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Comparison of baseflow separations based on tracers and recursive digital filters

Michael Stewart
GNS Science, Lower Hutt, New Zealand (m.stewart@gns.cri.nz)

Understanding the relative contributions of different sources of water to rivers is important for giving insight into hydrological processes and for management of surface and groundwater water resources. There can be a variety of water sources to rivers (e.g. Cartwright et al., 2014), however in this work, river flows are assumed to be dividable into quickflow (water that contributes to river flows quickly after rainfall events) and baseflow (water with longer residence times in the catchment that supplies the river between rainfall events). Many methods have been proposed to make this separation, and here tracer (i.e. isotope and chemical) hydrograph separations are taken as the reference for comparison (referred to as CMB for chemical mass balance below). Separation via several recursive digital filters are compared with the CMB for eight catchments covering a wide range of climatic settings, areas, topography, soils and vegetation (revisiting Chapman and Maxwell, 1996).
The digital filters tested were: 1. The BRM filter, which has parameters f describing rapid baseflow response to storm events, and k steady rise following events (Stewart, 2015). The parameters are determined by fitting to CMB separations. 2 The C & M filter, which is described as analogous to a low-pass filter (Chapman and Maxwell, 1996). Its parameters are determined by fitting to CMB. 3 The Eckhardt filter, which has parameters (a and BFImax) determined from catchment hydrogeological characteristics (Eckhardt, 2005). However, the Eckhardt filter is often used (and is used here) in hybrid form in which a is determined as a recession constant, and BFImax is determined by fitting to CMB. The Eckhardt filter becomes identical to the C & M filter when both parameters are obtained by fitting.
Application of the filters to the eight catchments showed that on average the three methods produced baseflow indexes (BFIs) within 6% of that of CMB. The quality of the fits to the CMB, however, varied strongly, with the BRM fitting the best with Nash Sutcliffe Efficiency (NSE) of 0.86 $\pm$ 0.14. The C & M fits were similar with NSE = 0.81 $\pm$ 0.12. However, the Eckardt fits were worse with NSE = 0.28 $\pm$ 0.34. Generally, an NSE = 0.65 or greater is taken to indicate an acceptable fit of a model to data.
This study has indicated that the BRM and C & M filters can adequately simulate tracer (CMB) baseflow separations.