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Field and laboratory evidence of large scale dynamics in braided rivers

Abstract

In the last century human activities have strongly affected the natural behaviour of the rivers, resulting in a simple single-thread channel with the aim to convey water flow and floods. In much of the world, the remarkable degree of spatio-temporal heterogeneity characterising riverine landscapes has been masked by a long history of river engineering. Floodplain reaches, which exhibit the highest heterogeneity in the natural state, have been the most severely altered (e.g. Ward & Stanford, 1995), resulting in a distorted perception of patterns and processes in riverine landscapes. An accurate comprehension of spatio-temporal heterogeneity in the unaltered state is crucial for a holistic understanding of the structure and function of river ecosystems and is essential for successful protection, conservation and restoration (Ward et al., 2002).

Within this context, the research activities is focussed on braided rivers because this river pattern displays a highly complex eco-morphodynamics, that should have characterised the pristine state of the low valley alpine rivers. At present, very few rivers show pristine condition and one of these is the Tagliamento River (Italy). The Tagliamento River still displays a semi-natural morphodynamic behaviour even though it has been undergone changes due to human activities.

It is well known that single-thread rivers show inherent spatio-temporal scales related to the bedforms and/or to the planimetric evolution, like bars and meanders wavelength , but this is not clear in braided rivers yet.

The aim of this work is to investigate the equilibrium configuration and the superimposed inherent spatial and temporal scales in gravel-bed braided rivers in order to gain a better understanding of the morphological processes occurring and to provide a scientific basis for river management, conservation and restoration activities. Moreover it was investigated the long term morphological changes and the inundation dynamics of the Tagliamento River, in order to characterise the morphological behaviour of the river network due to external forcing like human impacts and floods.

The characterisation of these scales is undertaken with laboratory experiments and field measurements.

The time scales involved are investigated by analysing the sediment transport rate temporal fluctuations measured during experimental runs. Three distinct inherent temporal scales have been individuated and then related to the morphological processes of the river network.

The braiding indices, the channel width and the bed topography were monitored throughout the runs, in addition to the outgoing sediment transport rate. Two inherent spatial scales have been found by analysing the spatial fluctuations of these parameters along the longitudinal flume direction. The scales rising both from the planimetrical and the altimetrical parameters are the same, furthermore it has been found that these scales are related to the average width of the river network.

In order to characterise the equilibrium configuration of the river network the measured parameters were averaged both in time and in space. The average values of the representative parameters of braiding are related to the hydraulic parameters (discharge, slope and sediment size), showing an increasing complexity of the system with the water discharge and slope.

These result shows that the key parameter is the channel width, suggesting an analogy between braided and single-thread pattern (river bars and/or meanders).

Field activities were carried out on the Tagliamento River, in order to compare the spatio-temporal scales found in the laboratory experiments and to understand the real behaviour of this river pattern subject to disturbances like no-steady flow, vegetation and sediment sorting. The planimetric evolution of the study reach was monitored by time-lapse images of the river network, using a digital camera installed on the top of a mountain. The image analysis allowed the investigation of the lateral spatial scales of the expansion and contraction phase of the braided rivers which characterises the inundation dynamics of the network. This cycle of inundation is related to the hydrological regime and in turn strongly related to the ecological aspects, like the connectivity and the exchanging processes of organic matter.

In order to investigate the spatial scales found in laboratory models, classical topographical and modern Lidar surveys were analysed. One of the two spatial scales mentioned above has been found, showing the same relationship with the average width of the network.

The analysis of the aerial images (covering a period of 60 years, since 1944) has allowed to understand the long term evolution of the river mainly due to the human

impacts. Moreover, this analysis suggests that a “new” morphological feature has to be considered: the river islands. Vegetation was not present in the laboratory experiments, but it seems they are a key features in the morphological processes, playing an active role in the evolution of the river (Gurnell and Petts, 2006).