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PARAMETERIZATION OF HYDROLOGICAL MODEL USING NOAA/AVHRR DATA

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Abstract -- The National Oceanic and Atmospheric Administration (NOAA) is currently developing a hydrological forecast system for the Nile river. Soil moisture capacity (SMC) is one of the parameters required to run this system. Lack of ground data permit us to simulate this parameter for only a few basins. Therefore, we attempted to use vegetation index as a tool for parameterization of the SMC. This paper presents these results.

Introduction.

The Nile is the main river of northeastern Africa which has considerable impact on economy, environment and human life of nine countries. Water resources and annual rhythm of the Nile river depend considerably on the environment, particularly on heavy tropical rainfall, their distribution, topography, and physical properties of soils in the entire Nile basin. NOAA is currently developing a hydrological forecast system for the Nile river which is based on a grid point distributed rainfall-runoff model. One of the important parameters required to run this model is the SMC which can be simulated base on hydrometeorological data. However, the amount of these data is very limited to cover the entire Nile basin. Therefore, polar orbiting satellite data were used in this study as a substitute for the SMC parameter.

Gridded Distribution Hydrological System (GDHS).

The forecasting system is based on the GDHS. It has a grid point structure with the hydrological sub-basins represented as connected grid points. Main component of the GDHS is a simple parametric water balance model which is based on the lumped parameter concept and probability theory to account for large orographic gradients in the environmental parameters and physical characteristics of the river basin, including some physical properties of soil (Schaake 1995. This model is used for each grid cell to simulate surface and sub-surface runoff.

The SMC is one of the most important parameter of soil properties, required to run the model. This parameter was obtained by calibrating the water balance model for 20 small basins (around 2,000 sq. km each) of the Blue Nile. Since the calibration area accounts for only ten percent of the entire Blue Nile basin, which provides more than half of the annual volume of the Nile flow, the attempt was made to simulate the SMC from ground data such as precipitation, potential evapotranspiration, soil characteristics, and topography. Unfortunately, the results of that were not successful (Table 1). In our further attempts we used vegetation index for SMC simulation.

NOAA/AVHRR Data as a Parameterization Tool.

Because soil moisture capacity (SMC) parameter reflects several physical and biophysical properties, such as soil type, composition, roots zone, volumetric weight, the Normalized Difference Vegetation Index (NDVI) was selected as an integral indicator of these properties. Nine years of NDVI values were collected for the region of Ethiopia plateau from the NOAA/NESDIS Global Vegetation Index (GVI) data set (Kidwell, 1990). The GVI is produced by sampling and mapping the 4 km AVHRR-derived radiance to a 16 km map base on a daily basis. The NDVI is calculated from visible (CH1) and near infrared (CH2) reflectance as (CH2-CH1)/(CH2+CH1). In order to minimize cloud effect, the daily maps of NDVI are composited over a 7 day period by saving the largest CH2-CH1 value during the 7 days for each map cell. The processing included also the application of post-launch calibration, noise reduction, and NDVI adjustment to take into account spatial differences in climate, vegetation type, and weather conditions (Kogan, 1995). Ecosystem resources of the Ethiopian plateau were estimated from maximum and minimum of NDVI calculated for each week and pixel from nine-year of data (Kogan, 1995). They were used as a criteria for calibrating the SMC.

Results and Discussion.

First, the maximum and minimum NDVI values were integrated during May-August which is the middle part of the growing season in the Northern hemisphere. The results of SMC calibration based on these values were not satisfactory. The analysis showed that the pick of the vegetation season in the Ethiopia plateau is shifted to the second half of the annual cycle, is changing in both directions north-south and west-east, and also dependents on elevation. Therefore, we started the integration of the NDVI extremes from the pick of the annual cycle. The time of this pick reflects spacial and topographic non-uniformity of the study area. Furthermore, we also attempted to incorporate temporal differences of the area. We integrated only the enhancing part of the annual NDVI curve in order to reflect the prime season of vegetation development. In addition, we tested several periods of integration: five, eight and eleven weeks. The best results were obtained when the SMC was correlated with the absolute minimum of NDVI averaged over five-week prior to its pick (Fig. 1). The values of the SMC for two outliers in the upper left corner, which represent Gummara and Ribb, are very high compared to the integrated NDVI. These basins are not representative because they are very small (several pixels) and located around lake Tana. The later create a problem in using NDVI for vegetation monitoring since the NDVI is composited from mixed pixels values both water and land.

Conclusion

The application of vegetation index as a parameterization tool will improve the described model, which, in turn, will provide a more accurate technique for monitoring water resources, short- and long-term forecasting runoff, and estimating trends in climatic parameters of the entire Nile basin which are important for regulating river condition.

Table 1. Correlation analysis for SMC and ground variables

Variable	Cor.Coef.	Mean Sq.Er.,mm
Rainfall	0.38	119
Elevation	0.52	201
PET	0.37	220

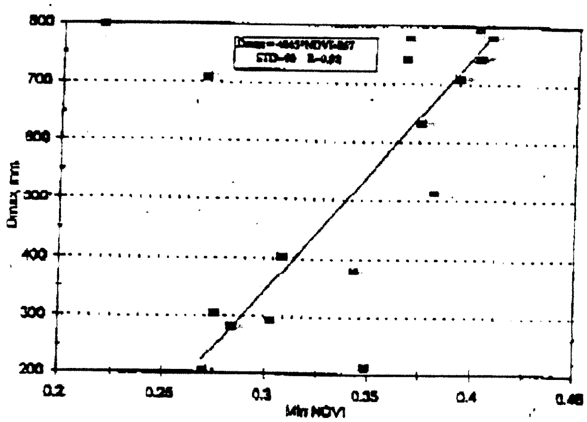

Fig. 1. Correlation of SMC (Dmax) with 9-year minimum NDVI averaged over 5 weeks prior to the seasonal maximum value.

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