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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

# Hydrological modelling

## Evaluating the ECOMAG hydrological model for use in South Africa

A WRC-funded study has evaluated the application of the ECOMAG hydrological model in South Africa.

## Water resources management

The complexity of current approaches to water resource management poses many challenges. Water managers need to solve a range of interrelated water dilemmas, such as balancing water quantity and quality, flooding, drought, maintaining biodiversity and ecological functions and the supply of water services to people.

Water availability is highly variable in South Africa, both spatially and temporarily, with low runoff coefficients of less than 9% conversion of mean annual precipitation to mean annual runoff. With predictions of water scarcity conditions, caused by rapid population growth, expanding urbanisation, increased economic development and climate change, water looks set to become a limiting resource in southern Africa. The dynamics of demand and supply will have a large impact on the future socio-economic development of the region.

A mismatch also exists between resource availability and demand, with some of the greatest demand located in semi-arid areas, posing challenges for resource allocation. Thus, the reliable quantification of hydrological variables, such as rainfall and streamflow, is a prerequisite for mutually beneficial, cooperative and sustainable water resource management, planning and development within basins.

## Hydrological simulation models

Over the past few decades, hydrological simulation models have become standard tools for the generation of data, and have been used extensively in South Africa. As a result, water resource management, decision- and policy-making have been heavily dependent on model-generated information. Computer-based hydrological models of varying complexity have been developed during the past four decades for simulating the complex physical relationships that exist within a catchment during the rainfall-runoff phase of the hydrological cycle. the key reasons for that are twofold: a) improved models and methodologies are continuously emerging from the research community, and b) the demand for improved tools increases with the increasing pressure on water resources. It has therefore not been easy for the hydrologist or the water resources engineer to choose the right model for their particular problem.

Models are required partly because it is impractical to measure streamflow or groundwater at a sufficiently representative number of points to provide water resource management authorities with the information needed to quantify the availability of natural resources. They are also required because human activities constantly modify the natural environment, and it is essential to be able to obtain estimates of the impacts these modifications may have on the availability of water resources.

In a region such as South Africa where the natural availability of water is highly variable both in time and space and where the financial and human resources available to sustain long-term monitoring programmes are limited, practical hydrological estimation tools assume great importance. Models have therefore a great deal more to offer society than simply interesting scientific exercises and have the potential to contribute to the social and economic development of the country.

## Objective of this review

While a vast array of hydrological models is available, the choice of which one to use for a given basin is not easy. Each model works within specific spatial (field to basin) and

temporal (event based to annual water balances) boundaries, and can only simulate specific hydrological processes.

It is important to select the 'right' model for the 'right' kind of modelling exercise. Numerous criteria are used for informing the choice a hydrological model, or a suite of models, to use for an individual exercise or as part of a suite of models use for data generation, analysis, assessment, and decision-making with respect to national water resources.

Several well-conceptualised hydrological models are already in use in South Africa, the most common of which are the Pitman and the ACRU models. These two models have served well the many diverse requirements of the water sector in South Africa. However, once in a while some models come to the attention of the modelling society, and it is prudent that before these can be recommended for widespread use they be evaluated for their ability to assist planners in assessing different land-use scenarios.

## ECOMAG

In addition to the suite of models currently in use in the country, the Russian developed ECOMAG (ECOlogical Model for Applied Geophysics) model has been suggested as a possible candidate for use in South Africa. It is thus necessary to evaluate the suitability of the use of this model under South African conditions. This review assesses the applicability of the model in the country, and compares it with models currently used for the same purpose in order to make recommendations about adopting the model for local use.

ECOMAG was primarily constructed for solution of applied tasks of regional ecological monitoring. It is a fully distributed, physically-based catchment model that works at the region scale. It is contended that ECOMAG is an attempt at an integration of a 'physically-based representation of hydrological processes into a conceptual model' framework developed to work in data sparse regions.

The current version of ECOMAG consists of a hydrological and a geochemical module. The hydrological module is a representation and description of the main catchment hydrological processes, while the geochemical module dwells on surface accumulation of pollutants, their precipitation, dissolution and penetration into soil, interaction with soil solution and solid body, transfer of pollutants by surface, subsurface, ground and river flow.

The model's flexibility allows it to represent a drainage basin by either irregular elements or a regular grid network, which has, over the years, enabled relatively easier integration with groundwater models. Each element is considered as an individual hydrologic landscape unit characterised by specific topography, land use and soil types. In general, ECOMAG describes the processes of infiltration and evapotranspiration, soil heat and moisture properties, overland and subsurface flow, groundwater and river flow, snow accumulation and snowmelt at a daily time scale.

The model consists of a geographic information system (GIS) interface, databases of hydro-meteorological data in real-time and landscape description. The GIS interface is used in the 'model dimensional patterning of the river basin' using ArcView. The databases contain information on soil properties, land use, vegetation, pollutants, and hydro-meteorology.

## Conclusions following evaluation of the model

The most significant aspect arising from the review is the stark differences in the environment conditions between the region of model development and potential application in South Africa. Each model is constructed for, and to solve practical problems in, a particular environment.

The ECOMAG was developed specifically for the boreal environment, which implies that the processes conceptualised and represented in the model would be fundamentally boreal. Given that South African conditions are different, it is logical to expect that the ECOMAG model may not be set up for use in South Africa without fundamentally compromising conceptual integrity. This does not mean that it will fail to produce acceptable results, but the question needs to be ask if it would be modelling the processes in the right way.

In terms of process representation and outputs, there is very little to separate the ECOMAG from the local models. The project team, however, found insufficient evidence and data to suggest that the ECOMAG model will add any value to water resources assessment, as the local models cover the most significant bases, and their results have served the country well for the past four decades. On-going improvements of these models will make them better as process understanding is improved through targeted research.

**Further reading:**
To order the report, *ECOMAG: An evaluation for use in South Africa* (**Report No. TT 555/13**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za, or Visit: www.wrc.org.za to download a free copy.