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Similarity indices for hydro-climatology of diverse hydrological regimes

R. A. Woods

NIWA (National Institute of Water and Atmospheric Research), Christchurch, New Zealand
(r.woods@niwa.co.nz / Fax: +64 3-3485548 / Phone: +64 3-3488987)

Hydrological similarity indices are frequently used to provide measures of hillslope-scale similarity – this relatively high level of spatial detail implies that the processes being represented have a relatively short timescale. In this paper I present an overview of recently-developed similarity indices for catchment-scale hydrologic processes, in a variety of physically diverse settings. I use three settings which provide "end-members", where water storage occurs predominantly in one of three forms: (i) frozen water (snow-dominated regions) (ii) pore water (both unsaturated and saturated zones) (iii) open water (lakes and wetlands). In all three cases the similarity indices are derived by making numerous simplifying assumptions, relative to the full governing equations and the true heterogeneity.

Similarity variables for the three cases are quite different, reflecting the differing processes taking place. For frozen water, the similarity variables depend on temperature (mean, seasonality and intermittency), precipitation (mean, seasonality) and linkage of these by a melt factor. For pore water, the variables depend on precipitation (mean, seasonality and intermittency), potential evaporation (mean and seasonality), the maximum storage in the plant canopy and the soil, the ratio of soil conductivity to both typical event rainfall intensity and long-term average rainfall, the degree of nonlinearity in the storage-discharge characteristics of subsurface flow, and an exponent summarising the convergent nature of surface topography. For open water, the key variables are essentially a subset of those for pore water, but it is the storage-discharge characteristics of the water body, rather than the subsurface which play the key role.

The emphasis here is on deriving similarity variables which explain the hydro-climatology of various hydrologic processes, rather than the event-scale dynamics.

The strategy is to first establish an understanding of the longer timescales, so that processes with shorter timescales can later be embedded within this context.