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TerraceM: A Matlab® tool to analyze marine terraces from high-resolution topography

Julius Jara-Muñoz, Daniel Melnick, and Manfred Strecker

University of Potsdam, Institut für Erd-und Umweltwissenschaften, Earth Sciences, Potsdam, Germany
(jara@geo.uni-potsdam.de)

To date, Light detection and ranging (LiDAR), high- resolution topographic data sets enable remote identification of submeter-scale geomorphic features bringing valuable information of the landscape and geomorphic markers of tectonic deformation such as fault-scarp offsets, fluvial and marine terraces. Recent studies of marine terraces using LiDAR data have demonstrated that these landforms can be readily isolated from other landforms in the landscape, using slope and roughness parameters that allow for unambiguously mapping regional extents of terrace sequences. Marine terrace elevation has been used since decades as geodetic benchmarks of Quaternary deformation. Uplift rates may be estimated by locating the shoreline angle, a geomorphic feature correlated with the high-stand position of past sea levels. Indeed, precise identification of the shoreline-angle position is an important requirement to obtain reliable tectonic rates and coherent spatial correlation. To improve our ability to rapidly assess and map different shoreline angles at a regional scale we have developed the TerraceM application. TerraceM is a Matlab® tool that allows estimating the shoreline angle and its associated error using high-resolution topography. For convenience, TerraceM includes a graphical user interface (GUI) linked with Google Maps® API. The analysis starts by defining swath profiles from a shapefile created on a GIS platform orientated orthogonally to the terrace riser. TerraceM functions are included to extract and analyze the swath profiles. Two types of coastal landscapes may be analyzed using different methodologies: staircase sequences of multiple terraces and rough, rocky coasts. The former are measured by outlining the paleo-cliffs and paleo-platforms, whereas the latter are assessed by picking the elevation of sea-stack tops. By calculating the intersection between first-order interpolations of the maximum topography of swath profiles we define the shoreline angle in staircase terraces. For rocky coasts, the maximum stack peaks for a defined search ratio as well as a defined inflection point on the adjacent main cliff are interpolated to calculate the shoreline angle at the intersection with the cliff. Error estimates are based on the standard deviation of the linear regressions. The geomorphic age of terraces (Kt) can be also calculated by the linear diffusion equation (Hanks et al., 1989), with a best-fitting model found by minimizing the RMS. TerraceM has the ability to efficiently process several profiles in batch-mode run. Results may be exported in various formats, including Google Earth and ArcGis, basic statistics are automatically computed. Test runs have been made at Santa Cruz, California, using various topographic data sets and comparing results with published field measurements (Anderson and Menking, 1994). Repeatability was evaluated using multiple test runs made by students in a classroom setting.