MONHYSENSE: Monitoring and characterizing Hydromorphology at the reach scale by emerging Remote Sensing technologies

Surveillance et caractérisation de l'hydromorphologie à l'échelle de portée par les nouvelles technologies de télédétection

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RÉSUMÉ

La WFD exige que les évaluations Hydromorphologiques (HYMO) des rivières et des cours d'eau fassent partie des programmes de surveillance opérationnelle de chaque État membre, à des intervalles de six ans, ce qui constitue la base d'un vaste réseau de surveillance. Dans ce contexte, le projet REFORM financé par l'UE a développé un cadre hiérarchique fluvial (RHF) multi-échelle basé sur les processus pour aider les gestionnaires des rivières à évaluer le caractère HYMO des rivières de l'UE (Gurnell et al., 2016). L'un des résultats les plus importants du FRH a été le développement d'indicateurs clés de contrôle des processus et des formes HYMO à différentes échelles spatiales (de la portée à l'échelle des bassins versants) (del Tánago et al., 2016). L'objectif principal du projet MONHYSENSE est de développer une méthodologie opérationnelle appropriée utilisant les nouvelles technologies de télédétection (RS), pour surveiller et caractériser le statut HYMO de différents systèmes fluviaux à l'échelle de portée. Plus précisément, le projet vise à déterminer quelle est la technologie la plus rentable entre les données RS à haute résolution (principalement hyperspectrales et LiDAR) obtenues à partir de plates-formes aéroportées ou UAV (Unmanned Aerial Vehicles), pour surveiller certains des indicateurs HYMO identifiés comme importants à l'échelle de portée, par la RHF (del Tánago et al., 2016) et donc définir une méthodologie opérationnelle pour cartographier ces indicateurs.

ABSTRACT

The WFD requires Hydromorphological assessments (HYMO) of rivers and streams to be part of the operational surveillance programs of each Member State at six-year intervals, which forms the basis of an extensive surveillance network. In this context, the EU-funded REFORM project has developed a process-based, multi-scale river hierachical framework (RHF) to help river managers assess the HYMO character of EU rivers (Gurnell et al. , 2016). One of the most important results of the RHF has been the development of key indicators of process control and HYMO forms at different spatial scales (from the catchment scale to the reach scale) (del Tánago et al., 2016). The main objective of the MONHYSENSE project is to develop an appropriate operational methodology using new remote sensing (RS) technologies to monitor and characterize the HYMO status of different river systems at the reach scale. More specifically, the project aims to determine the most cost-effective technology between high-resolution (mainly hyperspectral and LiDAR) data obtained from airborne platforms or Unmanned Aerial Vehicles (UAV) to monitor some of the HYMO indicators identified as important at the reach scale by the RHF (del Tánago et al., 2016) and therefore define an operational methodology for mapping these indicators.

KEYWORDS

Hyperspectral, UAV, LiDAR, Hydromorphological indicators

1. INTRODUCTION

The Water Framework Directive (WFD) is the most substantial piece of EU water legislation to date and, together with the EC Habitats Directive, it requires Member States (MS) of the EU to assess, monitor and, where necessary, improve the ecological quality and ecosystem health of river systems, which are partly determined by their Hydromorphological (HYMO) conditions. The WFD requires that HYMO assessments of rivers and streams should form part of the operational monitoring programs of each MS, at 6-year intervals, putting the basis for an extensive network of monitoring.

In this context, one of the aims of the EU-funded REFORM project (http://www.reformrivers.eu/) was to develop a process-based, multi-scale, River Hierarchical Framework (RHF) to support river managers in assessing the HYMO character of EU rivers, exploring the causes of HYMO problems, and devising sustainable management solutions (Gurnell et al., 2016). One of the most important outcome of the RHF was the development of key controlling indicators of HYMO processes and forms at different spatial scales (from reach to catchment scales) (del Tánago et al., 2016).

The main objective of MONHYSENSE project is to develop a proper operational methodology using emerging Remote Sensing technologies (RS), for monitoring and characterizing the HYMO status of different river systems at the reach scale. More specifically the project aims to determine which is the most cost-efficient technology between high-resolution RS data (mainly Hyperspectral and LiDAR) obtained from either Airborne and UAV (Unmanned Aerial Vehicles) platforms, for monitoring some of the HYMO indicators identified as important at the reach scale, by the REFORM RHF (del Tánago et al., 2016):

<u>1. Riparian habitats:</u>

-mapping riparian plant communities (with a special concern of Natura 2000 habitats)
-mapping riparian forest age structure: bare, pioneer (1-2 y), early growth (< 5y 2-5 y), juvenile (5-15 y),
-mature forest (15-50 y), and old forest (> 50y)
-mapping riparian ecological condition (moisture, stem density, biomass)
-identification of potential threats to valuable riverine ecosystems, such as presence of dominant and/orinvasive species and its effect on shore/island stability

<u>2. Aquatic habitats:</u>

-mapping aquatic vegetation (if present, with main aquatic plant species)
-mapping in-stream mesohabitats (in-stream geomorphic units: riffles, pools, glides...)
-mapping in-stream mesohabitats physical characteristics (e.g.: water depth, velocity, sediment size classes)
-large woods automatic detection

Several of these indicators can be nowadays monitored through a various range of RS sensors (e.g. Multispectral, Hyperspectral, LIDAR or Thermal) mounted on different platforms (e.g. Satellite, Airborne or UAV), depending on the scale of analysis. At the catchment and segment scale, mainly high-resolution Multispectral and LiDAR data are used (Demarchi et al., 2017), while at the reach scale mainly Hyperspectral and LiDAR are used. The advantage of Hyperspectral with respect to Multispectral consists in a much higher spectral resolution and therefore a much higher wealth of information useful for the extraction of different HYMO indicators and physical characteristics. In literature, Hyperspectral data are mostly collected from airborne platforms. Only recently, light LiDAR and Hyperspectral sensors have been started to be commercialized and therefore mounted on UAV as well. The potentials of such emerging UAV technologies in extracting detailed HYMO indicators is unknown and therefore it needs to be properly investigated.

The pioneer nature of the project consists in assessing the potentials of UAV-LiDAR and UAV-Hyperspectral data in defining an operational methodology for mapping those HYMO indicators required for the HYMO assessment. The objective is to shed lights on the cost-effectiveness of using UAV-LiDAR and UAV-Hyperspectral technologies in respect to airborne platforms and understanding benefits/limitations and technical requirements of each RS technology for mapping and characterizing riparian and aquatic habitats indicators.

2. METHODS

UAV and airborne acquisitions will be performed within WP1 using novel LiDAR and Hyperspectral sensors, over two case studies: Santerno river (IT) and Wisula river (PL). The focus of WP2 and WP3 will be on mapping and characterizing the riparian and aquatic habitats with both Airborne and UAV data. WP2 will focus on the main riparian habitats indicators, such as mapping of riparian plant communities, their age structure and their ecological condition. WP3 will focus instead on the main aquatic habitats indicators, such as mapping of aquatic vegetation, mapping in-stream mesohabitats and their physical characteristics. For both WPs, different image analysis techniques will be investigated, such as object-based vs. pixel-based, dimensionality reduction and Machine Learning. These results will be used in WP4 to develop a proper operational assessment framework for the HYMO characterization at the reach scale. The main river functional types will be identified using the RS-based indicators and the diversity of river characters will be highlighted by mapping the spatial variability of key HYMO indicators. Some process-based relationships will be tested between channel planforms and topographic features per river type, with the aim of assessing potential alterations at the reach scale.

3. CONCLUSION

The outcomes of MONHYSENSE are expected to have a crucial impact in the development of the Fluvial Remote Sensing discipline. From the one hand, the analysis of these emerging RS datasets will provide fluvial geomorphologist with an unprecedented database of HYMO indicators that did not exist before. Such type of objective and repeatable information has the potential to advance the ability in understanding existing and novel fluvial processes theories. From the other hand, the project will provide a method for river managers on how to perform the periodic HYMO assessments required by the WFD in a cost-effective way, by using the optimal RS technology.

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