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NEW FEATURES OF GLOBAL CLIMATOLOGY REVEALED BY SATELLITE-DERIVED OCEANIC RAINFALL MAPS

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LIST OF ILLUSTRATIONS

NEW FEATURES OF GLOBAL CLIMATOLOGY REVEALED BY SATELLITE-DERIVED OCEANIC RAINFALL MAPS

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ABSTRACT

Analysis of satellite derived oceanic rainfall maps reveal certain distinctive characteristics of global patterns for the years 1973-74. The main ones are (1) the forking of the Intertropical Convergence Zone in the Pacific, (2) a previously unrecognized rain area in the South Atlantic, (3) the bimodal behavior of rainbelts in the Indian Ocean and (4) the large interannual variability in oceanic rainfall.

These interesting features are discussed.

Quantitative rainfall maps over the oceanic areas of the globe were derived from the Nimbus 5 Electrically Scanning Microwave Radiometer (ESMR) data. The maps for the period December, 1972 through March, 1975 were published in the form of an Atlas (Rao, Abbott and Theon, 1976).

Several interesting aspects of global climatology are disclosed from a study of these maps. The objective of the contribution is to describe briefly four outstanding features.

(1) The Structure of the ITCZ

Although it has been known for some time that there is a dry zone near the Ellice Islands in the Pacific flanked by wet regions to the north and south (Seelye, 1950) the precise structure of the ITCZ in the Pacific has remained obscure. From the typical ESMR-derived oceanic rainfall map shown in Figure 1, it is seen that as we move eastwards along the equatorial belt in the Pacific, the ITCZ bifurcates in the neighborhood of longitude 170°E: the upper branch proceeds eastwards, maintaining itself slightly north of the Equator, whereas the lower branch runs east or southeastwards and merges with the southern Pacific convergence zone in the vicinity of longitude 160°W.

From the quantitative observations of rainfall over the oceans (derived from ESMR), zonally averaged rainfall rates were computed separately for each of the three major oceanic areas of the world, viz., the Pacific, the Atlantic and the Indian Oceans. Figure 2 reproduces the plot of the zonal averages of rainfall in the Pacific Ocean. This analysis confirms that the ITCZ splits in two during nearly all months of the year. However, it should be pointed out that the southern branch and its extension, the southern Pacific trough, attain their maximum development during the austral summer period (December through February).

(2) Previously Unrecognized Rain Area in the S. Atlantic

In the Atlantic, to the southeast of S. America, there is an extensive area of rainfall in the region approximately between latitudes 25°S and 50°S and longitudes 50°W and 25°W (see Fig. 1). This rainy region was not known before; it does not appear on any existing map of global rainfall, probably because few ships traverse the area. This rain area revealed in ESMR-derived maps is possibly an extension of the southern Pacific convergence zone mentioned previously. In other words, rainfall in the region could be produced by the same dynamical circulation pattern as the southern region of convergence, the flow being modified and the rain-pattern interrupted at the land protrusion of the S. American continent and an area to the immediate west of the land.

(3) The Bimodal Behavior of Rainbelts in the Indian Ocean

Zonally averaged rainfall rates in the Indian Ocean are displayed in Figure 3. Two distinct rain maxima are evident in the tropics between latitudes 20°N and 20°S (apart from a third extra-tropical maximum obviously related to the polar front, far to the south at about latitude 40°S). The maximum at northern latitudes appears to grow at the expense of the maximum immediately to the south of the Equator as the monsoon advances, and vice versa as it retreats. During June to August, the amplitude of the northern maximum is 3 times that of the other equatorial maximum, whereas during December to February, the southern tropical maximum grows in amplitude to 3 times the northern. This study leads to a modification of the beliefs of two schools of thought in tropical meteorology, one that the monsoon current is a progressive advance in the Indian Ocean from the Southern Hemisphere across the Equator to the Southeast Asian land-mass, and the other that monsoon rainfall is due to moisture picked up entirely in the Northern Hemisphere, mainly in the Arabian Sea. It seems necessary to postulate a circulation mechanism involving both the hemispheres, not necessarily demanding a regular progression of the entire monsoon air-stream from the Southern to the Northern Hemisphere, but affecting both in a coordinated way so as to sustain the bimodal changing wave pattern outlined above. This question is important (considering that the monsoon affects the lives of millions of people), and is under further investigation.

(4) Interannual Variation

The extent of variation of rainfall over the oceans from year to year has been largely a matter of conjecture until the present time. The weekly, monthly, seasonally, and annually averaged maps generated from ESMR data provide new insight into this problem. A typical example is the rainfall over the Pacific in the month of January of the years 1973 and 1974 (Fig. 4). In January 1973, intense rainfall occurred over a wide region along the Equator and to the south of it. This was at the time of the El Niño phenomenon (warm ocean current due to relaxation of upwelling along the coasts of Ecuador and Peru), with its disastrous effect on the plankton and fish in the waters of the Pacific off the west coast of S. America. In the corresponding month of 1974 (non-El Niño year), we see that the region was relatively dry. The ratio of rainfall in the Equatorial Pacific in the period December '73-February '74, to the rainfall in the period December '72-February '73 (see Fig. 2) is 1:6.

This is a distinctive example of rainfall anomaly. Investigations of similar anomalies and their correlations are very valuable in weather as well as climatic studies.

ACKNOWLEDGMENT. We thank Mr. William V. Abbott for his assistance in preparing the diagrams for this contribution.

REFERENCES

Rao, M. S. V., W. V. Abbott and J. S. Theon, 1976: "Satellite-Derived Global Oceanic Rainfall Atlas (1973-1974)," NASA Special Publication 410, 1976, p. 31.

Seelye, C. J., 1950: "Rainfall and Its Annual Variability Over the Central and Southwestern Pacific," New Zealand J. Sci. Tech., B 32, pp. 11-24.

GLOBAL OCEANIC RAINFALL RATE (AVG MM/HR)

JUNE 1973

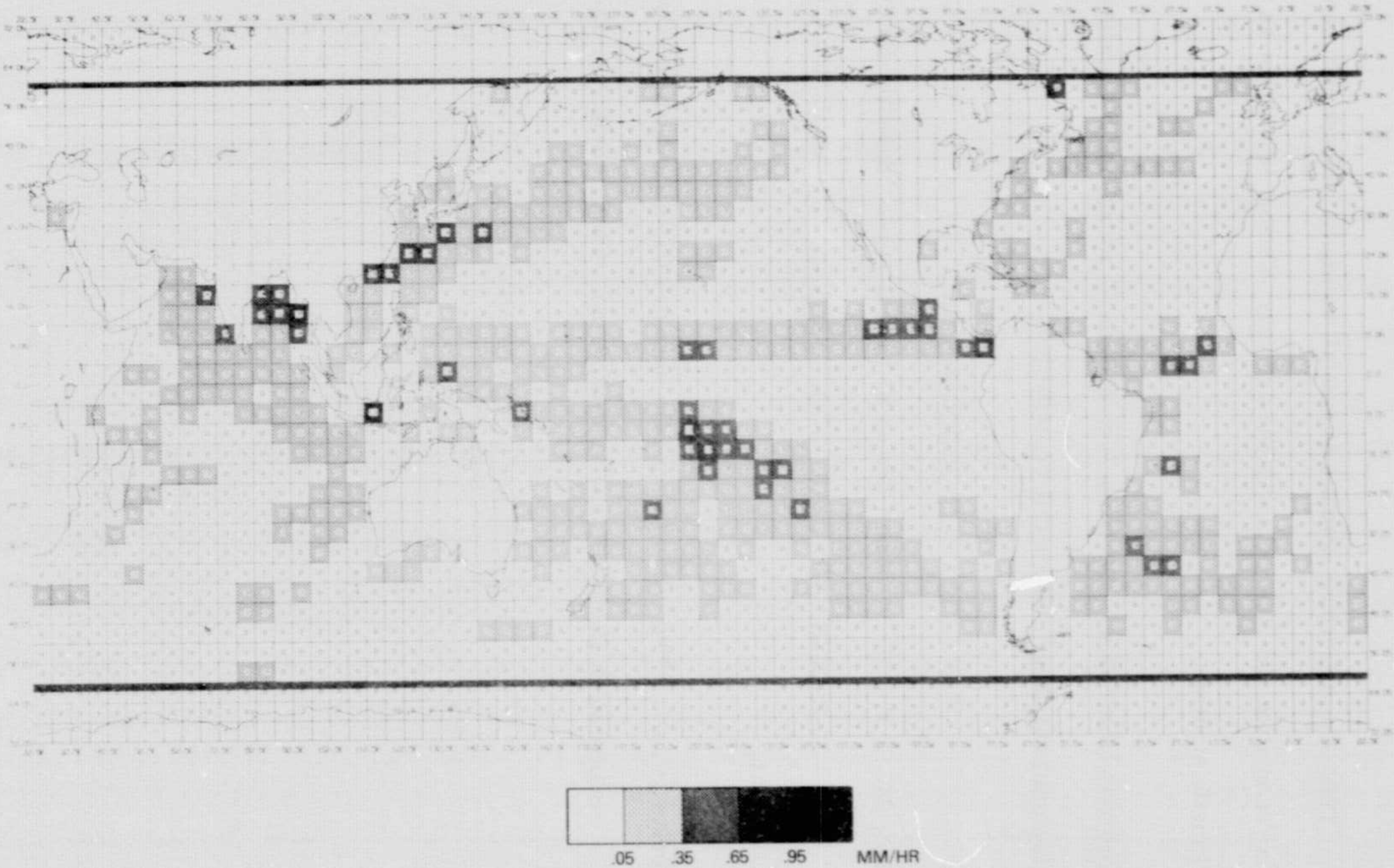

Figure 1. ESMR-derived global oceanic rainfall map, illustrating the forking of the ITCZ.

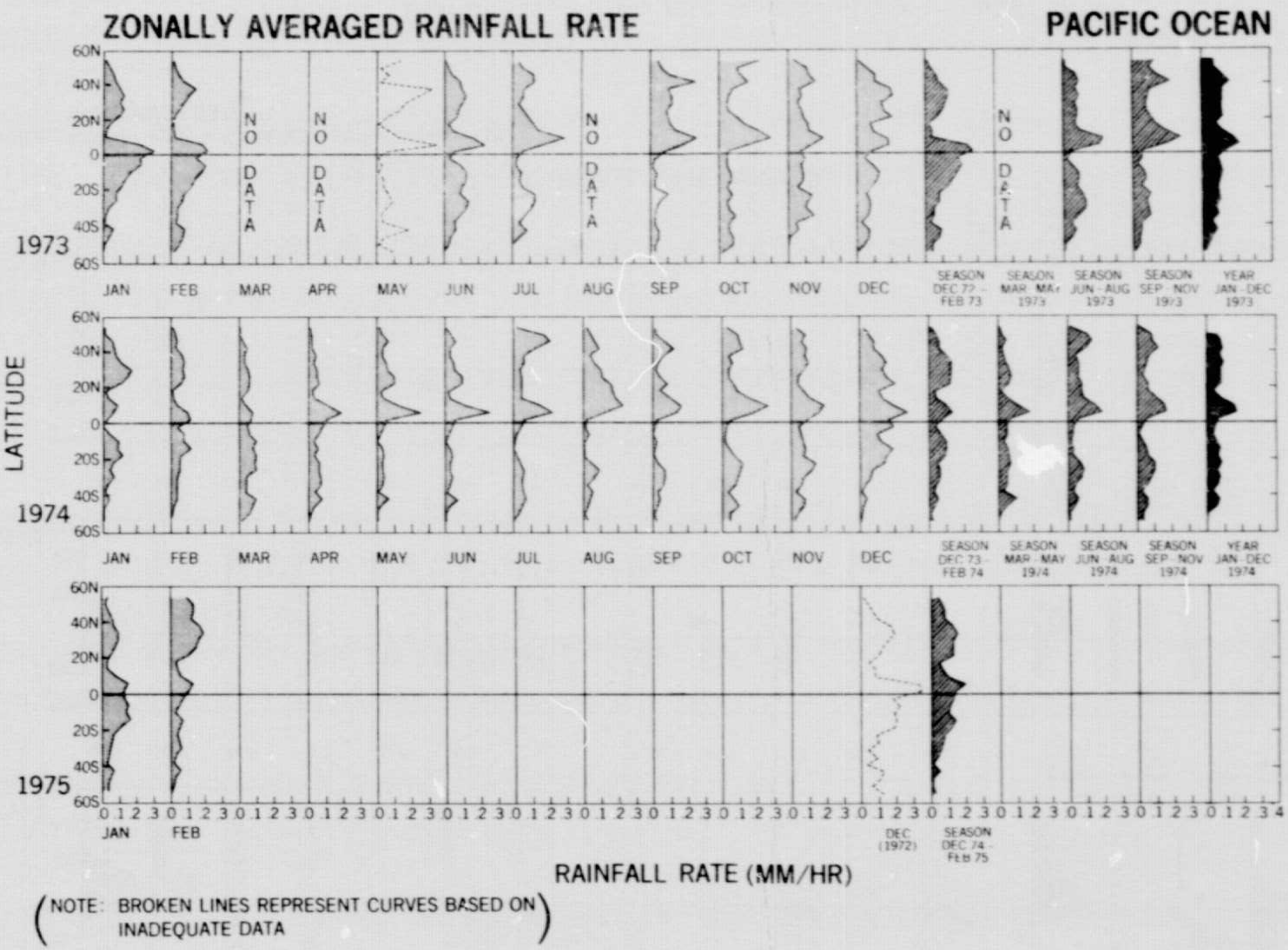

Figure 2. ESMR-derived rain-rate versus latitude — Pacific Ocean

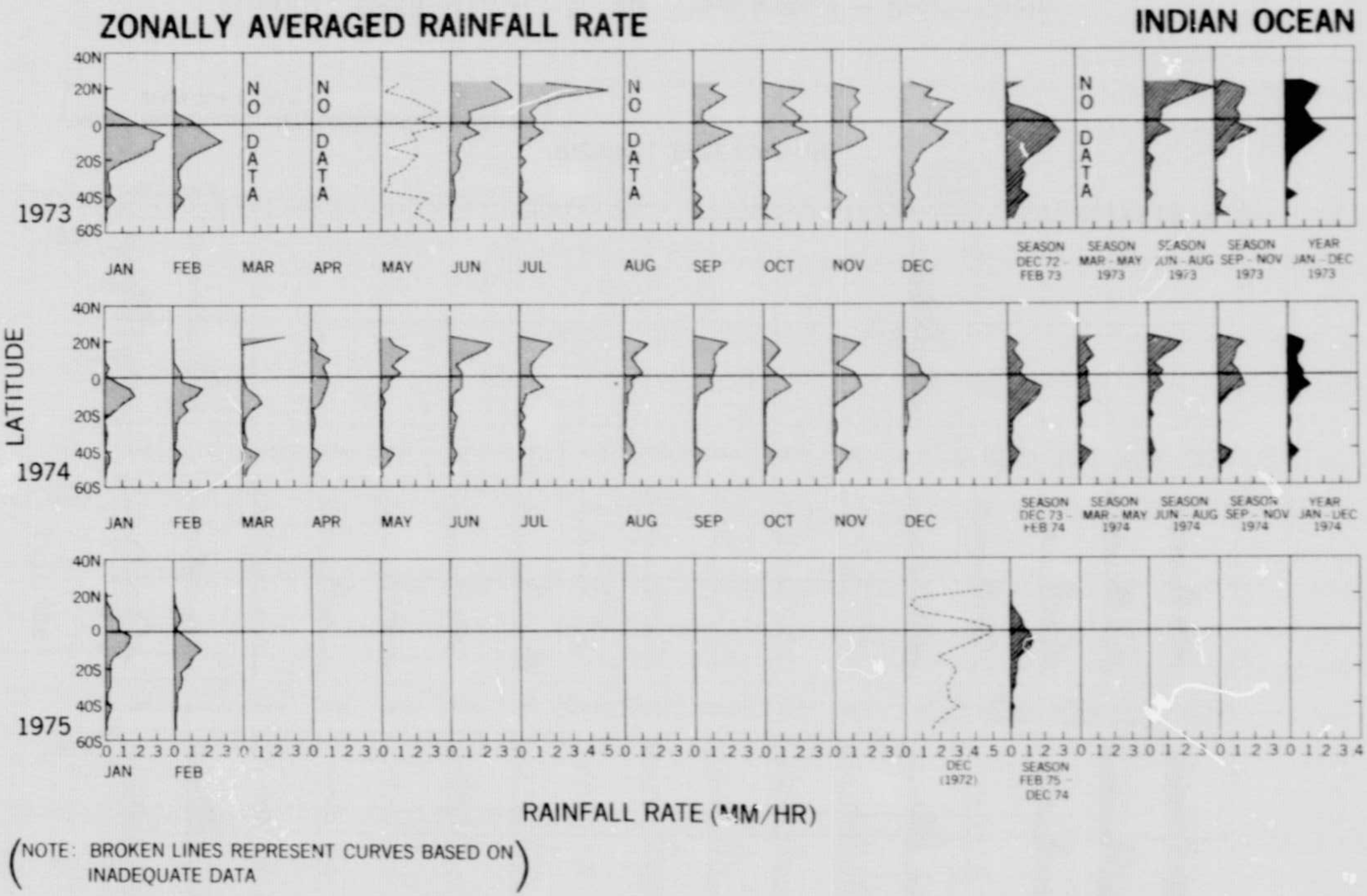

Figure 3. ESMR-derived rain-rate versus latitude — Indian Ocean

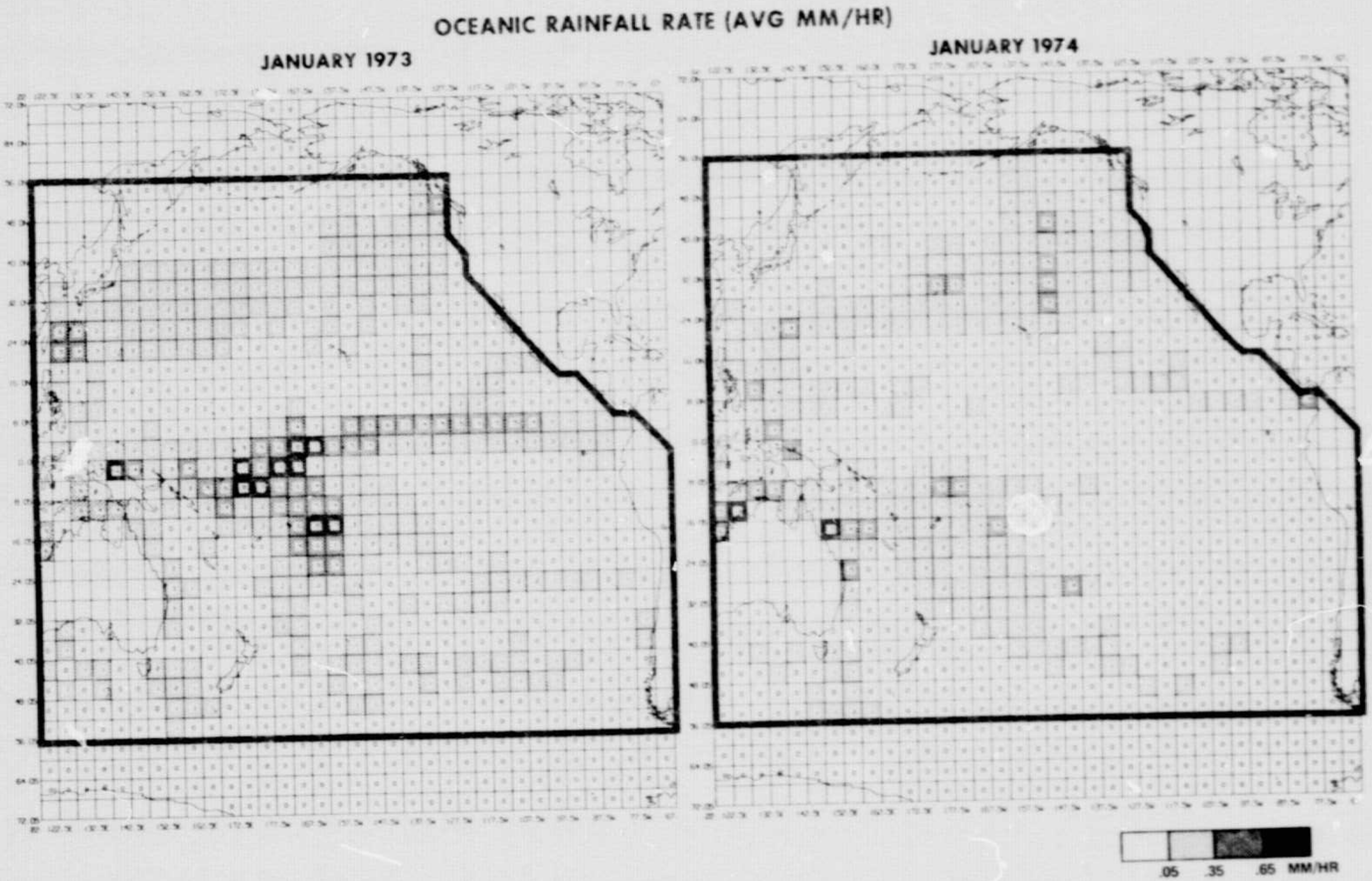

Figure 4. ESMR-derived Pacific Ocean rainfall maps for January 1973 (El Niño year) and January 1974 (non-El Niño year)