BARUMODEL : Combined Data Based Mechanistic models of runoff response in a managed rainforest catchment

Abstract

The impact of different forestry practices on headwater streams in the wet tropics is a serious environmental concern. Despite this, there are very few experimental catchment studies that quantify the hydrological impacts of specific tropical forestry operations. While new field studies are imperative, more could be gained from existing catchment studies by extracting information from the available time-series. Data Based Mechanistic (DBM) models can be used to extract hydrological information from such time-series by fitting a range of Transfer Function models using the simplified recursive instrumental variable (SRIV) algorithm and without a priori assumptions about the water pathways. An optimal model and its associated hydrological system parameters are then identified from objective statistical measures (e.g. View the MathML source, YIC) and only then by selection of that model with the most plausible physical explanation. While the DBM method has been applied to the relationship between rainfall input and streamflow output in tropical rainforests, it has never been used to simultaneously examine the relationships within rainfall–streamflow data and the component water pathways of overland flow, subsurface flow and transpiration. Modelling these component pathways is important to the understanding of likely changes in the rainfall–streamflow behaviour resulting from tropical forestry. We aim to show the value of our multiple component DBM models to simulate the sensitivity of stream behaviour to different densities of skidder vehicle trails within a managed rainforest in Borneo.

The first application of DBM modelling to the component water pathways of an equatorial rainforest catchment shows that the overall rainfall–streamflow response is flashy, with a residence time of 36.25 ± 0.19 min, when compared to other small catchments, but on minor aquifers. The overall response is, however, much less flashy in comparison to the infiltration-excess overland flow pathway which has a residence time of only 5.50 ± 0.09

min. The overland flow pathway is also less non-linear in its response in comparison to the subsurface pathway and overall response. A new DBM model of transpiration was found, and was similarly shown to give a rapid dynamic response to the input variable, in this case air temperature. The DBM approach indicated that higher order models (e.g. multiple subsurface pathways) were not statistically identifiable within any of the high frequency, 12-month time-series modelled. The first application of DBM modelling to land use/change scenarios in the same equatorial rainforest catchment suggested that the majority of the stream behaviour, in a period 7-years after selective logging, is insensitive to the skid trail densities associated with reduced impact logging (RIL) or clearfell systems in Malaysia. This is largely because of the relative insignificance of the overland flow pathway and the fact that changes in this pathway are predicted to occur on the rising stage of stream hydrographs, rather than at the more critical peak. While controversial, this result is consistent with our previous findings which show that some forestry impacts on hydrology are exaggerated in the popular perception.