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A continuing drying trend has been observed in south-western Australia since the 1970's. Mean rainfall has fallen by 10 - 15% over this period. Corresponding streamflow has fallen by over 70%. The relationship between rainfall and runoff (usually potted as annual rainfall and runoff) has changed dramatically over the period of interest. Hydro-metric observations show that hydrological response is related to reduced catchment storage. A series of commonly used conceptual models have been tested across this period with disappointing results. In most cases the conceptual models cannot match the long term declining trend in runoff.

Inspired by these problems we present two modifications to GR4J, a commonly used rainfall-runoff model, that (i) allow the sensitivity of storage dependant evaporation and streamflow production to differ significantly, effectively mimicking 'catchment memory', and (ii) account for temporal variation in catchment vegetation cover, for example due to land use change. Results are shown for the original and two modified models on a forested headwater catchment in the south west of Australia. In this catchment, a dataset of more than 21,000 individual groundwater records collected over a period of more than 40 years chronicle a significant decline in catchment groundwater storage, resulting in a non-stationary streamflow regime. Furthermore we demonstrate the relationship between catchment observations (particularly catchment groundwater storage) and model behaviour. The model was tested further in eastern Australia across an extended drought period to test the ability of the model to cope with similar drying conditions.