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Regionalization of the Turc-Mezentsev water balance formula

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The Turc-Mezentsev water balance formula (Turc, 1954; Mezentsev, 1955) is widely used because of its simplicity and its efficiency:

Q/P=1-1/[1+(P/E0)**n]**(1/n)

With: Q-streamflow, P-catchment precipitation and E0-reference evaporation, all in mm/yr.

Several studies have used it recently as a tool to study the sensitivity of runoff to climate change (Dooge, 1992; Choudhury, 1999; Arora, 2002; Donohue et al., 2011). Other studies have focused on investigating the links between its parameter(s) and environmental properties (Oudin et al., 2008; Potter and Zhang, 2009; Roderick and Farquhar, 2011). There is however no consensus on where in the formula exogenous information (i.e. catchment properties beyond P and E0) should be introduced.
Here, we use a large set of 609 French catchments and discuss four options of regionalization, based on either (i) the formula's relative error, (ii) the formula's absolute error, (iii) a correcting factor of the aridity index and (iv) the shape factor (parameter n) of the formula. Here, regionalization is understood in its geographical meaning, i.e. we wish to make use of the regional coherence of the formula's residuals or parameters to improve its predictive efficiency. These regional options are tested in an ungaged catchment context, i.e. regional values (of residuals or parameters) are computed from neighbor catchments. In this study, we compare the four alternatives in terms of efficiency and robustness, i.e. on how their performance degrades when the hydrometric network density is reduced.
We show that although several mathematical solutions seem close, using a correcting factor of the aridity index has definite advantages. We also discuss perspectives beyond geographical regionalization, i.e. prospects for a physical regionalization.

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