The use of remote sensing data for regional hydromorphological characterization

L'utilisation des données de télédétection pour la caractérisation hydromorphologique régionale

Simone Bizzi[1], Christof Weissteiner[1], Luca Demarchi[1], Van De Bund Wouter[1], Hervé Piégay[2],

[1]European Commission, Joint Research Centre, Institute for Environment and Sustainability, Via E. Fermi 2749, I-21027 Ispra, VA, Italy ((corresponding author: simone.bizzi@jrc.ec.europa.eu). [2] Site ENS Lyon, 15 Parvis R. Descartes, 69362 Lyon Cedex 07, France.

RÉSUMÉ

Cette communication montre le potentiel d'orthophotos multi-spectrales sub-métriques et d'un MNA (Modèle Numérique d'Altitude) dérivé du LIDAR pour caractériser l'hydromorphologie fluviale à l'échelle de la section de rivière jusqu'au réseau. Les données ont été prises simultanément pour l'ensemble de la Région du Piémont en Italie entre 2009 et 2010. Les données multi-spectrales et MNA sont combinées pour fournir des indicateurs hydrogéomorphiques. Un cadre d'analyse a été conçu afin d'utiliser l'information télémétrique pour la caractérisation hydromorphologique à grande échelle. La méthodologie a été appliquée sur certains systèmes fluviaux importants de la Région du Piémont et une base de données régionales des caractéristiques hydrogéomorphiques a été construite. Cette information permet l'identification d'une typologie fluviale fonctionnelle et régionale, une planification efficace des études sur le terrain, et des connaissances pour définir et prioriser les objectifs de restauration.

ABSTRACT

The paper shows the potential of multi-spectral sub meter orthophotos and Lidar derived DEM (Digital Elevation Model) for characterizing river hydromorphology from reach to network scale. The data have been simultaneously acquired for the entire Regione Piemonte in Italy between 2009 and 2010. Multi-spectral and altitude information are fused for providing hydromorphological indicators. A framework of analysis has been designed exploiting RS information for large scale river characterization. The methodology has been applied on some major river systems of Regione Piemonte and a regional database of river hydromorphological features have been built: this information supports the identification of river functional types in the area, an effective planning of field surveys, and provide a valuable basis of knowledge for defining and prioritizing restoration targets.

KEYWORDS

Hydromorphology, River Remote Sensing, Fluvial Geomorphology, Regional analysis, Geographic Object Based Classification

1 THE USE OF REMOTE SENSING DATA FOR REGIONAL HYDROMORPHOLOGICAL CHARACTERIZATION

1.1 Introduction

The assessment of river hydromorphology is a recognised basis for modern river management, as stated by modern legislations such as the Water Framework Directive in Europe, and traditional river surveys based on field works tend to be rather subjective and resource demanding limiting *de facto* their scale of application (Newson & Large, 2006). We propose a framework for river characterization which exploiting RS technology allows continuous hydromorphological assessments from reach to watershed scales, in a framework that is objective and repeatable through time. This is a river screening framework of possible interest for scientists, experts and river managers answering their needs of better understanding and monitoring river hydromorphology.

1.2 Methodology and main findings

Although our understanding of fluvial processes has made significant progress over the last decades, river classification and the derived knowledge about river systems has so far been based on discontinuous sampling along the river course through field works and/or (subjective) interpretation of aerial images. Remote sensing data is changing the way we look and analyse river systems (Carbonneau & Piegay, 2012). Pioneer continuous longitudinal characterization of river reach or network used aerial photographs and highlighted planimetric patterns (mainly channel style, width and sinuosity) but did not consider elevation, which is a very important parameter of channel forms. LiDAR being now more frequently available at large scale creates the opportunity to introduce such information for characterising longitudinal river patterns. Elevation can provide slopes, bank heights or some indicators of variability of in-channel features, which can be very meaningful for a geomorphic characterisation, previously based primary on planimetric measures.

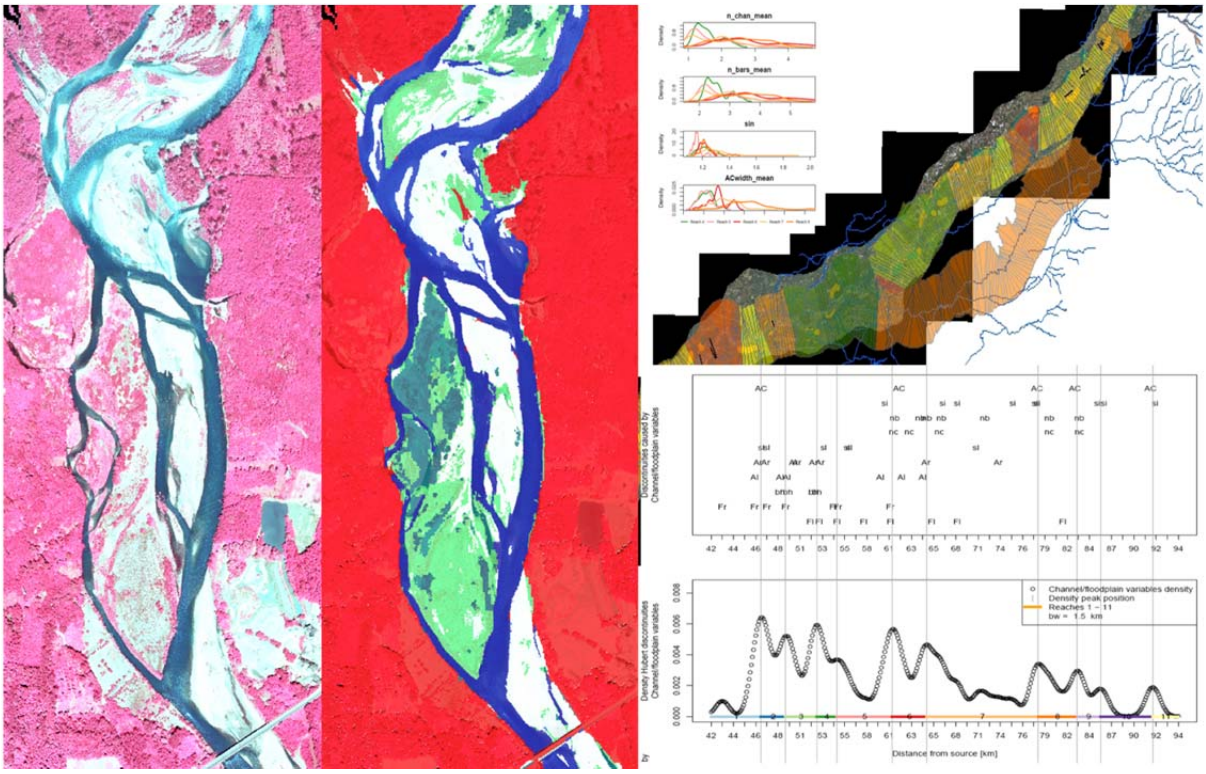

Figure 1 – Exemplificative outputs of the analysis framework: on the left the classification of active channel discerning between water channels (blue) and sediment bars, the latter further subdivided in unvegetated (white), sparsely vegetated (light green) and densely vegetated (dark green); on the top right the derived segmentation for a river stretch and a plot of indicators signatures; on the bottom right a graph reports the density of Hubert discontinuities along a river course and the derived segmentation.

We propose a set of river screening frameworks based on remote sensing data available at regional scale in Piemonte, Italy: namely color infrared orthophotos at 40 cm and a LIDAR derived DTM at 5 m acquired simultaneously in 2009-2010. A tool for the semi-automated detection of floodplain and active channel has been developed and implemented on several major river courses in the region (see Figure 1 on the left). The tool is able to automatically extract thirteen geomorphic variables virtually continuously along the river describing various river components: channel planform features (e.g. number of water channels and sinuosity), floodplain features (e.g. valley bottom shape), channel settings (e.g. width, confinement and slope), in-channel topography (e.g. sediment bars shape and height). A multi-dimensional river segmentation is proposed: first a Hubert segmentation is performed over each geomorphic variable, and based on that a density of discontinuities is calculated over the river course (see Figure 1 bottom right). Maxima over this density function are chosen as location for a first segmentation of the river course: these maxima identify locations of high occurrence of discontinuities in geomorphic variables, hence a river type shift is more likely to occur. The derived segments are then statistically analysed to investigate the difference in terms of river features: based on this analysis, segments are merged or further subdivided and a number of river functional types are eventually defined. Specific river signatures based on the distributions of the geomorphic variables can then be extracted for each river type (see Figure 1 top right). The method is completely data driven and has been applied on some major river courses in the Piemonte region. Where historical data about changes in channel width and elevation are available, the morphological trajectory occurred is analysed segment by segment and indications for quantitative processes-based river classification derived. This regional river geomorphic database can be used to inform restoration strategies, plan field campaigns, and prioritise the implementation of river management measures based on quantitative and objective indicators.

1.3 Conclusion

This methodology represents a step towards more quantitative large-scale river hydromorphological characterizations (Buffington & Montgomery, 2013) and shows the unprecedented potential offered by RS data for large scales river surveys. The framework allows continuous hydromorphological assessments from reach to watershed scales, in a framework that is objective and repeatable through time. These RS based river screening tools relevantly enrich more established field based river surveys and should be seen as integrative and not substitutive to these methods. Without doubt, river data is changing its forms and river scientists and managers need to create novel analysis tools to test, progress and implement our current understanding of river systems and monitor their changes through time.

LIST OF REFERENCES

Buffington, J. M., & Montgomery, D. R. (2013). Geomorphic classification of river. In J. Shroder & E. Wohl (Eds.), *Treatise on Geomorphology* (Accademic ., Vol. 9, pp. 730–767). San Diego, CA.

Carbonneau, P. E., & Piegay, H. (2012). *Fluvial Remote Sensing for Science and Management* (p. 444). Chichester: Wiley-Blackwell.

Newson, M. D., & Large, A. R. G. (2006). “Natural” rivers, “hydromorphological quality” and river restoration: a challenging new agenda for applied fluvial geomorphology. *Earth Surface Processes and Landforms*, *31*, 1606–1624.