Editorial: Geomorphic response to active tectonics: numerical and field-based approaches

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It is now common knowledge that climate, surface processes, and tectonics interact to determine the behaviour and the evolution of tectonic structures and geodynamic systems and the resulting shaping of the Earth's surface. Recognising this intricate coupling between deep earth and surface processes, the source-to-sink approach to sediment routing systems is now widely exploited as a major pathway toward the understanding of tectonic processes and histories (Castelltort et al., 2015). This includes all facets of sediment production, transport and accumulation, resulting from the degradation of tectonically created topography. However, sediments are rarely preserved in the exporting source areas, whose uplift-dependent histories are essentially recorded in landforms carved by erosion, from grand-scale features of mountain topography to the detailed morphology associated with individual active tectonic structures. There, tectonic geomorphology is thus primarily used as a tool for unravelling the spatio-temporal characteristics of the tectonic component that drives landscape evolution (Burbank and Anderson, 2011).

After the concepts of Davisian and Penckian erosion cycles (Davis, 1899; Penck, 1953) had been severely criticized and had more or less fallen into oblivion in the mid-20th century, tectonic geomorphology no longer received much attention. In the mid-1980s, the field experienced a revival when it was recognized that erosion plays a major role in the evolution of active orogens, through its interaction with lithospheric processes (Castelltort et al., 2015). Its recent flourishing has benefited strongly from rapid advances in (*i*) dating techniques and our new capabilities of estimating denudation rates (Rixhon et al., 2017), (*ii*) the conceptual and field-based numerical modelling of landscape evolution (e.g., Chase, 1992; Howard, 1994; Lague, 2014; Temme et al., 2017), and (*iii*) the development of elaborate morphometric analyses based on the availability of ever higher-resolution digital elevation models (e.g., Demoulin, 2011; Perron and Royden, 2013; Willett et al., 2014). River incision and, to a lesser degree, changes in drainage networks are the most direct geomorphic responses to uplift signals, resulting in a large majority of morphotectonic studies dealing with the analysis of (transient) river profiles (Kirby and Whipple, 2012; Demoulin et al., 2017). However, a number of issues on triggers and the nature of change in landscape evolution are still debated. Among these are, for instance, (*i*) the respective role of climate and tectonics in affecting fluvial erosion rates (e.g., Valla et al., 2010; Whittaker, 2012; Wang et al., 2015), (*ii*) the incision history of mountain relief (Montgomery and Korup, 2011), (*iii*) the response time of fluvial landscapes (Whipple, 2001; Whittaker, 2012; Goren, 2016), (*iv*) the interplay between glacial and tectonic signatures in mountain landscapes (Prasicek et al., 2014, 2015), and (*v*) the question of how far we can proceed with certain approaches (e.g., the inverse modelling of river long profiles; Roberts et al., 2012) without getting realistic but maybe questionable results.

This special issue is an outcome of session GM4.1/TS3.5 "Geomorphic response to active tectonics: numerical and field-based approaches", initiated by the Working Group "Tectonic Geomorphology" of the International Association of Geomorphologists (IAG) for the EGU meeting in April 2016 in Vienna, Austria. This session gathered field-based and numerical modelling studies about the evolution of landforms in response to the tectonic driver, of which they are meaningful indicators of the nature, amplitude, rate and stage at many space and time scales. The present special issue collects eight papers representing some of the topics dealt with in the session, and collectively representative of the main lines of research in tectonic geomorphology. These papers are issued either from the session itself or published in *Earth Surface Processes and Landforms* in recent years.

The first three papers are examples of how much the morphotectonic analysis of landscapes may contribute to an improved understanding of the rates and timing of tectonic deformation, in combination with geological, stratigraphical, and geochronological data. Coupling geomorphic field evidence and a morphotectonic study with sedimentary and structural analyses, and tephrostratigraphic and 40Ar/39Ar age data, Amato et al. (this issue) reconstruct the Quaternary evolution of the northern Camposauro Mountain front, sloping down to the lower Calore River in the axial zone of the Southern Apennines of Italy. They show how extensional tectonics governed the evolution of the mountain front from the Early Pleistocene, leading to the formation and later deformation of slope breccia wedges and four generations of stepped late Middle Pleistocene to present alluvial fans in the piedmont zone of the Camposauro Mountain.

In the east-west extensional setting of the south Tibetan Plateau, Jiang et al. (2016) compile profile steepness and concavity data of rivers flowing down the uplifted western shoulder of the Damxung-Yangbajain rift to evidence the existence of knickpoints. Combined with landform offsets at the foot of the rift's faulted margins, they document spatially varying tectonic activity along the bounding faults, which show prevailing left-lateral strike-slip in the north and normal slip and maximum uplift in the middle and southern rift segments. They also discuss the causes of this uplift and the possible link to known strong earthquakes in the area. A third paper, by Gasparini et al. (2016), addresses the geomorphic signature of normal faulting in the tectonically much quieter setting of a very-low elevation area in SE Louisiana, USA. They explore the response of three low-gradient sand-bed alluvial rivers to downstream-facing normal faulting through an analysis of channel sinuosity and meander direction and migration rate, which they combine with a one-dimensional modelling of steady water flow aimed at detecting local anomalies in channel parameters. They indeed identify fault-related channel anomalies, which lead them to suspect that recent fault slip rates are higher than Pleistocene rates. Although they note that fault control hardly emerges from other factors of river evolution, they conclude that low-gradient alluvial rivers might be more sensitive to faulting than previously thought.

Another topic that gained recent attention in tectonic geomorphology relates to the contribution of river-profile analysis to the deciphering of fault growth and linkage (e.g., Hemelsdaël and Ford, 2016; Roda-Boluda and Whittaker, 2018). In this special issue, Kent et al. (2017) demonstrate how transient river long profiles and the associated slope-break knickpoints reveal fault segment linkage in the Gediz Graben of Western Turkey. Looking at non-lithologic knickpoints that perturb the long profile of streams flowing down the Bozdag Range and crossing normal fault segments of the graben southern margin, they evidence a scaling between the present height of knickpoints above the toe of the fault scarp, and footwall relief and fault throw. Based on fault interaction theory and ratios of profile steepness above and below the knickpoints, they estimate a threefold increase in fault slip rate to have been responsible for generating the knickpoints. Combining this result with geomorphic and structural constraints, they calculate that the fault linkage that caused this increase in slip rate occurred between 0.6 and 1 Ma and derive fluvial landscape response times from their knickpoint retreat rate estimates. With a similar purpose of constraining fault growth and segment linkage from geomorphic and stratigraphic field evidence along the Cittanova Fault, which borders to the NW the Aspromonte Massif of Calabria, Southern Italy, Peronace et al. (this issue) exploit another morphometric approach of fault growth detection based on the computation of Hack's SL and chi maps, and the analysis of chi values at the upstream end of river profiles on both sides of drainage divides. Though they recognize the power of chi maps in this respect and conclude to post-24 ka segment linkage, these authors also underline the existence of perturbations (of unknown origin) in the relationship between chi and fault throw rate variations.

Further papers in this special issue use chi maps as key data in their analysis of different morphotectonic issues, namely drainage divide instability and the competing roles of rock uplift and glacial erosion in shaping mountain topography. They follow an approach introduced by Willett et al. (2014) that, though recently challenged by Forte and Whipple (2018), has proven promising in various contexts. For instance, Goren et al. (2015) based their identification of basin rotation in the Lebanon restraining bend of the Dead Sea fault system on the chi metric, allowing inferences about the modes and rates of horizontal deformation. Yang et al. (2015) also relied on chi estimations, complemented by numerical landscape evolution modelling, to discuss the origin of high-elevation, low-relief surfaces on the southeastern margin of the Tibetan plateau. Here, Struth et al. (2017) combine a chi-based digital topographic analysis of the drainage network in the Eastern Cordillera of Colombia with 10Be-constrained denudation rates to evaluate drainage divide migration and plateau size reduction. They show how higher profile steepness (and derived stream power estimates) and higher denudation rates along the plateau’s flanks than in its interior, as well as chi contrast across divides, consistently highlight focused erosion of the steepened flanks of the plateau and the latter's subsequent reduction, caused by progressive shortening and thickening of the Eastern Cordillera. The next paper, by Adams and Ehlers (2017), presents another use of chi plots, which the authors include in a suite of metrics describing the topography at the hillslope, river profile, and basin scales in order to decipher the respective contributions of glacial and tectonic processes in the shaping of the Olympic Mountains (Cascade Range, north-western USA). Based on this quantitative landform analysis, they succeed in separating the Plio-Pleistocene topographic signature of alpine glaciers and ice sheets from the still preserved record of the long-term rock uplift pattern imprinted on the broad relief structure. This study nicely illustrates how powerful an appropriate set of topographic metrics may be in extracting quantitative information about surface processes and their spatio-temporal characteristics, making the morphometric analysis a complementary technique to the study of sedimentary deposits.

The last paper (Collignon et al., 2016) is the only one of this dedicated volume that makes exclusive use of numerical modelling to examine the topographic response (and feedbacks) to a specific tectonic signal, namely fold growth. As such, it is a new and interesting addition to the wealth of published modelling studies that have explored the drivers and responses of, and the controls on, the making of topography (to be very brief, e.g., Godard et al., 2004, 2006; Codilean et al., 2006; Lague, 2014; Braun et al., 2015; Yanites et al., 2017). Here, Collignon et al. (2016) test the conditions of uplift and river erosion that determine deflection, endorheism, or in-situ incision of antecedent streams during the growth of fold(s) under different lithological configurations. They use examples from the Zagros Fold Belt of Iran to show that drainage patterns are controlled by rock uplift rate and the erodibility ratio between rock layers of contrasting resistance, and discuss the implications for sediment deposition within fold-and-thrust belts.

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