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Analysis of distributed deformation in Central America using remote sensing analysis of geomorphic features

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Active crustal deformation in northern Central America is mainly due to the relative motion of the Cocos, Caribbean, and North American plates. The motion between these plates is not only accommodated along the trench and the Polochic-Motagua fault system but also along distributed deformation zones. Studying such widespread deformed areas is challenging due to the low seismicity and deformation rates and also to the dense vegetation which precludes detailed studies along active faulting. Thus the extent, intensity, and kinematics of most active structures are still largely unknown. Our objective here is to investigate distributed deformation in Central America using remote sensing analysis of geomorphic features such as stream profiles and drainage patterns. Using TecDEM, a MATLAB-based software allowing the analysis of tectonic geomorphology from digital elevation models, we performed quantitative measurements of several geomorphic indices (Hack index, concavity index, steepness index and relative uplift rates) that are commonly used in tectonic geomorphology studies in order to identify areas experiencing deformation. These data were reported on GIS and then used to produce maps of the deformation. In some areas we also analyzed the geommetry of drainage patterns in order to identify offset rivers and asymmetric basins associated with block tilting. We applied these methods both to transpressional (Sierra de Chiapas in Southern Mexico) and transtensional (Belize and Northern Guatemala) settings. The first area is located along the Tuxtla Fault in Sierra de Chiapas which produced a Ms 7.2 earthquake in 1902. All geomorphic indices derived from extracted river profiles (Hack index, concavity index, steepness index and relative uplift rates) show a variation along the supposed fault trace. Fault trace is mainly associated with a significant increase of the Hack-index gradient with respect to the areas located afar. River profiles also display several knickpoints, suggesting a non-equilibrated state. Uplifting and tilting of the range boarding the fault is associated with an asymmetry of the drainage basins. The second area corresponds to the Maya mountains in Belize and the Peten depression in Guatemala. Analysis of rivers offsets in the Maya mountains clearly argue for a left-lateral motion along the faults affecting the area. Topographic profiles made across the Peten area suggest half-graben geometries with blocks tilted toward the north. The analysis of the basin asymmetries suggests stream migration toward the faults and is thus coherent with block-tilting along normal faults. These results are important because they reveal structural differences between strike-slip faulting occurring in the Maya Mountains and extension occurring to the north. Fault-slip measurements performed along normal faults show N304°-trending extension, while measurements along left-lateral strike-slip faults show N297°-trending extension and N030°-trending shortening. It is possible that normal and strike-slip faults were coeval in a transtensional setting. Although the Maya Mountains are marked by a lack of seismicity and are often considered inactive, these results also suggest that the tectonic activity in this area is recent enough to have survived the tropical climate and to be seen in the geomorphology.