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ESTIMATING DESIGN FLOODS FOR GAUGED URBAN CATCHMENTS UNDER CLIMATE CHANGE CONDITIONS
Case Study: Cooks River

The project involved extending a flood study to include a catchment sensitivity analysis for climate change using regionally downscaled rainfall. The focus was to compare how presently applied methods of IFD (Intensity Frequency Duration) scaling compared to rainfall and flow results derived from continuous simulation approaches from various Global Climate Models (GCMs). The outcomes of the project were based on adopting a regional downscaling model to directly downscale GCM rainfall sequences from a selection of the AR4 GCMs and then applying a non parametric disaggregation model to derive a stochastic series of fine scale rainfall data by the application of a statistical bootstrap. The project also looked at the non linear relationship between rainfall, flow and flood extents and a method with which continuous sequences of rainfall at fine time steps could be derived from GCM outputs for climate change flood studies. As a consequence, the relative merits of continuous simulation approaches compared to design rainfall (IFD) scaling were able to be assessed for the case study catchment (Cooks River, Sydney).

MAJOR FINDINGS AND OUTCOMES:

The hydrological model results identified that it is unreasonable to adopt simple scaling approaches to account for climate change variations due to all the uncertainties that underpin its examination. The continuous simulations showed large variability in terms of catchment flows, where IFD scaling methods of up to 30% only marginally captured the median values of the predicted flow ranges derived from the continuous simulations. This result highlights the limitations associated with the IFD scaling approaches and their assumptions about the exceedance probability of floods being directly relatable to the exceedance probability of the rainfall. The results from the hydraulic analysis of the Cooks River illustrated that the variability in the catchment flow is not reflected in the inundation of the catchment to the same order of magnitude. The results illuminate the inherent non-linear relationships between rainfall and flow, and, flow and flood inundation.

The study was subject to a cascade of uncertainties, which must be explored in future studies. There is a great deal of uncertainty entailed with the future climate and as there are no ways to certify the emission scenario or the ability of the model to simulate future climatic system, the model outputs should be taken as comparative rather than predictive outcomes until these issues are better addressed. The simple downscaling methodology used assumed that the complex weather-generating mechanisms, which produce rainfall in the future, operate in the same manner as the current climate paradigm. Linear scaling methods assume that the rain-producing mechanisms behave in the same way between the climate epochs and carry over the different meteorological regimes of the past. Even though looking at the trends in the relative changes (over direct and uncorrected GCM outputs) compensates for a part of the statistical biases of the GCMs, the length and statistical properties of the modified daily weather series are constrained by the variability of the historic weather sequences. The sensitivity of the results associated with adopting a different downscaling approach has not been investigated and should be explored further.

The Method Of Fragments disaggregation (MOF) model used assumes the temporal characteristics of the current climate and uses the logic that given the quantity of rainfall, estimates about the temporal pattern could be made for future rainfall based on making comparisons to similar rain days in the past. As this method relates the future magnitudes of rainfall to the current magnitudes of rainfall before adopting the historic fractions, the adequacy of the model is contingent on the different sub-daily temporal pattern. When used in conjunction with linear statistical downscaling methods, the input data fed into the MOF model assumes a sequence which is related to the historic rainfall sequence. This implies that the rainfall sequence used in the model, maintains the order of the rainfall and class structure as exactly those observed at the catchment gauge. This is a major drawback since the window of rain adopted from the disaggregation output (to feed into the hydrological model) will reflect the window observed in the historic sequence in terms of days with rain or no rain, thereby providing a biased and unlikely stochastic sequence.

The results from the study indicated a strong non-linear relationship however, the number of runs conducted for each GCM to produce the stochastic series, were not sufficient to make conclusions about the extent of uncertainty. Further applications of the method can be used to produce more convergent results for this relationship and make statistical inferences about the extent and nature of the non-linear relationship.

PROJECT SIGNIFICANCE TO ADAPTING AND PROTECTING AUSTRALIA'S SETTLEMENTS AND INFRASTRUCTURE:

Climate change has raised many questions about the reliability of design rainfall estimates based on historical records, and as such, provided the impetus for greater understanding of hydro-climatic systems such that the changes can be modeled given our understanding of the rain producing mechanisms. Most engineering applications of hydrology have opted to consider conservative, arbitrary values to account for climate variability with hydrological design, and have yet to adopt a formal unanimous policy as it entails many uncertainties. This study was able to look at how the occurrence and pattern of extreme flood producing rainfall will evolve with changed climatic regimes using the method of fragments approach. Although the sensitivity of using different methods was not tested, this study was able to provide insights about the applicability of the simple scaling methods for hydrological planning and design for climate change adaptation and how it may be unreasonable to adopt these approaches to account for climate change variations due to all the uncertainties that underpin its examination.

FURTHER RESEARCH SUGGESTIONS:

Future studies are recommended to quantify the magnitude of the uncertainties introduced at each stage of the climate change flood analysis to better capture the "true" variability. The dependability of the results from this study could be improved by reiterating the data with other downscaling methods to determine the variability of predictions for extreme daily rainfall for the future window. Future Studies can also seek to apply the MOF disaggregation model in conjunction with downscaled stochastic daily sequences which can provide more realisations of results (the historic data used for this study provides only one realisation of future climate per GCM, based on biased daily sequences). Stochastic inputs for the disaggregation runs will improve the model and more meaningfully represent future rainfall. Studies are required for other catchments across Australia to determine the nature of the relationships identified on a catchment by catchment basis.

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