COMMISSION OF EUROPEAN COMMUNITIES

AFORISM

A COMPREHENSIVE FORECASTING SYSTEM FOR FLOOD RISK MITIGATION AND CONTROL

NTUA-DWR, National Technical University of Athens

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1. OBJECTIVES

The research of NTUA-DWR has two basic lines within the framework of AFORISM: The study of intense, flood producing, rainfall and the study of rainfall-runoff models. The study of intense rainfall includes:

(a) analysis and modeling of the temporal structure of storm events at a point and areal (lumped) basis,
(b) construction of a stochastic rainfall generator by using disaggregation techniques, and
(c) application of the rainfall generator for generation of storm scenarios and testing of the model results.

Modern techniques, based on the theory of self-similar (scaling) processes are used for the modelling of the time distribution of rainfall (see Annex 4). In addition, the meteorological conditions of the area are considered in order to classify storm events by weather type. New disaggregation techniques which can be combined with the stochastic rainfall model and have simple structure and reduced sets of parameters are developed.

The second line of research is to evaluate the performance of several rainfall-runoff models with emphasis on their runoff production part. The transfer to the watershed's outlet is deliberately treated in a uniform way. The FDTF method is used to objectively estimate the ordinates of the Unit Hydrograph or Transfer Function. Thus, knowing the Transfer Function, different runoff production functions are calibrated. The performance of the models is compared with data sets from a few European basins. Two different situations for model operation are hypothesized: The first one corresponds to a continuous operation with inclusion of the recession periods. The second context of operations assumes that the model activates only when a flood event occurs. In the latter case the problem of model initialisation is properly addressed.

Parallel to the model testing we attempt to treat a problem related to data availability in more than one time scales. In Greece, as in many other countries, long periods of daily data exist, based on daily readings of non-recording gauges. Very often the installation of recording devices is related to a study of floods and the available small time-step data sets may accordingly be very short. The idea is the interconnection of a daily rainfall-runoff model with a short time-step (e.g. hourly) one and the extraction of information from the former to the latter. Both the event and the continuous-time model operation are explored with this scheme.

2. ACTIVITY

2.1 Data preparation

The first nine-month period of the of the project execution has been devoted to the construction of an appropriate data set for rainfall and rainfall-runoff modelling and testing. The Evinos River Basin at Poros Righaniou with an area of 884 km has been chosen as the area of study. The tasks of data collection, digitisation and entry into a regional data base and validation by standard techniques (e.g. linear regression) have been laborious as the data were in the form of charts. The following data sets have been constructed:

a. Hourly rainfall data of three rain recorders for a 20-year period.
b. Daily rainfall of six rain gauges for an about 30-year period.
c. Hourly runoff data at the outlet for 28 flood events.
d. Hourly runoff data at the outlet and maximum and minimum daily temperatures for a continuous 2-year period.
e. Daily runoff at the outlet for a 9-year period.
f. Daily mean temperature of 3 measuring stations, for a 9-year period (as in e.).

2.2 Rainfall modelling

In the framework of the rainfall analysis and modelling a scaling model for the temporal structure of a storm was developed. A data set of another area (Aliakmon river basin) was used during this phase of study, since the rainfall data set of Evinos basin was not ready during the initial period of the project execution.

Empirical analysis of the data suggested that statistical properties of storm rainfall within a homogeneous season have a well structured dependence on storm duration. For example, the mean and standard deviation of total storm depth increase with duration each according to a power law with the same exponent; the lag-one correlation coefficient of hourly rainfall depths increases with duration; and the decay rate of the autocorrelation function of hourly rainfall depths decreases with duration. Motivated by the first observation, a simple scaling model for rainfall intensity within a storm was hypothesized and was shown both analytically and empirically that such a model can explain reasonably well the observed statistical structure in the interior of storms providing thus an efficient parameterisation of storms of varying durations and total depths. This simple scaling model is also consistent with, and provides a theoretical basis for, the concept of mass curves (normalized cumulative storm depth vs. normalized cumulative time since the beginning of a storm) which are extensively used in hydrologic design. In contrast, popular stationary models of rainfall intensity are shown unable to capture the duration dependent statistical structure of storm depths and are also inconsistent with the concept of mass curves. A detailed presentation of this analysis is given in Annex 4.

2.1 Rainfall-runoff modelling

The SACRAMENTO model was applied on a daily time basis to the Evinos River Basin. The results seem to be useful within the framework of exploitation of the daily information with regard to the calibration and initialisation the same model on an hourly time basis. A detailed presentation of this application is given in Annex 2.

As a first step to calibrating various rainfall-runoff models, a Transfer Function or Unit Hydrograph was estimated by using 20 relatively short flood events extracted out of the 28 events that have been collected. The FDTF method was used and the results are presented in Annex 3.

3. FUTURE WORK

3.1 Rainfall modelling

The process of selecting intense rainfall events from the data of Evinos River Basin and classifying them by weather type is under way (see Annex 1). After the establishment of the final, classified into categories, data set, a stochastic analysis will be made separately for each category. A final model for the storm structure combining the results of the analysis will then be developed.

During the second year of the project, a disaggregation model compatible with the model of rainfall structure will be developed in parallel. After the two models are linked, computer programs for the rainfall generation and testing of results will be developed and applied.

3.2 Rainfall-runoff modelling

The process of testing different rainfall-runoff models is under way. After constructing an appropriate data set, setting-up the computer environment for model testing and performing a number of preliminary tests, much additional work remains to be done within the second year of the project. This includes :

- Calibration of the SACRAMENTO model on hourly continuous-time data. It is reminded that the same model has already been calibrated on daily data.
- Inclusion of the daily information in the hourly SACRAMENTO model (e.g. parameters of the slow response of the basin's hydrologic system) and evaluation of this information
- Extension of the above steps to other rainfall-runoff models such as the TANK or the XINANJIANG or the SSARR model.

In addition to the application to the Evinos River Basin, the above approach will be validated on one or two data sets from other European countries. The Reno River Basin in the Emiglia Romagna Region in Italy may be one of the test basins.