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Ensemble modelling of runoff across southeast Australia and quantification of uncertainty

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Reliable information on current and future water availability are required to properly manage and share limited water resources. This paper describes an ensemble modelling approach used to estimate runoff for 0.05° x 0.05° grid cells (~ 5 km x 5 km) across southeast Australia. There are about 250 'unimpaired' streamflow gauging stations with more than 50 percent data from 1975 to 2006, and they cover less than 1 percent of the over one million square kilometres study region.

Several lumped conceptual daily rainfall-runoff models are used. Interpolated daily rainfall and potential evapotranspiration data for 0.05° grid cells are used to drive the models. For each grid cell, runoff can be estimated using any of the rainfall-runoff models with optimised parameter values from any of the gauged catchments. For the application here, an ensemble modelling approach is used where runoff for each grid cell is estimated as a weighted combination of the runoff from the different models using parameter values from different gauged catchments. The weights and the number of ensembles used are determined from cross-validation analyses of modelling results for the gauged catchments.

The models are calibrated to maximise the Nash-Sutcliffe efficiency of daily runoff with a bias constraint used to ensure that the total modelled runoff is within 5 percent of the total observed runoff. In the cross-validation analyses, each catchment is considered in turn as an 'ungauged' catchment, and runoff for that catchment is estimated using each of the models with optimised parameter values from each of the remaining gauged catchments. The Nash-Sutcliffe efficiencies of daily runoff and biases in the total runoff for each of the simulations are calculated. The results are then analysed to determine the models and characteristics of the donor catchments (whose parameter values are used) that give the better runoff simulations for the 'ungauged' catchments. The models and donor catchment characteristics considered include: the different rainfall-runoff models; quality of model calibration in the donor catchment; and catchment similarity measures (geographical proximity, precipitation, dryness index, terrain, stream density, woody vegetation, effective soil storage, soil transmissivity, etc...).

Based on the cross-validation analyses, weights are used to favour the choice of models and donor catchments to estimate runoff for an ungauged catchment or grid cell. As the runoff simulations come from a weighted ensemble of many simulations, the uncertainty in the runoff simulations can also be determined directly.