Implementing a travel time model for the water and energy budgets of complex catchments: Theory, software, and a preliminary application to the Posina River

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Abstract. Estimation of travel times of water and associated variables in catchments is important for treatment of natural tracers, temperature, nutrients or pollutants. With the recent advances and routine use of tracers, the travel time of water flows has been investigated widely. However, in our opinion, the extremely fast development of the theory has obscured some conceptual parts. This paper purpose is therefore to clarify notation and fully explain concepts, to better bridge old and new theories, and to show how it can be applied to catchment analysis and modelling. To this aim, we focused on estimation of outflows, at an hourly time-step, and water age of Posina River, a 116 km^2 catchment in the northern Italy. The modelling solution presented is based on small hydrologic response units and, for each of them, we solve the hydrological budget, including snowfall and melting, and runoff production, evapotranspiration. A semi-distributed hydrological system called JGrass-NewAge is used to model and forecast the hydrology and related resources. It is deployed using the object modeling system (OMS version 3), JGrasstools, and Geotools. NewAge is comprised of components, which can be connected at run-time, to provide a variety of modelling solutions. Different hydrological components simulate different hydrological processes, or simply model tasks as human actions. The framework is well suited to estimate impacts of the climate and land-use changes. In order to expand the possibilities of JGrass-NewAge, in this work we developed some new components to integrate the theory of transport for travel times that we coupled with the existing hydrological components. The hydrological budget of the river is therefore presented, and travel time distributions of water are also discussed.

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