Geophysical Research Abstracts
Vol. 19, EGU2017-10187, 2017
EGU General Assembly 2017

Deconvolving regional and fault-driven uplift in Calabria using drainage inversion techniques and field observations

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A key challenge in the Earth Sciences is to understand the timing and extent of the coupling between geodynamics, tectonics, and surface processes. In principle, the landscape adjusts to surface uplift or tectonic events, and present-day topography records a convolution of these processes. The inverse problem, the ability to find the 'best fit' theoretical scenario to match present day observations, is particularly desirable as it makes use of real data, encompasses the complexity of natural systems and quantifies model uncertainty through misfit.

The region of Calabria, Italy, is known to have experienced geologically rapid uplift ($\sim$1 mm/yr) since the Early Pleistocene, inferred from widespread marine terraces (ca. 1 Myr old) at elevations greater than 1 km. In addition, this is a tectonically active area of normal faulting with several highly destructive earthquakes in recent centuries. Since there has been some debate about the relative magnitudes of the uplift caused by regional processes or by faulting, the ability to model these effects on a regional scale may help resolve this problem.

Therefore, Calabria is both a suitable and important site to model large magnitude recent geomorphic change. 1368 river longitudinal profiles have been generated from satellite digital elevation models (DEMs). These longitudinal profiles were compared to aerial photography to confirm the accuracy of this automated process. The longitudinal profiles contain numerous non-lithologically controlled knickpoints. Field observations support the presence of knickpoints extracted from the DEM and measurements of pebble imbrication from fluvial terraces suggest the planform stability of the drainage network in the last 1 Myr.

By assuming fluvial erosion obeys stream power laws with an exponent of upstream area of 0.5 ± 0.1, the evolution of the landscape is computed using a linearized joint inversion of the longitudinal profiles. This has produced a spatially and temporally continuous model of cumulative uplift for the Calabria region. We have used independently-collated stratigraphic data to provide absolute ages for the inversion model. In particular, uplift rates of well-dated marine terraces constrain the inversion near the coastline and we are using cosmogenic isotope isochron burial dating to refine the timing of the onset of uplift. Preliminary inversion results show the initiation of uplift at approximately 1.9 Ma. The model output is consistent with field observations of regional uplift, later combined with fault related extension. Furthermore, these results are consistent with an increase in regional uplift rate prior to fault initiation.