The GEOframe system: a modular, expandible, open-source system for doing hydrology by computer according to the open science paradigms.

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The scope of this work is to present new insights of the GEOframe system. GEOframe is an open-source, semi-distributed, component-based hydrological modeling system. It is developed in Java and in Python and based on the environmental modeling framework Object Modeling System V3 (OMS3). Each part of the hydrological cycle is implemented in a self-contained building block, commonly called component. Components can be joined together to obtain multiple modeling solutions that can accomplish from simple to very complicated tasks. More than 50 components are available for the estimation of all the variables of the hydrological cycle. Starting from the geomorphic and DEM analyses, GEOframe allows the spatial interpolation of the meteorological forcing data, the simulation of the radiation budget, the estimation of the ET and of the snow processes. Runoff production is performed by using the Embedded Reservoir Model (ERM) or a combination of its reservoirs. Model parameters can be calibrated using two algorithms and several objective functions. The graph-based structure, called NET3, is employed for the management of process simulations. NET3 is designed using a river network/graph structure analogy, where each HRU is a node of the graph, and the channel links are the connections between the nodes. In any NET3 node, a different modeling solution can be implemented and nodes (HRUs or channels) can be connected or disconnected at run time through scripting. Thanks to its solid informatics infrastructure and physical base, GEOframe proved a great flexibility and a great robustness in several applications, from small to big scale catchments. GEOframe is open source, is chain of development is based on open source products, and its codes are engineered to be inspectionable. This because it helps the reproducibility and replicability of research. Developers and users can easily collaborate, share documentation, and archive examples and data within the GEOframe community. We believe that these are a priori condition to verify the reliability and the robustness of models. GEOframe modular structure allows for the fair comparison of model structure units and algorithms implementations because just the component performing that specific task has to be changed. In this contribution we list the components available and discuss some applications at different scales whit different modeling tools which return what we think realistic results. We show that there exist no perfect model of a
process but that the modelling art and science can be made more evolutionary even when they are revolutionary.