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Using the stream order to model the internal structure and function of the wetlands within a catchment from the headwater to the sea

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The Strahler stream order is a well known indicator ranking rivers, stretches, catchments and sub-catchments. It is widely used in one hand for geomorphology and in a second hand for hydrobiological purposes. We attempt here to extent the use of the stream order as a relevant indicator for modelling the spatial distribution of the hydromorphic soils – or the valley bottom wetlands – and the buffering efficiency of these wetlands. This attempt was illustrated by 2 case studies: the Vilaine River, 10 000 km^2 and the Scorff River, 400 km^2.

a) Many researches have been done for predicting the occurrence of hydromorphic soils in small catchments, based on a simple topographic index taking into account the local slope and the upslope drainage area, as defined for instance by Beven & Kirkby (1979). In our study, this simple topographic index modelling predicts an increase in hydromorphy in high-order channel settings (orders 6–7). By contrast, field mapping suggests that hydromorphic zone extent remains stable with increasing order and decreases significantly for high-order settings (orders 6–7).

Therefore, topographic index modelling appears effective in upper catchment settings (1st, 2nd and 3rd order). On the contrary, modelling efficiency is limited in high-order settings where the indices prove to be inappropriate: in such contexts, interactions between adjacent hillslope and hydromorphic zone are of secondary importance. In high-order settings, the fine-scale valley bottomland topography and the spatial organisation of deposits control waterlogging duration and possibly play a major role in hydromorphic zone extent. Finally, the integration of stream order data should considerably improve the efficiency of modelling the spatial distribution of soils over large catchments.

b) In the second case, our study aims to assess the role of wetland and river systems, in relation with the seasons and stream order, in buffering the fluxes and concentrations of nitrate in a 400 km agricultural catchment. A statistical analysis allows us to identify the relations between these characteristics and the nitrate fluxes and concentrations.

The two main factors identified as controlling annual nitrate fluxes are on the one hand, the nitrogen surplus derived from agricultural activities and, on the other hand, the system comprising the wetland zone and adjoining watercourses. This latter factor exhibits a depletion of nitrate fluxes proportional to the surface-area of the riparian wetland and the flowpath distance of these fluxes in the stream network. The buffer role of riparian wetlands and rivers is more important during periods of low water level and for high stream orders. This dependence on stream order can be explained by the landscape structure, the increased mean length of in-stream watercourse in the drainage network, and the joint processes.

In these 2 cases, we observed a change in the controlling factors: interactions between adjacent hillslope and hydromorphic zone become progressively weak when the stream order increases and, in reverse, the impact of local bottomland topography and the exchange with the stream increase.

Finally, the integration of stream order data to understand and model the structure and the function of catchments in geomorphology, but also in soil science, geochemistry, and hydrology is a relevant tool to capture their heterogeneity at different scales.