
What can in-situ ^{14}C from river sediments reveal about landscape evolution?

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Abstract

Paired in-situ ^{14}C and ^{10}Be measurements offer a promising way to investigate sediment storage, transient erosion, soil mixing, and process-specific erosion such as landsliding, because the two nuclides have contrasting half-lives and production profiles. However, many landscape processes can influence their concentrations, making interpretation difficult. We present two paired ^{14}C – ^{10}Be river-sediment data sets from mid-sized catchments in Crete, Greece, and the Northern Andes of Colombia, together with a new code package, the Unsteady Calculator, to test what information these data can reliably recover about landscape evolution.

The Unsteady Calculator includes forward models for cosmogenic nuclide concentrations under nine complex erosion scenarios, with or without soil mixing, and an inversion framework for reconstructing transient erosion histories from multiple samples. Synthetic experiments show that in joint inversions of multiple paired samples, some parameters can be reasonably constrained, but others, remain poorly recovered because of strong trade-offs among model parameters.

Applying the inversion to Crete suggests either a 1–2 order-of-magnitude increase in erosion rates, or 50–200 cm of regolith loss, around 500 years ago. In Colombia, ^{10}Be -derived apparent erosion rates span 0.01–0.5 mm/yr and correlate with landscape steepness, whereas apparent ^{14}C erosion rates cluster between 1 and 2 mm/yr. This offset does not correlate with landslide frequency, sediment storage, deforestation history, or plausible soil mixing depths.

Overall, paired ^{14}C – ^{10}Be data can reveal transient landscape signals, but robust interpretation is limited by parameter trade-offs and a persistent, unexplained tendency for ^{14}C -derived apparent erosion rates to exceed ^{10}Be -derived rates.

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