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Drainage Analysis of the South American Landscape and its Tectonic Implications

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The majority of studies aimed at investigating topographic growth and landscape evolution have limited spatial coverage. Frequently, spot measurements of uplift and denudation are only available, which hampers spatial resolution of the growth of regional topographic features. This limitation can be overcome by quantitatively analysing substantial, continent-wide, drainage networks. The shapes of long wavelength longitudinal river profiles appear to be mainly controlled by regional uplift and moderated by erosional processes, both of which can vary as a function of space and time. By parametrizing erosional histories, it is feasible to develop inverse models that permit spatial and temporal patterns of regional uplift to be reliably retrieved. Here, a drainage inventory for South America consisting of 1827 rivers has been inverted. River profiles were extracted from the SRTM topographic dataset and modelled using a simplified version of the stream-power law, in which erosional processes are described using a linear advective formulation. The inverse problem is then solved by seeking smooth uplift rate histories that minimize the misfit between observed and calculated river profiles using a linearized, damped, non-negative, least squares algorithm. Calibration of erosional processes is achieved by inverting the complete drainage inventory and seeking a calculated uplift history that best honours independent geological observations from the Borborema Province of northeast Brazil. This province experienced regional Cenozoic uplift. Calculated uplift rate histories for South America suggest that the bulk of its topography developed during Cenozoic times. The model suggests, for instance, that the Andean mountain chain mostly arose in late Eocene-Oligocene (i.e. 40-28 Ma) times with an increase in elevation during Miocene times (i.e. the last 20 Ma). Uplift of the Central Andean Altiplano from an elevation of $\sim$ 1 km to its present-day height of $\sim$ 4 km occurred within the last 25-30 Ma. Our results are consistent with a wide range of independent geological observations across South America (e.g. elevated marine deposits, thermochronology, paleoelevation estimates from paleobotany, standard/clumped isotopes analyses). Finally, an important test of our thesis concerns offshore sedimentary flux. For example, our calculated uplift history can be used to predict the history of sedimentary flux into the Foz do Amazonas basin. This prediction agrees with offshore studies of the Amazon delta which suggest a rapid increase in clastic deposition since middle Miocene times. In summary, we propose that South American drainage contains useful information about spatial and temporal patterns of regional uplift which can help our understanding of regional topographic growth and landscape evolution.