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Morphological expression of active tectonics in the Southern Alps

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Evolving drainage pattern and corresponding metrics of the channels (e.g. normalized steepness index) are sensitive indicators for tectonic or climatic events punctuating the evolution of mountain belts and their associated foreland basins. The analysis of drainage systems and their characteristic properties represents a well-established approach to constrain the impact of tectonic and climatic drivers on mountainous landscapes in the recent past. The Southern Alps (SA) are one of the seismically most active zones in the periphery of northern Adria. Recent deformation is caused by the ongoing convergence of the Adriatic and European plate and is recorded by numerous earthquakes in the domain of the SA. Deformation in the SA is characterized by back-thrusting causing crustal thickening and should therefore result in uplift and topography formation. The vertical velocity field determined by GPS-data clearly indicates a belt of significant uplift in the south South alpine indenter between Lake Garda in the west and the Triglav in the east and strong subsidence of the foreland basin surrounding the Mediterranean Sea near Venice, although subsidence is often related to ongoing subduction of the Adriatic microplate underneath Appennines. Despite of these short term time series, timing, rates and drivers of alpine landscape evolution are not well constrained and the linkage between crustal deformation and topographic evolution of this highly active alpine segment remains unclear for the following reasons: (1) The eastern Southern Alps were heavily overprinted by the Pleistocene glaciations and tectonic signals in the alpine landscape are blurred. Only the transition zone to the southern foreland basin remained unaffected and allows an analysis of a glacially undisturbed topography. (2) The major part of this domain is covered by lithology (carbonatic rocks) which is unsuitable for low temperature geochronology and cosmogenic isotope dating so that exhumation and erosion rates are not well constrained for the entire domain. Despite of that, extensive karstification in some areas limits the validity of a morphometric analysis in particular of the upper reaches of the drainage system and leads to a long term persistence of landforms (e.g. plateaus).

In this study we focus on the drainage pattern of the eastern Southern Alps and the adjacent southern foreland basin. We use a high-resolution digital elevation model and a novel numerical approach to extract characteristic parameters of the morphology for the entire eastern Southern Alps with a high spatial resolution. We explore deviations in the steepness of channels from an equilibrium state and knick-points in longitudinal channel profiles and interpret these features in terms of (a) active tectonics, and variable uplift rates, (b) lithological effects like erodibility contrasts and karstification, and (c) base level lowering caused by glacial erosion and Messinian pre-conditioning. The drainage system of the Adige shows the most significant deviations from a fluvial equilibrium. This is documented in the normalized steepness index of the main channel and all tributaries as well as in the longitudinal channel profile. The main channel shows several sections of downstream steepening and extremely low channel gradients in the lower reach. Similar deviations are also observed in the Brenta catchment situated east of the Adige drainage system. In contrast to the two large western catchments of the study region, the Piave and particularly the Tagliamento catchment show well graded channel profiles and uniform normalized steepness indices despite of the glacial history. This clear west to east trend from highly disturbed to overall well graded channels has never been documented before and may be explained in the light of increased uplift rates in the east and differences in onset and timing of topography formation between the western and eastern sector of the study region.