Modular Assessment of Rainfall–Runoff Models Toolbox (MARRMoT) v2.1: better, faster and more accessible hydrological modelling through object-oriented programming.

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The Modular Assessment of Rainfall–Runoff Models Toolbox (MARRMoT) is a flexible framework for hydrological modelling designed for model intercomparison studies and hypothesis testing. It reproduces 47 established conceptual hydrologic models of varying complexity including Sacramento, HBV, GR4j, VIC and TOPMODEL, amongst others. The package also allows to modify them or create new ones by mixing-and-matching components and modules from different models. We radically restructured MARRMoT compared to versions v1.x using an object-oriented programming approach to enhance code clarity and computational efficiency.

MARRMoT v2.1 is structured around two hierarchical classes, where a high-level superclass provides the template of all common model operations, while model-specific code is defined into individual subclasses derived from the single superclass. This reduces the verbosity and repetitiveness of the code, improving readability and facilitating debugging. Additionally, it simplifies the procedure to modify model structures or create new ones, also ensuring that best practices for solving model equations are followed as these are contained in the definition of the superclass and deployed automatically across all models.

We also updated MARRMoT's numerical solving routine by including a Newton-Raphson solver. This lets us obtain satisfying solutions to the implicit Euler approximations of the models' differential equations in a number of cases where the previous solving routine had failed, while also obtaining a 2.6-fold runtime improvement on average. We tested these changes by comparing outputs of 36 of the models in the framework between this object-oriented version and the previous version (v1.4) using calibrated parameters and climate inputs from the CAMELS US dataset.

The new version of the toolbox (v2.1) and user manual, including several workflow examples for common application, is available from GitHub (https://github.com/wknoben/MARRMoT).