

LandSeaLot: improving (also sediment dynamics) observation capacity in the land-sea interface area

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Conference theme number(s): 5. Data Collecting, Sharing and AI

The Horizon Europe funded project LandSeaLot (February 2024 – January 2028) links *in situ*, model and earth observations (EO) together and connects related communities, citizens and initiatives such as Copernicus, ESA, EEA, GEOSS, EMODnet and the European Digital Twin of the Ocean. All engage in a gap analysis used to co-design a joint and common land-sea interface observation strategy and its implementation plan.

LandSeaLot experts simultaneously work on improving: *in situ* and EO capabilities, models to reduce the model/observations gap and the integration of model, *in situ* and satellite data. Observation capacity is mainly increased through tested, improved and guided use of low-cost sensors by citizens, facilitated by the network of European marinas. The sensors identified are piloted in Integration Labs (ILs) together with improved and integrated *in situ* and EO observations techniques and model outputs.

LandSeaLot ILs cover strategically selected areas in the Black, Aegean, Mediterranean, Atlantic, North and Baltic Seas, with a range of catchment, tidal and meteorological regimes (see Fig. 1).

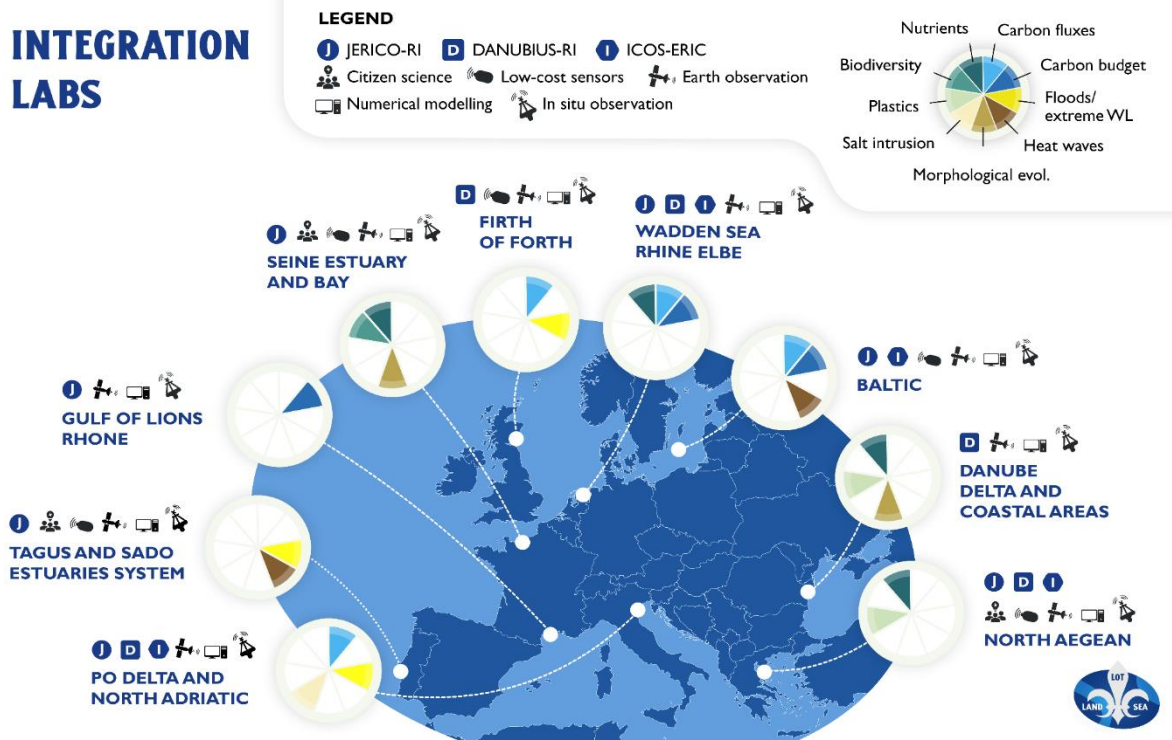
In LandSeaLot experts and citizen science initiative leaders will work in the ILs together with JERICO-RI, DANUBIUS-RI and ICOS-RI and with regional policy makers and managers to tailor integrated observations that will provide them information to manage societal challenges. These include assessment of morphological evolution (**sediment dynamics**), the lateral carbon fluxes and stocks, plastics transfer, nutrients impact on primary production and eutrophication, supporting biodiversity conservation, improving modeling capability and supporting climate change adaptation (storm surge, floods, heat waves, **coastal erosion**, saltwater intrusion).

Data generated in the ILs will be made FAIR available via EMODnet and interoperability and semantic solutions for existing, international data flows will be developed.

Relevant communities are engaged by workshops, conferences, trainings, a high-tech summit and by a communication strategy including videos and policy briefs to ensure LandSeaLot's legacy.

References: <https://landsealot.eu>

Fig. 1: LandSeaLot Integration Labs



Introducing the Sediment Management Framework Application

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Conference theme number(s): 5

Introduction:

Shifting the perception of sediment disposal from a waste stream to a potential beneficial material use presents many challenges [1]. Chief among these is the need for an understanding of the contaminants within sediments at extraction and potential disposal sites. A key element to achieving this is accurate and reliable historical data, a need for the operator and the regulator alike.

In England (and Northern Ireland) the Marine and Coastal Access Act 2009 [2] requires that anyone wanting to perform a dredging activity must apply for a Marine Licence Application (MLA) through the Marine and Maritime Organisation (MMO). Applicants are required to ensure adequate sediment analysis is performed and results are supplied by the applicant via a bespoke results template along with the other MLA documents. Despite these results being publicly available via the MLA public register, no single repository for the data for England was available. Here we describe a purpose-built database and web-based application, the [Sediment Management Framework Application](#), that makes quality-checked contaminants data freely available and adopts the FAIR principles (Findability, Accessibility, Interoperability, Reuseability).

In a complementary paper, we detail a sister web-based application that ensures up-to-date, quality assured data is added to the contaminants database in a controlled and audited manner [3].

Methods: Dredge sediment contaminant concentrations, including trace metals, organotins, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), organochlorine pesticides (OCs), and polybrominated diphenyl ethers (PBDEs) data collated under the Action Level Review Project (ME5226/ C7590) by Centre for Environment, Fisheries and Aquaculture Science (Cefas) [4]. The purpose of this study was to determine potential impacts of proposed action levels in the assessment of dredged sediment for licensing of disposal at sea. A bespoke database was created to host quality checked sediment data and potential action levels for their use. To visualize the data, and provide guidance on their collection and potential use, a web-based app was

created in R-Shiny that connected to the database and allowed easy to use spatial and temporal analysis of the data and the application of action levels.

Results:

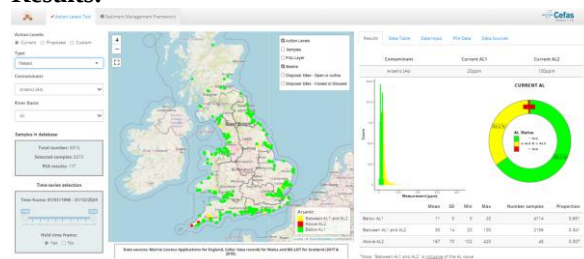


Fig. 1: Sediment Management Framework Dashboard

The application can be found at <https://rconnect.cefas.co.uk/content/692515e9-65a5-41d8-9117-79a9798a0519> and a screen shot is shown in Fig. 1. Users can select and download dredge sediment contaminant concentrations from a dashboard, apply action levels, as well as find out more about the licensing process for dredge sediment assessment.

Discussion: Ensuring all stakeholders have sight of the available data is essential to progressing more sustainable use of dredge material, and will support restoration initiatives [5].

Acknowledgements: Cefas colleagues & involved in the Action Level Review Project (ME5226/ C7590).

References: [1] USAR (Sediment Recycling Strategy) (2018); [2] Marine and Coastal Access Act (2009) [3] Heal et al, SedNet 2025 [4] Mason, C. et al. (2022) Reviewing the UK's Action Levels for the Management of Dredged Material. Geosciences 2022, 12, 3. <https://doi.org/10.3390/geosciences12010003> [5] Manning WD, Scott CR, Leegwater E. 2021. Restoring estuarine and coastal habitats with dredged sediment: A handbook. Bristol, UK: Environment Agency <https://catchmentbasedapproach.org/wp-content/uploads/2021/10/Restoring-Estuarine-and-Coastal-Habitats-with-Dredged-Sediment.pdf>

Using a web application to ensure quality-assured data entry into an open access sediment contaminant database

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Conference theme number(s): 5

Introduction: Shifting the perception of sediment disposal from a waste stream to a potential beneficial material use presents many challenges [1]. Chief among these is the need for an understanding of the contaminants within sediments at extraction and potential disposal sites. A key element to achieving this is accurate and reliable historical data, a need for the operator and the regulator alike.

In England (and Northern Ireland) the Marine and Coastal Access Act 2009 [2] requires that anyone wanting to perform a dredging activity must apply for a Marine Licence Application (MLA) through the Marine and Maritime Organisation (MMO). Applicants are required to ensure adequate sediment analysis is performed and results are supplied by the applicant via a bespoke results template along with the other MLA documents. Despite these results being publicly available via the MLA public register, no single repository for the data for England was available. In a separate paper we describe a purpose-built database and web-based application [3] that makes quality-checked contaminants data freely available and adopts the FAIR principles (Findability, Accessibility, Interoperability, Reuseability).

In this paper, we detail a sister web-based application that ensures up-to-date, quality assured data is added to the contaminants database in a controlled and audited manner. In doing so, the application also supports the marine advisors during the process of vetting the Marine Licence Application.

Methods: The Disposals Database Quality Control app was developed as web-based R-shiny application [4] and employs the packages *openxlsx* [5] to upload the MMO Licence application, *pool* [6] for database connectivity, *sf* [7] for manipulation of spatial data, and *leaflet* [8] for mapping of sample sites.

Results: A web-based app was designed to fit within the marine advisor vetting process. The app is linked to the sediment contaminant database to ensure quality control of the data prior to its inclusion (see Fig. 1). Under this workflow the marine advisor uploads the applicant's MLA Application form, and a series of automated checks are performed. The outcome of these checks is presented to the advisor. Any automated changes made, and potential areas for

consideration, are highlighted and presented for manual editing if necessary (e.g. data using incorrect units). The approach is advisor led allowing them to make their own informed edits to the data, and all edits are recorded in an audit trail. Furthermore, the advisor can download a copy of the MLA template with any new changes or additions which they can return to the applicant for further work. Once complete the data is uploaded to the database, along with the audit information. This data is then immediately publicly available and searchable.

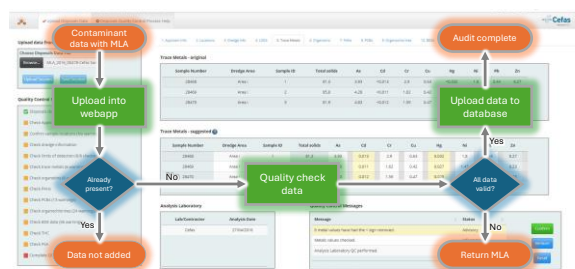


Fig. 1: A web-based app for quality-assurance of sediment contaminant data.

Discussion: We present here a workflow and application developed to ensure that the sediment contaminant database for England is routinely updated with the latest, quality-assured data that has been checked and audited by an expert advisor. Using this methodology, applicants for marine operations applications have the best and latest evidence available thus enabling them to plan and cost out the best options for beneficial use of any sediment resource created.

Acknowledgements: Cefas colleagues & involved in the Action Level Review Project (ME5226/ C7590).

References: [1] USAR (Sediment Recycling Strategy) (2018); [2] Marine and Coastal Access Act (2009); [3] Mason et al. SedNet 2025; [4] Chang et al Shiny: Web Application Framework for R (2024); [5] Schauburger et al (2024). *_openxlsx*: Read, Write and Edit xlsx; [6] Cheng et al. Pool: Object Pooling (2024); [7] Pebesma et al (2018) *The R Journal* 10:439–446; [8] Cheng et al. (2024) Leaflet: Create Interactive Web Maps with the JavaScript “Leaflet” Library.

Tools to Inform Sediment Assessment, Management, and Regulation: Book Update

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5.Data Collecting, Sharing and AI

Introduction: In the nearly 20 years since the Wenning et al. (2005) comprehensive review of the state of the science for sediment quality guidelines (SQGs) and related tools and their use [1], the methods used to derive numerical chemical concentrations intended to be either protective of aquatic life or predictive of adverse effects, have changed little.

However, considerable progress has been made in establishing SQGs internationally for the prospective and retrospective assessment of sediments. National environmental agencies have advanced the understanding and value of their jurisdiction's unique marine and freshwater ecosystems. New monitoring tools for passive sampling, in-situ field monitoring, ecotoxicity testing, and eDNA provide deeper insights to healthy and poor sediment conditions. Further, significant developments have been made for assessing other lines of evidence required to inform sediment management in the 21st century.

Need to Review Current State of Practice Involving Sediment Assessment to Support 21st Century Management: The consensus recommendation from 2005 remains unchanged; current SQGs are useful for screening purposes and should not be applied as definitive determinations of sediment risk or cleanup goals [1]. Still, there is a strong desire to use SQGs for sediment monitoring, management, and regulatory purposes. A review of this practice is needed—where and why are SQGs used, and how old and new analytical and assessment tools can better inform decision-making.

Because aquatic ecosystems and management goals differ widely, more than one sediment assessment tool is needed to evaluate sediment and biotic interactions and to derive ecologically meaningful assessment approaches. Further, there is a need for a critical assessment of how various lines of evidence (LOEs) should be integrated to inform a range of management and regulatory decisions. New approaches and tools can help account for biodiversity, climate change, chemical mixture interactions, and different sediment management objectives.

Among the new sediment management tools quickly evolving in recent years are ecosystem-based approaches that consider non-chemical stressors. Approaches have been developed for evaluating

previously un-assessed or sensitive species, predicting sediment mobility and transport, and *in situ* chemical and toxicity testing, and addressing adverse outcome pathways (AOP).

In this new edition of the SQG book, 17 chapters prepared by 65 experts working worldwide will discuss their work and collaborate to define a practical and meaningful future for sediment management. The book is planned in three parts: (1) a summary of current sediment assessment and toxicity testing methods used to determine sediment quality; (2) a review of the new and emerging methods for assessing healthy and poor-quality sediments in different aquatic ecosystems; and (3) a discussion of how sediment data are interpreted using tools such as SQGs, WOE, and statistical methods to inform different sediment management approaches. External peer review of this collaborative work before publication will strengthen its value for the academic, governmental, and professional communities.

The theme throughout this book effort is the question of whether both “classical” and emerging approaches are fit for the management of sediments in the 21st century. Global conditions, from sea level rise and increasing extreme events, to changes in population, production, consumption and pollution, are changing at increasing rates. Emerging contaminants, not generally assessed or regulated just two decades ago, are being detected in sediments globally. A drive towards circularity, including the valorization of sediments as a resource, rather than a waste, all have the potential to change “standard” thinking about how sediments should be managed. Are the assessment regulations and tools still fit for purpose? Do decision-makers have access to the data essential for modern, sustainable sediment management? What is the state of science in support of such goals, and what developments in science, engineering, and policy are needed?

Progress and highlights emerging from content of the book will be presented, along with a call for reviewers to get involved in this process, which, ideally, will be completed by the end of 2025.

References: [1] Wenning et al. (eds.) (2005) SETAC Press, Pensacola FL

Time-integrated sediment quality monitoring in large rivers. Temporal variations in suspended and floodplain sediments in the Drava River.

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Conference theme number(s): 1 / 5

Introduction: Sediments act as an important sink and secondary source of contamination for many hazardous chemicals as a major carrier of pollutants in rivers through geochemical processes at the sediment-water interface [1]. The study was carried out within the framework of the EU Interreg SIMONA project, which aimed at establishing appropriate sampling, analytical, and evaluation techniques, as well as time-integrated (quasi continuous) monitoring tools for sediment quality monitoring and assessment in the Danube River Basin countries.

This study aimed to evaluate temporal variations of examined elements in both suspended and floodplain sediments over a one-year monitoring period at the Barcs station in the Croatia-Hungary border section of the Drava River.

Methods: The sampling approach used two ISO standard sediment trap boxes (Joint Danube Survey 4; JDS4), originally developed for large rivers and adapted by the SIMONA project for shallow rivers. One JDS4 sediment trap box was submerged in Drava River, while other one was installed on the overbank of the river [2]. Suspended sediment trapped in the boxes were collected every months. The concentrations of the studied elements in sediment samples (<2mm) were analysed using inductively coupled plasma mass spectrometry (ICP-MS) after aqua regia digestion [3]. In addition, loss on ignition (LOI), total organic carbon (TOC) and total inorganic carbon (TIC) were measured.

Results and Discussion: The concentrations of TOC, Na, K, Al, Fe, P, in addition to Ni, Cr, Co, Cu, and Ba were significantly higher in floodplain sediments (high flow conditions) than those in river suspended sediments channel (baseflow conditions). This chemistry originates from soils and pollution sources eroded from the catchment slopes during heavy

rainfall and related flood events. However, the concentrations of Ca, Mg, Sr, Li, Mn, in addition to Pb, Zn, Cd, and As, Hg, were higher or the same in river channel suspended sediments than those of floodplain sediments. This chemistry originates from groundwater draining the overwhelming calcareous rock in the Alpine hinterland and associated Pb-Zn Mississippi-type mineral deposits and historic mines, thereby defining a geochemical background.

Consistently, the time-integrated monthly suspended sediment concentrations of Ca, Mg, Sr, Li, Mn, Pb, Zn, Cd, and As, Hg remained constant during the monitoring experiment, while all the other analytes showed a statistically significant (95% confidence level) increasing trend from the beginning of the 2021 monitoring year.

Monthly peak concentrations for most studied elements were detected in March, May, and during the period from September to December.

Among the EU-defined hazardous substances, only Zn concentrations exceeded the Environmental Quality Standards (EQS) in both sediment types.

Acknowledgements: This research was co-funded by the European Union Fund, ERDF, IPA, ENI (DTP2-093-2.1 SIMONA project), and by the DanubeSediment_Q2 (DRP0200029), an Interreg Danube Region Programme project co-funded by the European Union.

References:

[1] Schubert et al. (2012) Trends in Analytical Chemistry 36: 58-70; [2] Šorša et al. (2019) EU Interreg Danube Transnational Programme SIMONA Project Output 4.1 45p; [3] Čaić Janković et al. (2019) EU Interreg Danube Transnational Programme SIMONA Project Output 4.2 37p.

Suspended Sediment Load Prediction using Machine Learning models

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Introduction: Precise estimation of Suspended Sediment Load (SSL) is crucial, as it plays an important role in river management and is also associated to pollution, water quality, and ecosystem degradation. (K. Khosravi et al. 2022)

In recent years, numerous studies have demonstrated the ability of machine learning (ML) (D. Gupta 2021) models to accurately predict SSL, often outperforming traditional models due to their ability to capture implicit relationships within the data. As part of the Rhône Sediment Observatory (OSR), we propose an approach that considers streamflow and rainfall data collected from multiple stations to predict SSL across multiple tributaries of the Rhône River (France).

Methods: We used a Random Forest (RF) model to predict hourly SSL data from 2014 to 2024 based on observations from various streamflow and rainfall stations across each river basin. Two strategies are implemented: one considers the variables at the same time instance as the SSL, while the other uses variables at the time lag that maximizes their correlation with the SSL. Additionally, we developed a neural network model (CNN-LSTM) that considers sequences of lagged observations of the input data to capture temporal dependencies. The lag is treated as a hyperparameter, established within a window based on the correlation analysis performed in the RF model. To assess the performance of our methodology, the ML models are compared with a rating curve approach, namely the SiRCA model (M. Sadaoui et al. 2016), using coefficient of determination (R^2 , ranging from 0 to 1, with the latter being the perfect score) and Root Mean Squared Error (lower values indicate better performance). Moreover, we established and evaluated a Transfer Learning (TL) strategy using the proposed CNN-LSTM model to predict SSL in tributaries with limited data. For this approach the model was pre-trained on a *source river* identified as similar to the *target river* using clustering methods based on the statistical properties of the data. Then the first layer of the pre-trained model was frozen and the remaining ones were fine-tuned on the target data.

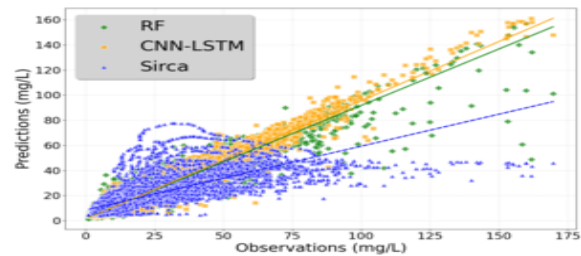


Fig. 1: Comparison of models: Saône river case

Results: While the empirical model (SiRCA) already demonstrates good performance for some tributaries with values ranging from 0.5 to 0.7, the performances are significantly improved by the RF and CNN-LSTM models (R^2 values around 0.9). For the tributaries where the SiRCA model does not perform well (R^2 values below 0.3), the ML models achieve R^2 values close to 1. Overall, the CNN-LSTM model outperforms the RF model across most tributaries by closely aligning with measured values and successfully reproducing hysteresis effects. Furthermore, while only using a small portion of data for training, the TL can achieve enhancement of performances up to 0.3 gain in R^2 .

Discussion: The ML models consistently outperform the rating curve approach across all tributaries. Furthermore, variable importance analysis reveals that rainfall data contributes minimally to the models, suggesting that streamflow data from different stations is sufficient. The TL methodology proves to be effective, enabling significant performance gains when data availability is limited. However, one could argue that the variables used for classifying the rivers are not fully explanatory. More work can be done to get better clusters thus enabling more performance gain using TL.

Acknowledgement: I would like to express my deepest gratitude to the OSR team for ensuring the availability of data.

References: [1] Khabat Khosravi et al. 2022, *Journal of Hydrology* 610, 0022-1694; [2] Gupta 2021, *Environ Earth Sci* 80, 1866-6299; [3] Mahrez Sadaoui et al. 2016 *Journal of Hydrology*. 540, 1002-1015

Streamlining erosion and sediment transport modelling: the ‘pywatemsedem’ package

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Introduction: A standardized model and scenario development procedure is crucial for effective use of simulation models for water erosion and sediment transport management [1]. The erosion and sediment transport model WaTEM/SEDEM [2], developed by KU Leuven, serves as a valuable tool for scientific research and soil management, offering a spatially distributed framework for assessing erosion and sediment dynamics. Its key strengths include the capability to compute net erosion and deposition in two dimensions, as well as its rapid computation time. However, the extensive data processing required and the numerous extensions available can pose challenges, making the transition from a base model to specific scenarios labour-intensive. To address this issue and operationalise WaTEM/SEDEM in Flanders, the government of Flanders has been financing the development of a Python API, ‘pywatemsedem’ aimed at providing data scientists with a tool to automate and standardize the data processing workflow for WaTEM/SEDEM.

Methods: The pywatemsedem package is designed to enable users to implement customized workflows for WaTEM/SEDEM using their specific source data. The package provides tools for clipping and transforming spatial data, generating and validating WaTEM/SEDEM inputs, and performing advanced post-processing and analyses. An example of user interaction is provided in a Jupyter Notebook. This example guides users through defining source data, setting up static model elements (e.g. an elevation model), selecting scenario options and processing functions, and executing data processing and model runs.

Results:

The development of the pywatemsedem package aims to enhance clarity in the methodology for processing data related to erosion and sediment transport modelling, thereby improving traceability and transparency in model usage. The package is

developed to facilitate the implementation of WaTEM/SEDEM for policy and practice in Flanders, but is also generally applicable worldwide. An example application for different catchments in Flanders illustrates the key differences in erosion and deposition rates, and subsequent loads transported to the river (Fig. 1).

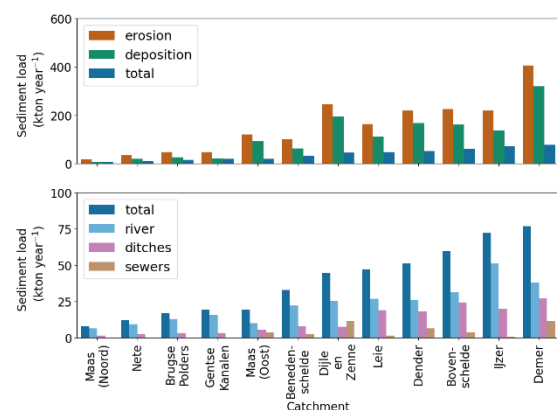


Fig. 1: Comparison of results for different catchments in Flanders (year: 2022).

Discussion: The package has been rigorously tested by the government and stakeholders in Flanders, generating valuable feedback to guide improvements and investments in user-friendly infrastructure. Future efforts will focus on expanding its user base to include academics, policymakers, and managers, while applying the package to regions beyond Flanders. Planned updates include advanced processing options for land use, erosion control, and transport coefficients, enhancing flexibility for diverse modeling needs. The WaTEM/SEDEM's source code is available on GitHub [2], with pywatemsedem to follow soon.

References:

- [1] Choi, et al. (2021) *Environ. Model* **135**: 104888.
- [2] Verstraeten et al. (2024). *watem-sedem/watem-sedem*: 5.0.2.

The synergistic use of bathymetric measurements and ADCP for the hydromorphological monitoring of waterways

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Conference theme number(s): 5

Introduction: This study aims to determine the complex relationship between river bed morphology and hydrodynamic forces to ensure safe navigation in river environments [1]. Using multibeam integrated bathymetry and Acoustic Doppler Current Profiler (ADCP) data, we aim to identify and analyze critical navigation hazards such as sediment deposition and erosion. High-resolution bathymetric maps are combined with ADCP-derived flow velocities to identify riverbed dynamics and predict changes over time[2]. The multi-beam bathymetric measurements are aimed at mapping the bed of the navigable waterway, and combined with the flow currents, flow rates and flow speeds, optimal solutions can be identified to reduce sediment transport, erosion, as well as the application of measures leading to the maintenance of the navigable channel.

Methods: The monitored site is located on the Danube River, with a length of 25 km. The alluvial riverbed is composed of different types of sand size. Approximately 90% of sand is medium sand type with a $D_{50}=0.36$ mm. During the November 2024 survey campaign, with a low flow condition, multibeam bathymetric (MBES) and discharge and water velocity (ADCP) surveys were done. The MBES used was the EM 2040C by Kongsberg for the navigable channel and GeoSwath 250 kHz interferometric sonar for a very shallow section of river. The ADCP survey was made with Riversurveyor M9 ADCP by Sontek. With the aims of computing the combined measurements technique and comparing the results and overcoming the referencing errors, the original and the filtered bathymetries were resampled along the 25-km-long thalweg with a 1-m spacing.

Results: The multibeam bathymetric survey revealed a dynamic riverbed with features such as thalwegs,

sandbars, and scoured pools. The main channel depth varied between 0.5 in shallow sandbar regions to 9 m in scoured pools. Sand dunes with crest heights of 0.5–1.2 m and wavelengths of 5–25 m were detected along the channel bed, particularly in regions of high flow velocity.

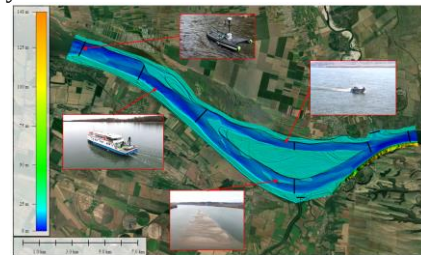


Fig. 1: November 2024 MBES, ADCP and SS from survey

Discussion: The combined survey of MBES and ADCP is very important for monitoring the sediment deposition, in terms of quantity and quality. In meander bends, secondary flow structures were evident, with velocity vectors forming helical patterns. These flows were strongest at outer bends, contributing to localized erosion [3]. High velocities and shear stresses in outer bends led to erosion and sediment entrainment, while depositional zones were identified in inner bends and downstream sandbars.

Acknowledgments: This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS/CCCDI - UEFISCDI, project number PN-IV-P8-8.1-PRE-HE-ORG-2024-0212, within PNCDI IV
The project PN-IV-P8-8.1-PRE-HE-ORG-2024-0212 is implement within the REXDAN Infrastructure.

References: [1] M. Guerrero et al. (2011) *J. Hyd. Eng.* **12** 1576–1587; [2] S. Baranya (2024) *Int. J. Sed. Res.* **6** 1015–1026; [3] A. Banescu et al. (2020) *App. Sciences*. **23** 8327.

Rivers do not only transport sediment: Monitoring and quantifying the instream large wood regime combining field and drone surveys and AI techniques

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Rivers not only convey water and sediment from the mountains to the oceans but also transport and store large instream wood (i.e., downed trees, trunks, branches, and root wads laying on the river). Large wood's essential physical and ecological roles in channels and floodplains have been largely proven [1, 2]. The instream large wood, together with the flow and sediment, create habitats supporting abundant and diverse biotic communities, sustaining river's health [3]. On the other hand, like sediment, large quantities of wood can be entrained (e.g., uprooted trees from riverbanks) and transported during floods, which can pose a danger to infrastructures such as bridges e.g., [4]. This has been the reason why instream large wood has been traditionally removed from rivers, without considering the potential environmental impacts [5], and although it continues to be indiscriminately removed, the practice of wood reintroduction as a river restoration measure has spread across Europe [6].

Therefore, like for sediment, assessing the quantity of instream wood is very important to diagnose river status and evaluate the potential success of restoration measures and the potential hazards and risks. However, the current legislation rarely considers wood management in its effort to support environmentally sustainable rivers.

Similarly to the flow and sediment regime, the wood regime is characterised by frequency, magnitude, timing and mode, considering supply, transport and deposition [1]. However, unlike the water and sediment regimes that have been intensively studied over the past decades, the instream wood regime has only recently been defined and remains rarely quantified [6]. Compared to flow or sediment, we are still unable to monitor or measure the wood regime with the same level of accuracy due to several limitations. The lack of long-term observations, monitoring networks, and data are the most crucial gaps. The significant temporal and spatial variability of wood supply and availability, and transport processes contribute to this data scarcity.

The amount of wood stored in rivers (referred to as wood load and measured in volume of wood per area)

is a critical value to quantify the wood regime. How much wood is being entrained and transported during floods, the so-called wood flux (e.g., the number or volume of pieces per time), is another essential variable. Different approaches have been developed to estimate wood loads and fluxes [6]. This contribution summarises the most recent advances to quantify these elements of the wood regime, providing exemplary cases from ongoing research. For example, we show how using sensors like radio transmitters can help to track wood displacement; or how machine learning algorithms can be trained to identify, map and quantify instream wood load stored in rivers using high-resolution imagery acquired by drones and wood fluxes from footage recorded by cameras.

The information gathered by these monitoring frameworks is key for river restoration and flood management.

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