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Deciphering the patterns and controls on long-term basin-averaged erosion rates from *in-situ* ^{10}Be in Madagascar using random within-between modelling

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Cosmogenic nuclide analysis of river sediment provides insight into erosion and catchment dynamics. Studies on factors controlling spatial variations in long-term erosion rates have often focussed on tectonically active mountainous areas, where strong linkages with topographic variables like catchment gradient and normalized river steepness have been found. Less is known about rates and controls in tropical areas with deeper soils in tectonically less active regions which are often intensively used by people. Information on long-term erosion rates is crucial if human impact on landscape dynamics is to be understood in these areas.

Here, we investigate spatial patterns and controls on ^{10}Be -inferred erosion rates in Madagascar, a moderately seismically active island surrounded by passive margins, with considerable relief and a climate that varies from humid tropical to semi-arid. We use a dataset of 99 detrital *in-situ* ^{10}Be measurements from a wide range of catchments (combining new measurements with data from the literature), covering more than 30% of the country and including a wide range of topographic, bioclimatic, and geological characteristics. Overall, ^{10}Be erosion rates are very low (2.4 - 51.1 mm kyr⁻¹) but clear differences were found between different geomorphic regions with some of the highest rates on the eastern escarpment while most catchments in the central highlands had extremely low erosion rates. The latter shows that, under (sub-) tropical climax vegetation catchments can be very stable, despite a pronounced topography with convex slopes exceeding 30° and the presence of a thick and erodible regolith mantle covered by a protective laterite. Statistical tests indicate that 27% of the observed variation in ^{10}Be erosion rates is associated with

elevation (lower rates for higher catchments) and an additional 18% of the variation is associated with river concavity, seismicity, and lithological erodibility (higher rates for more convex, more seismically active and more erodible catchments). An additional test using random within-between (REWB) analysis, in which different geomorphic regions are also considered as independent variables, shows that the main variations in ^{10}Be -inferred rates between the different regions are linked to river concavity, seismicity and gully abundance, where additional variation within geomorphic regions is linked with seismicity only. The random within-between model explained 73% of the observed variation, suggesting that differences between regions are indeed important, yet are only partly explained by the environmental controls we considered in our analysis. The fact that the association between topographical controls and ^{10}Be -inferred erosion rates is weaker in Madagascar in comparison to tectonically (very) active areas is likely to be related to the long time scale considered and the fact that sediment buffering as well as individual random events may have a more important impact on ^{10}Be -inferred erosion in relatively stable environments such as the ones we studied in Madagascar.