RAINFALL DETERMINATION BY USING THE AVHRR-NOAA SATELLITE CLOUD COVERAGE

OSAMA M. MOUSSA
Assistant Professor
Military Technical College
Kobry El-Kobba,
Cairo, Egypt.

ABSTRACT

During the last decade, the rainfall eroded large amount of soil surface of the Ethiopean Highlands. The main reason of that was the drought years that covered most of the North Eastern part of the African Continent. The climate of the Ethiopian Highlands is based upon atmospheric circulation which follows the tropical division (Hurst et al., 1931). The main objective of this research is to determine the relationship between rainfall amounts and the cloud coverage area. The Advanced Very High Resolution Radiometer (AVHRR) scenes were used to determine the cloud coverage areas. The regression analysis was carried out to determine the relationship between these two variables. Results offer a new tool for rainfall determination from cloud coverage, which extracted from space Imageries.

KEY WORDS: Hydrology, Image Interpretation, Remote Sensing Application, Space Imagery, Water Applications.

INTRODUCTION

The past drought in Ethiopia had resulted in a massive loss of vegetation within the watersheds of the Blue Nile and Atbara Rivers. Consequently, the rainfall eroded large amount of soil surface of the Ethiopean Highlands. The climatic features of the study area, Blue Nile in Ethiopia region, are based on atmospheric circulation which follows the tropical division (Hurst et al., 1931).

Due to the lack of rainfall observations for the study area (the Blue Nile Basin) during the storm period (August-October), the potential AVHRR data were used to determine the rainfall amount. The mean monthly rainfall data given by Henricksen, 1986 and Hielkema et al., 1986 were regressed with the monthly mean cloud coverage data, extracted from the AVHRR images of the drought years 1983-1984. The cloud coverage data were limited by the data which extracted from the available AVHRR scenes, processed images, for the months of August and September. The resulted regression rainfall models for months of August and September were found to be a logarithmic curve and second order power type curve, respectively.

RAINFALL OF THE STUDY AREA

The Abyssinian Plateau's climate varies with latitude, altitude and exposure or slope. The rainy season is extended from June until September (hurst et al., 1931). The west of Ethiopia receives higher rainfall than does the remainder of the country. Highland rainfall normally peaks in August in the administrative regions of Welo and the northern part of Shewa (Figure 1). Rains decreased over much of the highlands during September (Henricksen, 1986).

The available mean August (1984) rainfalls, for the Abyssinian Highland, were found to be 44 mm and 164 mm for Kombolcha (in Welo region) and Debre Markos (in Gojam region), respectively (henricksen, 1986).

Fig. 1 Map of the Regions of Ethiopia

Based on the mean monthly rainfall distribution over the study area, given by Thompson (1965), it was found that only two rainfall station, Ed Damazin and Abu Nama, in the Savanna Zone of Sudan had total rainfall values, 1 May - 30 Oct., of 677 mm, 322 mm for 1983 and 599 mm, 371 mm for 1984, respectively (Hielkema et al., 1986).

CLOUD COVERAGE DETERMINATION

The Ramtek Image Processing System interfaced with the A-Series computer was used to process AVHRR images, and to resampled fifteen-day geographically registered set of images onto a polar stereographic projection. The cloud coverage was represented by a low values of the normalized difference vegetation index (NDVI) which is generated from the red and near-infrared (NIR) bands, (NIR-red)/(NIR + red). The count numbers resulted from resampling the 15-day set of images range from 0 to 1023. The NDVI for each pixel was determined as follows:

$$\text{NDVI} = (\text{count number} - 511)/512. \quad \ldots\ldots\ldots \quad (1)$$

The cloud coverage appears as a dark areas in the available AVHRR images, about 20 scenes for the period of August/October of the drought years 1981-1985.

By using the aid of the electrical slide projector the areas of Lake Tana and cloud coverage, shown in each slide, were drawn. The magnification factor of the different scene was varied. The Planix 5000 Digitizing Area-Line Meter was used to measure the area of each dark spot as well as the Lake Tana boundaries.

Based on the mathematical interpolation procedure, the area of each dark area was determined in Km^2.

REGRESSION RAINFALL MODELS

According to the rainfall isohyets, given by Thompson (1965), for the Ethiopia and Sudan region, the mean monthly rainfall (in mm) for Ed Damazin and Abu Nama were determined for the months May-October as an average mean of the lower and upper values given by the isohyets. These values as well as the percentage of the total mean for each month are tabulated in Table 1.

Mean August and September rainfalls for Ed Damazin and Abu Nama (for 1983 and 1984) were determined from the resulted percentage of total rainfall, recorded in Table 1 and given as follows:

Table 1. Mean Monthly Rainfall (mm) and percentage of total (May, 1st - Oct. 30th)

Station \ Month	May	June	July	August	Sept.	Oct.	Total
Ed Damazin	75 (10.71)	150 (21.43)	150 (21.43)	150 (21.43)	150 (21.43)	25 (3.57)	700
Abu Nama	25 (4.35)	75 (13.04)	150 (26.09)	150 (26.09)	150 (26.09)	25 (4.35)	575

	Total (mm) May-Oct., 1983	Aug. & Sep.	Total (mm) May-Oct., 1984	Aug. & Sept.
Ed Damazine	677	145	599	128
Abu nama	322	84	371	97

Mean August rainfalls (in mm) for different stations, for the years 1983 and 1984, were regressed with the corresponding cloud coverage area (in Km^2). Also, the mean September rainfalls (in mm) for Ed Damazine and Abu Nama, for the years 1983 and 1984, were regressed with the available cloud coverage (Km^2) extracted from AVHRR scenes. The available rainfall (in mm) and the corresponding cloud coverage area (in Km^2) for each station and for the month of August and September were tabulated in tables 2 and 3, respectively.

RESULTS AND ANALYSIS

The resulted regression Rainfall models for the month of August and September during the drought years 1983 and 1984 were found as follows:

For month of August

$$R = 37.85 \ln (C_A) - 161.71 \quad \ldots\ldots\ldots\ldots \quad (2)$$

and for month of September

$$R = 81.76 + [5.8 + 0.5 (C_A)]^{1/2} \quad \ldots\ldots\ldots\ldots \quad (3)$$

Table 2. Rainfall Amount (in mm) and corresponding cloud coverage (in Km^2) for month of Aug.

Rainfall (mm)	Cloud coverage (Km^2)	Remarks, source of rainfall
164	7167.7335	Debre Markos - Aug., 1984 Henricksen, 1986
44	300.1243	Kombolcha - Aug., 1984 Henricksen, 1986
145	3081.9888	Ed Damazin-Aug., 1983 Hielkema et al., 1986
128	1322.5439	Ed Damazin-Aug., 1984 Hielkema et al., 1986

Table 3. Raifall Amount (in mm) and corresponding Cloud Coverage (in Km^2) for month of Sept.

Rainfall (mm)	Cloud coverage (Km^2)	Remarks, source (Hielkema et al., 1986)
145	7941.9213	Ed Damazine-Sept., 1983
128	4417.3825	Ed Damazine-Sept., 1984
97	344.9261	Abu-Nama-Sept., 1984
84	125.1704	Abu Nama-Sept., 1983

where R is the mean monthly rainfall in mm and C_A is the cloud coverage area in Km^2.
The best fitted curves for data of August and September are shown in Figures 2 and 3, respectively.

CONCLUSIONS AND RECOMMENDATIONS

The use of the AVHRR to predict mean monthly rainfall during the drought time will be of vital importance to hydrologists. The satellite images may be used to extract the cloud coverage area (in Km^2). Then, these data can be regressed with the corresponding mean monthly rainfall to determine the regression rainfall model for any place allover the world. It is recommended to use data of daily rainfall observations and the corresponding daily cloud coverage area for the same regions.

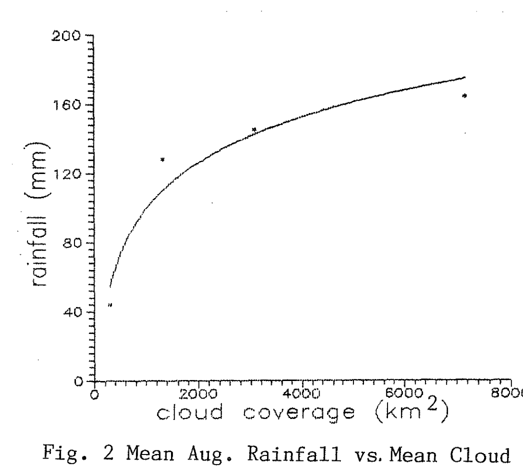

Fig. 2 Mean Aug. Rainfall vs. Mean Cloud Coverage for the Blue Nile Basin

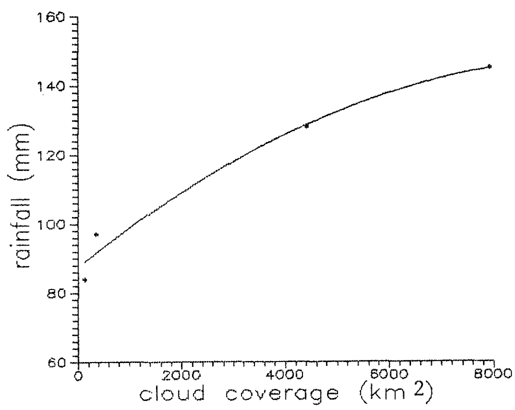

Fig. 3 Mean Sept. Rainfall vs. Mean Cloud Coverage for the Blue Nile Basin

REFERENCES

+ **Henricksen, B.L., 1986,** Reflections on drought: Ethiopia 1983-1984, International Journal of Remote Sesing, Vol. 7, No. 11, Nov. 1986, PP. 1447-1451.

+ **Hielkema, J.U., Prince, S.D., and ASTLE, W.L., 1986,** Rainfall and vegetation monitoring in the Savanna Zone of the Democratic Republic and Sudan Using the NOAA Advanced Very High Resolution Radiometer, International Journal of Remote Sansing, Vol. 7, No. 11, Nov. 1986, PP. 1499-1513.

+ **Hurst, H.E., and Philips, P., 1938,** The Nile Basin, Vol. V. The Hydrology of the Lake Plateau and Bahr el Jebel. Physical Department Paper No. 35, Schnidlers Press, Cairo, 235 PP.

+ **Thompson, B.W., 1965,** The Climate of Africa, oxford University Press.