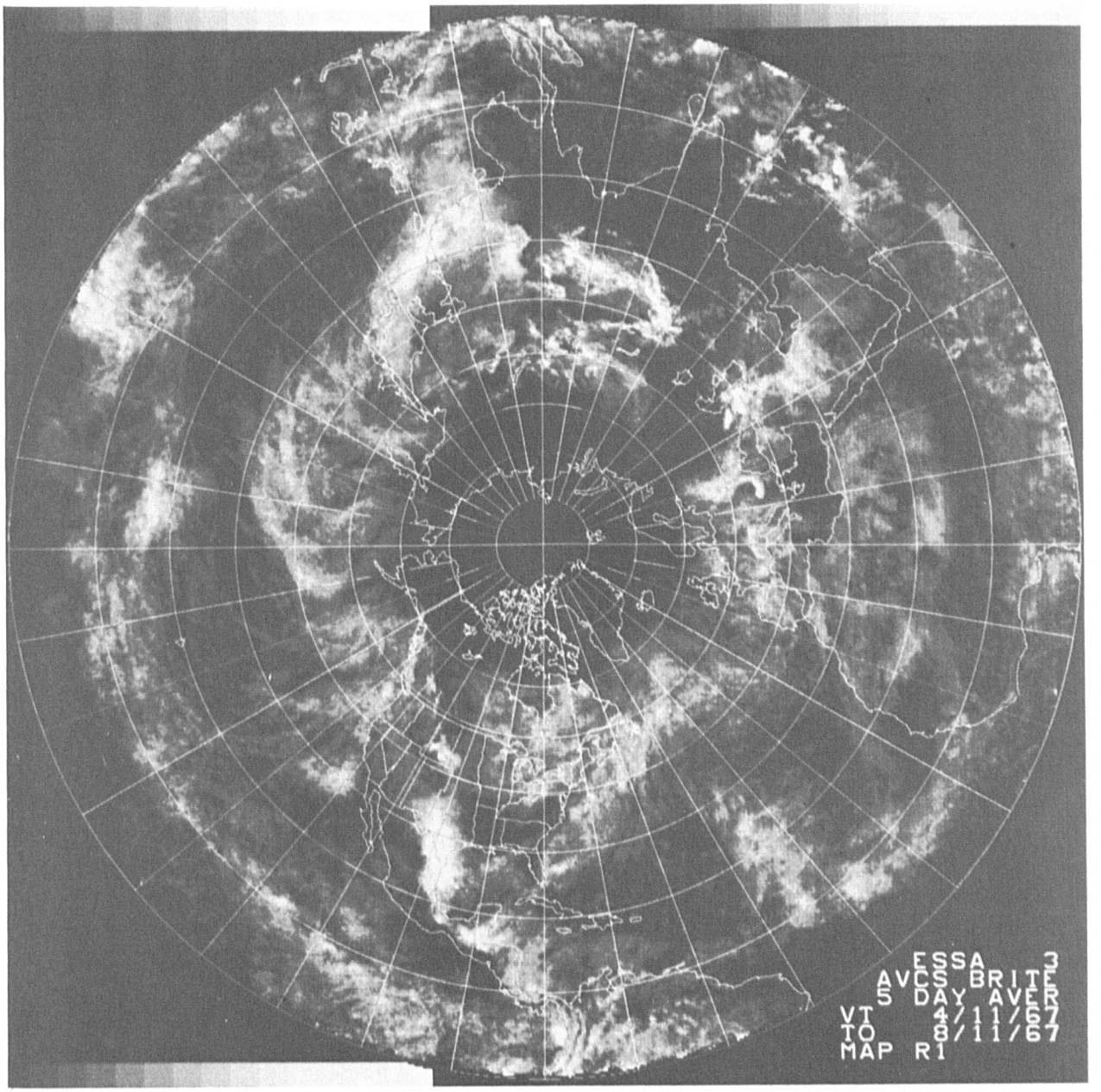

Figure 1. Five-day average brightness - November 4-8, 1967.

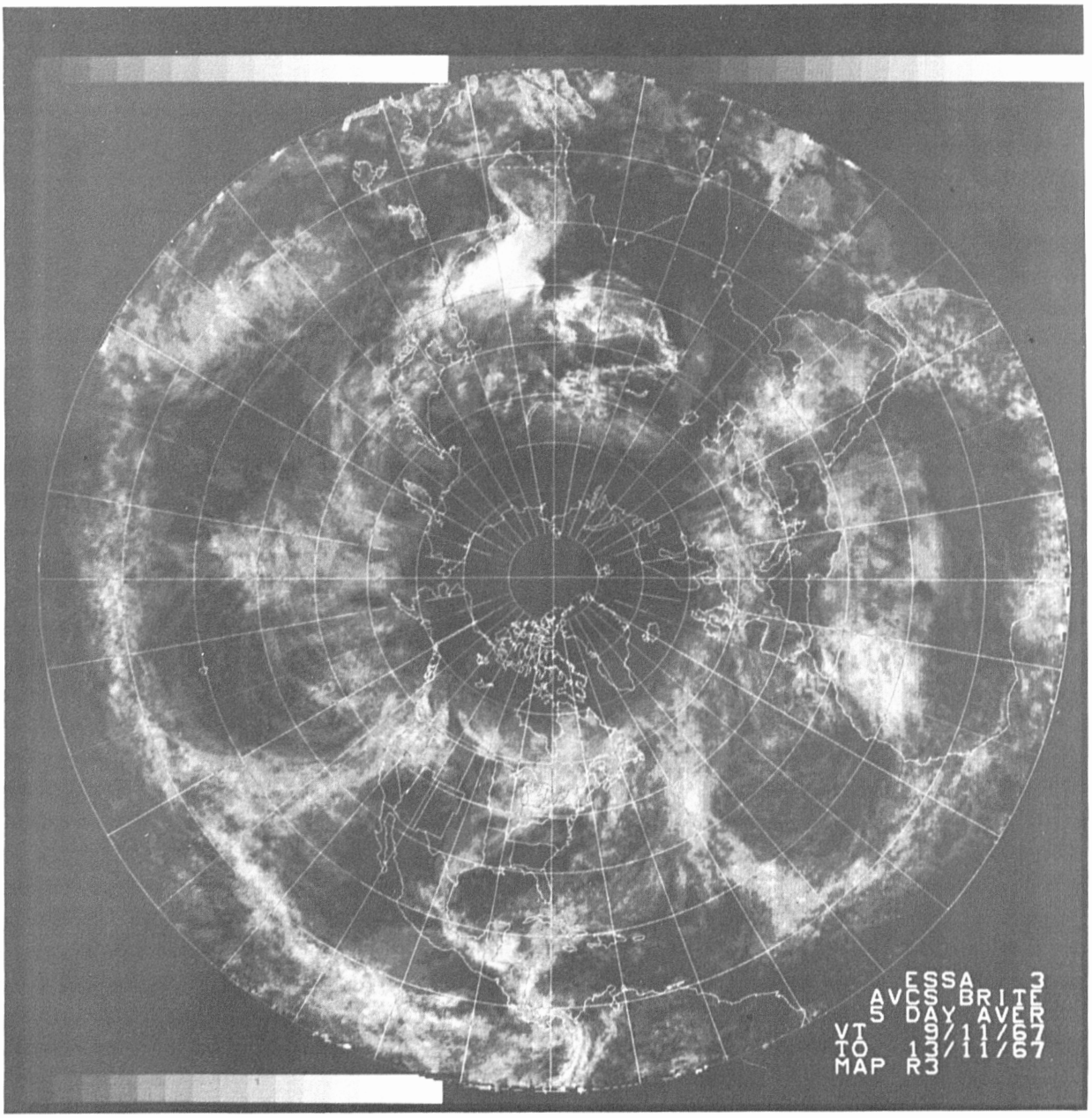

Figure 2. Five-day average brightness - November 9-13, 1967.

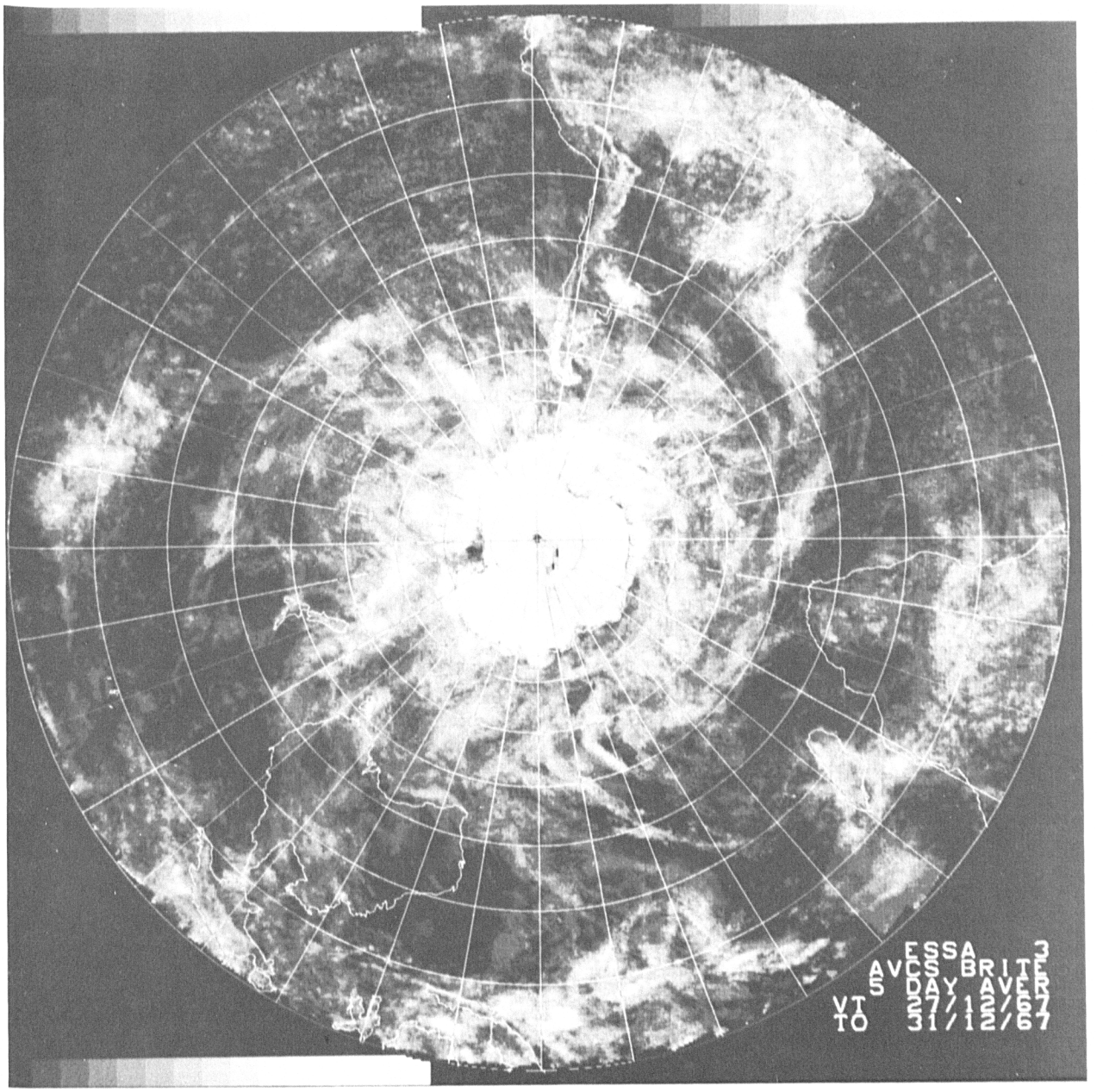

Figure 3. Five-day average brightness - December 27-31, 1967.

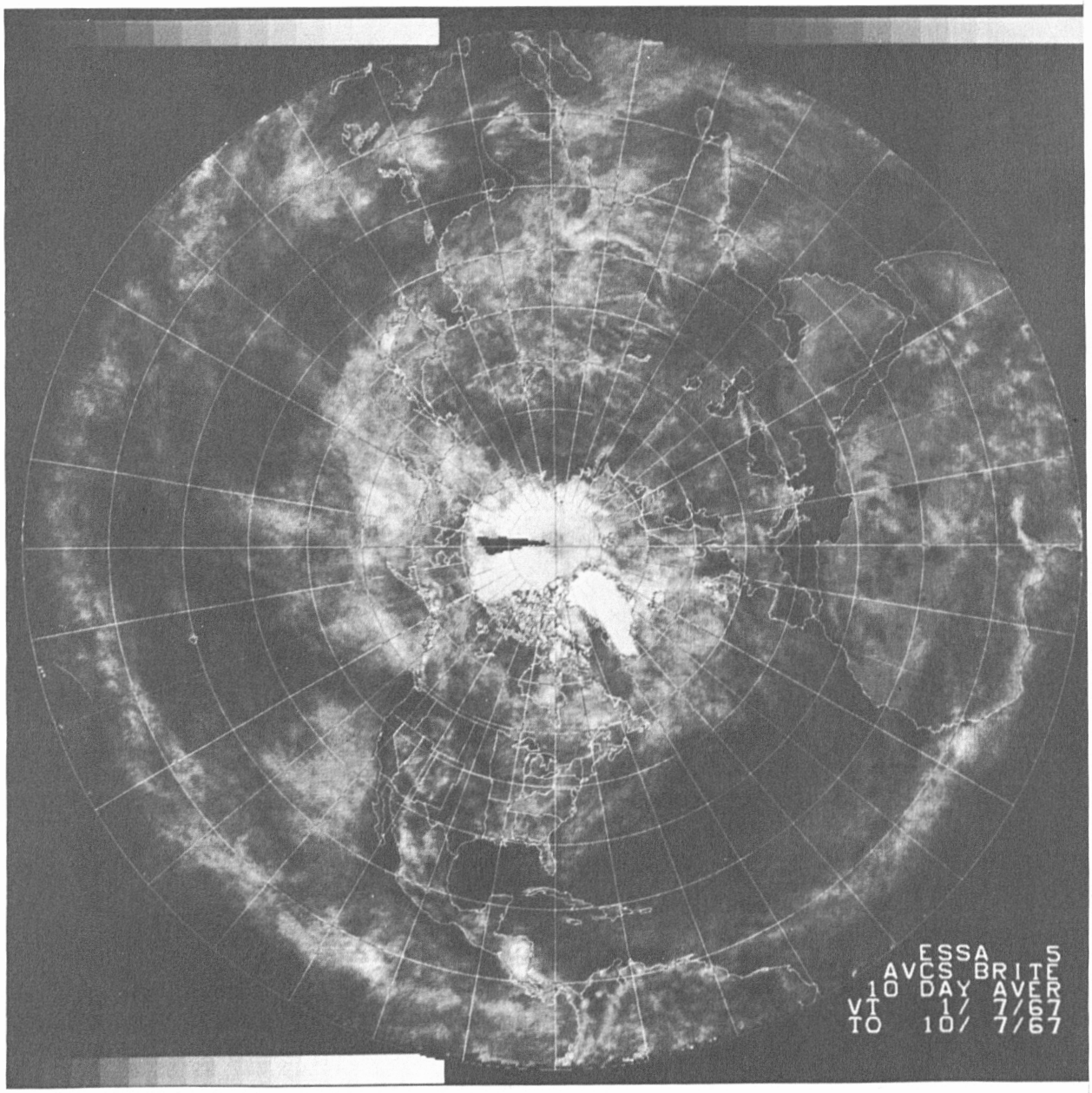

Figure 4. Ten-day average brightness - July 1-10, 1967.

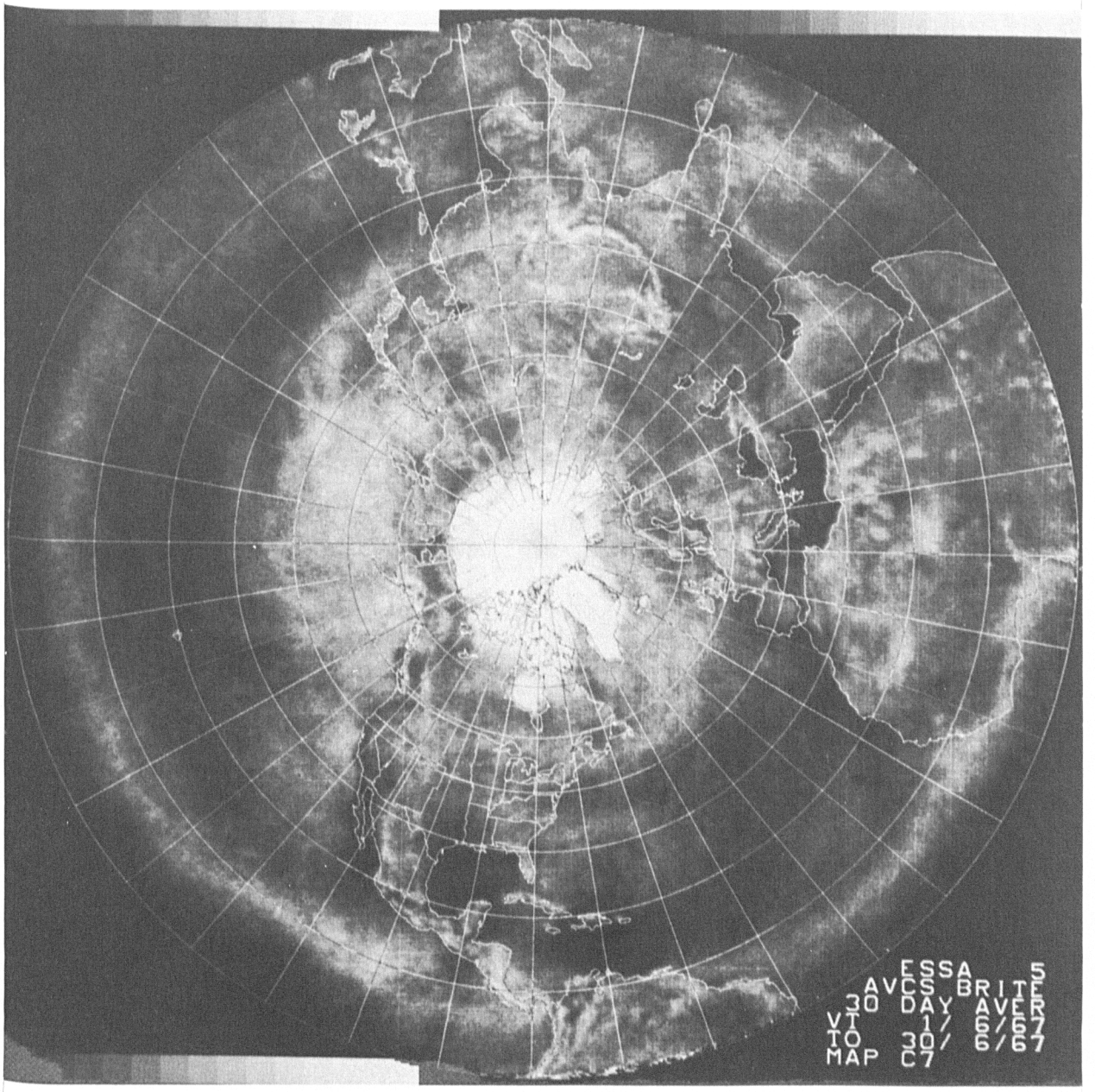

Figure 5. Thirty-day average brightness - June 1-30, 1967.

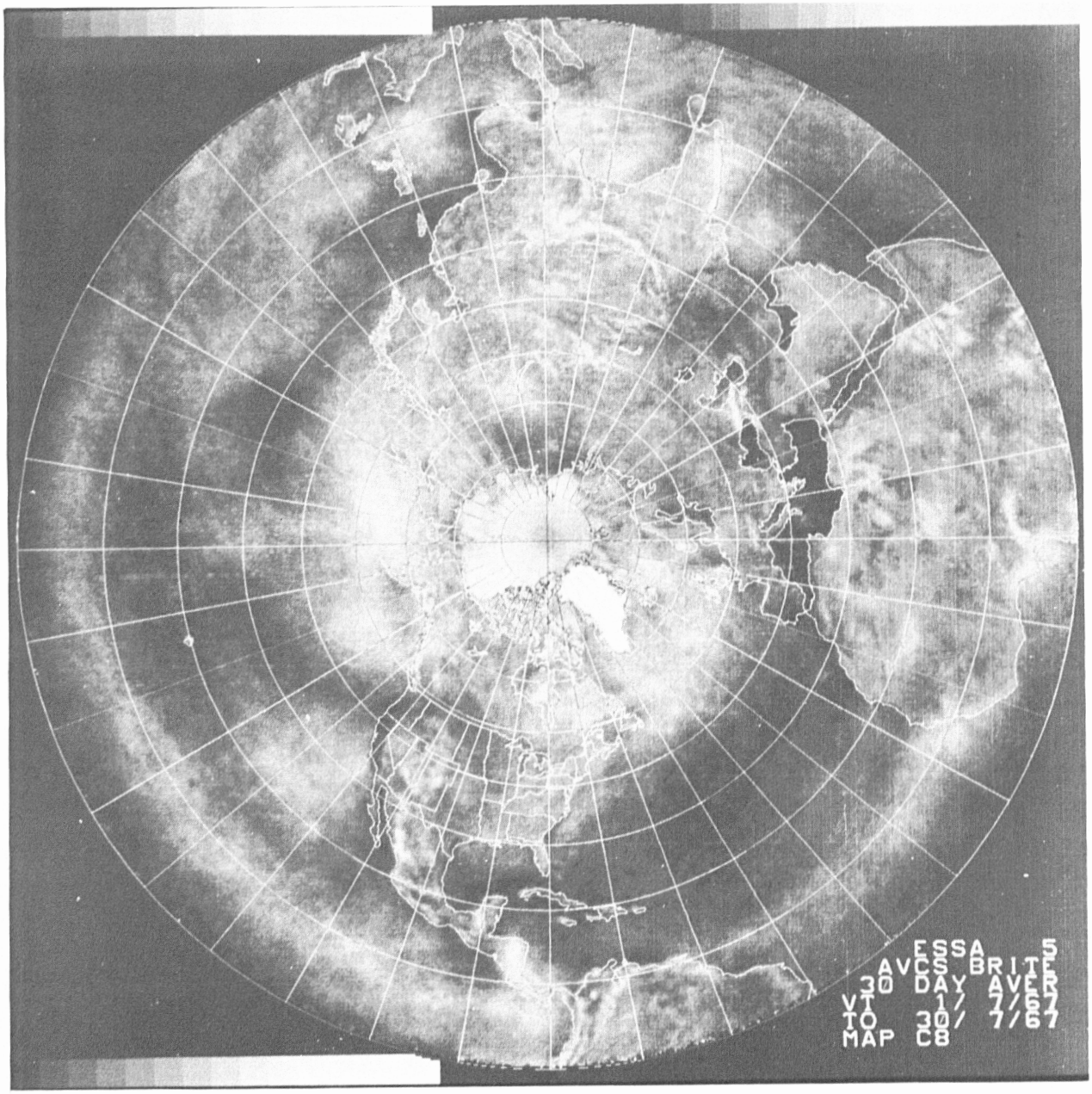

Figure 6. Thirty-day average brightness - July 1-30, 1967.

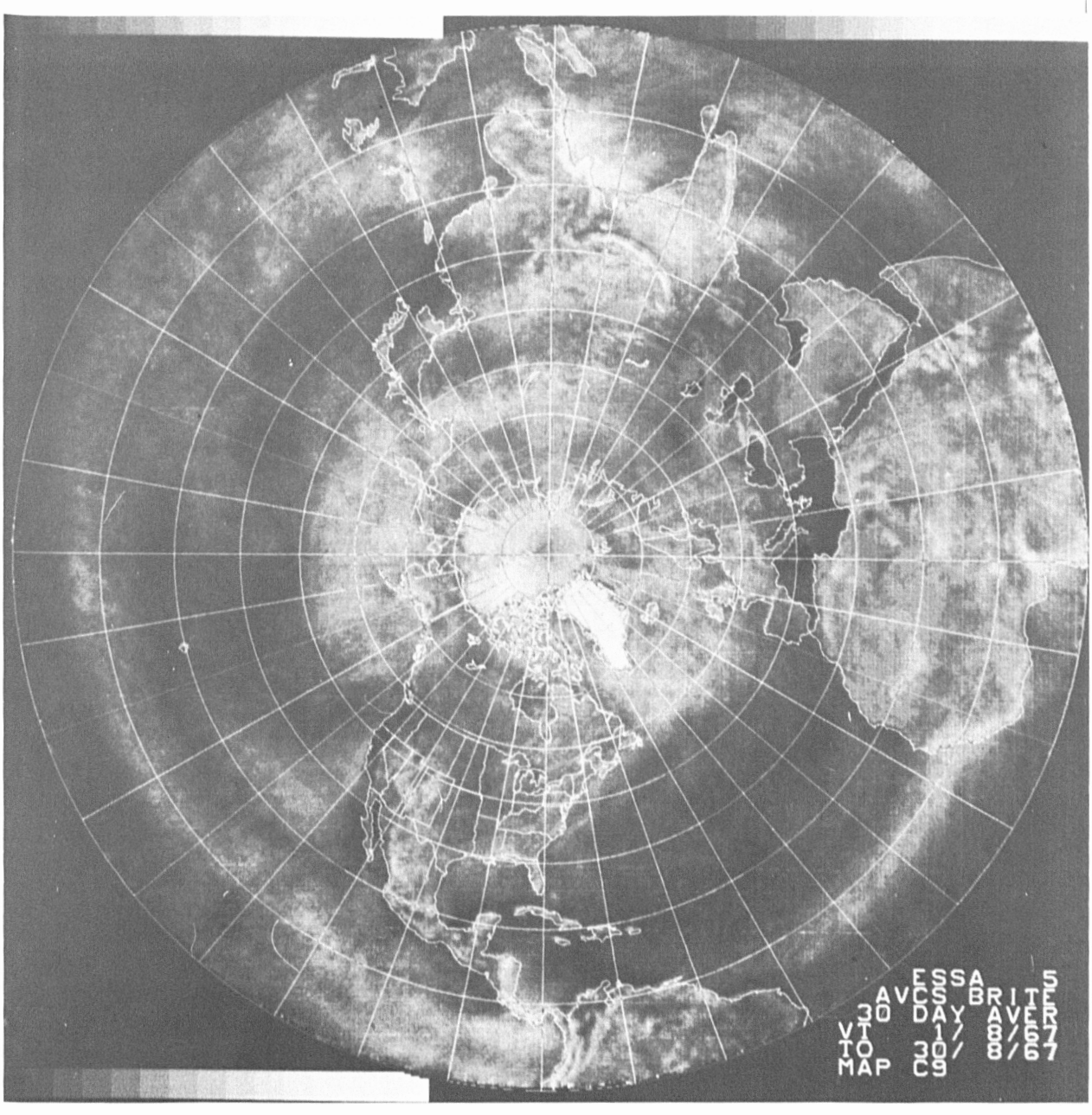

Figure 7. Thirty-day average brightness - August 1-30, 1967.

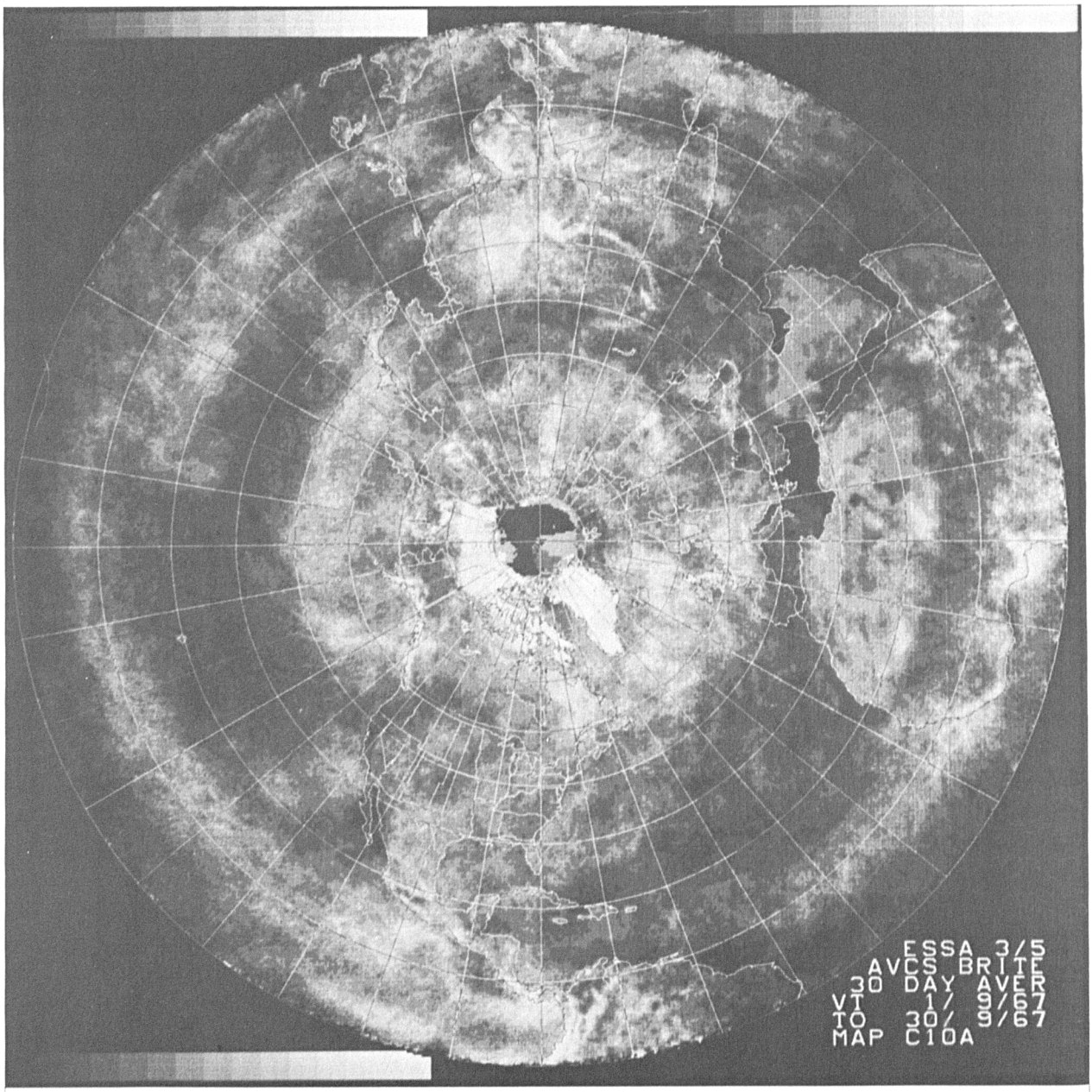

Figure 8. Thirty-day average brightness, enhanced - September 1-30, 1967.

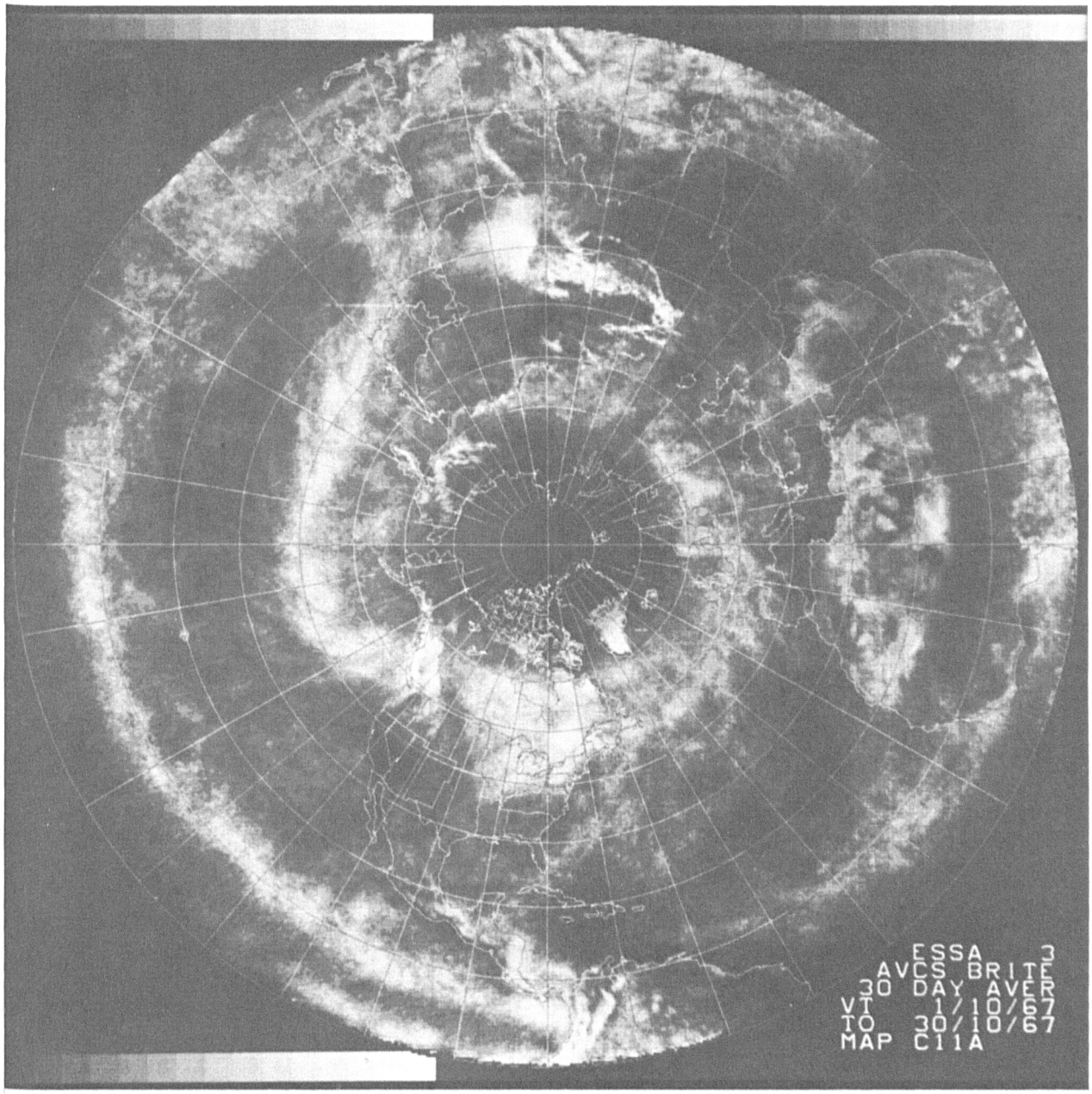

Figure 9. Thirty-day average brightness, enhanced - October 1-30, 1967.

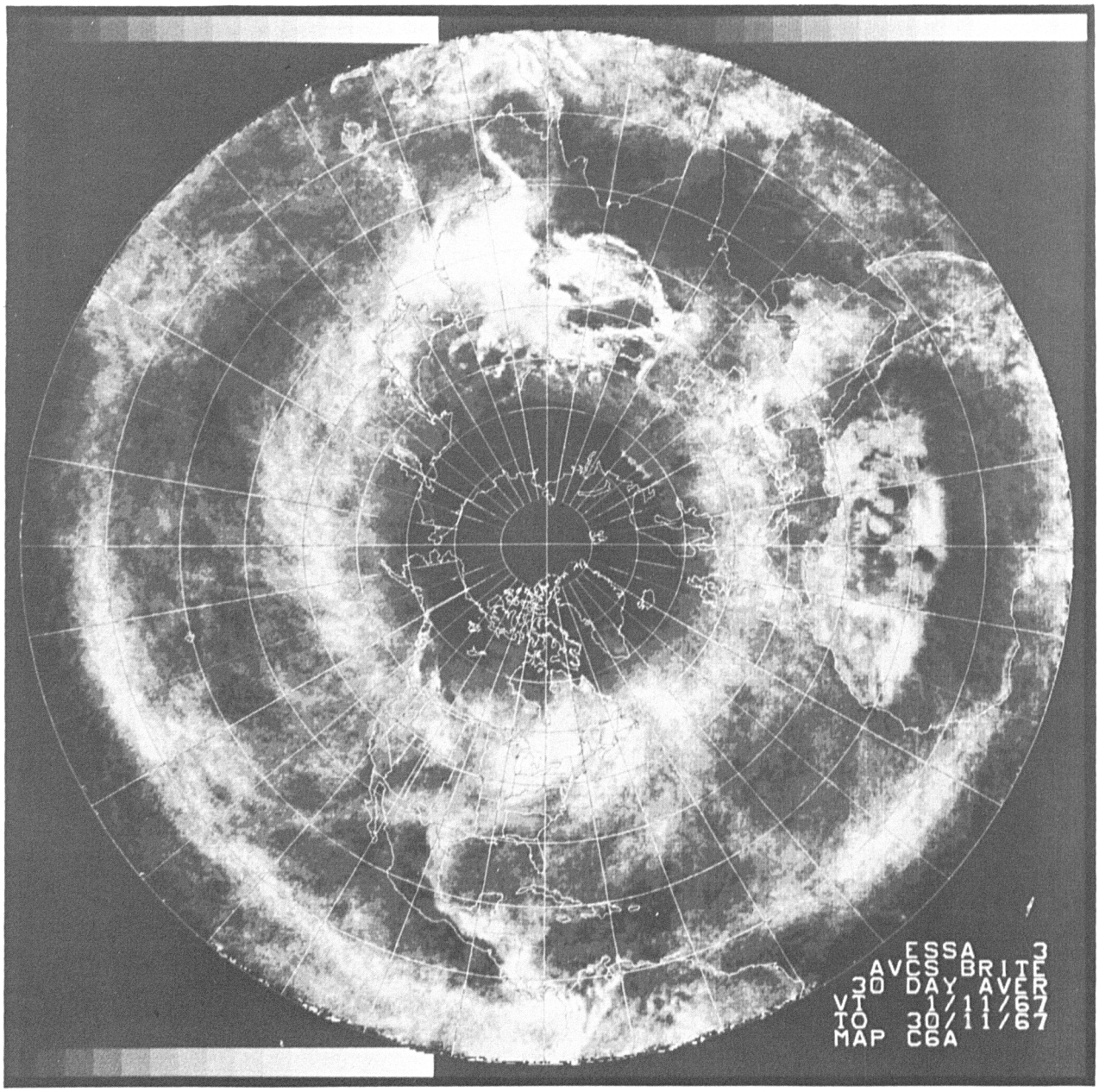

Figure 10. Thirty-day average brightness, enhanced - November 1-30, 1967.

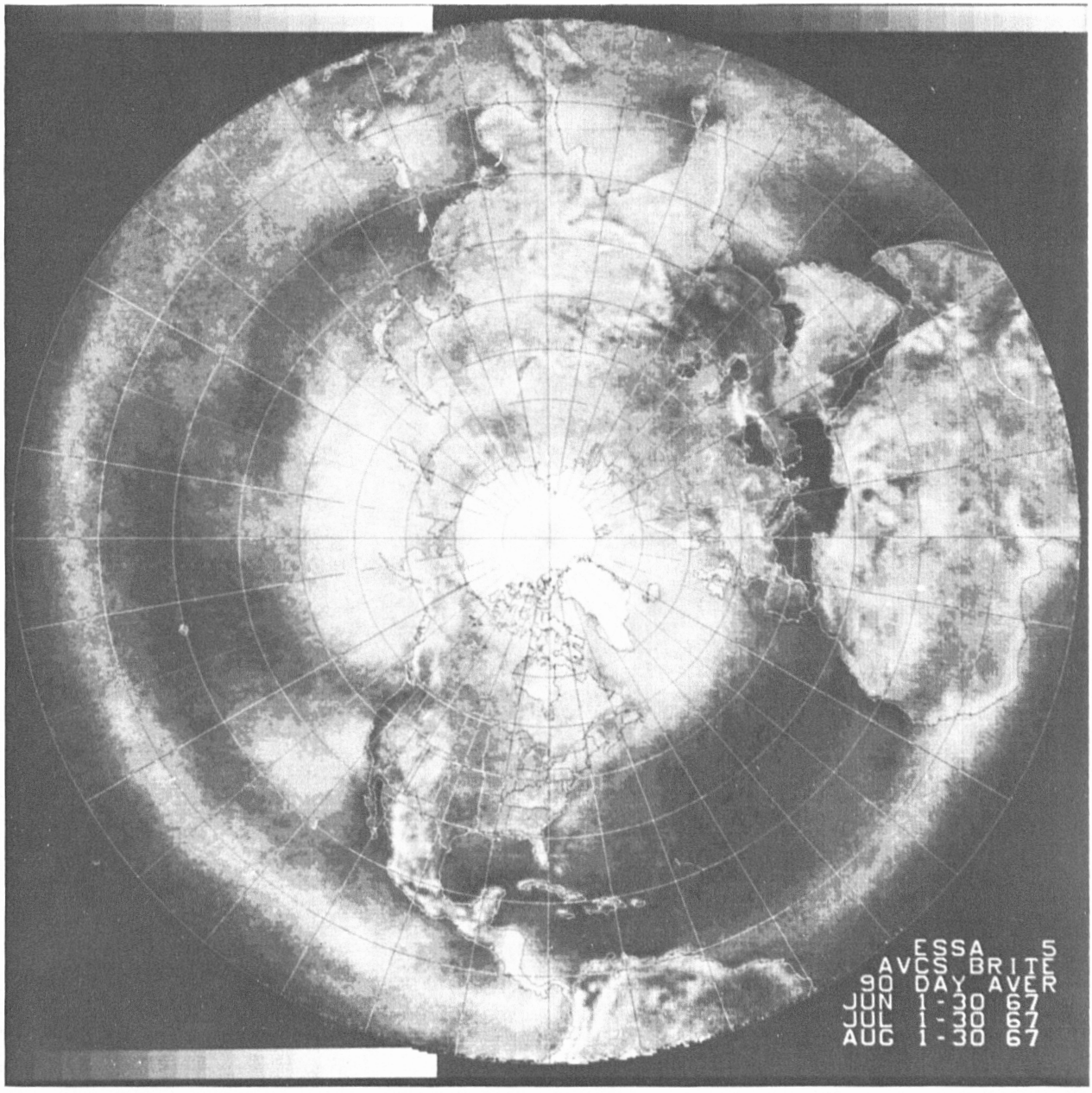

Figure 11. Ninety-day seasonal average brightness, enhanced - June - August 1967.

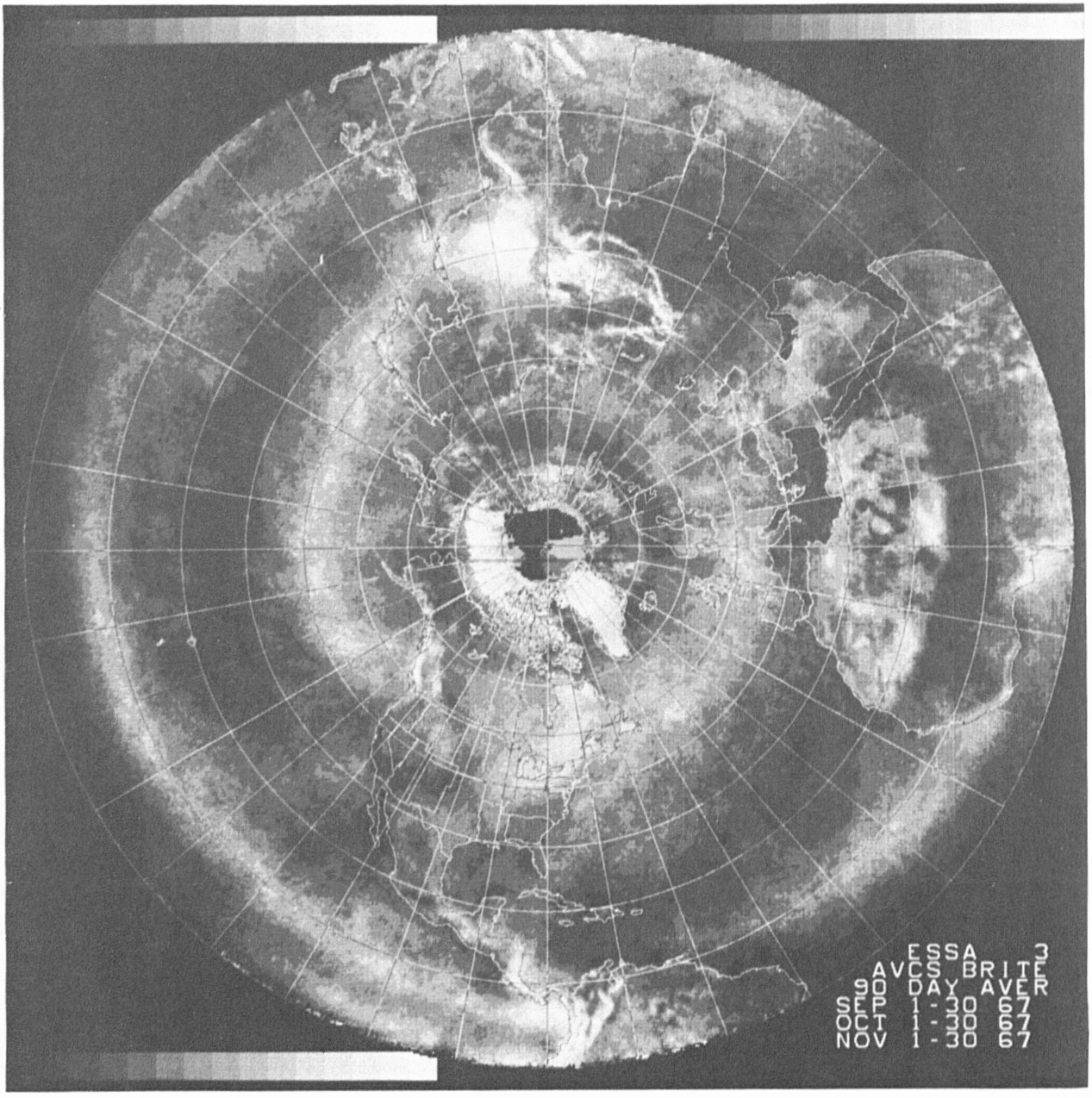

Figure 12. Ninety-day seasonal average brightness, enhanced - September - November 1967.

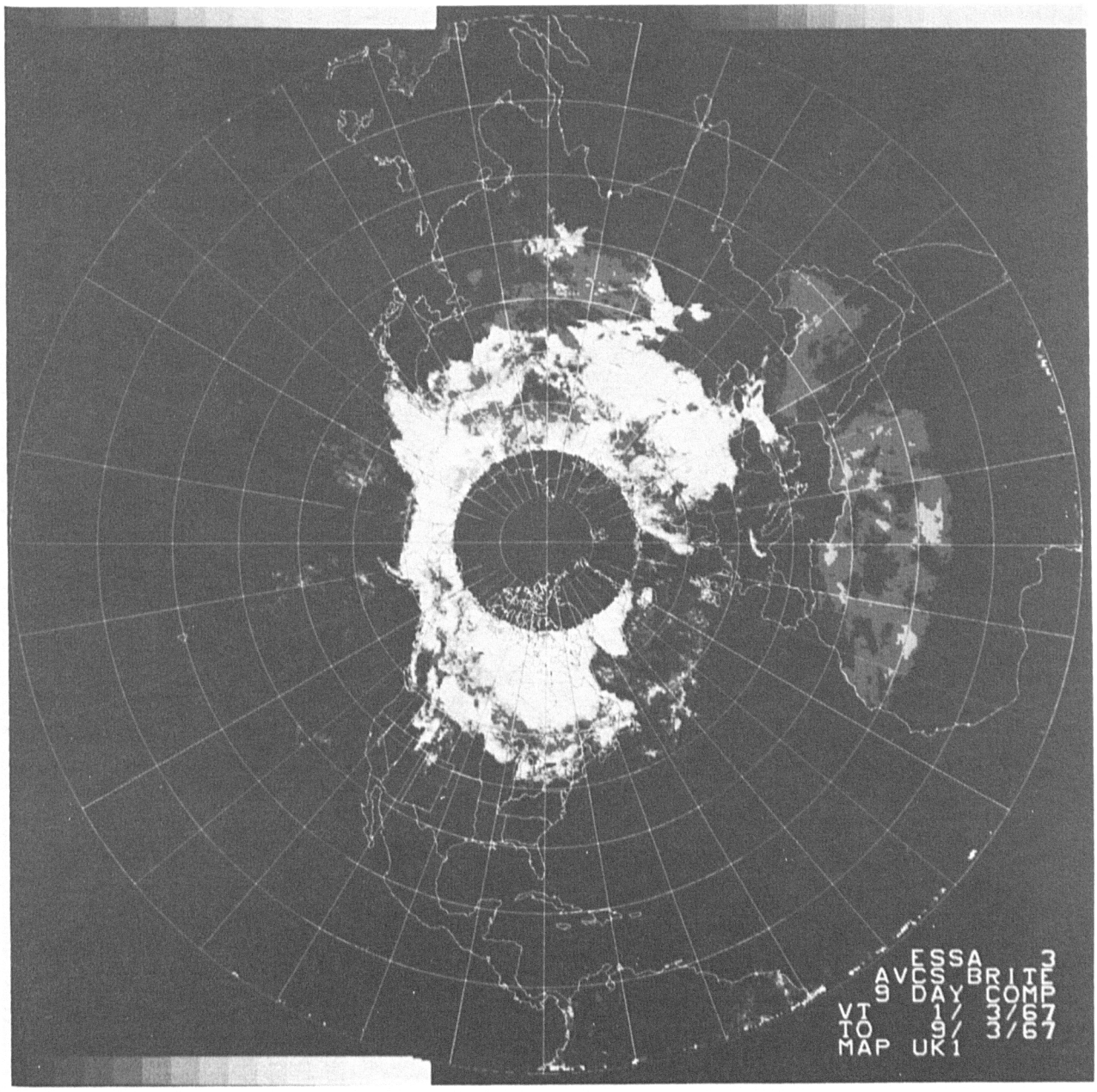

Figure 13. Nine-day minimum brightness composite - March 1-9, 1967.

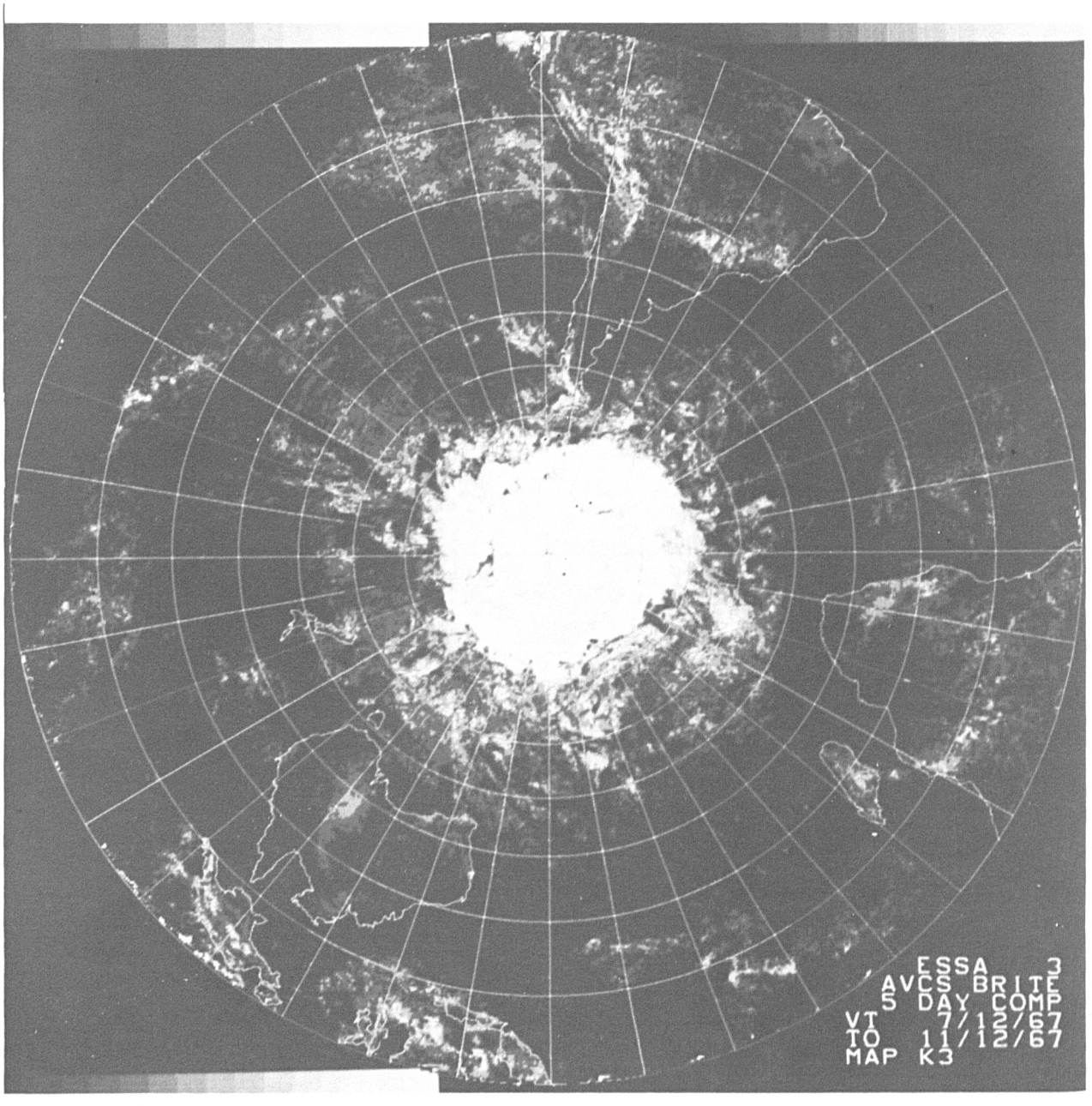

Figure 14. Five-day minimum brightness composite - December 7-11, 1967.

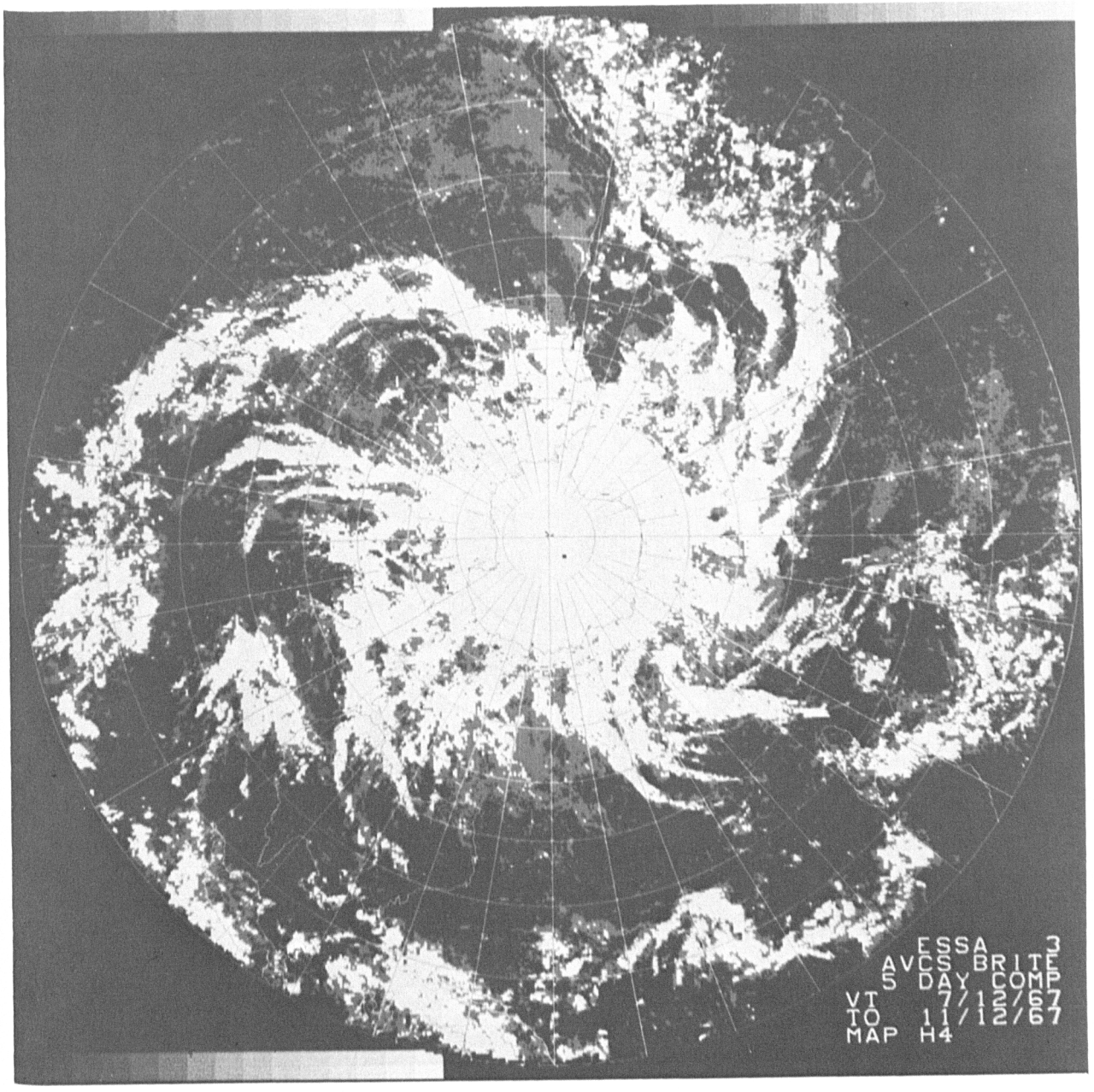

Figure 15. Five-day maximum brightness composite - December 7-11, 1967.

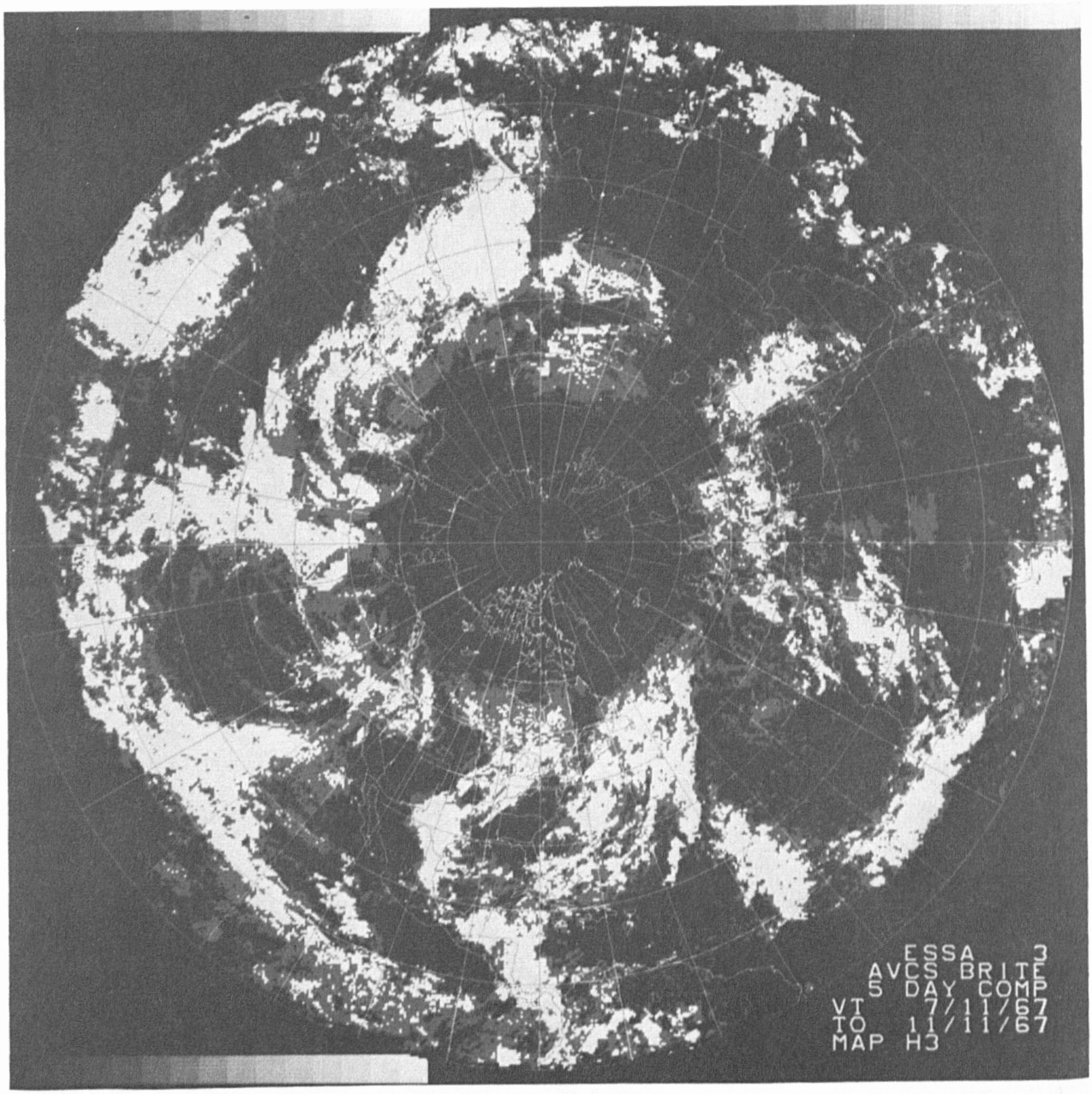

Figure 16. Five-day maximum brightness composite - November 7-11, 1967.

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6. ESSA, Catalog of Meteorological Satellite Data - ESSA 3 Television Cloud Photography, Part 2, Environmental Data Service, ESSA, January 1 - March 31, 1967.

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APPENDIX

Format of the Meso-Scale Data Tape

1. Data Group Format

Each meso-scale spot will be represented by 48 bits or six 8-bit bytes, described in order as follows:

First (flag) byte	= 0 if all 5 brightness class population numbers are given in the following bytes
	= 1 if byte no. 2 is not used for population of brightness class no. 1
Second byte	= experimental descriptor(s) if byte (1) = 1
	= population of brightness category 1 if byte (1) = 0
Third byte	= population of brightness category 2
Fourth byte	= population of brightness category 3
Fifth byte	= population of brightness category 4
Sixth byte	= population of brightness category 5

The population of category 1 can be determined, when it is not given, by subtracting the sum of categories 2-5 from 64. "No Data" spots contain all zeros.

2. Tape Format

Each day's data constitutes one file of 1025 records of 408 sixty bit words written in the binary mode. The first record is documentation. The first and last columns of the 512 x 1024 grid never contain data and are eliminated. Therefore, data are contained in the 2nd through 1025th records each of which is made up of 510 contiguous 48 bit bytes.

One end-of-file ends a day's data; two EOF's end the tape. Three days of data usually reside on one tape. The tape is standard 7 track 556 bpi.

More room is available in the format than is required for the data in its present form. This extra space may be used if more information becomes available in the future. In addition, the format is 6 and 8 bit compatible and the tape may be read by 12, 24, 32, 36, 48, and 60 bit word machines.

3. Limitations

For a large variety of reasons, the reliability of the data on the archival tapes is less than perfect. Occasionally blocks of noise or other erroneous data may be inserted; day to day quality and calibration may vary; some data blocks and occasionally whole days may be missing; or data may occasionally be mislocated geographically. Such occurrences, however, usually are relatively rare, and the user is referred to the cloud catalogues listed in the Reference. Since the meso-scale tapes are derived from the same source

as the photographic reproductions in the cloud catalogues, the data on the tapes usually will be as good (or as bad) as the pictures in the catalogues.

4. Future of Meso-Scale Archive Format

The format and content of these tapes will be held as invariable as possible. Even though future developments may dictate that changes be made to fulfill storage and general user requirements. Such changes might include experimentation with and implementation of various computed descriptors such as one-dimensional laplacian indices, or conversion to 800 bpi.

Though the unused (2-8, 17, 25, 33, 41) bits of each 48-bit data group usually contain zeroes, occasional experiments may be conducted using these spaces. In using the meso-scale tapes, some "protective" programming might be in order. By masking out unused bits, future experiments with these bits will not affect user's programs.

Users will be informed insofar as possible of such changes, and comments or suggestions are earnestly solicited.

5. Meso-Scale Archival Tape Documentation Record Format

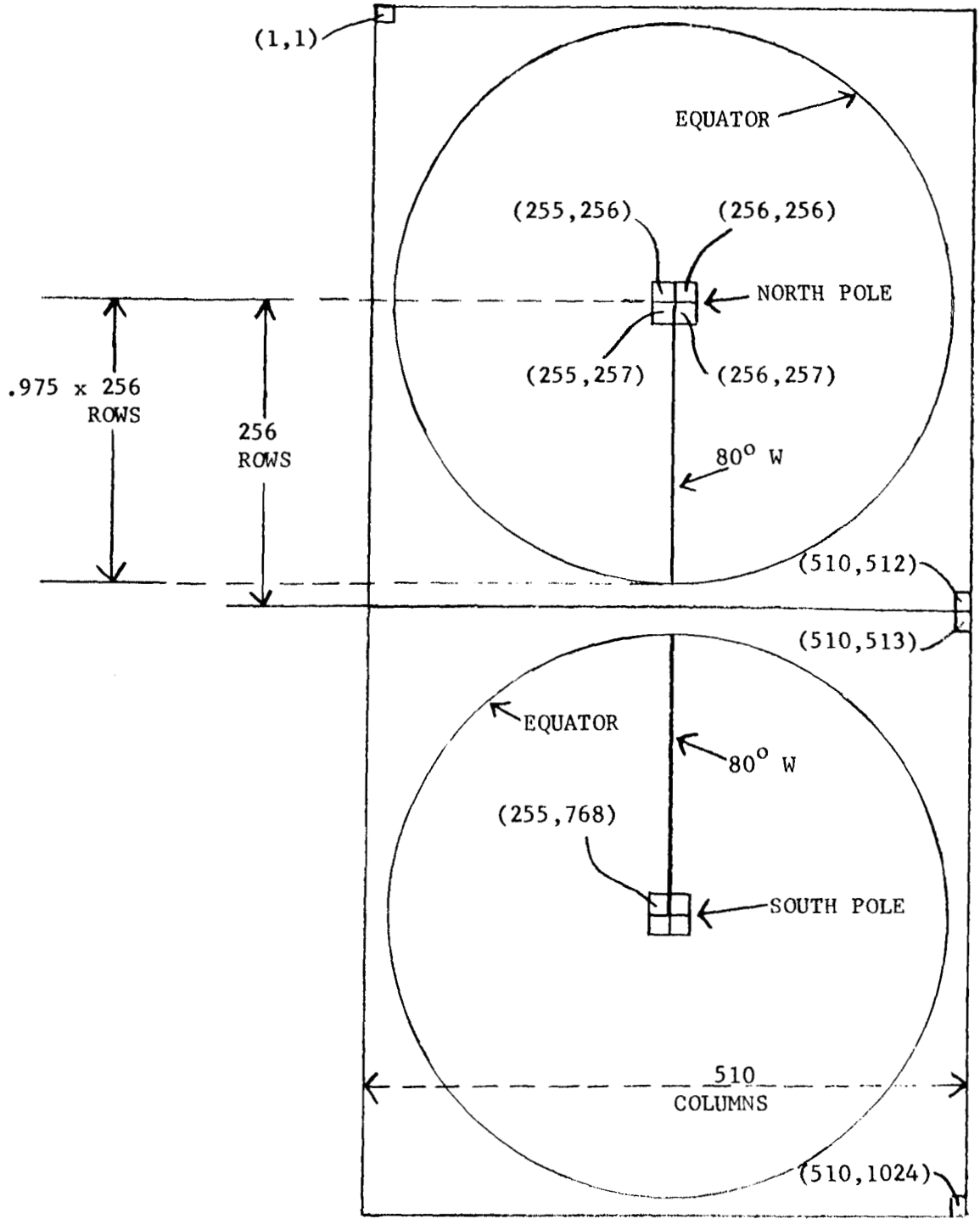
The documentation record consists of 408 sixty bit words written in the binary mode. This record contains the basic information concerning each orbital pass contributing data to the field.

Word #	Contents
1	pointer word of latest pass contributing to data
2-17	information for the 1st pass of the day
18-33	information for the 2nd pass of the day
34-49	information for the 3rd pass of the day
50-65	information for the 4th pass of the day
66-81	information for the 5th pass of the day
82-97	information for the 6th pass of the day
98-113	information for the 7th pass of the day
114-129	information for the 8th pass of the day
130-145	information for the 9th pass of the day
146-161	information for the 10th pass of the day
162-177	information for the 11th pass of the day
178-193	information for the 12th pass of the day
194-209	information for the 13th pass of the day
210-408	not used

Each 16 word group contains the following information:

Word	Contents
1	pass number (integer)
2	satellite identity (A10)
3	camera number (integer)
4	track (integer)
5	CDA station (A10)
6	ascending node (integer)
7	year of asc. node (integer)
8	month of asc. node (integer)
9	day of asc. node (integer)
10	hour of asc. node (integer)
11	minute of asc. node (integer)
12	second of asc. node (integer)
13	number of pictures (integer)
14	mean local sun time (integer)
15	not used
16	not used

Time and date are in GMT; the century is omitted from the year group, e.g. 1967 = 67. Mean local sun time is documented as of April 1, 1968.

6. Data Grid Format

One documentation record preceeds data grid.