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Simple process-led algorithms for simulating habitats (SPLASH v.2.0): robust calculations of water and energy fluxes in complex terrain

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Complex models suffer from a multiplicity of parameters, allowing many combinations of values to yield apparently acceptable results and thus entailing a risk of obtaining “right answers for wrong reasons”. Aiming to compute key components of the water and energy balances from readily available meteorological observations while reducing the need for free parameters, we propose new formulations to extend the SPLASH model of Davis et al. (2017, Geoscientific Model Development) to deal with complex topography. SPLASH is a parsimonious, multi-purpose set of algorithms designed principally for ecological and ecohydrological applications. Wherever possible we based model construction on first principles, attempting to balance realism with robustness. By adopting analytical rather than numerical solutions for many processes, we have been able to apply the model at high spatial resolution without unreasonably inflating computational demands – allowing us to include terrain effects directly in the calculations of water and energy fluxes. Slope and aspect were included in the analytical integrals originally used to compute accumulated energy fluxes through the day. Upslope area, the terrain-induced hydraulic gradient, and an analytical solution for the soil column transmittance were included in the calculations of subsurface water flow, following TOPMODEL ideas. Whenever empirical calculations were used (pedotransfer functions, albedo-snow cover functions), they were recalibrated using a combination of remote sensing data and globally distributed observational datasets. Simulations of soil water content, evapotranspiration and snow-water equivalent were compared against in situ measurements using diverse and combined data sources (including FLUXNET and SNOTEL). The statistical performance of the model was tested with pooled measurements from multiple stations. Global simulations were run at 5 km resolution and compared with remote-sensing retrievals and state-of-the-art land surface models.