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Rainfall–runoff modelling as a tool for constraining the re-analysis of daily precipitation and temperature fields in mountainous regions

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Abstract Hydrological modelling in mountainous regions, where catchment hydrology is heavily influenced by snow (and possibly ice) processes, is a challenging task. The intrinsic complexity of local processes is added to the difficulty of estimating spatially-distributed inputs such as rainfall and temperature, which often exhibit a high spatial heterogeneity that cannot be fully captured by the measurement network. Hence, an interpolation step is often required prior to the hydrological modelling step. In most cases, the reconstruction of meteorological forcings and the calibration of the hydrological model are done sequentially. The outputs of the hydrological model (discharge estimates) may give some insight on the quality of the reconstructed forcings used to feed it, but in this two-step approach it is not possible to easily feed the interpolation scheme back with the discrepancies between observed and simulated discharges. Yet, despite having undergone the rainfall–runoff (or snow–runoff) transformation, discharge at the outlet of a (sub)catchment is still an interesting integrator (spatial low-pass filter) of the forcing fields and is an ancillary areal information complementing the direct, point-scale data collected at raingauges. In this perspective, choosing the best interpolation scheme partly becomes an inverse hydrological problem. In this study, we present a one-step calibration strategy where the parameters of both the interpolation model (i.e. reconstruction procedure of meteorological forcings) and of the hydrological model (i.e. snow cover evolution, soil moisture accounting, and flow routing schemes) are jointly inferred in a multi-site and multi-variable approach, using a multi-objective evolutionary algorithm. Interpolated fields are daily rainfall and temperature, whereas hydrological prognostic variables consist of discharge and snow water equivalent (SWE) time series at several locations in the 3600 km^2 Upper Durance River catchment (French Alps).

Key words rainfall re-analysis; temperature reanalysis; geotatistics; rainfall–runoff modelling; multiobjective calibration; assimilation