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Monthly Surface Thermal Forcing in the Tropical Pacific from 1980 to 1983

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16. Abstract

Monthly distributions of surface latent heat flux and solar irradiance in the tropical Pacific were computed from observations of the Scanning Multichannel Microwave Radiometer on Nimbus-7 and the Visible Infrared Spin Scan Radiometer on GOES-W. They are the dominant variable components of the surface heat flux, the sum of which gives the approximate thermal forcing on the ocean. Monthly maps of this sum, from January 1980 to September 1983, and within 20° N and 20° S, 180° and 80° W, are presented in this report.

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ABSTRACT

Monthly distributions of surface latent heat flux and solar irradiance in the tropical Pacific were computed from observations of the Scanning Multichannel Microwave Radiometer on Nimbus-7 and the Visible Infrared Spin Scan Radiometer on GOES-W. They are the dominant variable components of the surface heat flux, the sum of which gives the approximate thermal forcing on the ocean. Monthly maps of this sum, from January 1980 to September 1983, and within 20° N and 20° S, 180° and 80° W, are presented in this report.

CONTENTS

Figures

MONTHLY SURFACE THERMAL FORCING IN THE TROPICAL PACIFIC 1980-1983

The El Niño Southern Oscillation (ENSO) is one of the most prominent climatic signals in time scales from a few months to a few years. An important manifestation is the ocean surface warming in the central and eastern equatorial Pacific, with far-reaching economic and ecologic impacts. Understanding the physical mechanism responsible for the sea surface temperature (SST) variability is a major objective of the decade-long Tropical Ocean and Global Atmosphere (TOGA) program. Changes in SST are largely governed by the balance of surface heat flux, heat advection, and turbulent heat transport in the ocean. Until now, the surface heat flux was derived from meteorological reports from volunteer ships whose distribution is inadequate to describe the month-to-month variability. Satellite sensors can provide basin-wide coverage from days to years. In the tropical ocean, the latent heat flux and the surface solar irradiance are the two dominant variable components of the heat flux. The TOGA Heat Exchange Project (THEP) is a research effort initiated to derive these two components, using a combination of satellite data (Liu and Niiler, 1985). This report includes monthly maps of the sum of the two flux components produced under THEP as an estimation of the surface thermal forcing on the ocean.

The latent heat flux is computed with the model of Liu et al. (1979) which is based on the similarity theory in the atmospheric surface layer. The application of this model is similar to the use of bulk aerodynamic formulas with variable transfer coefficients which depend on atmospheric stability and surface roughness. Over the tropical ocean, the use of such a model instead of a constant transfer coefficient is important, due to the weak wind and high humidity conditions. At low winds, the surface is aerodynamically smooth and the transfer coefficient increases with decreasing wind speed. At high humidities, the moisture-induced buoyancy becomes significant in destabilizing the atmosphere and increasing evaporation. Using a constant coefficient or one which depends only on the temperature stratification would lead to a large underestimation of the evaporation. Like any bulk parameterization method, the model of Liu et al. (1979) requires the input of SST, wind speed, and humidity. Satellite sensors can measure sea surface temperature and wind speed, but not near-surface humidity. They can, however, measure precipitable water. Liu (1986) found that, at the monthly time scale, atmospheric water vapor has a single dominant mode of variability, and near-surface humidity can be derived from the precipitable water measured by microwave radiometers. A global relation was established using 17 years of radiosonde reports from 46 mid-ocean meteorological stations. Based on this relationship, Liu (1988) computed monthly fields of latent heat flux from 1980 to 1983 in the tropical Pacific using data from the Scanning Multichannel Microwave Radiometer on Nimbus-7. The results were evaluated with measurements from volunteer ships, research moorings, and operational weather stations.

Employing calibrated visible radiance measurements collected by geostationary satellites, Gautier et al. (1980) developed a method of computing daily surface solar irradiance. First, the clear sky reflectance is computed as a function of the ocean surface albedo and climatological values of atmospheric parameters. This computed clear sky reflectance value defines a threshold above which clouds are present. Second, each pixel is then tested to define whether it is clear or cloudy. Third, with that determination being made, clear or cloudy sky solar irradiance models are applied to compute the instantaneous surface solar irradiance. Daily values are obtained by means of a trapezoidal time integration procedure, and monthly estimates are determined by averaging a varying number of daily values. Based on this procedure, monthly fields of surface solar irradiance were computed from observations of the Visible Infrared Spin

Scan Radiometer on GOES-W (Gautier and Frouin, 1989). Validation with measurements on research vessels in the tropical ocean were made during GATE (Gautier, 1981) and Tropic Heat experiments (Gautier, 1988).

Limited by the coverage of one geostationary satellite, the flux fields presented in this report are confined to 20° N to 20° S, 180° to 80° W. Microwave radiometer data were not available within 600 km from land. The period analyzed extends from January 1980 to September 1983 (Figures 1 through 8). Oceanographic implications are discussed by Liu and Gautier (1990).

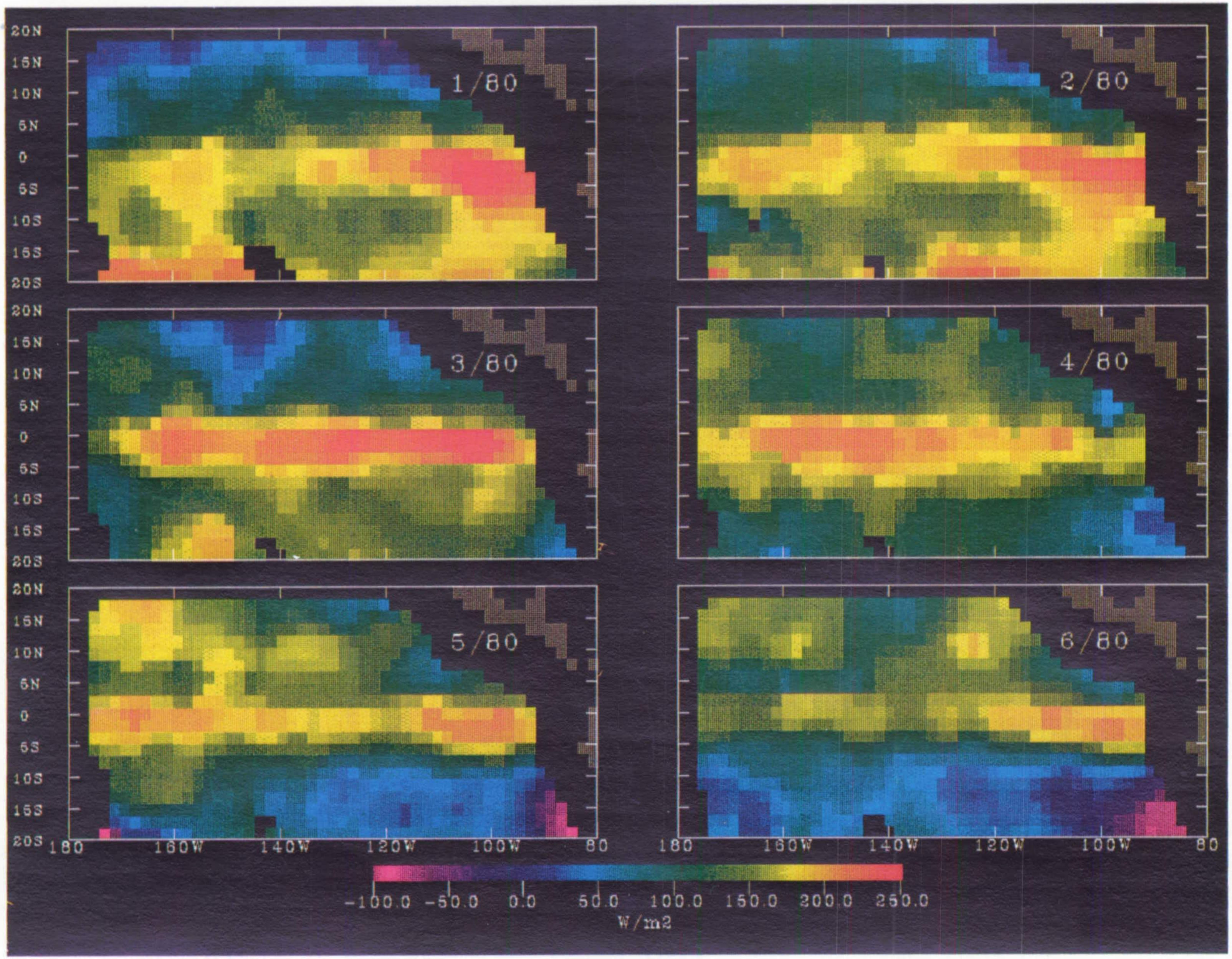

Figure 1. Distribution of the Sum of Surface Latent Heat Flux and Solar Irradiance: January 1980 through June 1980

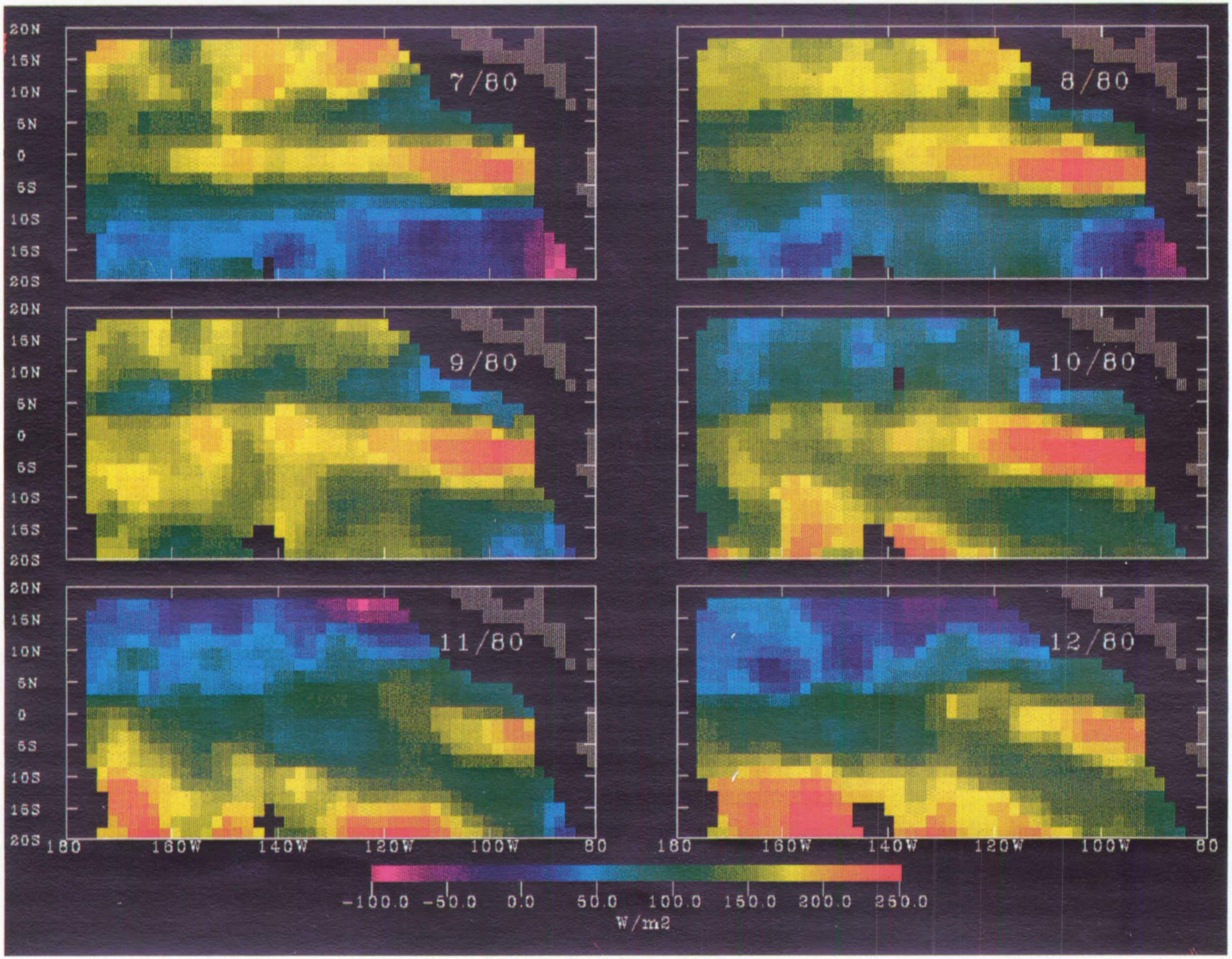

Figure 2. Distribution of the Sum of Surface Latent Heat Flux and Solar Irradiance: July 1980 through December 1980

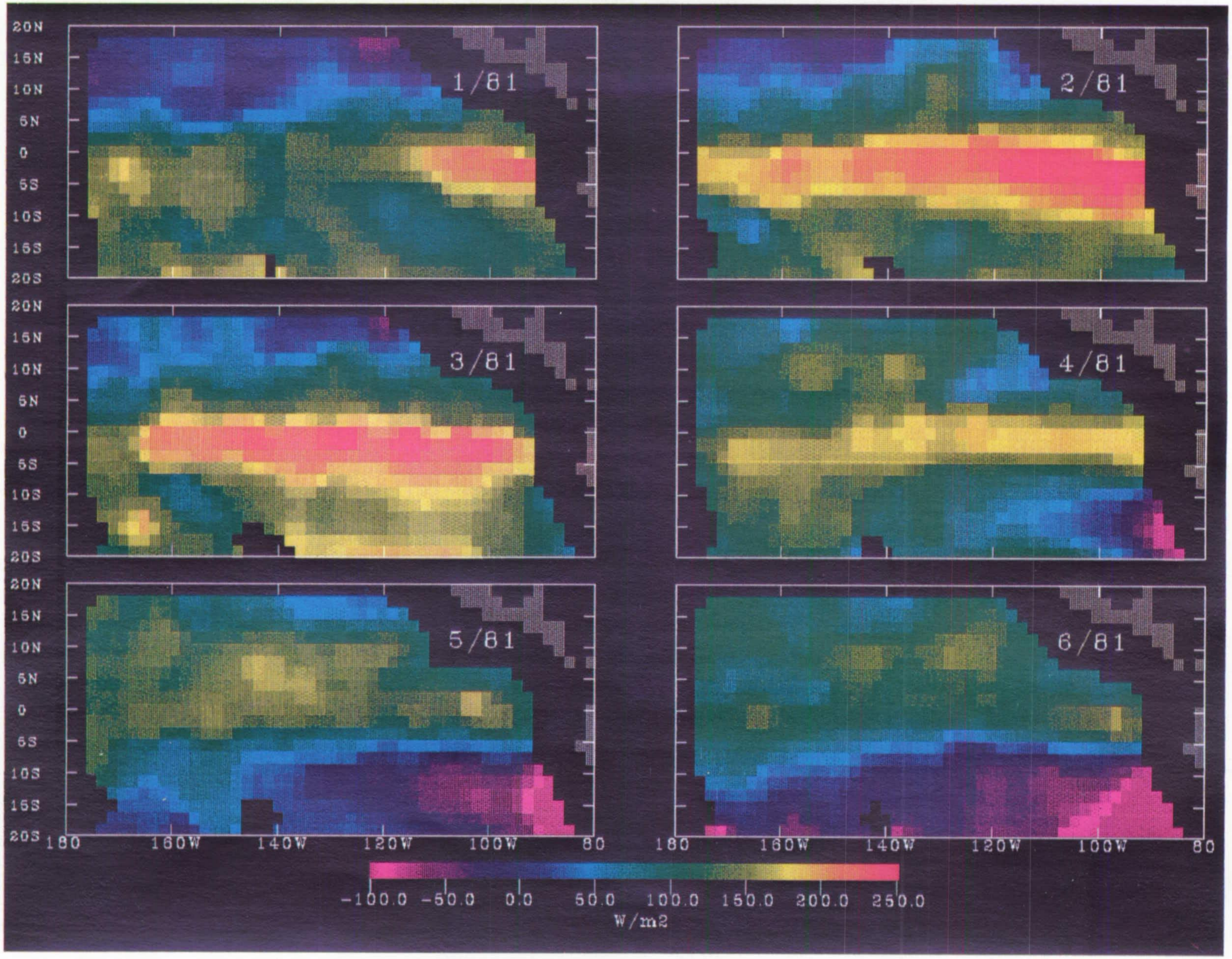

Figure 3. Distribution of the Sum of Surface Latent Heat Flux and Solar Irradiance: January 1981 through June 1981

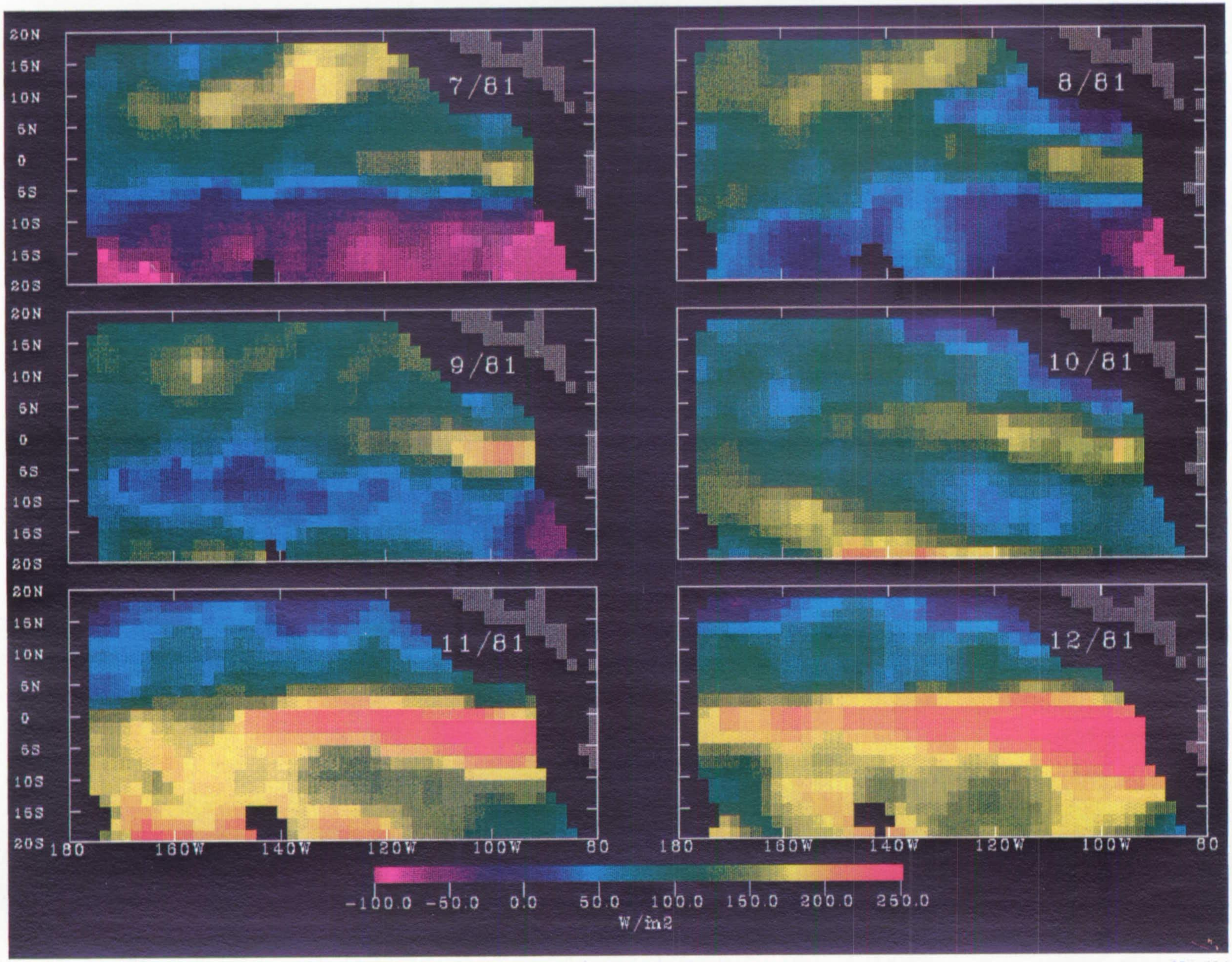

Figure 4. Distribution of the Sum of Surface Latent Heat Flux and Solar Irradiance: July 1981 through December 1981

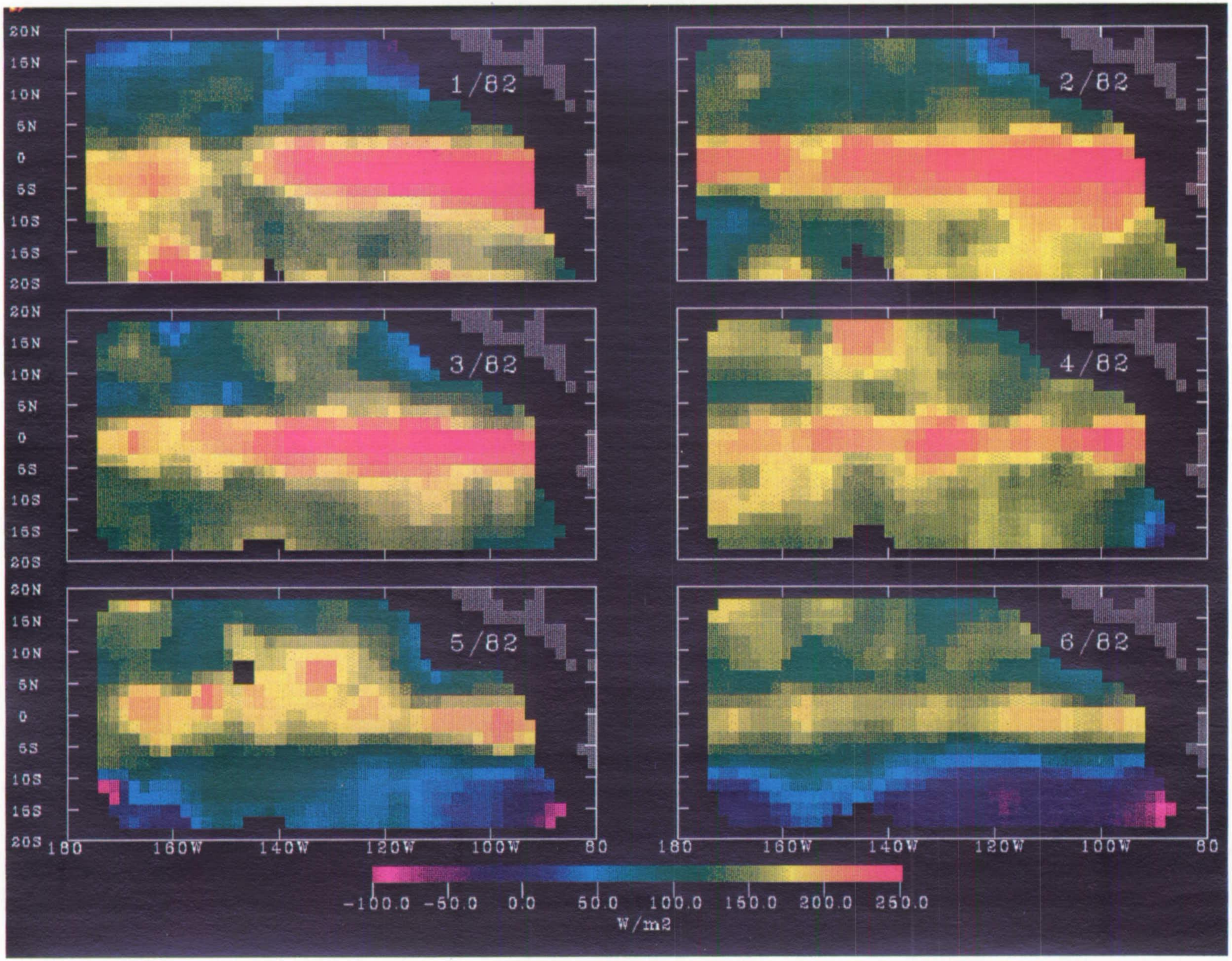

Figure 5. Distribution of the Sum of Surface Latent Heat Flux and Solar Irradiance: January 1982 through June 1982

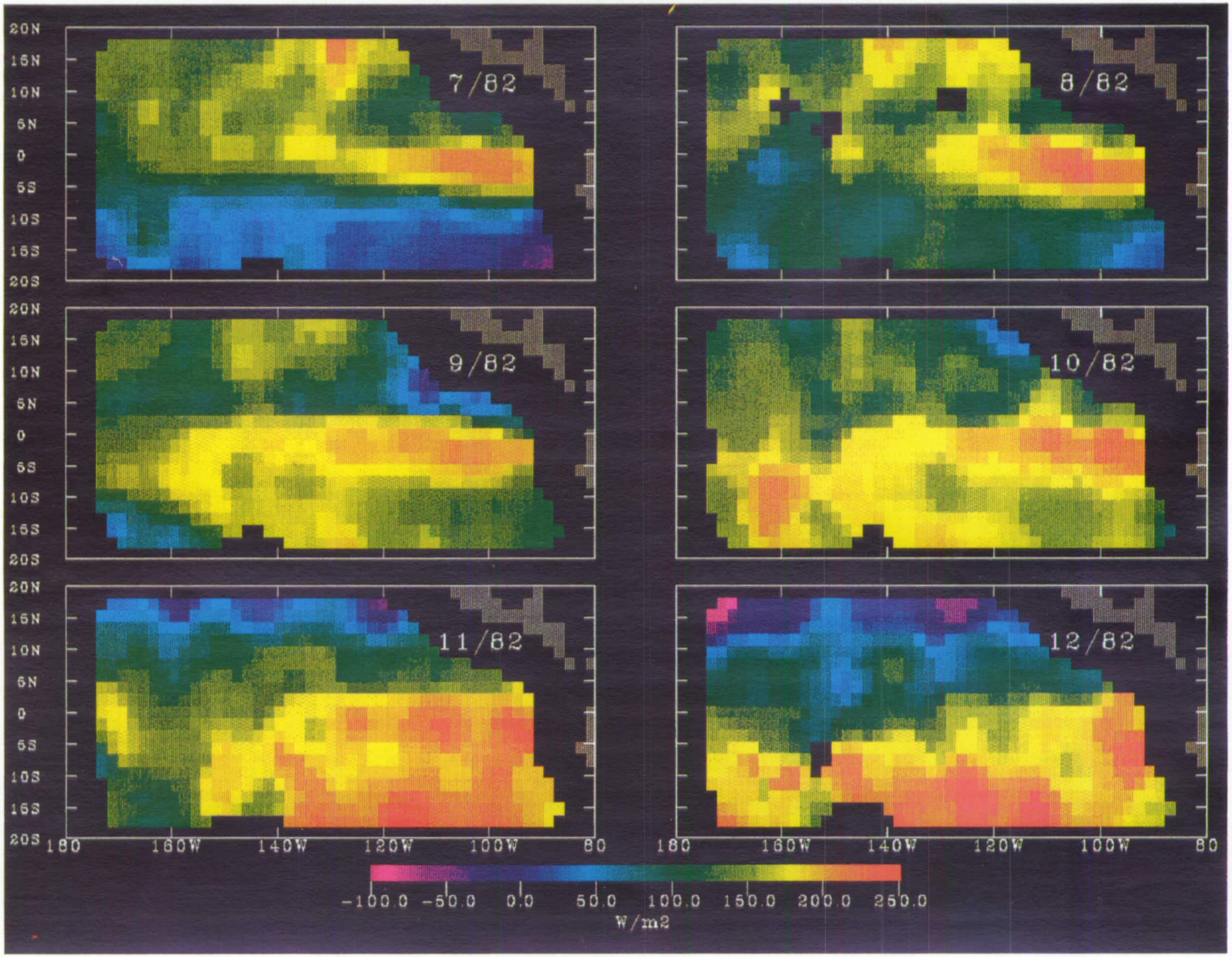

Figure 6. Distribution of the Sum of Surface Latent Heat Flux and Solar Irradiance: July 1982 through December 1982

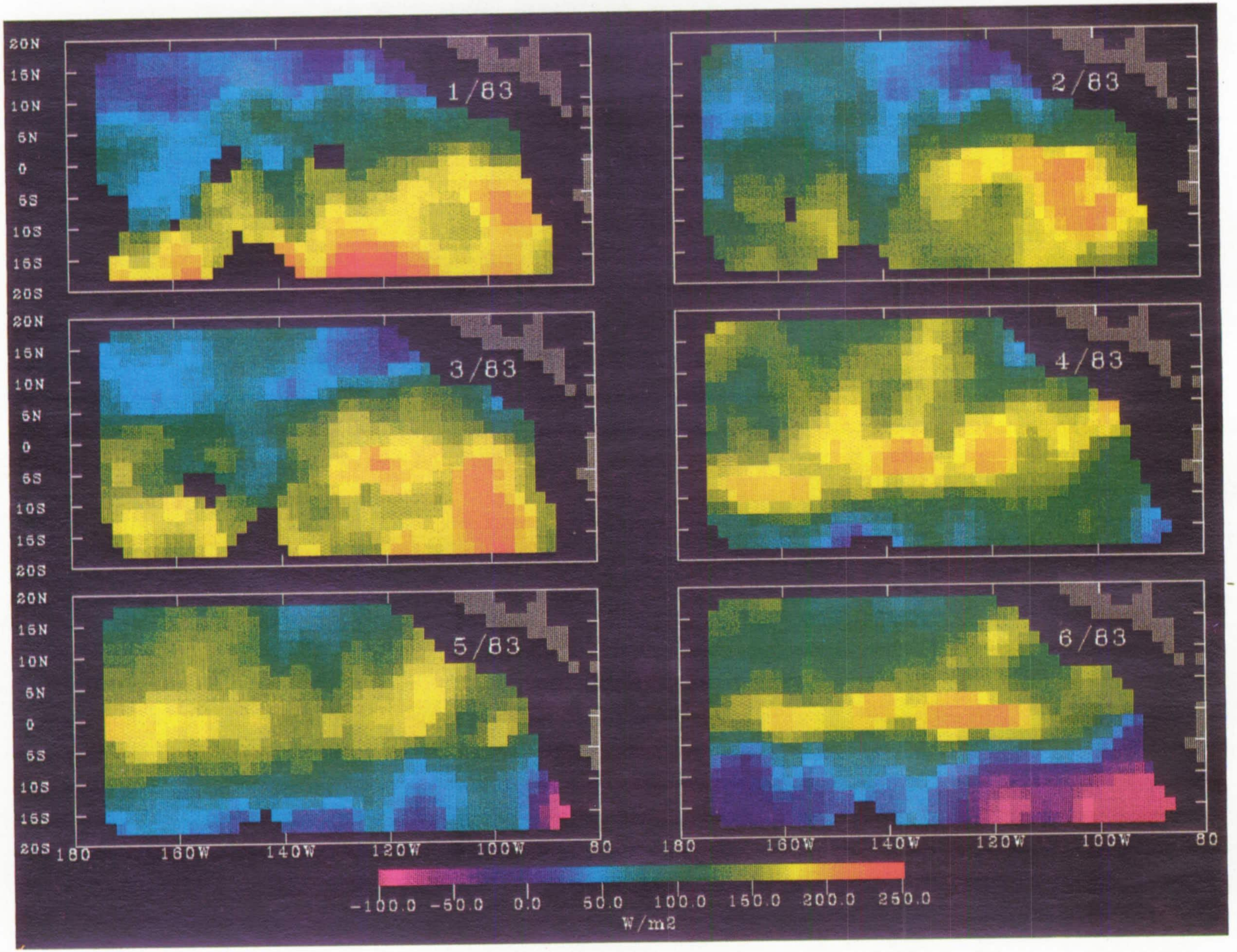

Figure 7. Distribution of the Sum of Surface Latent Heat Flux and Solar Irradiance: January 1983 through June 1983

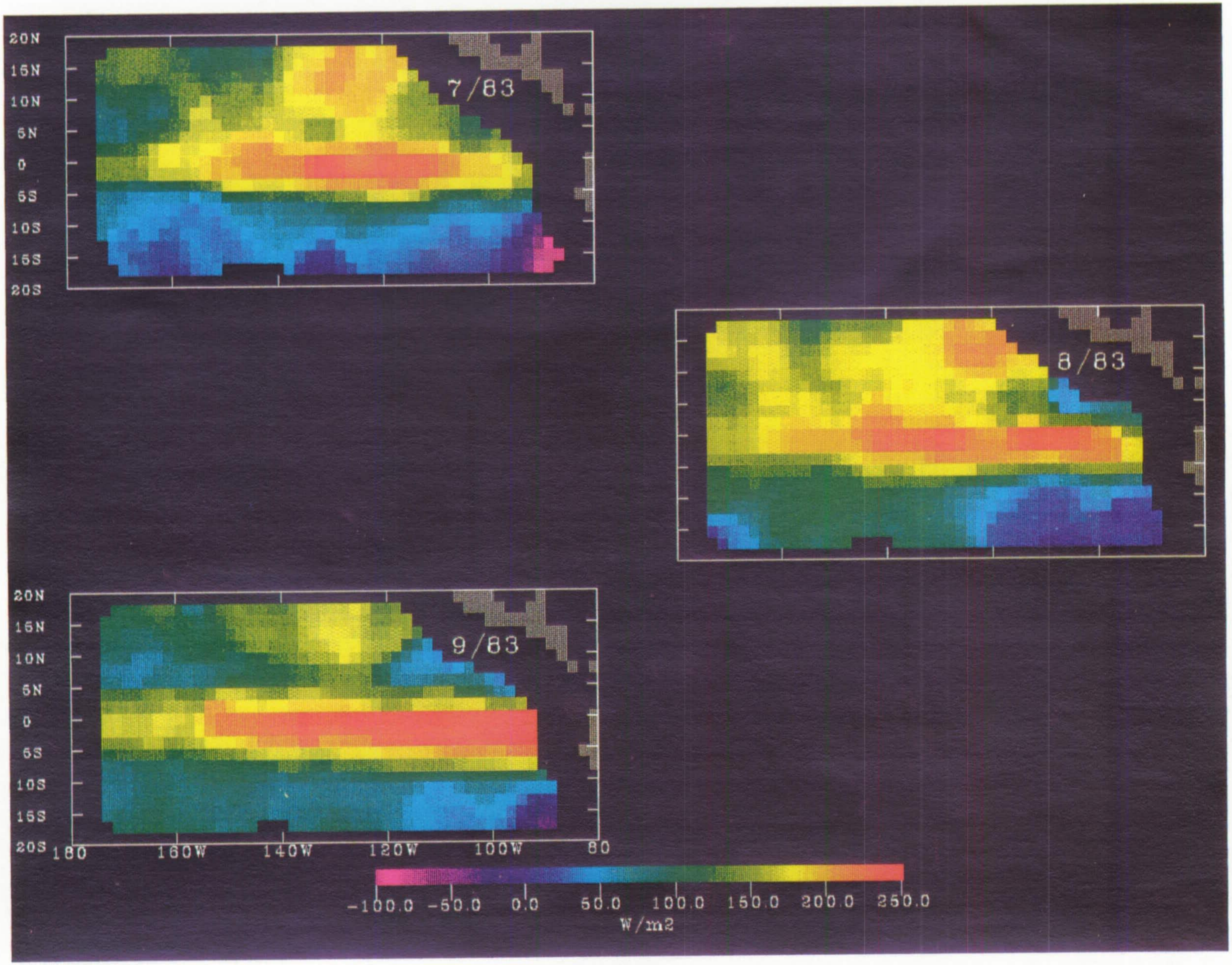

Figure 8. Distribution of the Sum of Surface Latent Heat Flux and Solar Irradiance: July 1983 through September 1983

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