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Semi-annual report for NASA Grant NAG5-1125 entitled

"The Role of Global Cloud Climatologies in Validating Numerical Models"

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October 1, 1990 - March 31, 1991

(NASA-CR-188542) THE ROLE OF GLOBAL CLOUD CLIMATOLOGIES IN VALIDATING NUMERICAL MODELS Semiannual Status Report, 1 Oct. 1990 - 31 Mar. 1991 (Purdue Univ.) 33 p CSCL 04[illegible]

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During the period October 1, 1990 - March 31, 1991, we have devoted ourselves to two major tasks. The first is the completion of a project to produce global maps of the net longwave radiation at the surface over oceanic areas. This was the thesis topic of Mr. Hui Zhi who defended his M.S. thesis in December, 1990. This work is being prepared for publication. In order to summarize his work for this report we have attached the Abstract, Table of Contents, List of Figures and Tables and all the figures in his thesis. The attachment will provide all the information that we have obtained from this project.

The second effort undertaken during this grant period has been the analysis of ISCCP C-1 cloud data. We have acquired this data from NSSDC for a period starting in October 1986 to their most current release. In addition, we have ISCCP and ERBE S-4 data for selected months. We have made a preliminary analysis of the distribution of cloud optical depths (or albedo) at two selected grid points. One is off the coast of California in the marine stratocumulus region. The other is a tropical convective area in the Western Pacific. We have studied the period July 17-31, 1985 for both areas.

Figure 1 shows the distribution of mean optical depth inferred from daytime GOES radiances as a function of the cloud fraction of the 2.5° lat × 2.5° long area centered at 36.25N, 126.25W. Figure 2 is a similar plot for the tropical convective area. Both plots show that exceedingly thick (or bright) clouds occur only when the area is completely filled with clouds. Current models assign cloud fraction and albedo (or optical depth) independently.

Figures 3 and 4 show the distribution of optical depth for all pixels. These distributions are very similar to the observations made during field experiments such as FIRE. The stratified distributions shown in Figures 3b and 4b can perhaps be used to model subgrid scale cloudiness.

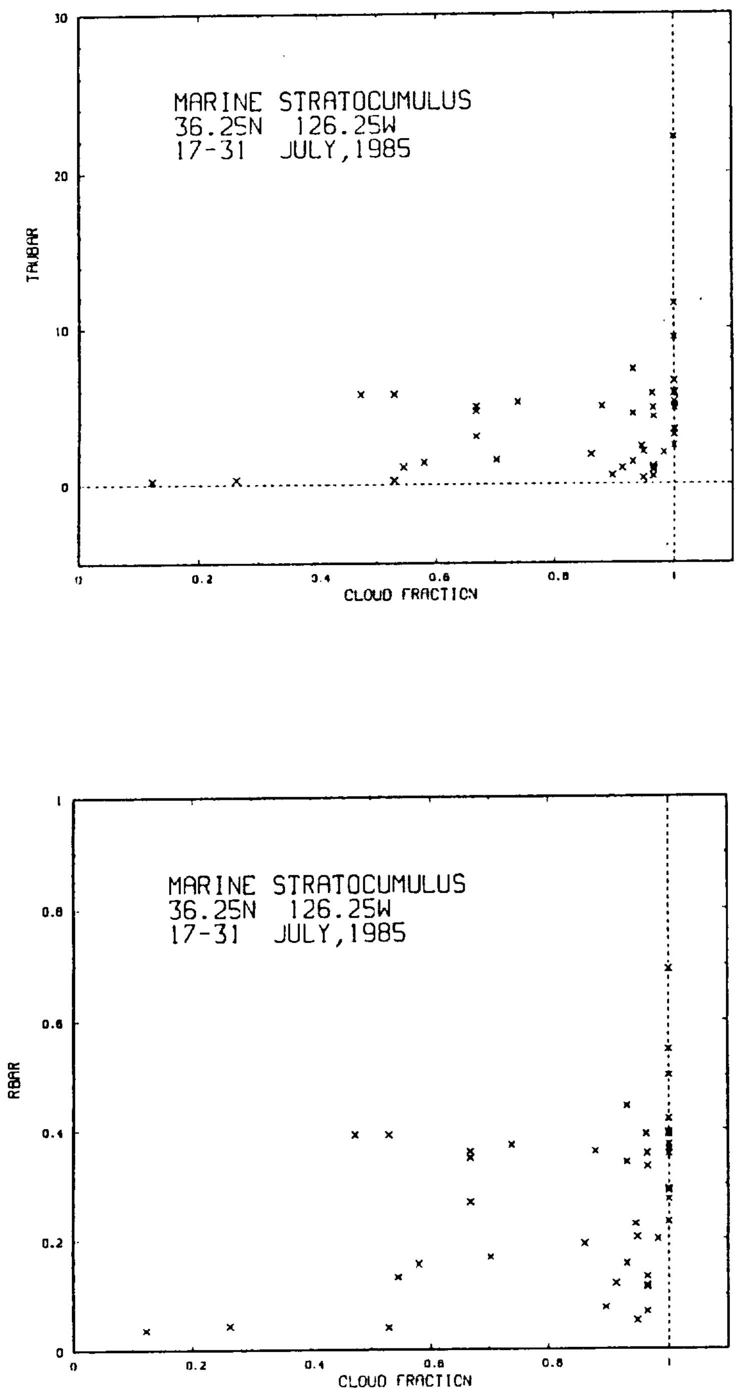

Fig. 1. The distribution of mean optical depth (a) and mean diffuse albedo (b) versus cloud fraction for a marine stratocumulus area from ISCCP C-1 data.

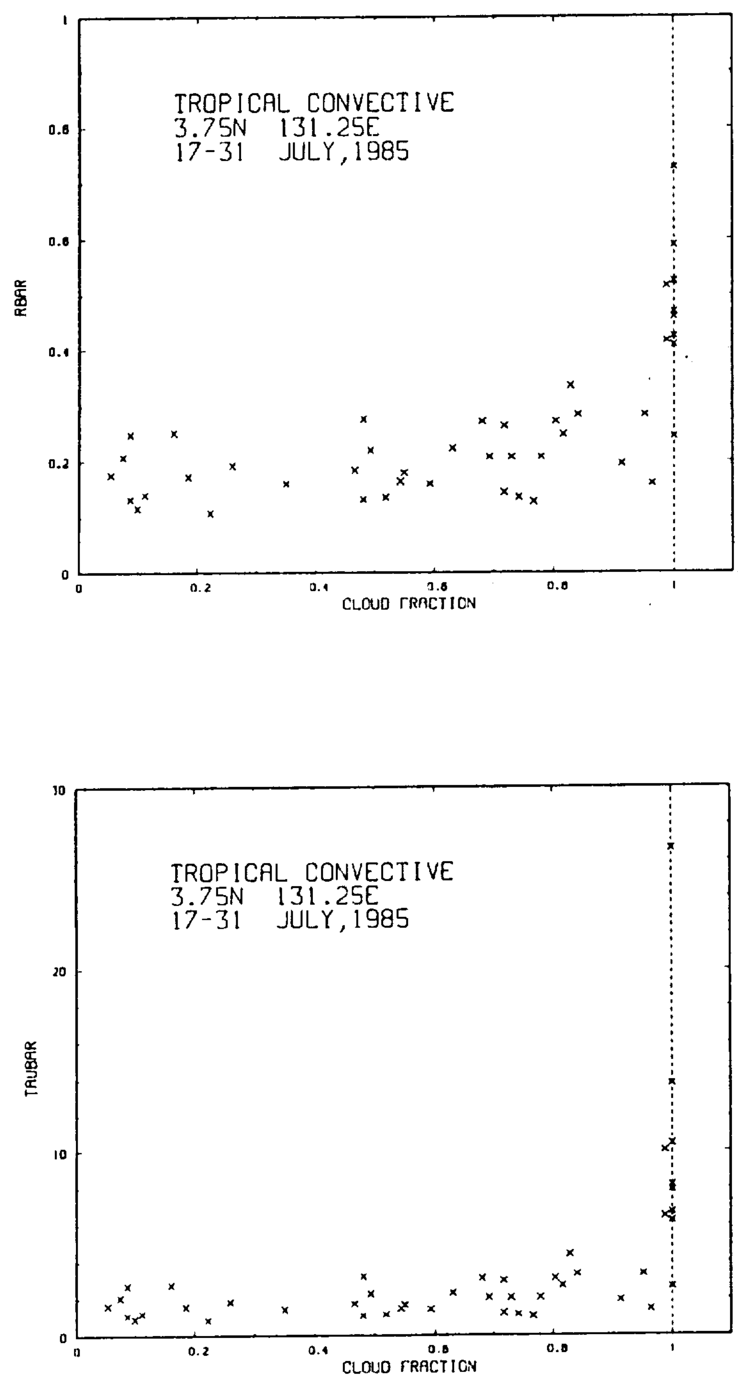

Fig. 2. As in Fig. 1 but for a tropical convective area.

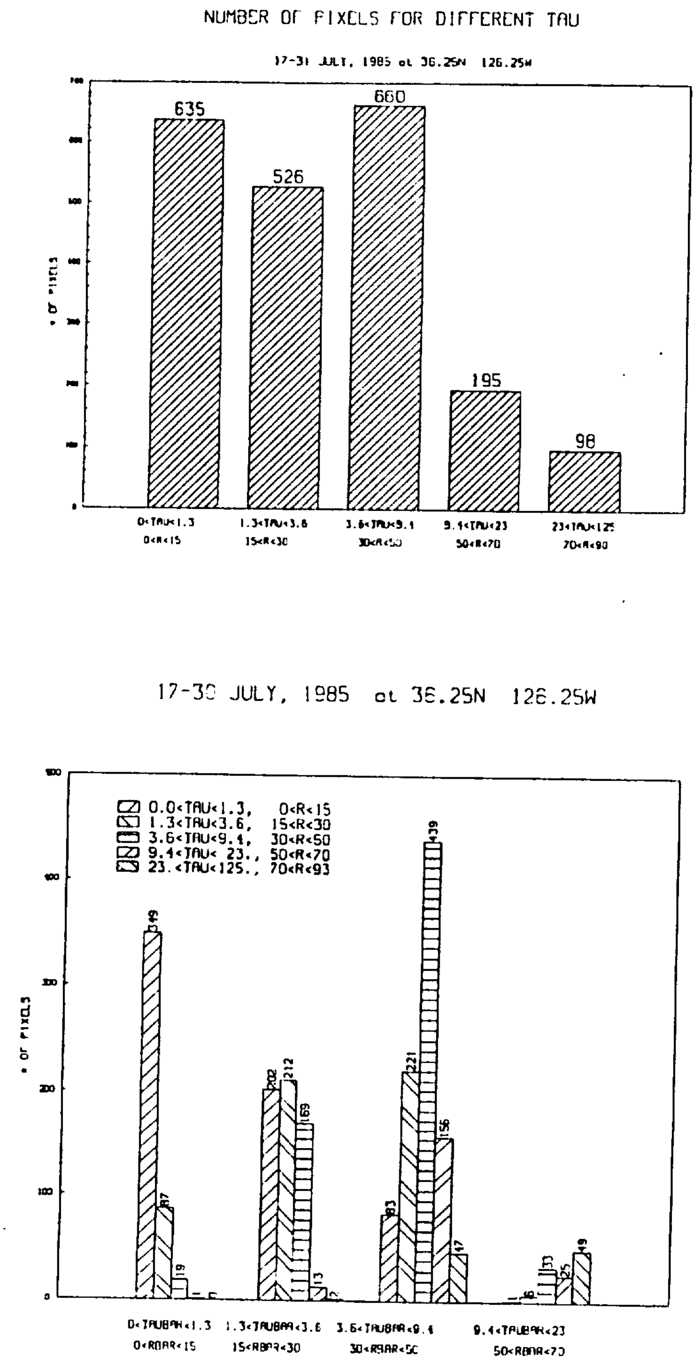

Fig. 3. The frequency distribution of all cloudy pixels for the area in Fig. 1.

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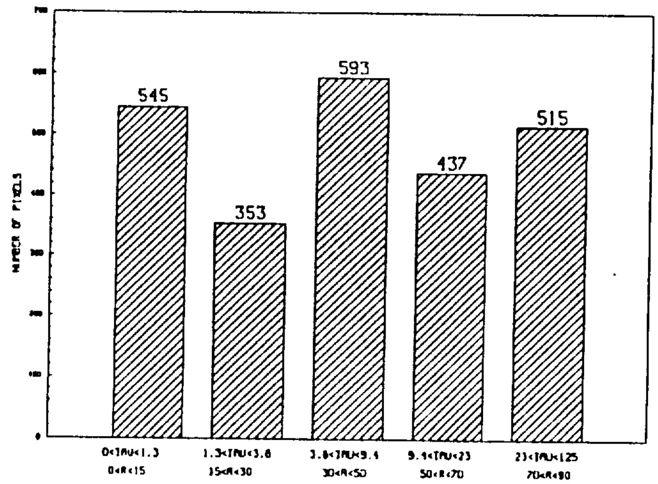
NUMBER OF PIXELS FOR DIFFERENT TAU
17-31 JULY, 1985 at 3.75N 131.25E



17-31 JULY, 1985 at 3.75N 131.25E

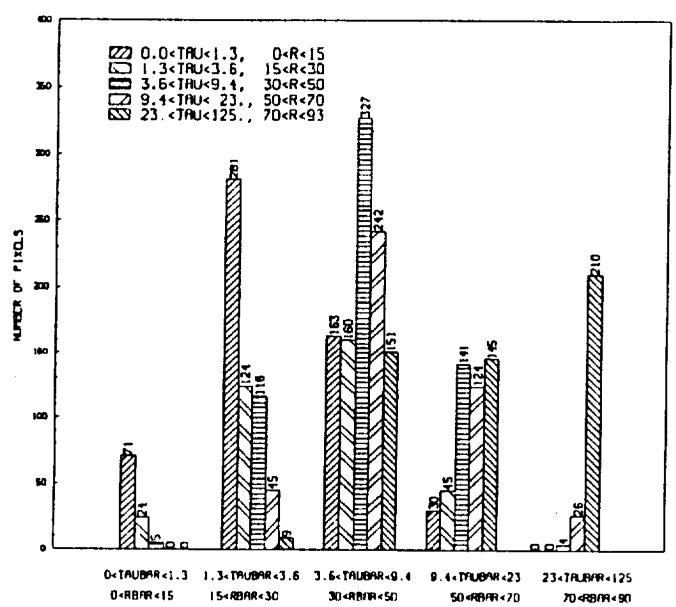


Fig. 4. As in Fig. 3 but for the area in Fig. 2.

ATTACHMENT

CLOUD RADIATIVE FORCING

AND THE SURFACE LONGWAVE RADIATION

A Thesis

Submitted to the Faculty

of

Purdue University

by

Hui Zhi

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science

December 1990

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ABSTRACT

Zhi, Hui. M. S., Purdue University, December 1990.
Cloud Radiative Forcing and the Surface Longwave Radiation.
Major Professor: Dr. Harshvardhan.

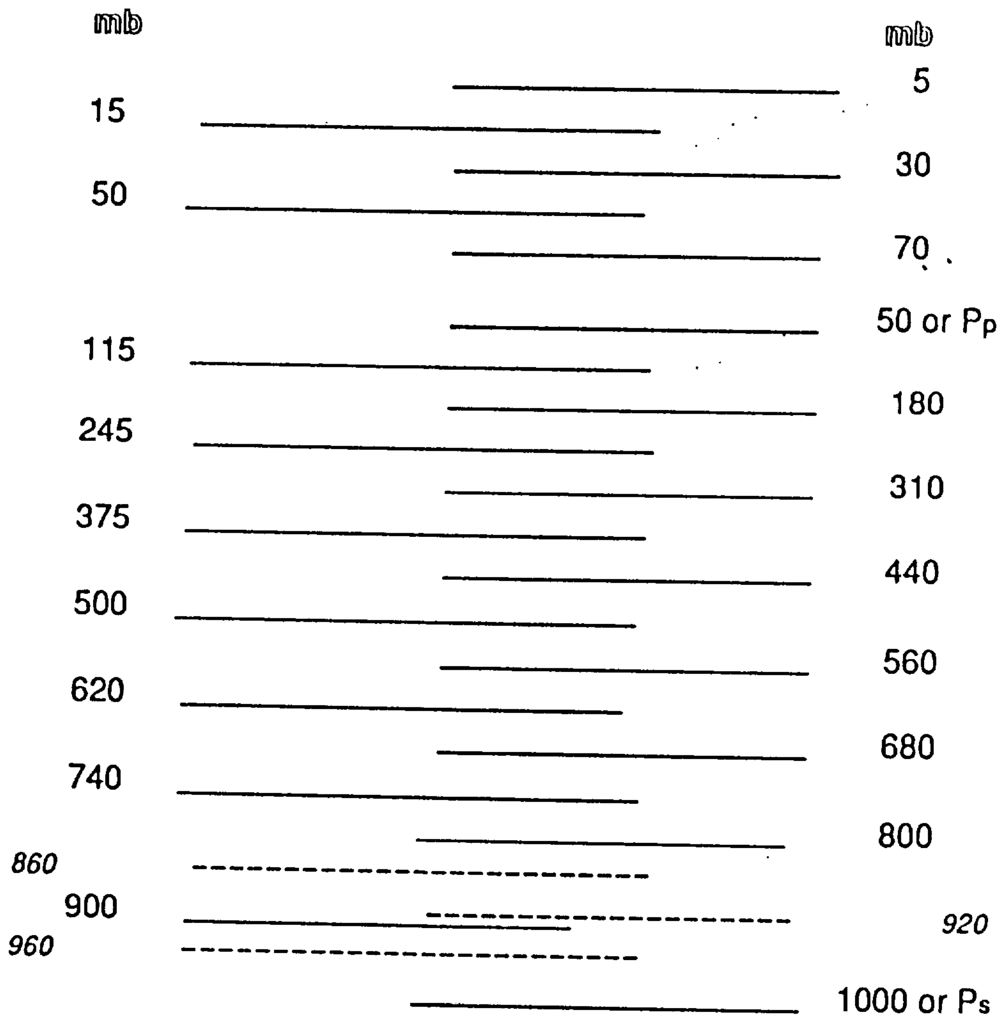
Reliable estimates of the components of the surface radiation budget are important in studies of ocean-atmosphere interaction, land-atmosphere interaction, ocean circulation and in the validation of radiation schemes used in climate models. The methods currently under consideration must necessarily make certain assumptions regarding both the presence of clouds and their vertical extent. Because of the uncertainties in assumed cloudiness, all these methods involve perhaps unacceptable uncertainties. In this work, a theoretical framework that avoids the explicit computation of cloud fraction and the location of cloud base in estimating the surface longwave radiation has been presented.

Estimates of the global surface downward fluxes and the oceanic surface net upward fluxes have been made for four months (April, July, October and January) in 1985-86. These estimates are based on a relationship between cloud radiative forcing at the top of the atmosphere and the surface obtained from a general circulation model. Monthly mean clear sky downward longwave fluxes at the surface and upward surface emission are computed from the retrieved profiles (such as temperature and humidity profiles) that are included in the ISCCP (International Satellite Cloud Climatology

Project) data set. The radiation code is the version used in the UCLA/GLA general circulation model (GCM). The longwave cloud radiative forcing at the top of the atmosphere as obtained from Earth Radiation Budget Experiment (ERBE) measurements is used to compute the forcing at the surface by means of the GCM-derived relationship. This, along with clear-sky fluxes from the computations, yields maps of the downward longwave fluxes and net upward longwave fluxes at the surface.

The calculated results are discussed and analyzed. The results are consistent with current known meteorological knowledge and explainable on the basis of previous theoretical and observational works; therefore, it can be concluded that this method is applicable as one of the ways to obtain the surface longwave radiation fields from currently available satellite data.

Atmospheric parameters:



P_p = Tropopause pressure
P_s = Surface pressure (≤ 1000 mb)

Figure1. Vertical structure of ISCCP data

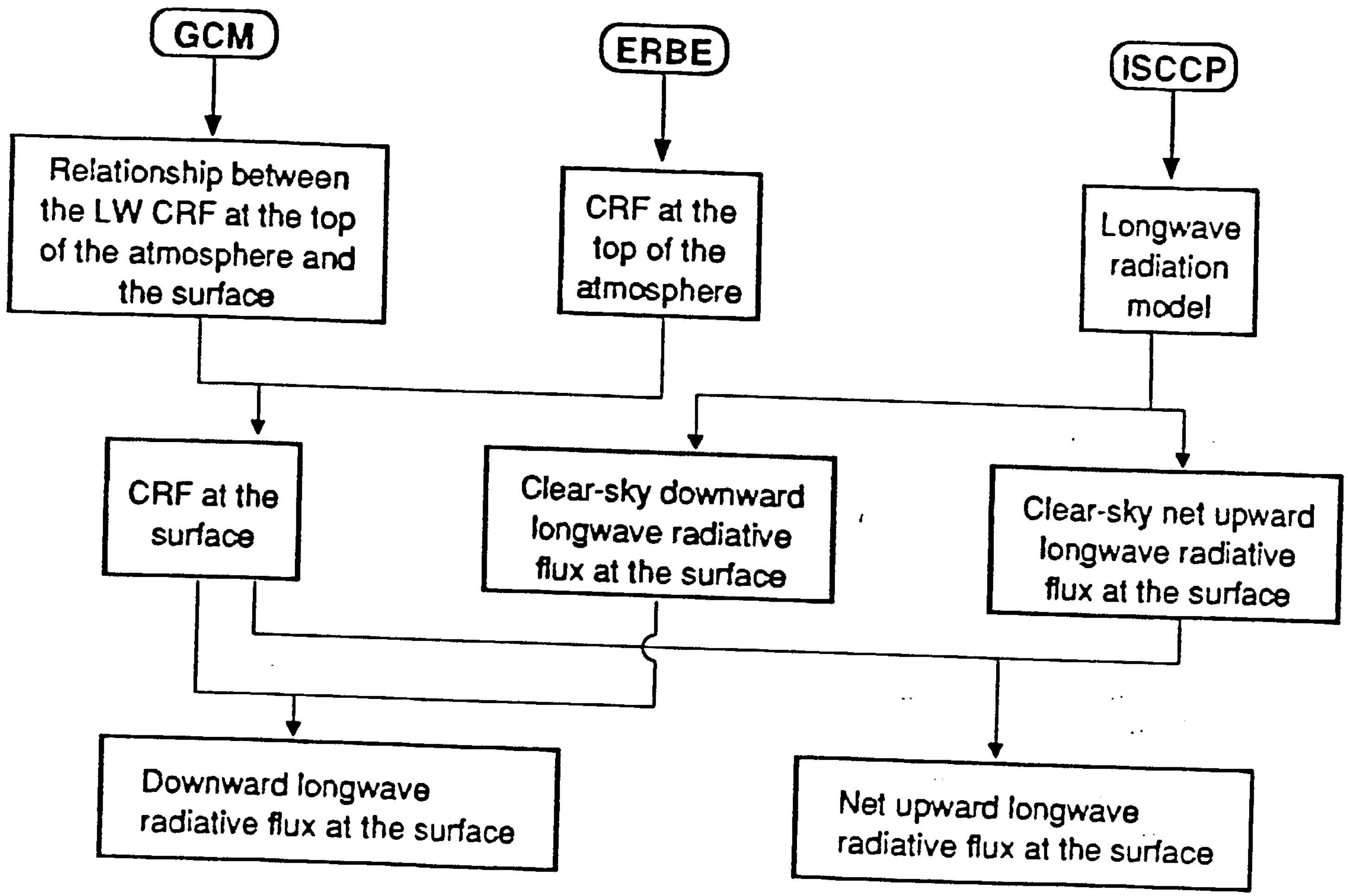


Figure 2. Flow diagram of the procedure used to obtain maps of monthly mean longwave fluxes at the surface

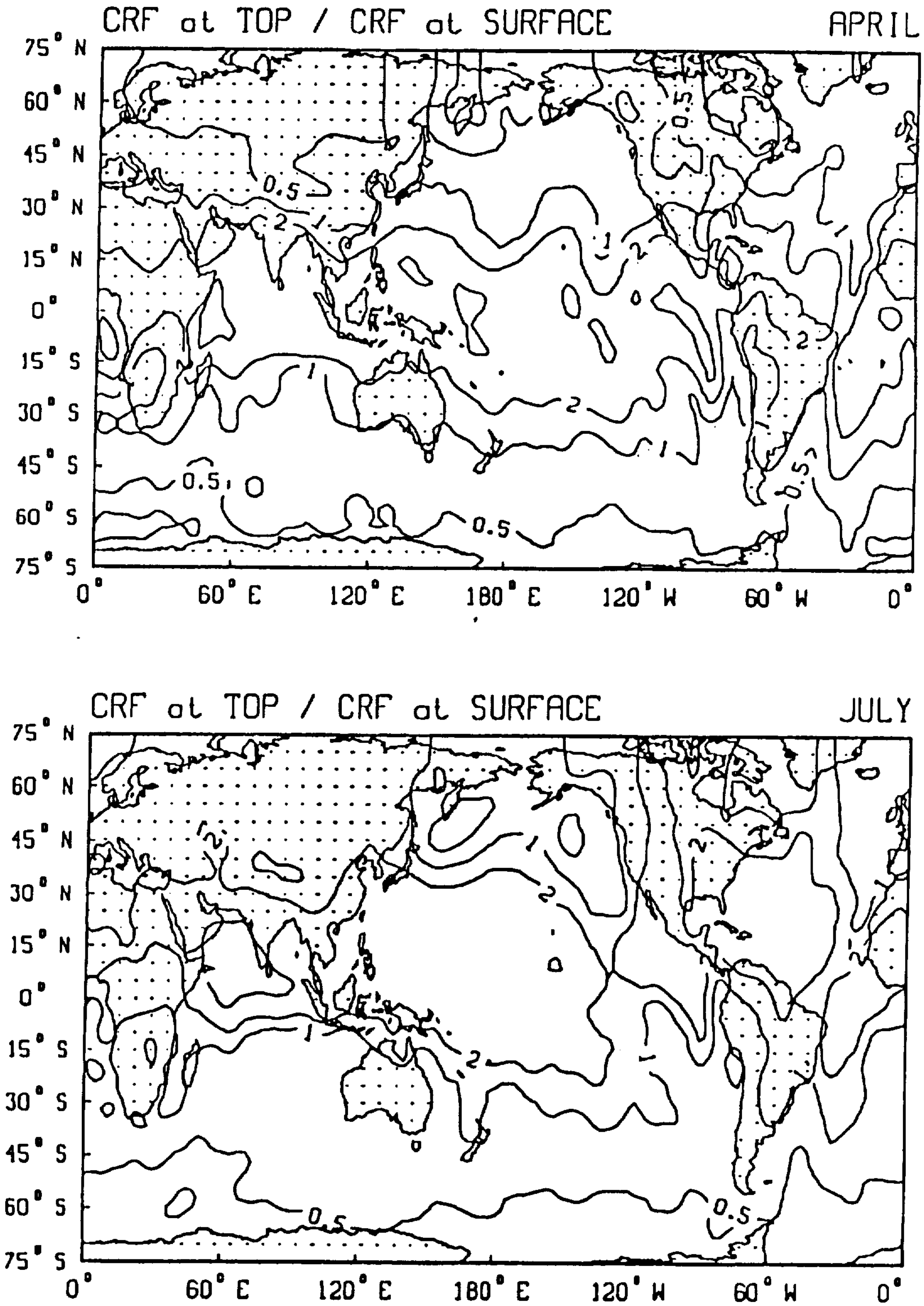


Figure 3. Ratio of longwave CRF at the top of the atmosphere to that at the surface for April, July, October and January

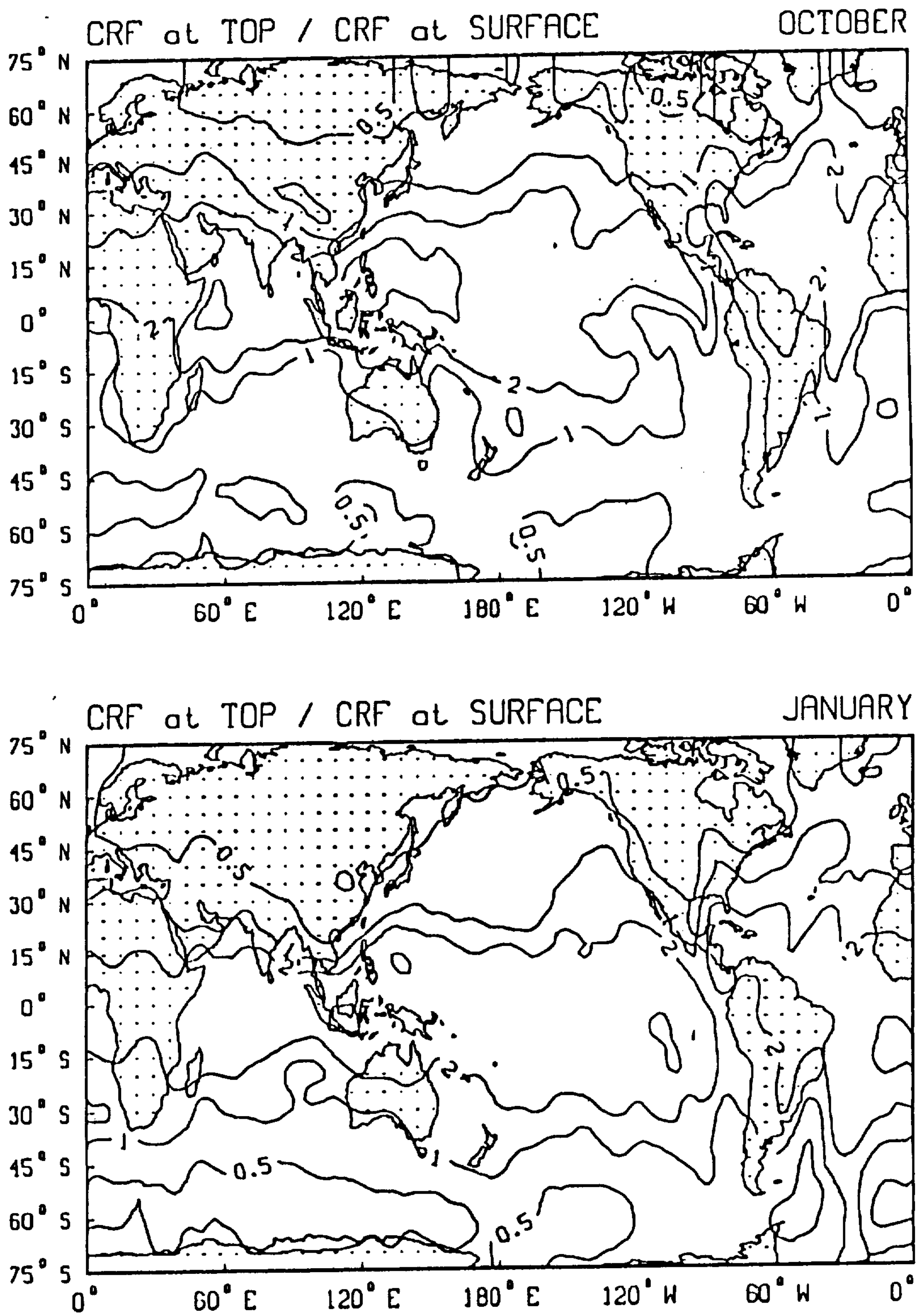


Figure 3. Continued

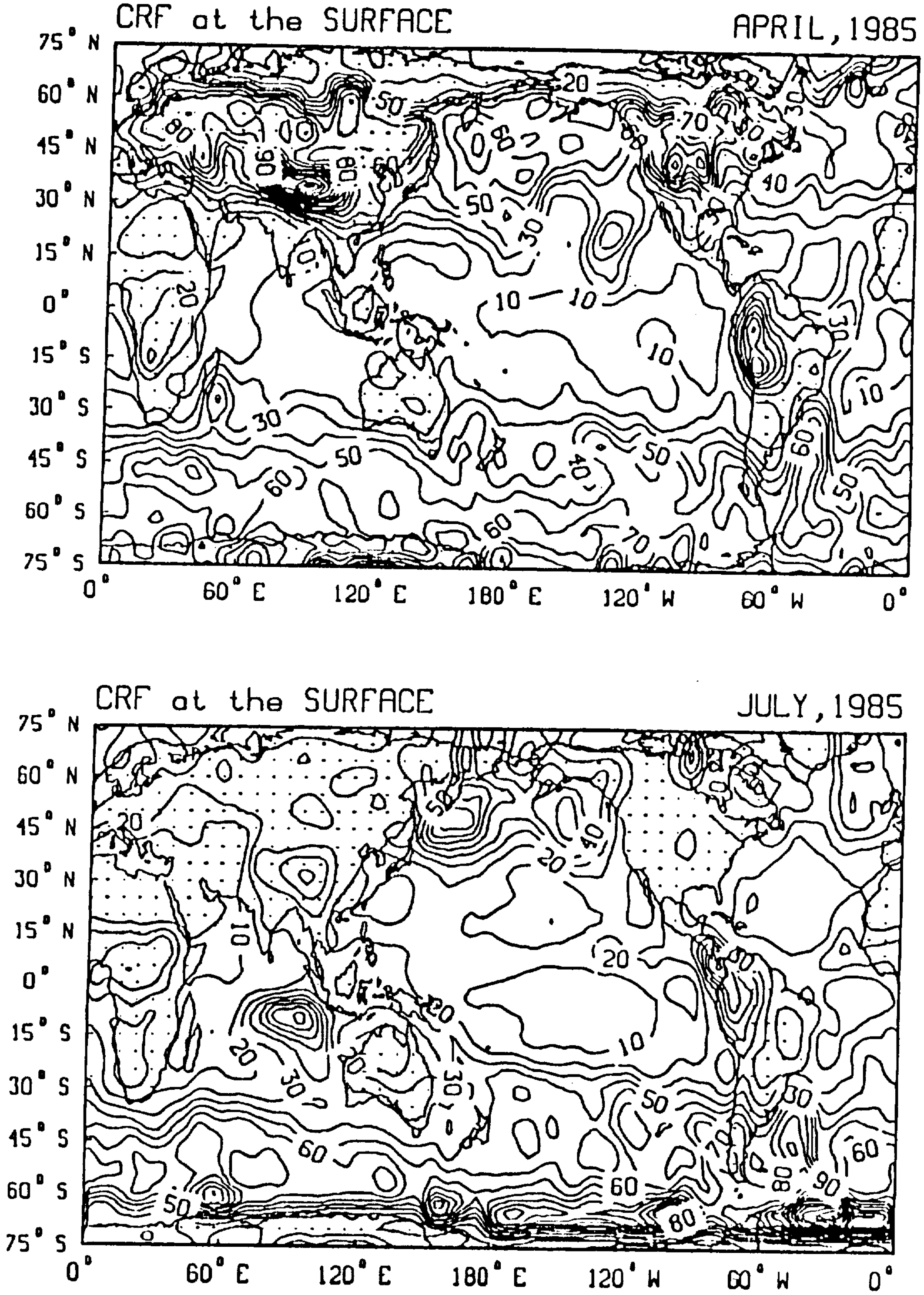
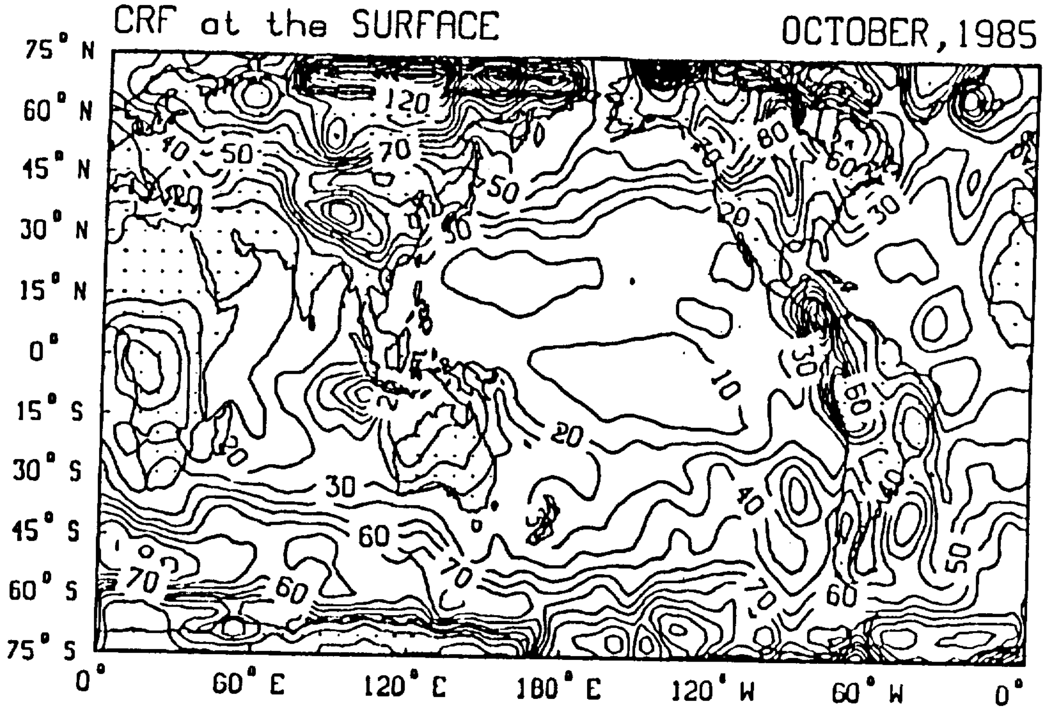
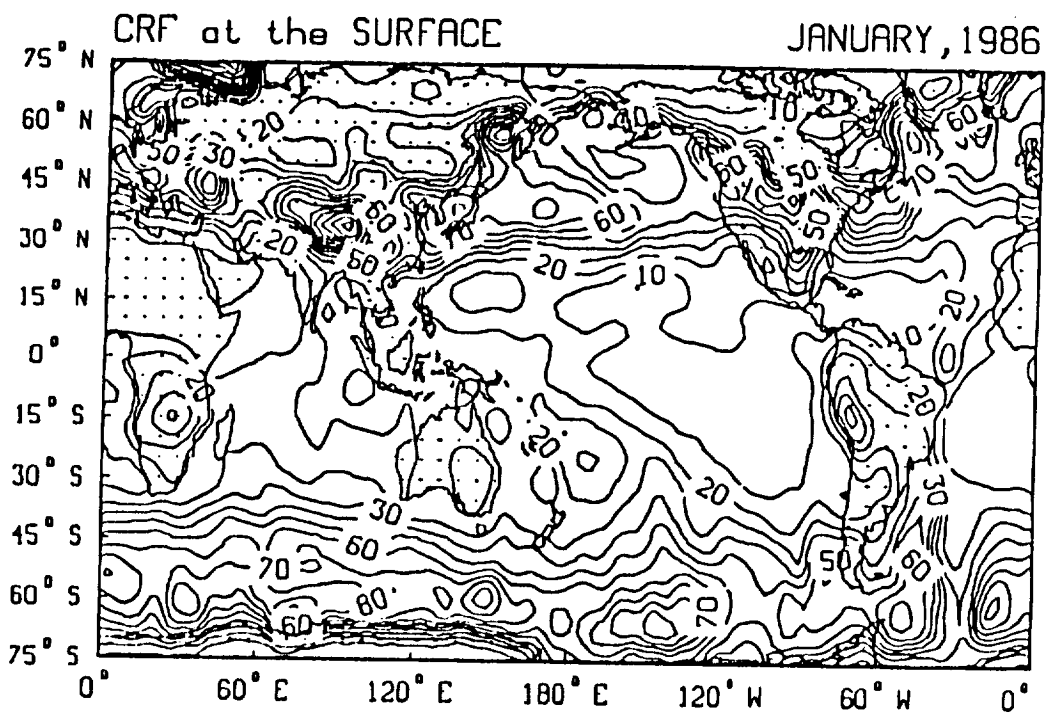


Figure 4. Longwave CRF at the surface in Wm^{-2} for April, July, October and January in 1985-86





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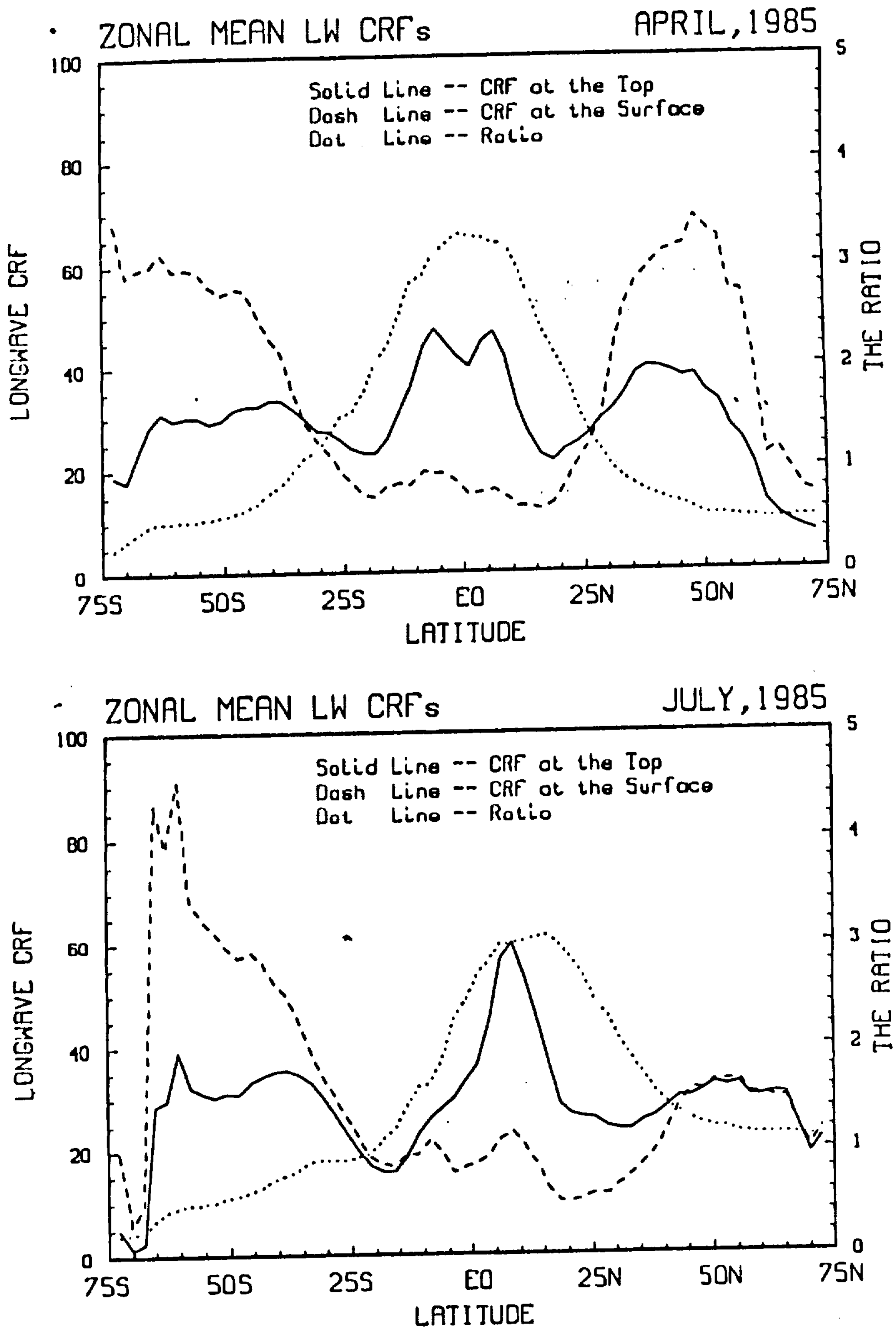
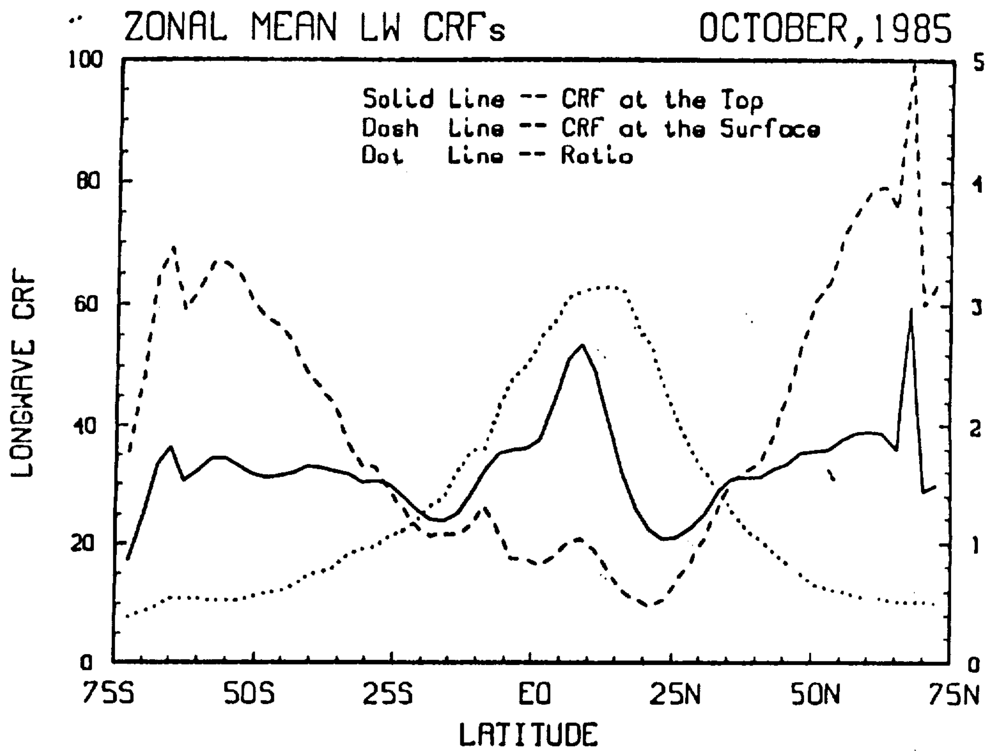


Figure 5. The zonal variation of longwave CRF in Wm^{-2} for April, July, October and January in 1985-86



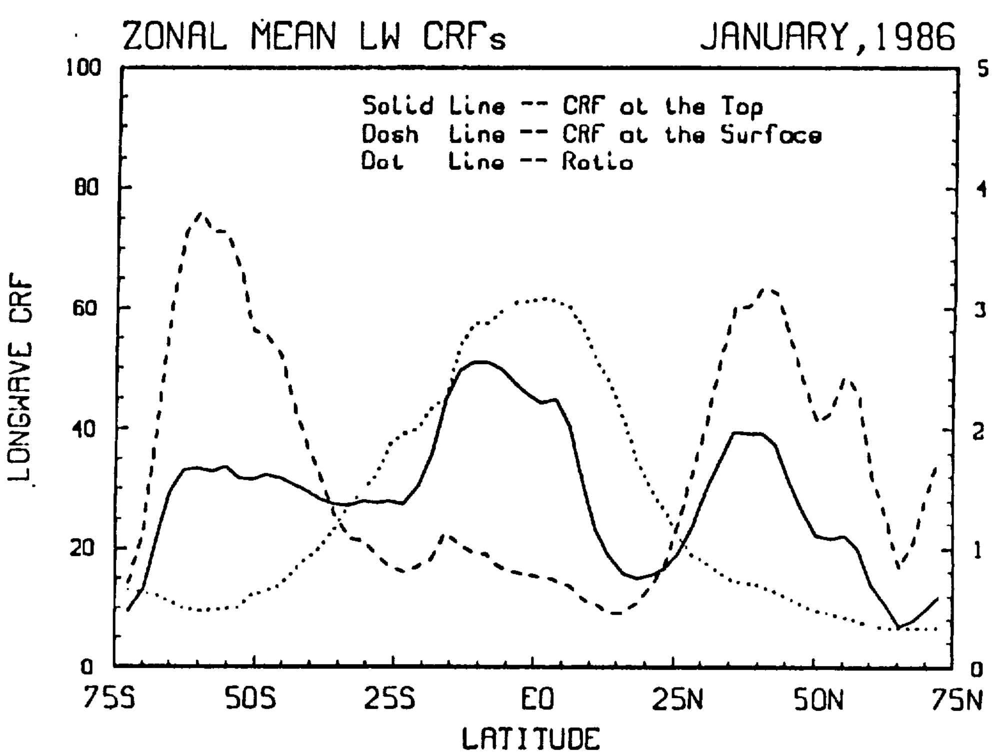


Figure 5. Continued

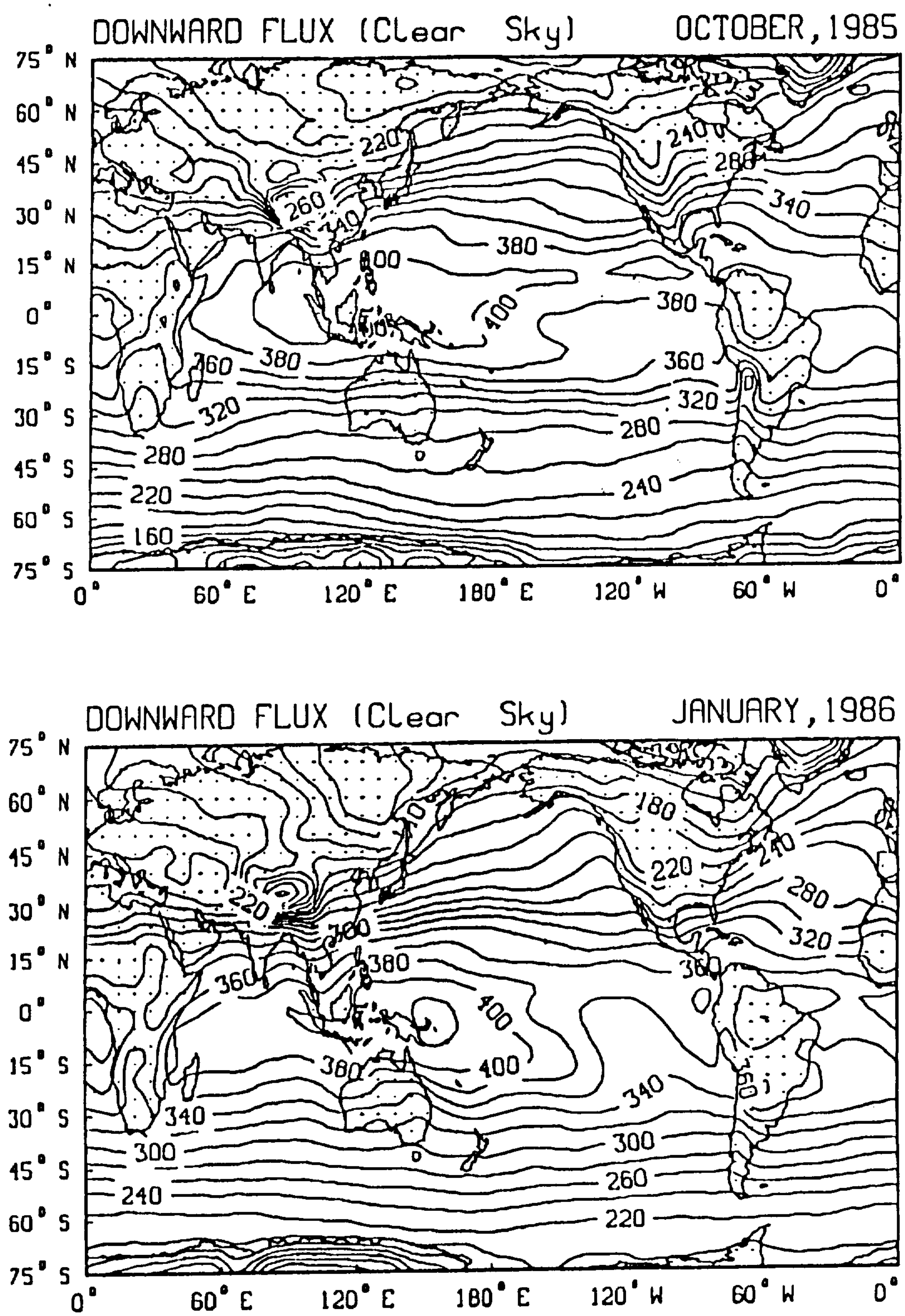


Figure 6. Continued

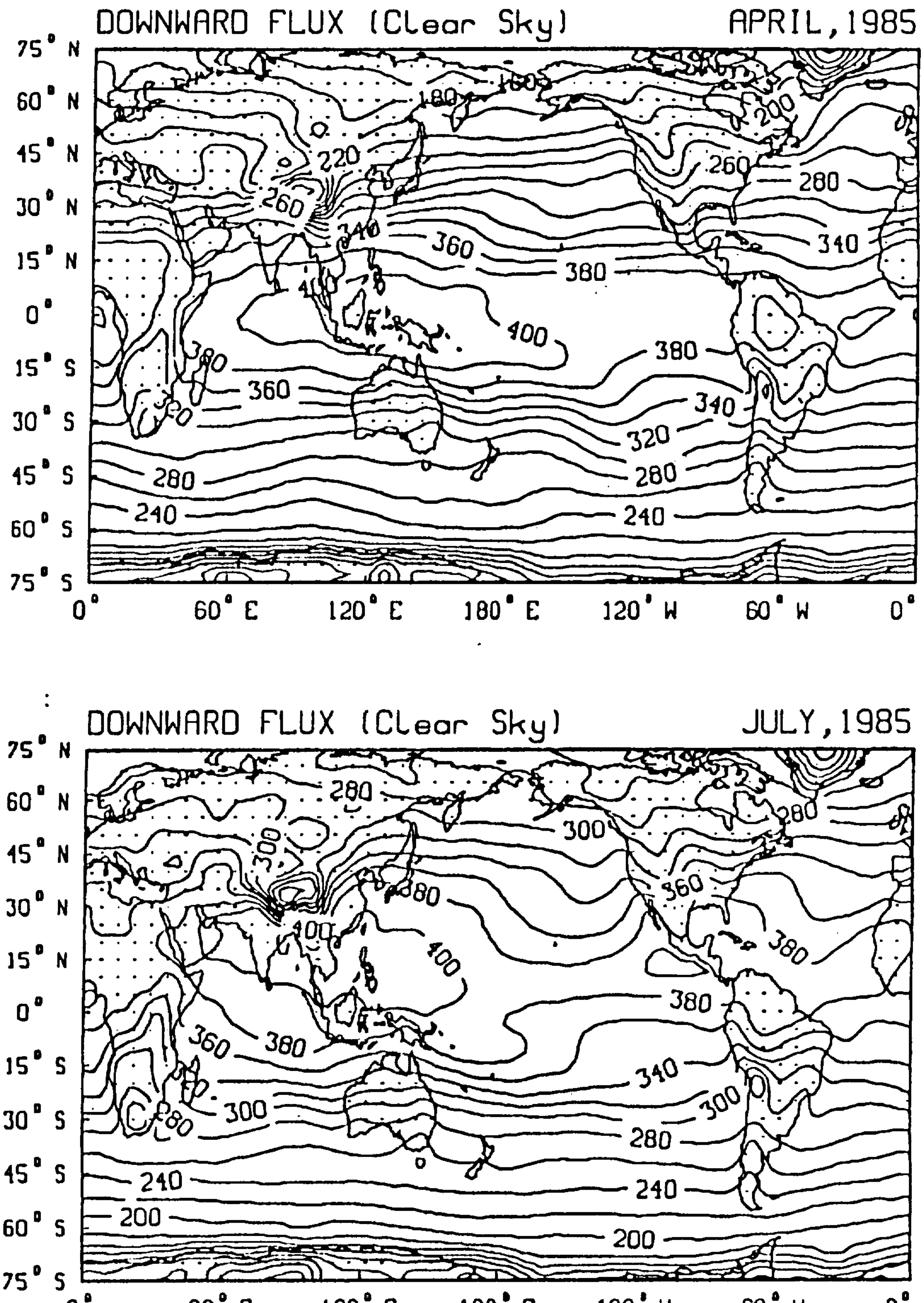
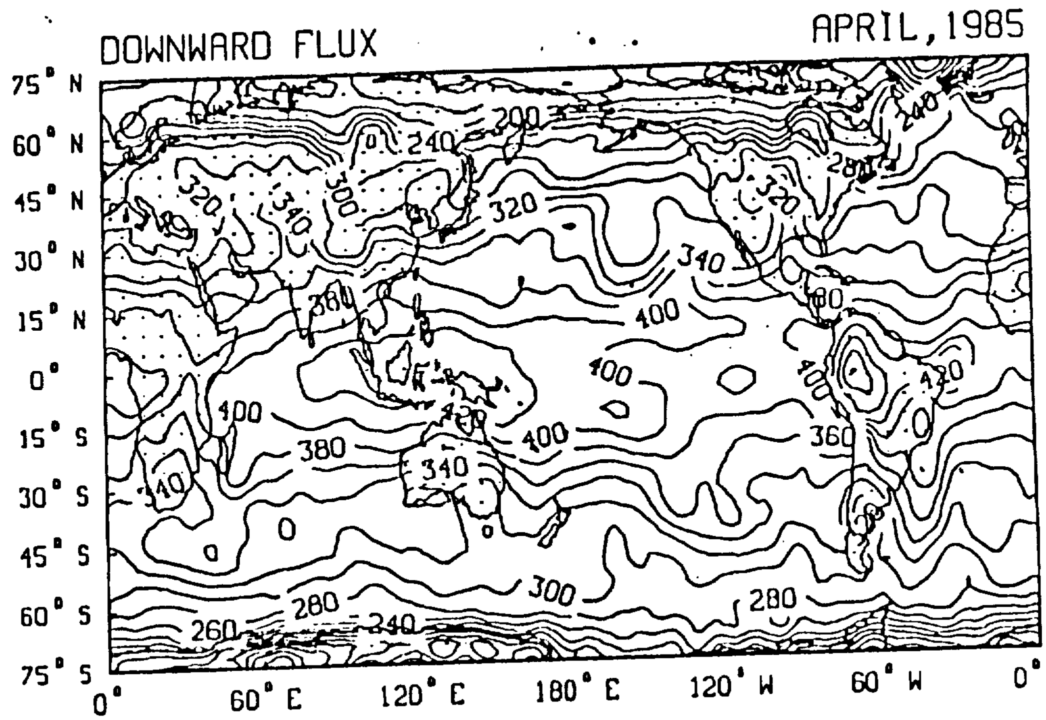


Figure 6. Monthly mean clear-sky downward longwave fluxes (Wm^{-2}) at the surface for April, July, October and January in 1985-86



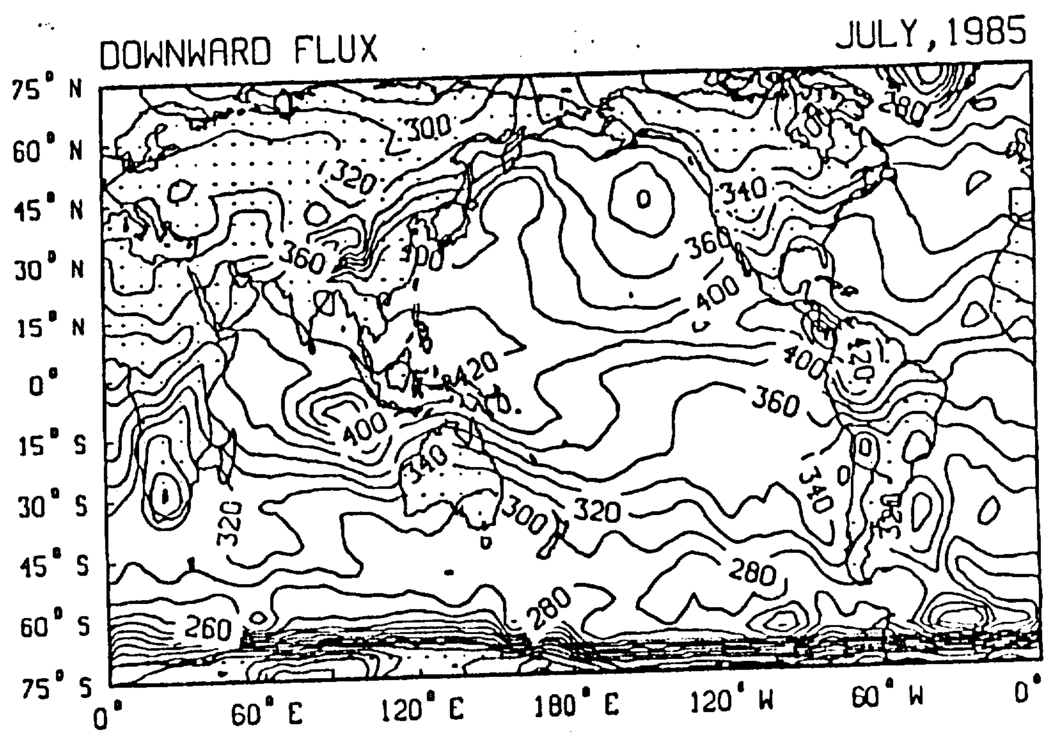
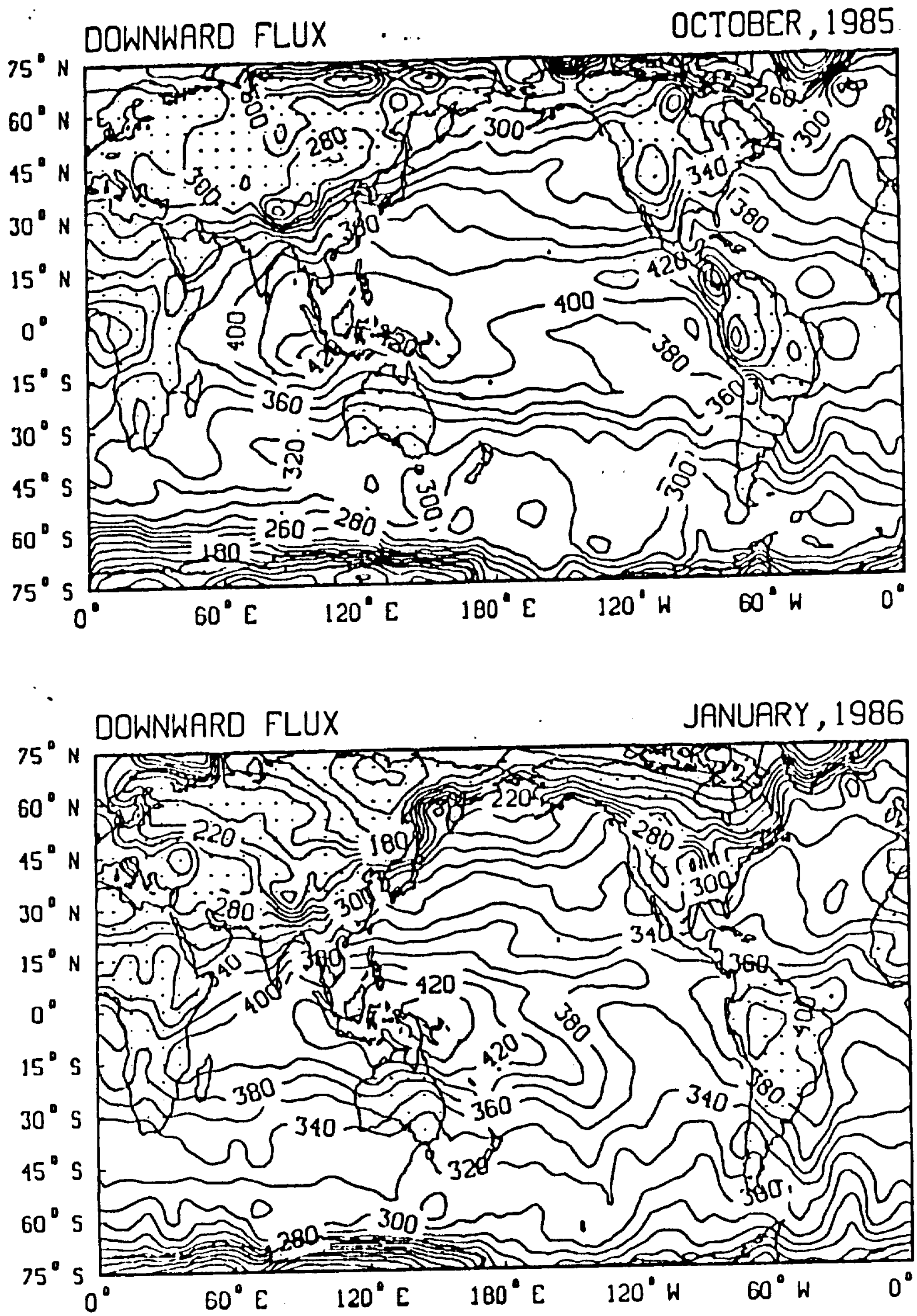


Figure 7. Monthly mean downward longwave fluxes (Wm^{-2}) at the surface for April, July, October and January in 1985-86



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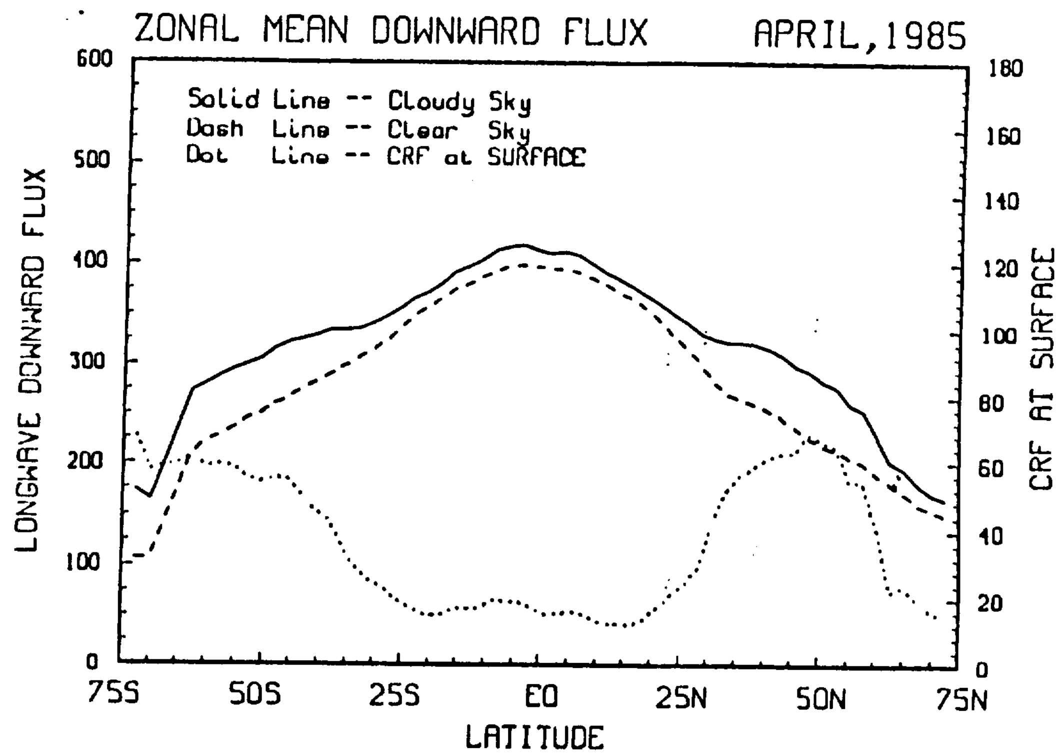


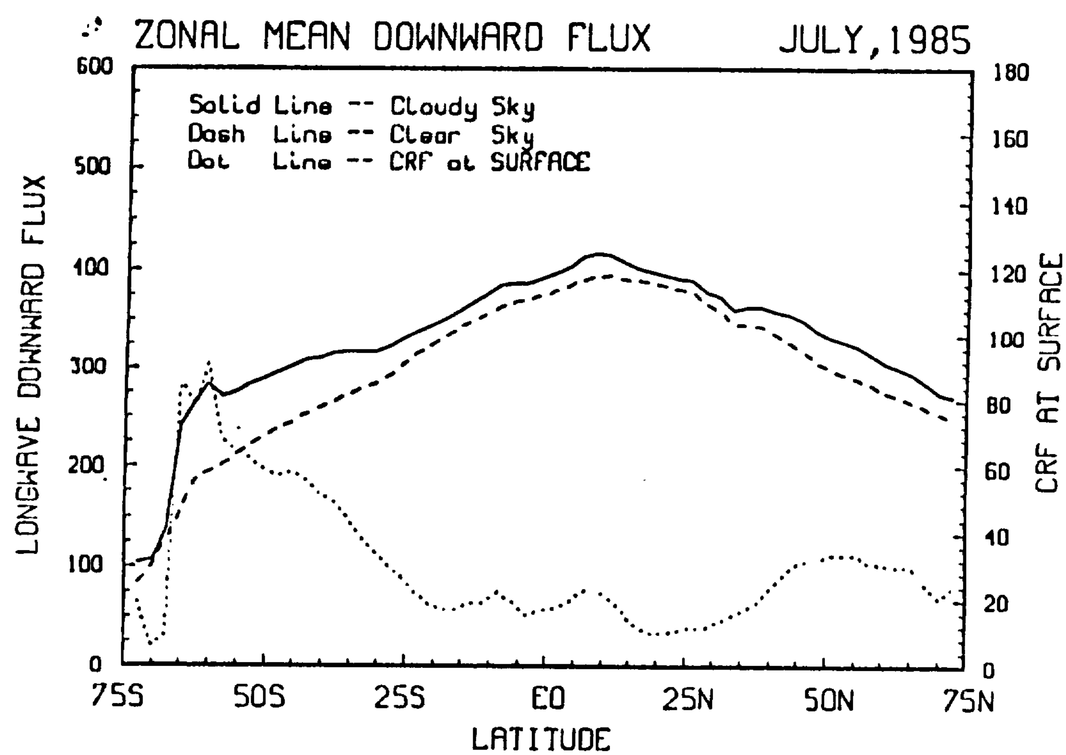
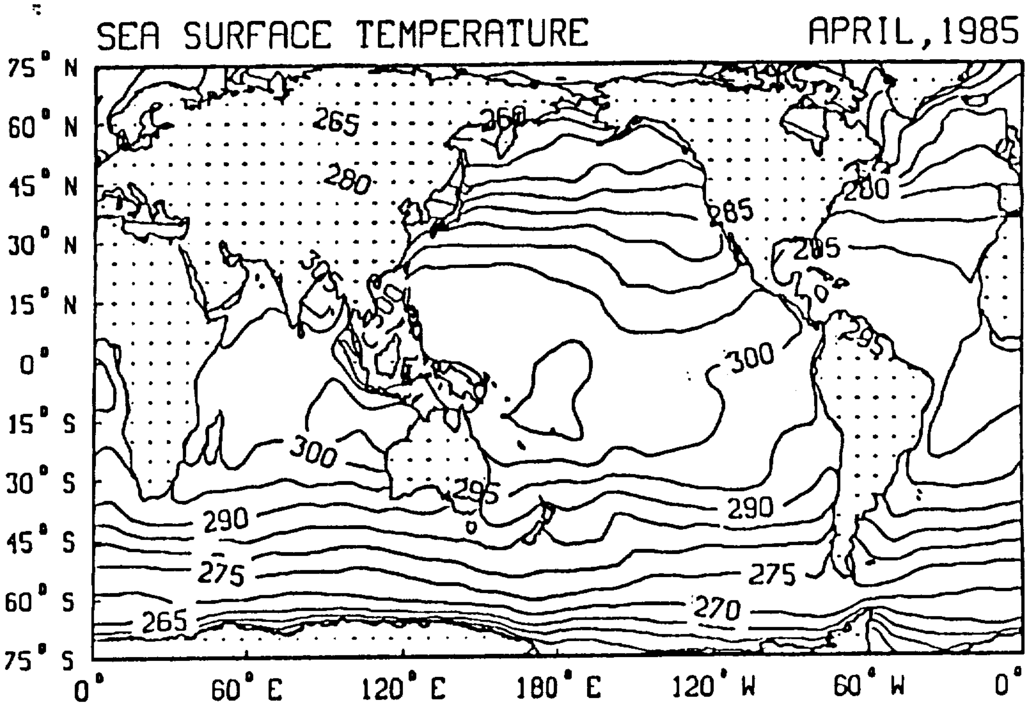


Figure 8. The zonal variation of downward longwave fluxes (Wm^{-2}) at the surface for April, July, October and January in 1985-86



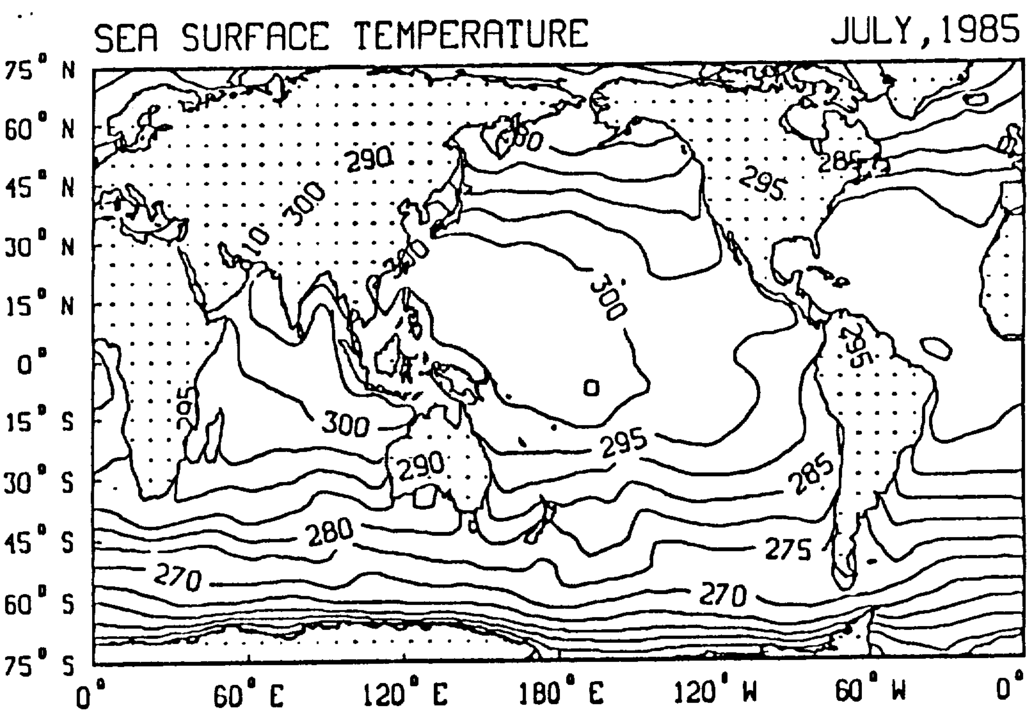


Figure 9. Sea surface temperature (K) from ISCCP satellite data for April, July, October and January in 1985-86

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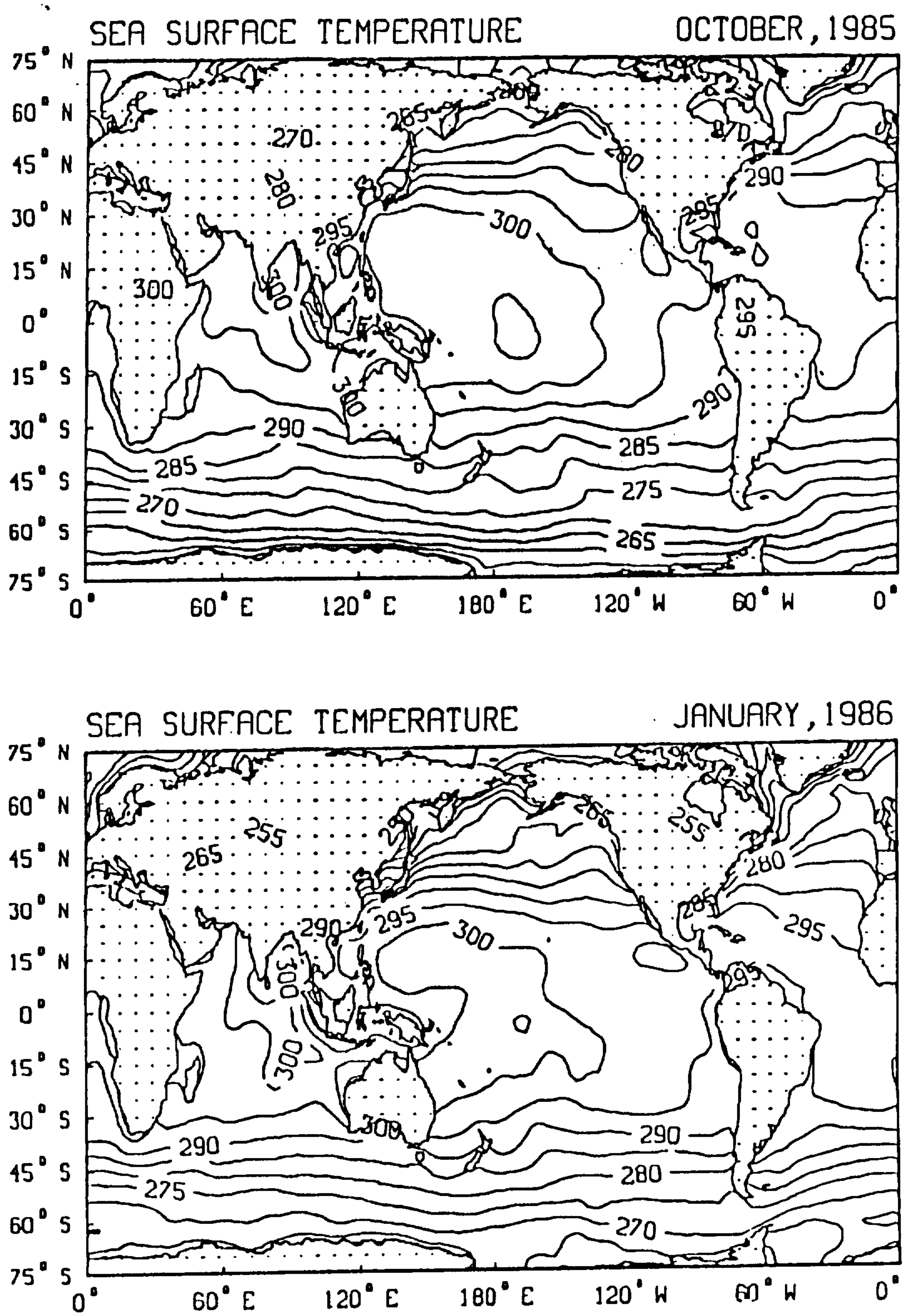

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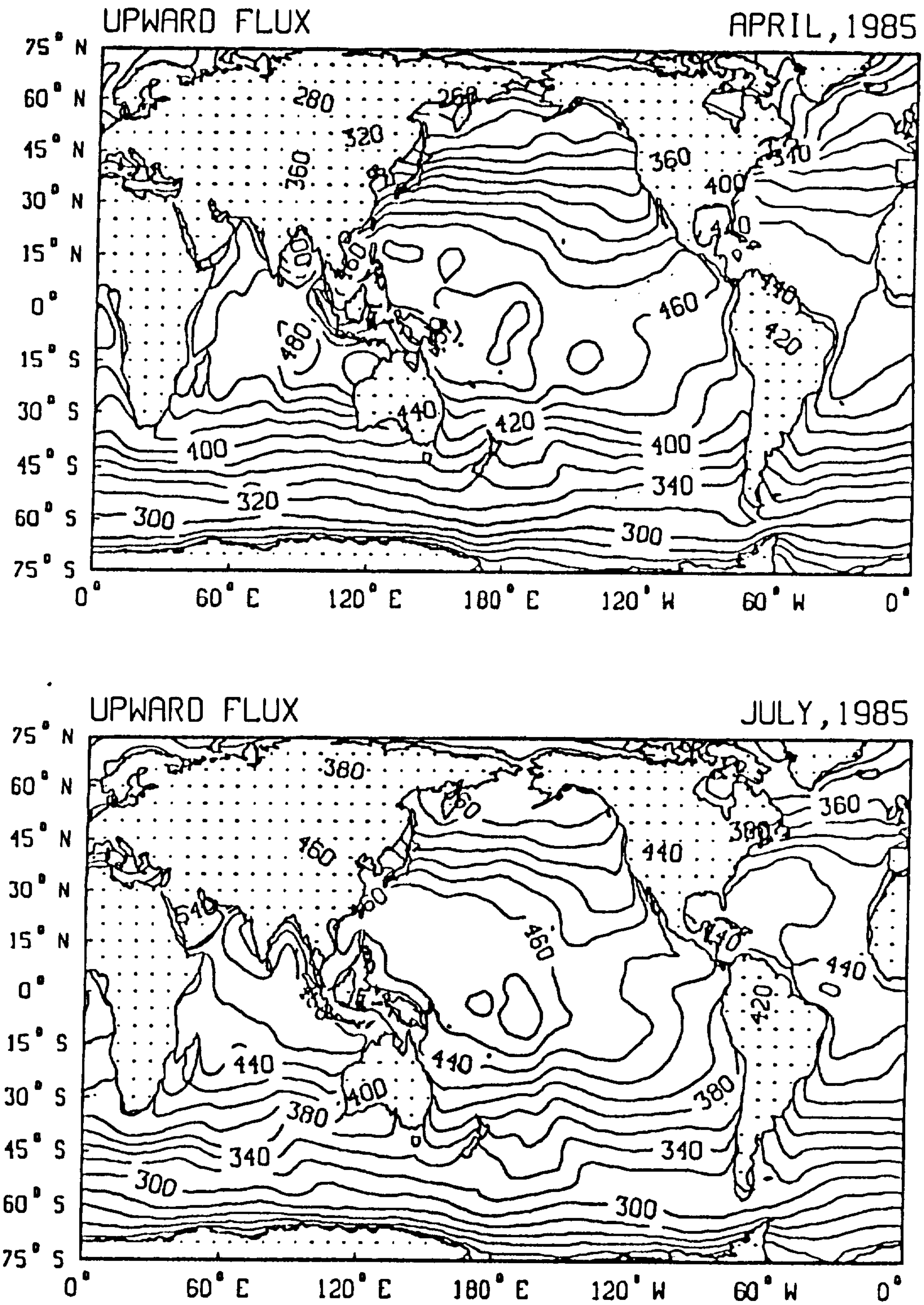
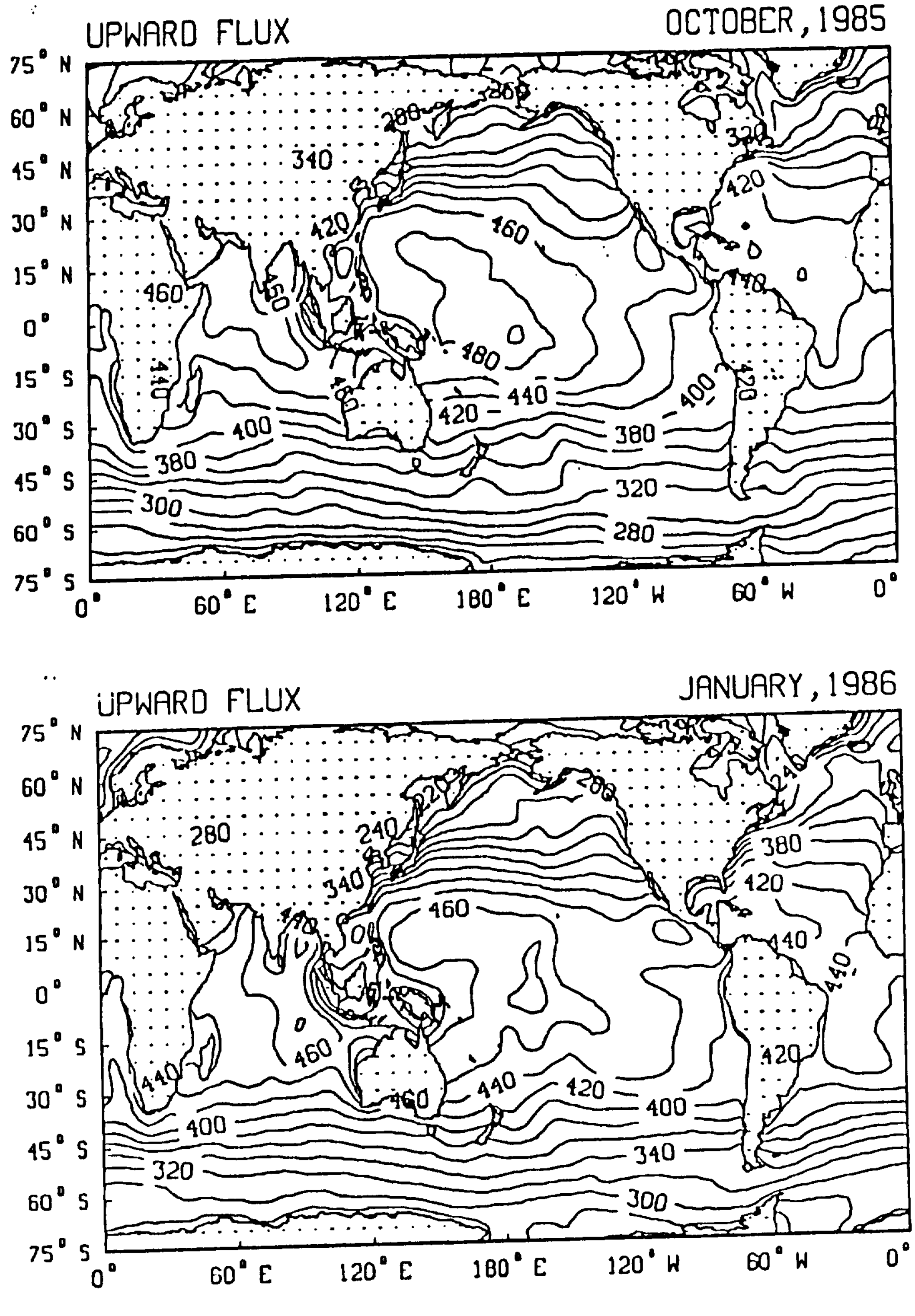


Figure 10. Upward fluxes (Wm^{-2}) for April, July, October and January in 1985-86



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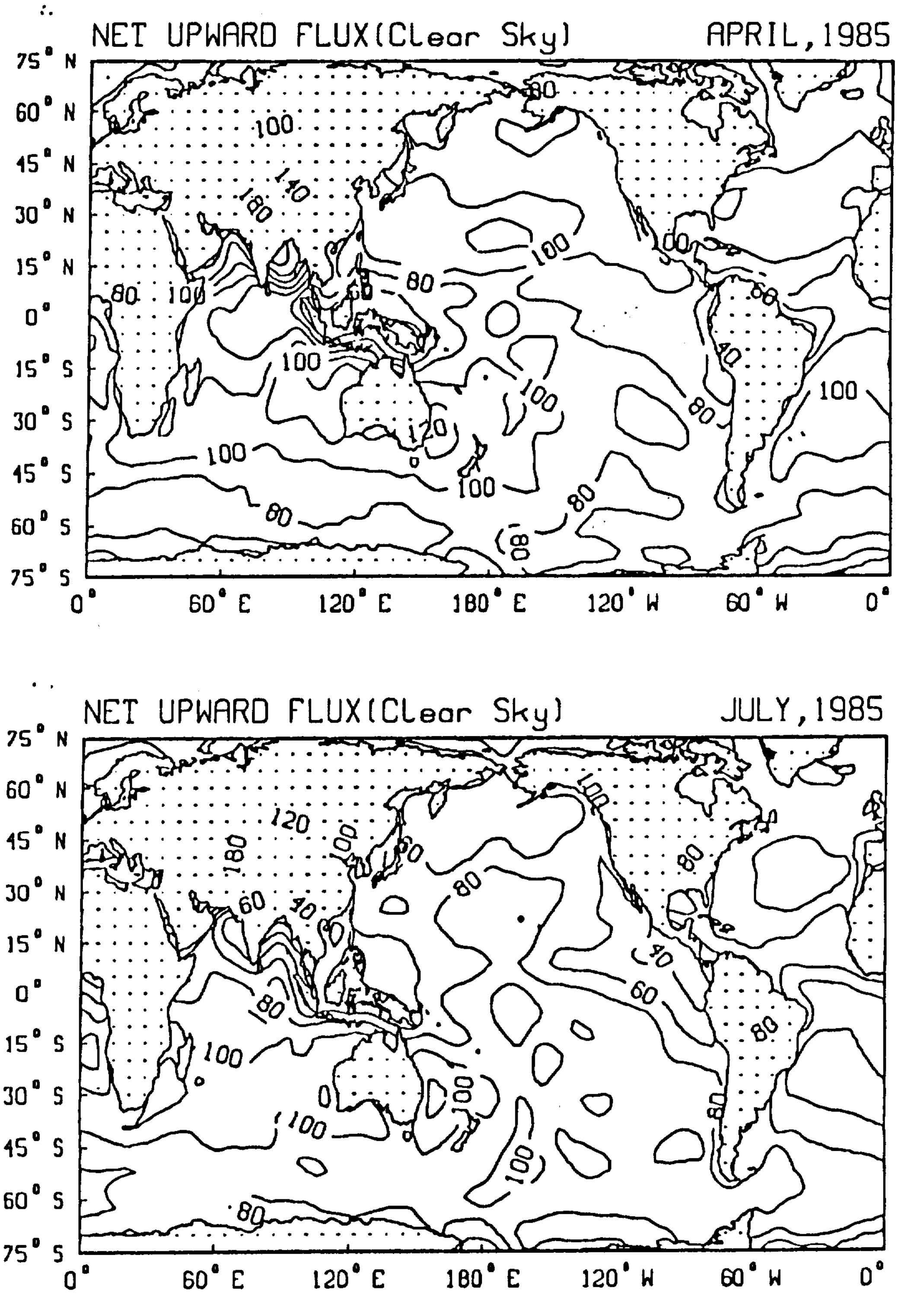
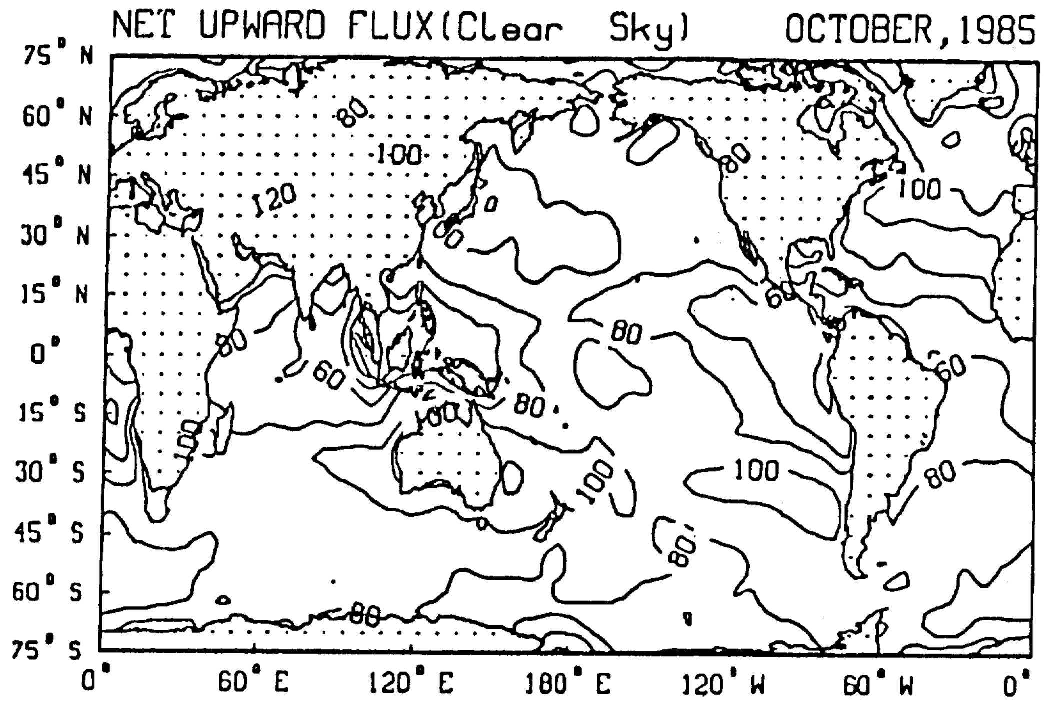


Figure 11. Monthly mean clear-sky net upward longwave fluxes (Wm^{-2}) at the surface for April, July, October and January in 1985-86



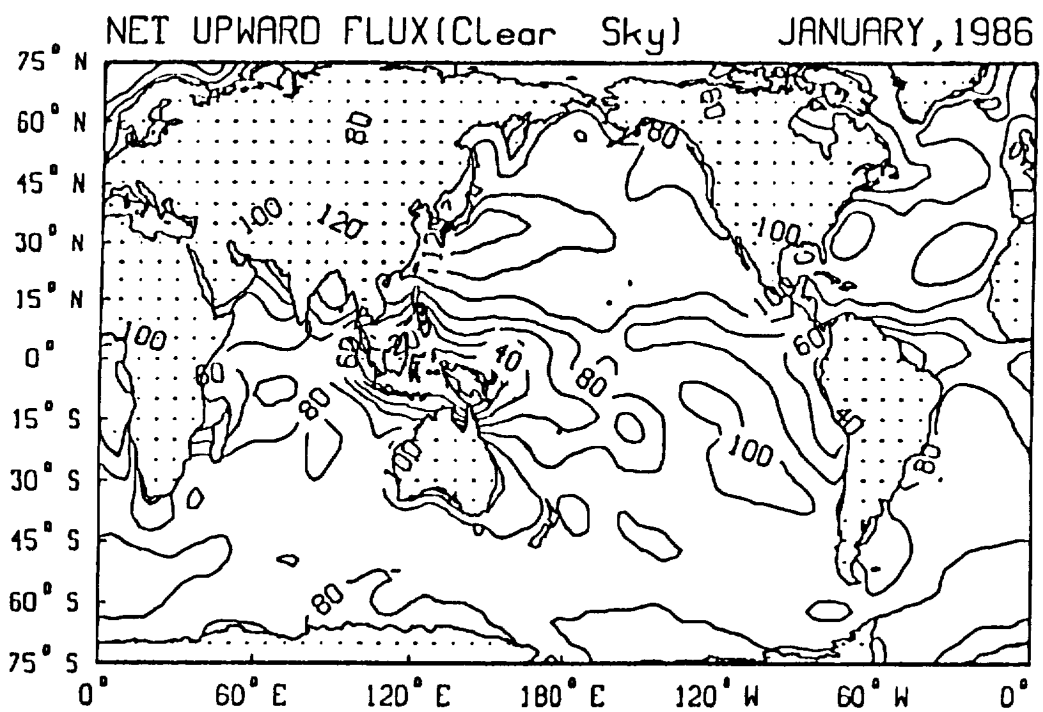
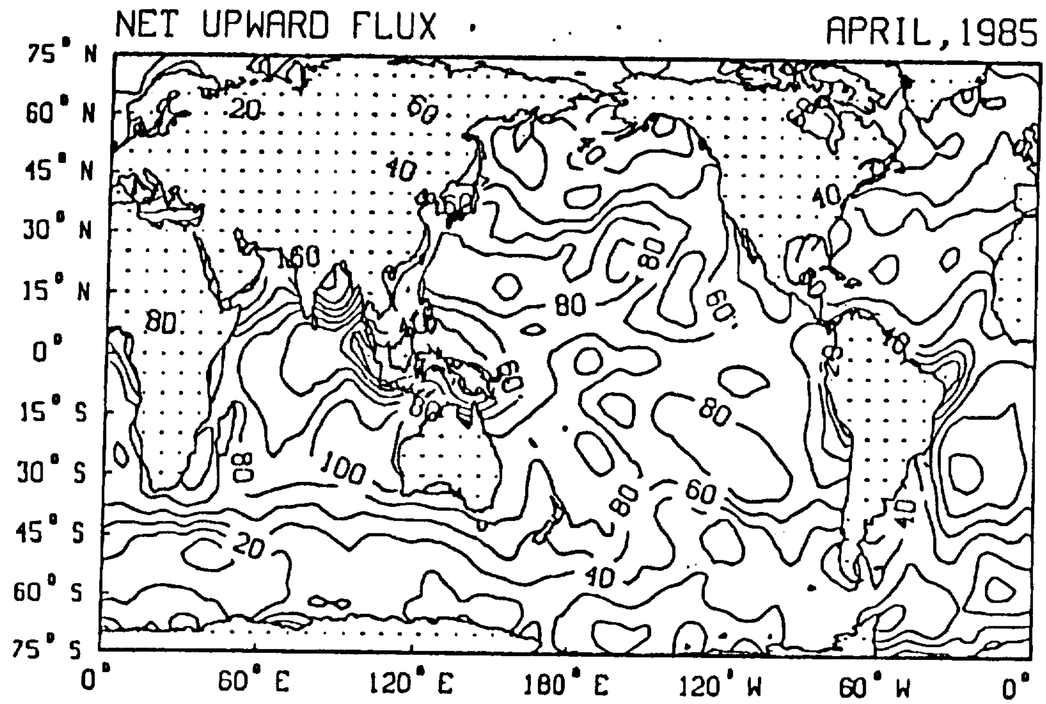


Figure 11. Continued



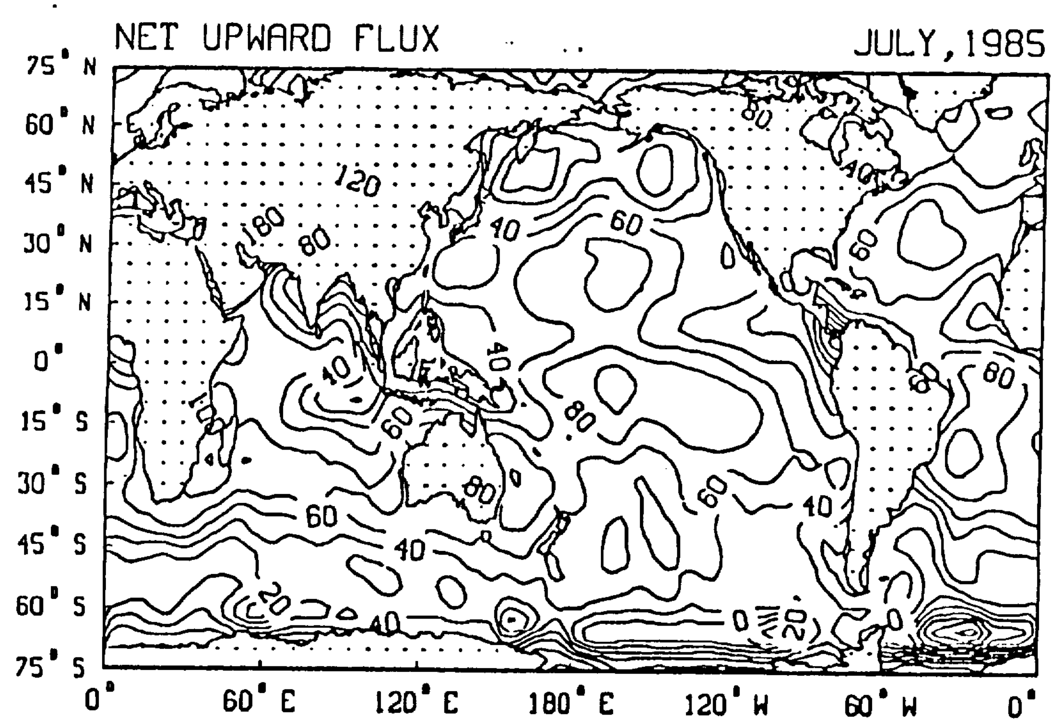
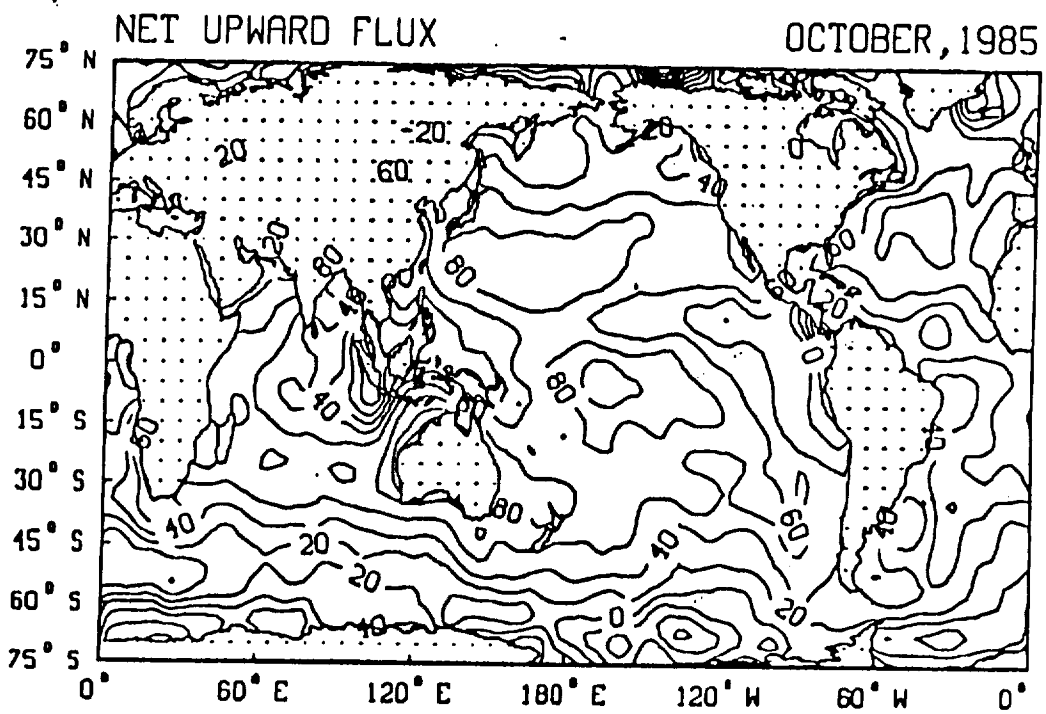


Figure 12. Monthly mean net upward longwave fluxes (Wm^{-2}) at the surface for April, July, October and January in 1985-86



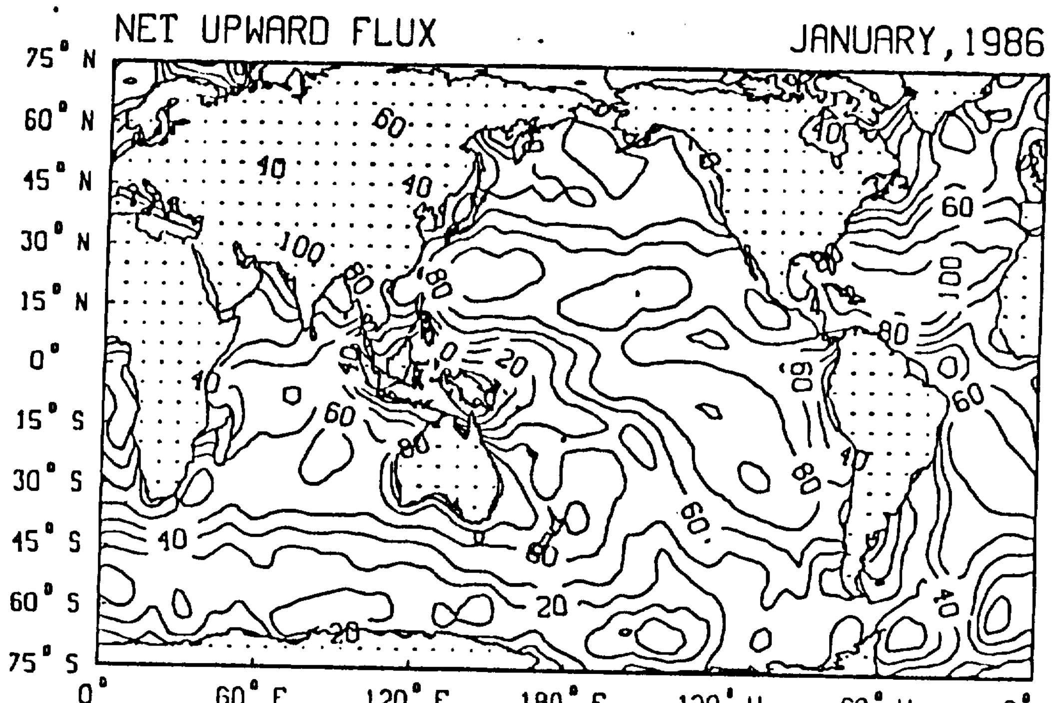


Figure 12. Continued