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Modelling daily DOC concentrations in a agricultural headwater catchment: test of simple hypotheses

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The controls of DOC concentrations in headwater streams are actively investigated to understand how the current and future changes in climate and landuses may affect the fluxes of soluble organic compounds and associated elements. Most studies agree that saturated areas in bottomlands play a major part as a source of DOC, but the dynamics of the production, decay and delivery to the streams are not fully understood, and may vary depending on the physiographic context. Secondarily, in-stream DOC production can affect the concentrations in summer and fall. The complexity of the processes involved and the time and space scales of variations justify the use of modelling approaches to investigate these issues. A few simple models of DOC variations at the catchment scale have been implemented and tested locally, but a limited number of conceptual assumptions have been tested so far. In this study, based on a long-term (9 years), high frequency (daily) monitoring of DOC in a headwater agricultural catchment in Western France, several hypotheses on the processes controlling the concentrations in the stream have been tested using a simple, semi-distributed model. Like in previous studies, the hydrological model framework used is TOPMODEL, owing to its ability of simulating the dynamics of the saturated areas. The stream discharge has been separated in three endmembers, namely overland flow, shallow lateral flow in saturated zones, and groundwater flow. We tested three types of hypotheses. First, two different formalisms have been used to relate the extension of the saturated areas given by TOPMODEL to their contribution in terms of shallow lateral flow, one based on the average saturation deficit of the catchment, the other based on the local saturation deficit of the saturated zone. Second, the DOC concentrations in the three endmembers have been either considered constant or have been depleted according to the flux of water during the cold season, to simulate an exhaustion of the DOC store. Thirdly, an in-stream DOC production function has been introduced.

The different models are able to simulate the main features of the DOC variations over the monitoring period, i.e., the increase of concentrations during storm events (due to concentrations in overland and shallow flow higher than in groundwater flow) and the relative stability of the mean annual concentrations. The results show that (i) the simplest model is able to reproduced the major features of DOC variations, which demonstrates the predominant role of the fluxes from the riparian saturated zone (2) the DOC store exhaustion need to be simulated during the wettest winters only, which shows that this store is quantitively important and/or continuously replenished, even during the cold season, and (3) the in-stream production accounts for the increase of concentration observed in late summer/early fall, but its contribution is short lived and of little importance in terms of fluxes.