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Simulation of water-energy fluxes through small-scale reservoir systems under limited data availability

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Small islands are regarded as promising areas for developing hybrid water-energy systems that combine multiple sources of renewable energy with pumped-storage facilities. Essential element of such systems is the water storage component (reservoir), which implements both flow and energy regulations. Apparently, the representation of the overall water-energy management problem requires the simulation of the operation of the reservoir system, which in turn requires a faithful estimation of water inflows and demands of water and energy. Yet, in small-scale reservoir systems, this task in far from straightforward, since both the availability and accuracy of associated information is generally very poor. For, in contrast to large-scale reservoir systems, for which it is quite easy to find systematic and reliable hydrological data, in the case of small systems such data may be minor or even totally missing. The stochastic approach is the unique means to account for input data uncertainties within the combined water-energy management problem. Using as example the Livadi reservoir, which is the pumped storage component of the small Aegean island of Astypalaia, Greece, we provide a simulation framework, comprising: (a) a stochastic model for generating synthetic rainfall and temperature time series; (b) a stochastic rainfall-runoff model, whose parameters cannot be inferred through calibration and, thus, they are represented as correlated random variables; (c) a stochastic model for estimating water supply and irrigation demands, based on simulated temperature and soil moisture, and (d) a daily operation model of the reservoir system, providing stochastic forecasts of water and energy outflows.

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