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Morphodynamic analysis of diverse headwater reaches using remote sensing and historical reconstruction.

Francisco Javier Martín-Rodríguez[1], Manel Llena[2], and Carmelo Juez[1]
[1]Pyrenean Institute of Ecology, Spanish National Research Council (CSIC), Zaragoza, Spain.
[2]Fluvial Dynamics Research Group (RIUS), University of Lleida, Lleida, Spain.

Rivers play a crucial role in shaping landscapes through erosion, sediment transport and deposition. These processes, influenced by topography, geology, meteorology and land use, drive biological and chemical interactions with varying dynamics along the river course. Headwater streams, characterized by steep slopes and extreme weather conditions, are prone to erosion, making them significant sources of water and sediment that influence downstream geomorphology. Investigating historical and current changes in headwaters provides a detailed understanding of sedimentary dynamics and their relationship to physical characteristics and hydro-climatic regimes.

The study integrates historical and contemporary data analysis, focusing on four main objectives: (i) Historical and current hydrology tracking using official databases and field surveys; (ii) Conducting 3D analysis of historical geomorphic evolution through photogrammetric (Structure from Motion, SfM) reconstruction; (iii) Characterizing current morphodynamics using SfM techniques and unmanned aerial vehicles (UAV) for high-resolution seasonal monitoring; and (iv) Performing sedimentary and morphological analysis through traditional sediment characterization techniques. The studied headwater reaches are located in the Upper Aragón headwater, located in the Central Spanish Pyrenees.

By integrating multidisciplinary approaches, this study offers a comprehensive and precise framework to analyze sedimentary dynamics and fluvial morphodynamics. The innovative, rapid data collection procedure provides seasonal information, advancing our understating of river ecosystem evolution.

Preliminary results from historical reconstruction indicate a stabilization of streamflow over the past century, potentially driven by widespread forestation and land abandonment. These phenomena reduce erosion and sedimentary incomes, reducing morphologic diversity. Additionally, the observations in current morphodynamics confirms the methodology's success in terms of precision, accuracy and speed, delivering high-quality data while reducing survey effort.

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