Mapd'O - A new tool for visualization and hydromorphological analysis of river corridor networks at the national scale

Mapd'O - Un nouvel outil pour la visualisation et l'analyse hydromorphologique des réseaux fluviaux à l'échelle nationale

L. Helling[1], S. Dunesme[1], L. Vaudor[1], H. Piégay[1], L. Manière[2], G. Melun[3]

[1] UMR 5600 EVS-Biogéophile, ENS de Lyon - *leo.helling@ens-lyon.fr, samuel.dunesme@ens-lyon.fr, lise.vaudor@ens-lyon.fr, herve.piegay@ens-lyon.fr*
[2] National Research Institute of Science and Technology for Environment and Agriculture, Université de Tours
[3] Research and Scientific Support Department, French National Agency for Biodiversity - *gabriel.melun@ofb.gouv.fr*

ABSTRACT

The hydro-ecological functioning of river systems is influenced by the physical conditions within their corridors (e.g. topography, land use, geology). A systematic description of the physical functioning has so far been limited due to a lack of data on aspects such as lateral dynamics and floodplain connectivity. The Mapd'O project addresses this by providing datasets and a web interface that allow operators and scientists to analyze these conditions for the entire French river corridor network. Novel datasets such as a national land use map with a resolution of 1 m and the first national valley bottom and lateral continuity maps were created using the Fluvial Corridor Toolbox (FCT), a geographic information system toolbox for network-scale hydromorphic characterisation. Using the Mapd'O app, these datasets can be visualized, analyzed and interpreted to enable hydromorphological diagnosis of river systems at reach to network scales: the entire watershed, but also their sub-catchments and individual river axis level.

RÉSUMÉ

Le fonctionnement hydro-écologique des systèmes fluviaux est influencé par les conditions physiques au sein de leurs corridors (par exemple, la topographie, l'utilisation des sols, la géologie). Une description systématique du fonctionnement physique a jusqu'à présent été limitée en raison d'un manque de données sur des aspects tels que la dynamique latérale et la connectivité des plaines alluviales. Le projet Mapd'O répond à cette problématique en fournissant des ensembles de données et une interface web qui permettent aux opérateurs et aux scientifiques d'analyser ces conditions pour l'ensemble du réseau fluvial français. De nouveaux jeux des données tels qu'une carte nationale d'occupation des sols avec une résolution de 1 m et les premières cartes nationales de fond de vallée et de continuité latérale ont été créés à l'aide de la Fluvial Corridor Toolbox (FCT), une boîte à outils de système d'information géographique pour l'hydromorphologie à grande échelle. En utilisant l'application Mapd'O, ces données peuvent être visualisées, analysées et interprétées pour faciliter un diagnostic hydromorphologique des rivières à différentes échelles : l'ensemble du bassin versant, mais aussi leur sous-bassin versant et l'échelle de l'axe individuel de la rivière.

KEYWORDS

diagnostic application, floodplains, fluvial corridor, large scales, lateral continuity

MOTS CLÉS

application de diagnostic, continuité latérale, corridor fluvial, larges échelles, plaines d'inondation

1   BACKGROUND

The physical functioning of rivers at watershed level is regularly assessed for the preparation of local and regional water management plans in France, such as SDAGE or SAGE. These strategies aim at planning measures for sustainable water resources management and improvement of aquatic environments, as demanded by the EU Water Framework Directive (WFD), and are often carried out by watershed syndicates or consulting companies. Until today, there is only limited data available about the hydromorphological functioning of river corridors, including aspects such as lateral dynamics and floodplain connectivity, which makes a systematic characterization of the physical status and functioning difficult. The Mapd'O project was created by the EVS laboratory with the support of the French Biodiversity Agency (OFB). It aims to develop the needed datasets and a web-application with the aim of facilitating hydromorphological diagnosis of watercourses and catchments, identifying river corridors and defining the envelope of good functioning (DREAL *et al.* 2016). It thus aims to integrate indicators of riverscape statuts and lateral dynamics in relation to their ecological functioning. The application is therefore designed to be part of a watershed manager's large-scale toolbox, enabling him or her to initiate a pre-analysis and inventory, or to commission a specific study with a global vision of the hydromorphological functioning of a specific watercourse and the challenges facing this territory.

2   PRODUCTION OF DATA

The Mapd'O application is based on the results of the standalone version of Fluvial Corridor Toolbox (Rousson and Dunesme, 2024) applied to the French hydrographic network. Also developed by the EVS laboratory since 2015, the FCT is a GIS toolbox for large-scale hydromorphology, providing geomatic approaches to the analysis of topography and land use, and enabling the production of maps of lateral continuity and other fluvial features. Valley bottom and river corridor layers are first extracted from a digital elevation model. Various morphological measurements, such as land cover and use, width, slope, drained area and elevation, are then extracted from the network at regular intervals by merging the data with land-use maps. The FCT was launched for complete catchment areas. Running the FCT on such large volumes of data required the use of the resources of the Centre Blaise Pascal SIDUS infrastructure (Quemener and Corvellec, 2013) at ENS Lyon. The reference hydrographic network used is the BDTopo Hydro / BDTopage in its 2023 version.

2.1   Valley bottom delineation

The valley bottom delineation algorithm is based on methods from the literature (Alber and Piégay, 2011 ; Clubb *et al.*, 2017 ; Gilbert *et al.*, 2016). The main keys of the algorithm is to produce a DEM detrended from the valley longitudinal slope and then applying thresholds on the lateral distance and relative height to the reference network as well as lateral slope. The innovative feature of the standalone FCT is that these thresholds can be varied as a function of the drainage area, making it possible to process an entire network on a national scale in one iteration.

2.2   Landuse and lateral continuity maps

The BD TOPO® and the Registre Parcellaire Graphique (RPG) are used to produce a land use map and a lateral continuity map (with the FCT) of the rivers in order to determine the different compartments of the alluvial plain. Land use classes are defined according to different rules, resulting in a 9-class nomenclature (Water, Gravel bars, Natural, Forest, Grassland, Crop, Diffuse Urban, Impermeable Urban and Infrastructure). The result is presented in Figure 1. The lateral continuity map is then defined by aggregation and topological rules to arrive at the nomenclature shown also in Figure 1 on the Dordogne river.

2.3   Network segmentation and metric creation

The valley bottom is then divided into 200m surface sections (Disaggregated Geographic Objects, DGO) along the reference hydrographic network (Hergarten *et al.*, 2014 ; Roux *et al.*, 2015 ; Alber and Piégay, 2011). The aim of these sections is to enable a continuous extraction of metrics along the entire length of the hydrographic network. These metrics are extracted either by median value (e.g. for slopes or altitude), by median width (e.g. for lateral continuity classes) or by area (e.g. for land use classes) for each DGO. A total of 37 metrics were created to characterize elevation and slope, corridor features and their widths, and floodplain land cover and land use. Median cross-section profiles are also generated for each DGO.
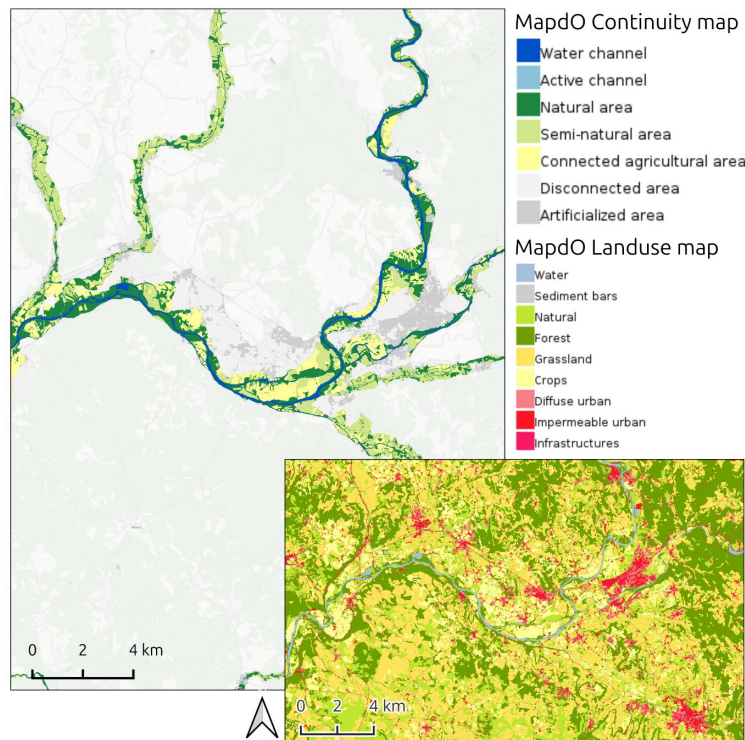
Figure 1: The Mapd'O Landuse map and the FCT-produced Continuity map on the Dordogne river.

3   WEB APPLICATION

3.1   Functionalities

Designed for practical use by researchers, planners, and developers, the application provides the produced metrics and indicators for all segments of the hydrographic network across mainland France, alongside tools for their analysis and interpretation. With its cartographic interface, interactive visualizations, and interpretation tools, it assists users in conducting diagnostics on river systems. In addition to the datasets created as part of the project, several other sources were included to aid systematic diagnosis. The location and type of flow obstacles and discharge gauges, 100-year return period flood hazard zones, and flood protection infrastructure are integrated into the map interface. Furthermore, a direct link to historical map and image analysis is provided. R Shiny was chosen as the development framework for its user-friendly design, scientific credibility, and compatibility with custom R-based analytical algorithms. Its wide usage ensures accessibility and ease of adaptation for new developers within the lab. The app consists of two main modules:

1. **Exploration & Classification** - The main page of the app, where the available river network and all complementary datasets are displayed in a cartographic interface. It allows the selection of specific hydrographic units, such as river segment, axis, region, or the watershed. Based on the metrics, various network classifications can be made, either via suggested categories such as topography, dominant land use, or confinement indices, or by manually applying thresholds. A second interface allows analyzing the longitudinal evolution of individual metrics or applied classifications on an axis and the visualization of the lateral cross-section of a selected river segment.
2. **Analysis** - This module provides tools for cross-scale comparison and analysis of applied classifications or individual variables, e.g. between an axis and its parent hydrographic region and watershed. In addition, a bivariate analysis of individual axes can be performed.

The app also contains a third module in which the datasets can be downloaded.

3.2   Use cases

The app supports diverse research and management needs in the frame of a preliminary study. It allows the user to highlight differences in river styles across various rivers and basins and to analyze selected corridors. Different aspects crucial for integrated river management can be assessed and compared, such as urban and agricultural pressures, lateral connectivity, and the presence of sediment bars, among others. Depending on these characteristics, critical reaches within a watershed can be identified and compared with the conditions at the regional, watershed, or national scale. The evolution of the conditions along the selected corridor can be tracked to pinpoint significant transitions and areas of interest, e.g. to identify the influence of stream obstacles on the water course.
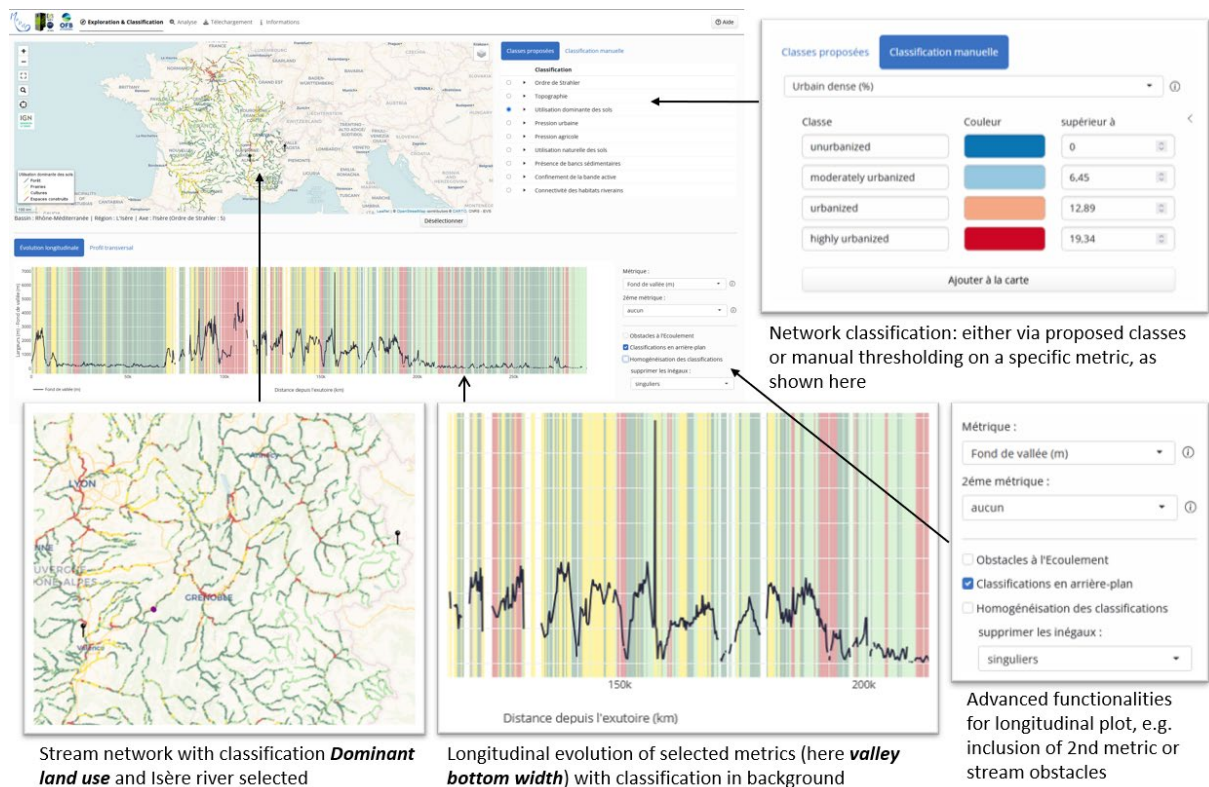

Network classification: either via proposed classes or manual thresholding on a specific metric, as shown here

Stream network with classification **Dominant land use** and Isère river selected

Longitudinal evolution of selected metrics (here **valley bottom width**) with classification in background

Advanced functionalities for longitudinal plot, e.g. inclusion of 2nd metric or stream obstacles

Figure 2: Interface of the Mapd'O app and its *Exploration & Classification* module

4   CONCLUSION AND OUTLOOK

The Mapd'O project provides new datasets and a web app for the hydromorphological analysis of the French river corridor network. They allow the assessment of aspects such as lateral dynamics and floodplain connectivity, which are crucial for a systematic characterization of the physical functioning of river systems. This enables, notably for river managers, the preparation of preliminary studies to diagnose riverscape status, plan restoration and conservation measures as required by the WFD and national water management plans such as SDAGE or SAGE.

The project actively supports the principles of open science and FAIR data by both reusing pre-existing datasets (e.g. BDTopo or RPG) and making the generated data sets and source code openly accessible in public repositories (Dunesme et al., 2024 ; Helling et al., 2024). Regularly updated, the data can also be downloaded directly within the application.

Once data production is complete, the entire national river corridor network of Metropolitan and Overseas France will be available. Upcoming project steps include the introduction of a temporal module and statistical methods for the segmentation of metric series. Generated with ancient versions of BDTopo and RPG databases, the temporal analysis will enable the assessment of temporal changes within the fluvial corridor. Automatic segmentation algorithms will reveal breakpoints and transition zones to identify homogeneity and discontinuities along the longitudinal extent of river axes.

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