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Overview of Hydrology with Hydrological Models and Modeling

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Abstract **--The growing pressure on the world's fresh water resources is enforced by population growth that leads to conflicts between demands for different purposes. A main concern on water use is the conflict between the environment and other purposes like hydropower, irrigation for agriculture and domestic and industry water supply, where total flows are diverted without releasing water for ecological conservation. As a consequence, some of the common problems related to water faced by many countries are shortage, quality deterioration and flood impacts. Hence, utilization of integrated water resources management in a single system, which is built up by river basin, is an optimum way to handle the question of water. However, in many areas, when planning for balancing water demands major gaps exist on baseline knowledge of water resources. In order to bridge these gaps, hydro-logical models are among the available tools used to acquire adequate understanding of the characteristics of the river basin.**

I. INTRODUCTION

All manuscripts must be in English. These guidelines include complete descriptions of the fonts, spacing, and related information for producing your proceedings manuscripts. Hydrological models have become an indispensable tool for study of hydrological processes and the impact of modern anthropogenic factors on the hydrological system. Mathematical models that are governed by the laws for conservations of mass and momentum are used to describe the temporal and spatial variation of a hydrological system in the field on the basis of information concerning climate, land use and land cover, and hydrology. Modeling the hydrological response to various natural and anthropogenic forcing has the potential to contribute to the understanding of these physical processes, such as flow and transport in the surface and subsurface and the atmosphere land surface interaction[3]. Two types of hydrological models have been used in most applications: lumped conceptual models and physically based modes. A lumped model is generally applied in a single point or a region for the simulation of various hydrological processes. The parameters used in the lumped model represent spatially averaged characteristics in a hydrological system and are often unable to be directly compared with field measurements. In general, lumped models use simple bookkeeping procedures to quantify physical processes by simulating the temporal variation of various physical processes in a hydrological system. The advantage of these models over physically based models is that the conceptual parameterization in the models is simple and computation is efficient. With the availability of spatially distributed digital and remotely sensed data sets of features such as precipitation, elevation, vegetation,etc., many distributed lumped models have been developed in recent years. These kinds of models have been widely used in most climate and meteorological studies to model hydrological processes. Many physically based distributed-parameter models have been developed to facilitate various hydrological and climatic applications over recent years. These models represent hydrological processes in a physically rigorous manner because they use process based partial differential equations (PDEs) to describe the spatial variability of hydrological processes. One disadvantage of such models is that the representation of physical processes in these models is often too crude and the scales of measurement for many hydrological parameters are incompatible with the scales used in the models.

These physically based distributed models can be referred to as conceptual lumped models in some sense. The physically based models are more complex and require more computing time for solving PDEs numerically and considerable effort to master all their intricacies, such as model calibration[4].

For simulating the hydrological response (e.g., soil moisture) to climate forcing (e.g., storms and human-induced global warming), these models currently offer no advantage over the traditional conceptual lumped water-balance models. Physically based hydrological models are an important evolutionary step in representing hydrological processes and spatially distributed data.

II. MODELS

Although the hydrological cycle is a system that is fairly easy to grasp and understand, it is far from easy to quantify the processes in the system. In order to do this various types of hydrological models are used. The term “hydrological models” is here used in wide sense, meaning all models describing the hydrological cycle or its major parts. Variations in climate, topography, land types and land-use as well as various man-made interferences with the system make it very difficult to construct general models that treat the whole hydrological cycle in any given catchment in the world. Most models only treat a part of the cycle, e.g., runoff or groundwater-flow. Models developed in a certain climatic or geologic region often have difficulties when used in a different setting. Models are simplified systems that represent real systems. In the case of hydrological models the real system may be an entire river basin or parts of it (e.g., only the river itself, a small headwater catchment, or a soil column). Hydrological models can range from sand-filled boxes to complicated computer program. The first type is called scale models. In these the real system is reproduced on a reduced scale[1].The second type, where a number of equations stand for the real system, is termed mathematical (or symbolic) model. Hydrological models can also be classified into conceptual models and physically based models. The conceptual models are rough simplifications of reality, conceptualizing the ideas of important processes and simulating internal variables, such as soil moisture, by various types of response functions. In physically based models the processes are described by detailed physical equations. In practice-, even physically based models often have elements of empirical or conceptual equations. Hydrological models basically aim at giving figures to various flows in the hydrological system they also have an important role as pedagogical and research tools. In a model, all parameters have to be quantified and specified, preferable so that their value can be deduced from actual field measurements.

III. USE OF HYDROLOGICAL MODELS

Before Hydrological models have become increasingly important tools for the management of the water resources of the Baltic basin. They are used for flow forecasting to support reservoir operation, for flood protection, in spillway design studies and for many other purposes. Recently hydrological models have found a new role in studies of climate change impacts on water resources (Saelthun et al., 1998). Hydrological models are used for several practical purposes. Imagine a flood disaster: during the flood event a model may help to predict when and where there is a risk of flooding (e.g., which areas should be evacuated). After the flood, models may be used to quantify the risk that a flood of similar or larger magnitude will occur during the coming years and to decide what measures of flood protection may be needed for the future. Furthermore, models may help to understand the reasons for the magnitude of flood (e.g., if the flood was enlarged by human activities in the catchment).

Other types of hydrological models are used in planning of groundwater management. These models are often referred to as groundwater models or hydro-geological models. The Soil-Vegetation-Atmosphere Transfer (SVAT) models concentrate on the evaporation and heat exchange at the Earth's surface and have a wide use in plant production studies and also in climate modeling[2]. Hydrological models focus on the pathways and the actual fluxes of the water, but since water also is the main transport media in nature attention to the transported substances is becoming more and more important. Groundwater models, e.g., are often able to quantify the transport of dissolved substances as well, making them important tools in pollution studies. Runoff models are used as a basis for calculation of sediment transport and substances dissolved in the river water. Soil water flows calculated by SVAT models are used as the basis for transport of nutrients and pesticides.

IV. HYDROLOGICAL MODELS

A. Water balance simulation and prediction

Runoff models are probably what most hydrologists spontaneously refer to when discussing hydrological models. This was also the first branch in which models were used when computers became easily available in the 1970s. The basic principle in hydrological modeling is that the model is used to calculate river flow based on meteorological data, which are available in a basin or in its vicinity. Hydrological models include subroutines for the most significant hydrological processes, such as snow accumulation and melt at different power stations.

V. CONCEPTUALIZATION, MATHEMATICAL MODELS & MODEL DEVELOPMENT

Many conceptual and mathematical models have been developed to describe physical processes in time and space and various numerical schemes are available to solve various equations for the simulation of hydrological variables.

Data Preparation

Data preparation is a major fundamental part of hydrological modeling. The work involves compiling various available field and digital data sets and processing and integrating these data sets into models for hydrological simulations. Sources of data can various government agencies and institutes. With the availability of new technology, ground-based and remotely sensed data sets as well as data collected through traditional field methods have been used for hydrological modeling.

Model Calibration

Complexity in hydrological modeling over large space and long times has prompted a significant need for model calibration. Model calibration is a demonstration that the model is capable of reproducing field observed values of various hydrological variables (e.g., stream flow, soil moisture, and well observed ground water level).

Prediction

With the set of optimized hydraulic parameters from the model calibration, the calibrated model can be used to conduct predictive simulations. The predictive simulations can be driven by external forcing (e.g., climate change scenarios) to derive the system response to future events. Some climate and hydrology problems require the hydrological modeling to predict the system response for as many as thousands of years.

For instance, the risk assessment of contaminant transport in the storage of low-level nuclear wastes in arid regions requires prediction of the water flow in the unsaturated and saturated zones for 10 000 years. How good predictions are depends on how well the model is calibrated and how credible are future external forcings that are used to drive predictive simulations. Because of the nonlinearity of natural hydrological systems and simplified model structures as compared to the actual complex natural physical processes, the calibration process cannot guarantee that the global minimum can be found, and so the calibrated model could produce unrealistic results beyond the confident period. In general, the calibrated model should not be used to predict the system in the future longer than twice the period of model calibration with available field-observed data.

VI. CONCLUSION

A hydrological model is an approximation of the complex reality using a system concept. A system is a group of interacting or inter-dependent components forming a complex whole. The overall intent of the hydrologic system analysis is to study the system function and predict its output. The models treat the hydrological cycle as a system that comprises its different components as inputs like precipitation and outputs like runoff, using a set of equations that links the inputs and outputs.

VII. REFERENCES

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