Morphological changes in rivers of South Tyrol (Italian Alps) attributable to climate variations occurred after the Little Ice Age

Changements morphologiques attribuables à des variations climatiques après le petit âge glaciaire dans les rivières alpines dans le Sud Tyrol (Alpes Italiennes)

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RÉSUMÉ

Cet article, à caractère scientifique, examinera les conséquences des changements climatiques et de l'extension des glaciers, qui ont eu lieu après le petit âge glaciaire (entre le début du XIXe siècle et le début du XXe siècle) dans plusieurs bassins versants en Tyrol du Sud (Province autonome de Bozen-Bolzano, Italie), où l'influence anthropique pendant le même laps de temps peut être considérée comme mineure. L'analyse des trajectoires évolutionnistes des morphologies des cours d'eau (échelle des corridors fluviaux) sera effectuée dans des bassins glacés et non glacés, tenant compte des changements dû à la grandeur du bassin. Le public à atteindre sont surtout des scientifiques, mais les gestionnaires devraient également être intéressés étant donné que les résultats donnent des informations sur la magnitude et le timing des dynamiques naturelles fluviales.

ABSTRACT

This scientific paper will investigate the consequences of climate change and glacier extension which occurred after the Little Ice Age (early 19th century – early 20th century) in several river catchments within South Tyrol (Autonomous Province of Bozen-Bolzano, Italy), where the anthropic influence during the same time frame can be considered as minor. The analysis of evolutionary trajectories of river morphologies (river corridor scale) will be performed in both glacialized and not glacialized basins, considering the changes that occurred at the basin scale. The target audience is mainly scientists, but managers should be interested too as results inform about the magnitude and timing of natural river dynamics.

KEYWORDS

Climatic variations, Little Ice Age, Morphological evolution, Mountain Rivers, River geomorphology.

1 INTRODUCTION

During the last century, river dynamics in Italian catchments have been significantly affected by human pressures such as channelization, dams, diversions, gravel and sand mining. However, rivers may have modified their channel morphology also in response to natural climatic variations. In fact, during the period know as Little Ice Age (1400-1850 AD, hereafter LIA) the increased frequency/magnitude of flood events coupled to a stronger glacial activity augmented river's morphological activity. Subsequently, after the end of the LIA, several rivers underwent channel narrowing and bed incision as evidenced by Rumsby and Macklin (1996) and Descroix and Gautier (2002). On the other hand, such an evolutionary trend observed during the last 150-200 years has been attributed to the increased forest cover deriving from land abandonment (Descroix and Gautier, 2002). Indeed, disentangling anthropic from climate-related effects in rivers recent evolution is quite challenging. This research investigates the evolutionary trajectories of Alpine mountain rivers, analysing in particular channels where anthropic pressures were relatively steady between the end of the LIA and the 1950s, in order to determine the likely contribution of climate and glaciers variations (i.e. warming and retreating, respectively) occurred after the LIA. In particular, rivers draining basins featuring different glacial cover are investigated.

2 METHODS

The study rivers (13, Figure 1) lie within the Autonomous Province of Bolzano-Bozen (Italy). The assessment of their evolutionary trajectory was performed with the use of GIS software (Esri ArcGis 10.1). Different historical maps (1820, 1858, 1917-30) and aerial photos (1945 and 1954) were used. In addition a high-resolution (2.5 m) digital elevation model (DTM), a geological and several land use maps were utilized. The morphological analysis included first river segmentation into homogeneous reaches, following the indications by Rinaldi et al. (2013). Key parameters as drainage area, reach length, average slope, sinuosity and braiding index were derived for each reach, beside its classification, based on the definitions proposed by Rinaldi et al. (2013). Data on glaciers extension (at different times starting from 1850) and climate (temperatures and precipitations, mostly starting from the early 20th century) were also collected.

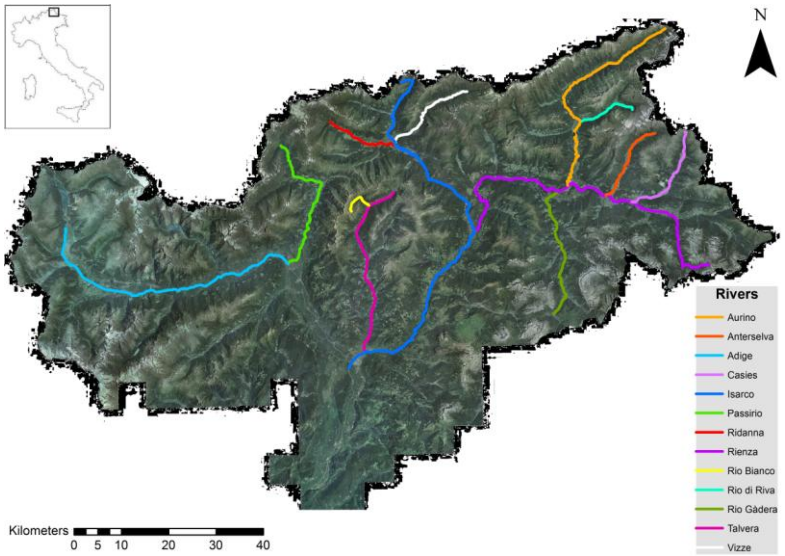

Figure 1: The Autonomous Province of Bolzano-Bozen and the thirteen studied rivers.

3 PRELIMINARY RESULTS

For the 13 rivers, the segmentation phase led to the identification of 127 reaches, of which 53 confined, 53 partly confined and 21 unconfined. Reach length varies between 630m and 5500m, average channel slope from 0.3 to 24 %, drainage area from 100 km^2 to ca.4000 km^2. Despite the definitely mountainous environment, partly to not confined reaches are quite common in the study areas due to the presence of relative wide valleys carved by glaciers during the Pleistocene. Morphological patterns displayed in 1858 for the study reaches include: straight channels (mostly in confined reaches, but also in partly-confined ones), sinuous, sinuous with alternate bars (only one reach), transitional/wandering, meandering and anastomosed (Figure 2). At the moment the

evolutionary trajectories are still under analysis, and only qualitative comparisons can be reported here. As an example, Figure 3 reports the evolution of the Ahr/Aurino River, which was anastomosed in the 1858 but presented a wandering morphology in the 1945. In other cases the changes appear to be rather minor, indicating how complex and varied was the response in a relatively small geographical area.

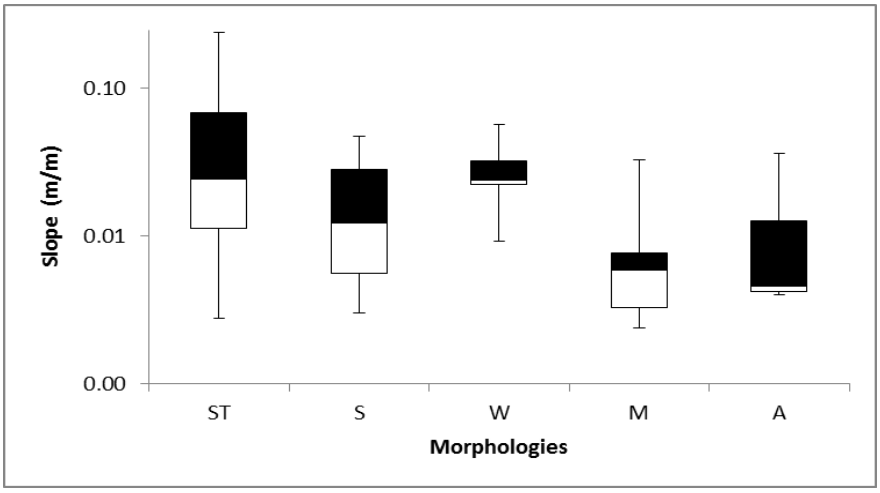

Figure 2: Slope range for each morphological pattern as seen in the 1858 map.
ST: Straight; S: Sinuous; W: Wandering; M: Meandering; A: Anastomosed.

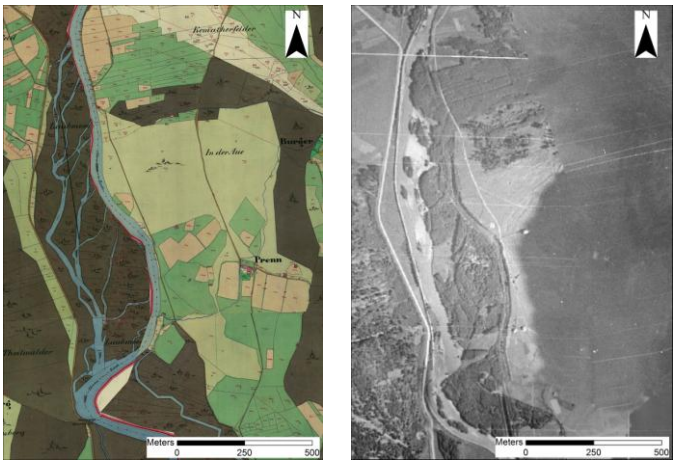

Figure 3: The Ahr/Aurino River in year 1858 (left) with an anastomosed pattern and in the 1945 (right) with a wandering morphology.

4 CONCLUSION

The preliminary results seem to indicate that rivers of South Tyrol varied their morphological pattern in response to climatic variations occurred after the LIA, but variations differed greatly in magnitude. The post-LIA changes in planform pattern appear to have been more pronounced in the less confined reaches, where the initial morphology was anastomosed or transitional.

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