The modelling of the water cycle within a GIS based SVAT-model framework

The process-oriented multiscale evapotranspiration model PROMET developed at the Institute of Geography, University of Munich, is applied for the Ammer basin (approx. 700 km²) in the alpine forelands of Germany. The physically based soil-vegetation-atmosphere-transfer model calculates hourly actual evapotranspiration rates along with the soil moisture for a 10-year time series. A rainfall-runoff model, based on an enhanced distributed TOPMODEL structure, is linked to the SVAT-model in order to provide a hydrological model covering the water-cycle at the basin scale. The model is driven with meteorological data taken from regular climatic stations of the German Weather Service. The necessary soil and plant parameters for the SVAT model were either measured in the testsite or taken from literature. The topographical parameters for the runoff model were derived from detailed digital terrain analysis. The major investigative goals of the study combine the understandig and application of basin inherent physical processes within a GIS based model framework such as the spatial distribution and temporal evolution of evapotranspiration and runoff patterns. Remotely sensed data, such as airborne SAR-interferometry and imaging spectrometry are involved in improving the actuality and accuracy of the parameters in use.

THROUGHFLOW VARIABILITY IN A SHALLOW FOREST SOIL ON A GLACIATED HILLSLOPE: IMPLICATIONS FOR MODELLING

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Many models of catchment hydrology incorporate the assumption that hillslope flow paths can be inferred from surface topography, i.e., that flow paths cross elevation contours at right angles. While this assumption provides computational efficiency, it has been brought into question by recent studies which have emphasized the role of bedrock topography (e.g. J.J. McDonnell, 1997, J. Hydrol. (N.Z.) 36:97-100). The present research investigated the controls on the pathways followed by throughflow in a forest soil underlain by relatively impermeable basal till. Throughflow was collected in a set of 9 troughs approximately 1-2 m in width at a road cut which exposed both the soil and underlying till, as well as for a 50-m-wide hillslope segment which included the trough outflow. A network of 37 piezometers was installed upslope of the troughs to determine saturated zone thickness and hydraulic gradients. Measurements were made throughout several storms. The results indicate that flow paths may not be reliably predicted from either surface or bedrock/till topography in macroporous forest soils, particularly at the small plot scale, due to lateral shunting of flow in macropores. Further research needs to address the density, orientation and connectivity of macropore systems, and whether these effects can be parameterized for modelling purposes.

SPECTRAL AND CROSS-SPECTRAL ANALYSIS OF THREE HYDROLOGICAL SYSTEMS

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Three agricultural catchments of about 5 km² located in France were studied using spectral and cross-spectral analysis of nitrate (NO_3) concentration in streamflow and discharge time series. The objective was to identify a transfer model and to evaluate an average residence time for water and nitrate for each catchment. The simple spectral analysis of NO_3 concentration revealed a unique and strong periodicity of one year for all catchments. The NO_3 concentration time series are always well correlated with discharge. However the time lag between the two time series is different for each catchment. This differentiation suggests specific hydrological controls of NO_3 exportation for each site. Either NO_3 is exported as soon as streamflow increases or exportation is delayed in comparaison of streamflow. For each catchment, we have also established the frequency response function (FRF) by the cross-spectral method between estimated NO_3 input and observed NO_3 output. By comparing the estimated FRF and FRF of theoretical transfer model, we have determined the mean residence time of NO_3. These residence times for NO_3, varying from 40 days to almost one year, are discussed in regard of field data and catchment description. This study shows that spectral and cross-spectral analysis are valuable and simple descriptive methods to get physical interpretation of water quality control in hydrological systems.

A CONCEPTUAL 10 DAYS WATER BALANCE MODEL WITH STEP WISE PARAMETER OPTIMZATION.

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Most of lumped Conceptual rainfall runoff models attempt to represent hydrological processes by mathematical equations and multiple layers of storages. These equations are sometimes over parameterized and moreover high correlation between parameters hinders identification of significance of a parameter. In this study a parsimonious lumped conceptual rainfall-runoff model for 10 days time step is described and among the parameters describing the model the base flow parameter is obtained by hydrograph analysis. The model structure consists of two interconnected layers of storages upper soil moisture and Groundwater storage. The upper storage is augmented by rainfall (infiltration) and depleted by evapotranspiration, inter-flow, and percolation to the underlying ground water storage. The groundwater storage is augmented by percolation and depleted by base flow. The link between the two layers and flow components generation are represented by fairly simple equations and water balance at a catchment scale. This model suit specially regions where two seasons rainy and dry seasons are easily identified to obtain the base flow parameter through hydrograph analysis. The model is applied to two semi-arid catchmenets, Awash (Ethiopia) and Miwmbashi (Zambia).

Modeling the Hydrological Patterns within a Hydrological-geochemistry Framework

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Using a physically-based topo-hydrological model, TOPMODEL, we investigated whether it is a sufficiently reliable conceptual tool to represent stormflow generation processes. The efficiency of TOPMODEL to represent internal hydrological processes within the basin was examined through confrontation of internal state variable predicted by TOPMODEL with tensiometer meausurements.
Having acknowledged the TOPMODEL modeling concept for the given catchment, to achieve a sound understanding of streamflow generation processes, we combined hydrological and hydrochemical methods within the TOPMODEL modeling framework in order to take into account both the hydrological and hydrochemical fluxes (chloride, potassium).
The proposed model was developed using the 'process' end-members - perched water table, recharge soil component and overland flow. Unlike the geochemical approach, the chemical signatures of these end-members were rather linked to the runoff generation processes than to the depths of origin. Beside the validation of TOPMODEL predictions of moisture status of the studied basin across the stormflow event, this study is intended to address the need for reconciling field results from a combined hydrological-geochemical approach.

ON THE USE OF THE DIFFUSIVE WAVE MODEL TO IDENTIFY GEOMORPHOLOGIC TRANSFER FUNCTION FROM DIGITAL ELEVATION MODELS

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Recently, several attempts have been made to relate the hydrological response of a catchment to its morphologic features. The aim of this paper is to present a methodology to automatically identify the transfer function, using digital elevation models for applications in distributed hydrological modelling. The transfer function proposed herein is based on the Hayami approximation solution of the diffusive wave equation. Digital elevation models were used to extract channel network and subdivide the basin into subcatchments. Each subcatchment produces, at its own outlet an impulse response which is routed to the outlet of the whole catchment using the diffusive wave model described by two parameters, celerity and diffusivity functions of geometrical characteristics of the channel network. First, a geomorphologic unit hydrograph obtained by routing an homogeneous effective rainfall was compared to the unit hydrograph identified by a lumped model scheme then the distributed model was applied to take into account the spatial variability of effective rainfall in the catchment. Results show that this new method seems to be adapted for distributed hydrological modelling; it enables to identify a transfer function response of each hydrological unit, here subcatchments, and then to simulate the contribution of each unit to the hydrograph at the outlet.