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Meander dynamics in a changing river corridor

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ABSTRACT

In the first decades of the twentieth century, the Ebro River was the Iberian channel with the most active fluvial dynamics and the most remarkable spatial–temporal evolution. Its meandering typology, the dimensions of its floodplain (with an average width >3.0 km), and the singularities of its flow regime produced a especially interesting set of river functions from the perspective of the fluvial geomorphology of the largest Mediterranean channels.

The largest dynamics of the Ebro River are concentrated along the meandering profile of the central sector. During the twentieth century, this sector experienced a large alteration of its geomorphological structure. We present here an analysis of this evolution through the cartographic study of a long segment of the river (~250 km) in 1927, 1956, and 2003. The study is focused on a wide set of geomorphic parameters and indicators that represent the forms of the meander belt, its lateral dynamics, and the overall mobility of the river corridor. The results of the analysis show a large transformation of the meander dynamics, as well as a massive loss of the river lateral activity, most of which occurred in the second half of the twentieth century. This intense geomorphological transformation becomes visible in (i) the large reduction of the bankfull width and the active channel area; (ii) the decrease in the rate of lateral channel migration; (iii) the loss of channel activity; and (iv) the large reduction of coincidence of the active channel areas. However, the most traditional form parameters (i.e., wavelength, amplitude, radius of curvature, and meander length) do not show significant differences throughout the time interval analysed. The study reinforces the necessity of integrating a wide range of dynamic indicators, which may complement the classical form parameters and represent the real functioning of the river corridor, in the geomorphological analyses of meander dynamics.

This work also shows the most important procedures for the recuperation of the ecomorphological processes of the meander belt. It highlights the most urgent measurement for ecological recovery and illustrates the management scenarios that have led to the present-day situation of the river system. This work further highlights the management scenarios that could be most important for the continued good status of the meander dynamics in this changing river corridor.

1. Introduction

Until 1970, the research on meandering channels was based primarily on the analysis of the meander morphology and its relationship with primary control factors, such as flow regimes (Schumm, 1960). Based on these studies, we generally assumed that meanders tend to present equilibrium, which was understood as the symmetry of forms in natural conditions. This form should be characterised through standardised parameters.

The rate of channel lateral migration depends on the resistance to erosion of the concave bank (Nanson and Hickin, 1986), the duration and magnitude of flows (Odgaard, 1987), the radius of curvature of the channel (Nanson and Hickin, 1983, 1986; Odgaard, 1987) and the capacity of the flow to convey sediments (Neill, 1987; Nanson and Hickin, 1986; Po-Hung et al., 2009). Channel migration is a non-continuous process, considering its association to certain hydrologic events (Brice, 1977; Nanson and Hickin, 1983). In earlier stages, channel bends migrate transversely to the main axis of the valley, but later on, bends also advance in the valley direction (Brice, 1977; Knighton, 1984; Leeder and Bridge, 1975; Nanson and Hickin, 1983, 1986).

Large channel lateral migrations have been documented in some meanders, including the lower reach of the Mississippi River (20 m/y). However, the rates of lateral migration most frequently measured are around 1 m/y or less (Lutgens and Tarbuck, 1995). Meanders also migrate downstream, which enhances large changes in their overall morphology. In most channels, the majority of meander activity occurs in periods when liquid and solid flows and bed erosion are much larger than usual. Because of incision processes, water conveys a higher amount of sediments in the inner bank of the bend. This

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