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SCIENCE DIRECT®
Catena 61 (2005) 196–209
CATENA
www.elsevier.com/locate/catena

Adjustment of CLIGEN parameters to generate precipitation change scenarios in southeastern Australia

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Abstract

Global climate model predictions are often downscaled with stochastic weather generators to produce suitable climate change scenarios for impact analysis. Proportional adjustment to generated daily precipitation and direct adjustment to parameter values for weather generators have been used for assessing the impact of climate change on runoff and soil loss. Little is known of how these parameter values should be realistically adjusted, the amount of adjustment, and whether the adjustments are correlated among different parameters. Rainfall in southeastern Australia has significantly increased since the late 1940s. Rainfall records in Sydney show a similar trend. Long term daily and 6-min intensity data from Sydney have made it possible to examine how CLIGEN parameter values have changed in relation to the underlying significant increase in rainfall. This study shows that for Sydney, most of the increase in rainfall is a result of the increase in wet day precipitation. The increase in the standard deviation of wet-day precipitation is greater than that in the mean, implying a greater rainfall variability during wetter periods. The wet-following-wet transition probability, and maximum 30-min rainfall intensity are all positively and significantly correlated with the change in wet-day precipitation. The change in peak intensity is about half the change in rainfall. No significant relationship can be established between the changes in mean monthly rainfall and those in the skewness coefficient for wet day precipitation and wet following dry transition probability for the site. Simultaneous adjustment of all these parameters is needed for generation of precipitation change scenarios for the region. Using simple proportional adjustment to generated precipitation sequences would lead to maximum impacts on runoff and soil loss predicted with WEPP, while attributing precipitation

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doi:10.1016/j.catena.2005.03.004

change equally to the change in wet day precipitation and the number of wet days would underestimate the magnitude of the impacts considerably for the site.

Keywords: Climate change; Runoff; Soil erosion; Weather generator; Sydney

1. Introduction

Global Climate Models (GCMs) are widely used to predict the likely climate change as a result of the enhanced greenhouse effect. Output from GCMs is often too coarse at the sub-regional and sub-monthly scales for impact assessment. To have climate input at the appropriate spatial and temporal resolution, stochastic weather generators are commonly used to downscale climate change scenarios produced by Global Climate Models (GCMs) (Semenov and Barrow, 1997; Wilby and Wigley, 1997; Goodess and Palutikof, 1998; Wilby et al., 1998). These weather generators are particularly useful in producing the required climate input to drive crop, hydrologic, and soil erosion models (e.g. Xu, 1999; Prudhomme et al., 2002, Favis-Mortlock and Savabi, 1996; Pruski and Nearing, 2002a).

Soil erosion prediction model such as WEPP (Water Erosion Prediction Project) can be used to assess the likely impact on runoff, soil loss, and biomass production for given climate change scenarios. CLIGEN is a stochastic weather generator to produce the required climate input for WEPP. Of the ten daily weather variables generated by CLIGEN, the four precipitation-related variables are most important because predicted runoff and soil loss are most sensitive to them (Chaves and Nearing, 1991). To generate daily precipitation variables, CLIGEN requires 84 parameter values (Table 1). Two additional relevant parameters were set internally, hence not accessible to most users of the program. Typically CLIGEN and WEPP are run based on the current climate conditions first. Some of the CLIGEN parameters are then perturbed to simulate future climates (Pruski and Nearing, 2002a,b). Alternatively, observed or simulated rainfall or temperatures values can be adjusted directly to generate climate change scenarios (Favis-Mortlock and Savabi, 1996; Favis-Mortlock and Guerra, 1999). The difference in terms of

Table 1
Precipitation-related parameters for CLIGEN

Required parameters	Variable name	Number of values
Average precipitation on wet days for each month	meanP	12[a]
Standard deviation of daily precipitation for each month	sdP	12[a]
Coefficient of skewness of daily precipitation for each month	skP	12[a]
The probability of a wet day following a wet day for each month	$\Pr(W\|W)$	12[a]
The probability of a wet day following a dry day for each month	$\Pr(W\|D)$	12[a]
Average maximum 30-min peak intensity	MX.5P	12[a]
Cumulative distribution of the time to peak as a fraction of the storm duration[b]	timePk	12[b]

[a] One value for each month.
[b] The distribution is represented by 12 discrete values.