March 2015
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

How will rain gauge measurement respond under climate change?

A completed Water Research Commission (WRC) project modelled daily rain-gauge network measurement responses under changing climate scenarios.

Background

Changes have been observed in the rainfall regime in South Africa. However, the pace of this change is not known as it is still subtle and the data is very noisy.

This WRC project specifically looked at gauge rainfall in relation to regional circulation model (RCM) rainfall estimates.

Status of rainfall regimes in SA

According to the WRC study there was a small change over South Africa from the decade 1990-2000 to the years 2000-2008 in terms of rainfall regime. Researchers observe change and can successfully model it, but they are not yet sure that what is observed is not just typical natural fluctuation.

Therefore, monitoring, frequent updates and analyses of data and most importantly adaptation are vital. As a result, maintenance of existing data monitoring networks is paramount.

We cannot manage on conjecture. Nor can we rely on remote sensing, because those estimates need conditioning on ground-based data.

Hence the need for the maintenance of existing and re-establishment of gauge networks measuring both rainfall and temperature. However, with what is available, researchers are confident in making some suggestions for the way forward, having devised the tools to monitor and model changes in the rainfall estimates offered by RCMs.

Main results

The final project report is based on two lines of research. The first is a study performed in Germany on four RCM records and

data from over 700 daily raingauges spanning 40 years over a large area (107 000 km^2). The principle outcome of interest there is that it showed that linking the rainfall regime to circulation patterns (CPs) of daily sea level atmospheric pressure, allowed researchers to effectively model the change in the rainfall regime, but at the 30 km spatial scale of the RCMs.

The lessons learned there were applied over South Africa, the difference being that here the RCM rainfall was downscaled to point measurements at the gauge-sites and direct validation of results was performed in a 'blind' study.

The results show that we can measure and model the change in the rainfall regime over 5 climatically different mesoscale regions in South Africa: the Western Cape (winter rainfall), the East London region (coastal supper temperate rainfall), central Free State (summer rainfall), the upper Vaal catchment (heavier summer rainfall) and Mpumalanga (East coastal subtropical).

Answering important rain vs climate related questions

The final report details answers to several questions.

1 How does one get a handle on the problem of monitoring and adapting to climate change?

When RCM rainfall estimates are downscaled, the amounts and occurrences of rain at gauges should be right. This can only be downscaled RCMs in this context where gauges are available. This is different from the usual idea of downscaling being the generation of a fine scale grid (covering the entire domain), using coarser resolution information.

2 What properties of data are needed?

It turns out that to link RCM and gauge data meaningfully the gauges should not be too sparse because they have a limited correlation length, beyond which they are not statistically linked; hence the importance of at least maintaining the current network and preferably growing it back to its earlier density.

3 How can the spatially averaged gauge data be related to the RCM block scale of about 50 km?

A special method of spatial block averaging is devised.

4 How can the information offered by RCMs be exploited?

It was established that rainfall regimes are captured by CP dependent RCM conditions – this was shown in Germany and confirmed in South Africa. Learning from the German experience it was identified that the sets of circulation patterns of atmospheric pressure at 700 hPa were better than sea level pressures at discriminating rainfall types.

This idea was applied part way through the study, and found that different CP sets affect the weather patterns in the 5 regions differently. Thus the CP sets are region dependent – one pattern does not fit all.

5 What are researchers looking for in 'good' gauge data and which RCM to choose?

For this study the PRECIS re-analyses data derived at the Climate Systems Analysis Group of the University of Cape Town was selected. Initial comparison of quantiles and correlations between block averaged gauge records and PRECIS data, before downscaling, showed that the RCM data were generally wetter than the gauges recording light rainfall and sometimes wetter than the gauge maxima.

6 How do we ensure that the PRECIS data is transformed to have the same characteristics as the block averaged gauge data?

Two procedures were required. The first was the decorrelation/recorrelation methodology devised in the final report. Second, this was followed by the quantile-quantile (QQ) downscaling from the block scale to the gauges. This combination was shown to be successful, and is the core of the methodology used here to decided where and how much the changes happen and under the umbrella of which CPs.

7 How practical are these ideas?

Of interest to hydrological practitioners and managers, is that the procedure can be adapted to produce a set of stochastically different downscaled rainfall sequences based on the RCM output. This has the benefit of determining the sensitivity of the output to the analysis method, giving realistic confidence in the results.

8 How to model the future?

The researchers carefully take the 'future' RCM rainfall output which they have in a validation period and downscale it

based on the recorrelation procedures and double QQ transforms that were introduced in this study.

9 How do we know that the modelling procedure captures change in the rainfall regime suggested by the RCM? How can we be sure?

This is achieved by comparing the downscaled daily rainfall at the networks with actual observations; firstly during a verification period and then using 'blind' data (not used in the downscaling procedure) in a validation period.

A range of statistics is checked to ensure that the features are right.

The body of the report relates the methodology in as visual a way as possible. Besides the organisation and cleansing of the data, the technical road to success was this work spent on developing the recorrelation methodology, which is completely original and at the core pf the project.

Further reading:
To order the report, ***Modelling rain-gauge network measurement responses under changing climate scenarios*** (**Report No. 1964/1/13**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.