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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

Climate change

Developing a stochastic rainfall model with applications to climate change

A completed Water Research Commission (WRC) study set out to develop a test a monthly non-parametric stochastic rainfall generator that would comprehensively incorporate climate change and changing variability.

Background

The planning and operation of most of the large water resource systems in South Africa has been applying a multi-site monthly streamflow generator since the 1990s, but it has recently been recognised that the use of stochastic rainfall generation may hold several advantages over stochastic streamflow generation.

Since rainfall is the main input into the hydrological cycle, applying stochastics on rainfall rather than streamflow is naturally more inclusive. With stochastic rainfall, probabilistic analysis can be included more realistically and easily in the analysis of catchment hydrological processes and rainfall-dependent activities, such as irrigation.

The impacts of climate change and increasing variability on basin hydrology and water resources can also be studied with more ease with a rainfall rather than a streamflow stochastic generator. Consequently, the Department of Water Affairs, now the Department of Water and Sanitation (DWS), commissioned the development of a prametric stochastic monthly rainfall generator (PEGRAIM-W).

Although parametric approaches have dominated stochastic hydrology, they exhibit several limitations in comparison to non-parametric approaches. They require the data to be fitted to specific probability distributions while non-parametric methods do not.

Parametric methods also typically use large numbers of parameters unlike most non-parametric methods. The ease of use and simplicity of some parametric methods has often led to their preference to parametric methods.

The development of an effective and efficient non-parametric rainfall generator is therefore likely to add significant value to water resources modelling in South Africa.

Climate change and stochastic modelling

As in other parts of the world, climate change is a major concern in South Africa. In South Africa, however, climate change impacts have not specifically been incorporated into the comprehensive probabilistic approach that is applied by DWS and its consultants in long term and operational planning of water resource systems.

Given this background, this WRC project set out to develop and test a monthly non-parametric stochastic rainfall generator that would comprehensively incorporate climate change and changing variability, including information from global climate change model projections. The project also compared the non-parametric generator with the parametric PEGRAIM-W generator.

Project outcomes

A literature review of stochastic hydrologic data generation (mainly rainfall and streamflow) was undertaken that enabled the selection of the non-parametric method to use. The Variable Length Bootstrap (VLB) approach that had previously been applied to streamflow generation was selected out of a group of 5 non-parametric methods.

A literature review on climate change and variability research revealed that global climate models fail to replicate long-term persistence and other important hydro-climatic characteristics.

The VLB generator adapted very well to rainfall generation as all the statistical measures were replicated reasonably well at the annual and monthly time scale. The VLB model performed better than PEGRAIM-W at the annual and monthly time scale although both VLB and PEGRAIM-W models were found to perform reasonably well for practical application.

The generation of stochastic rainfall for a wetter or drier or a more variable climate was achieved by appropriately biasing block selection based on the mean annual precipitation (MAP) of individual blocks. This approach was found to be effective and capable of generating sequences of highly varied characteristics (as quantified by the statistics).

It was demonstrated how the change on average MAP from global climate models can be achieved by simple iteration involving a single parameter of the block selection model. An approach for matching the monthly rainfall patterns to those of global climate models was developed and also demonstrated. The literature, however, revealed that global climate model projections are still highly uncertain and the methods developed here, therefore, allow for the generation of rainfalls for drier, wetter or more variable climate without the use of global climate models.

It is recommended that the VLB generator be tested for practical water resources systems studies. Furthermore, it is recommended that the climate change and variability modelling developed in this study be tested for climate change studies as it can effectively complement global climate change and/or regional circulation model rainfall outputs for a wide range of hydrological and water resources analysis.

It is likely that an effective daily stochastic rainfall generator can be developed by applying appropriate disaggregation to the monthly rainfalls generated by the VLB model, and this is proposed for future development.

Further reading:
To order the report, ***A non-parametric multi-site stochastic rainfall model with applications to climate change*** (**Report No. 2148/1/13**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.