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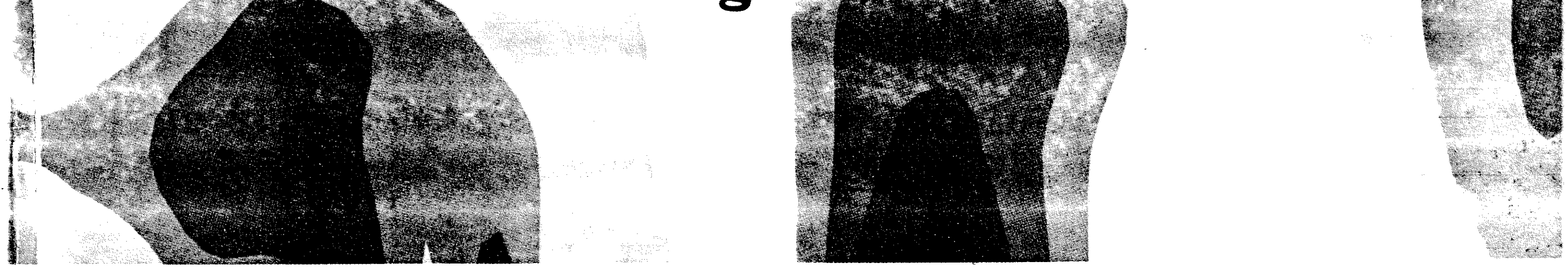

GEWEX — Global Energy and Water Cycle Experiment

WCRP — Project of the World Climate Research Programme

PARAMETER ESTIMATION OF LARGE-SCALE HYDROLOGICAL MODELS USING LAND SURFACE CHARACTERISTICS

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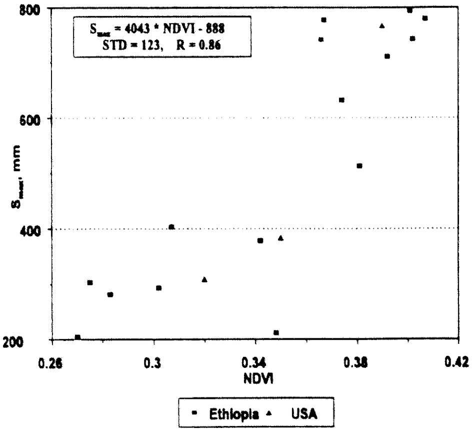
Introduction: One of key scientific objectives of the GEWEX Continental-Scale International Project (GCIP) is to develop and validate macroscale hydrological models, related high resolution atmospheric models and coupled hydrological-atmospheric models. How well these models represent the real world hydrological processes depends on how the model structures are formulated and how the model parameters are determined. Given the model structure, model parameters would take on different values according to local land surface characteristics. Procedures for estimating model parameters *a priori* according to vegetation and soil characteristics have been developed in the past for some model schemes. The effectiveness and reliability of such procedures are, however, largely unproven. Furthermore many such procedures rely on classifications of soil and vegetation characteristics that are too broad to be indicative of the local hydrological conditions. This study is aimed at developing improved methods of parameter estimation for large-scale hydrological models. The approach used is outlined below. Some preliminary and future research work is presented also.

Approach: The strategy for parameter estimation using land surface characteristics is outlined as follows. First, historical hydrological time series data (at least 10 years) and gridded fields of land surface characteristics (climate, soils, geology and vegetation) are collected for a large number of basins (>100). Second, the hydrological data are then used to calibrate the hydrological model to each individual basin. Third, statistical methods and other methods such as Artificial Neural Network are used to study the relationships between model parameters and land surface characteristics. The test basins are selected mostly from the Arkansas/Red River basin and the Columbia River basin. This outlined approach is used to investigate parameters of the Land Surface Subsystem of the Eta (Eta-LSS) model developed by National Centers for Environmental Prediction (NCEP), the Sacramento (SAC) model and the Simple Water Balance (SWB) model, both developed at the Office of Hydrology of the U.S. National Weather Service. The Eta-LSS is based primarily on the Soil Hydrology model of the Oregon State University (Mahrt and Pan, 1984). It considers both the energy and water flux exchanges within a soil column. Most of the parameters of the Eta-LSS are usually derived using the soil and vegetation classification information. The SAC model is a conceptually based rainfall-runoff model with many spatially lumped parameters (Burnash et al.,1973). The water budget is represented by equations based on strong physical justifications. The SWB was developed to fill a need for models with a small number of parameters and intermediate complexity between a simple bucket model and more complex many parametric models such as the SAC (Schaake et al., 1996). The SWB model was developed based on probabilistic averaging of the main hydrological processes and implicitly accounts for the spatial variability. Most of the SAC and SWB parameters have to be calibrated using historical data.

Preliminary Research: Some preliminary research has been conducted to test the feasibility of regional parameter estimation. The regional relationship between the parameters of the SWB model and the Normalized Difference Vegetation Index (NDVI) was investigated for selected basins in the Nile River basin, with area sizes ranging from 500 to 9000 km^2. The most important parameter of SWB, soil moisture capacity S_{max}, derived by calibration, was correlated to the long-term minimum NDVI values averaged over five weeks prior to its annual pick for each basin. Figure 1 displays the relationship between S_{max} and NDVI for the Nile River basins. Three basins representing dry, moderate, and wet regions in the USA were also plotted on that graph. This figure clearly indicated that there is a skill in NDVI as a variable to determine hydrological model parameters. However, the same type relationship was not found for more than 200 Columbia River basins, ranging from <200 km^2 to about 8000 km^2 in size, when the SAC model parameters, such as the total soil moisture capacity of the upper zone, was plotted versus NDVI. Other available climatological (precipitation, evaporation) data and land characteristics (vegetation type, soil type and texture, soil depth) did not show any apparent correlation to the SAC parameters either. One of the reasons that no relationships were found between SAC parameters and land surface characteristics for basins in Columbia River was that SAC parameters were sensitive to space/time scales. Another reason was that the space resolution of land surface data sets was not high enough to represent small basin averages. Therefore, more research is needed to understand space/time representativeness of land surface data sets like the vegetation index. Further, the scale/time dependency of model parameters should be considered as well.

Figure 1. S_{max} versus NDVI. The Blue Nile and selected USA basins



A sensitivity study was also conducted for the OSU model using *a priori* parameters estimated using soil texture data. The parameters were estimated for nine soil texture types using Clapp and Hornberger equations for soil hydraulic properties. Table 1 presents results of simulations for three different basins using each of nine soil class parameters. Mean square errors of daily runoff differ not much from one class to other.

Table 1. Mean square error of daily runoff, mm

River\Soil type	1	2	3	4	5	6	7	8	9
Bird Creek	1.46	1.48	1.49	1.50	1.53	1.50	1.44	1.49	1.46
Leaf River	1.47	1.81	2.01	1.56	1.86	1.76	1.75	1.62	1.47
French Broad	2.78	3.05	3.33	2.69	3.33	3.00	3.05	2.73	2.78

Future Research: A retrospective/historical hydrometeorologic data base is being established for the Arkansas/Red River basin to allow a more extensive model calibration study. The data base will provide historical daily and/or hourly precipitation, runoff and surface meteorological data. Gridded fields at various resolution of supporting land surface characteristics data such as climate, soils and vegetation information are also collected. A pilot study to produce and test model parameter estimates for pilot test locations selected from the Arkansas/Red River basin is being undertaken. The ultimate objective of this pilot study is to demonstrate the feasibility of regional parameter estimation approach on a large-scale area (LSA), and eventually on continental and global scales.

References:

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