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From source to sink with in situ cosmogenic nuclides: Modern to late Holocene denudation rates and sediment fluxes in the Po basin

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Cosmogenic nuclides are now established as an integral tool of Earth surface science, providing reliable measures of landscape change. Applications of in situ-produced nuclides to lowland basins, where sediment undergoes storage and deposition, are however still rare. Recently, it was shown for large cratonic river basins that cosmogenic nuclides can provide an integrated approach insensitive to a range of geological sources of bias thereby tracing signals from upstream mountainous areas to the lowlands (summary given in [1]). Given these advances of the method, we can proceed with the application to a geologically complex subsiding foreland basin.

In the Po basin, we constrained the long-term sediment delivery from source to deltaic sink using sediment fluxes from in situ 10Be-derived denudation rates and compared these to published short-term estimates from gauging. From the comparison of 10Be nuclide data measured upstream of dam influence to those measured downstream of major dams, we find that the average 10Be signal is not significantly modified. In the lowland reaches, we find that the average 10Be concentration is only marginally modified by floodplain processes, as 26Al/10Be ratios do not show differential decay due to burial. The close similarity in 10Be concentrations from the sources to the Po lowland sink suggests that LGM denudation rates prior to sediment trapping in periglacial lakes were similar to today's, as the sediment now contained in the Po lowlands must have been eroded from the orogen and deposited in the lowlands prior to lake formation. Today′s sediment in the Alpine and Apenninic source areas erodes at 10Be-derived rates ranging from 0.1-1.5 mm/yr in the Alpine and from 0.25-0.5 mm/yr in the Apenninic source areas. The highest 10Be-derived denudation rates are found in the western Central Alps (1.5 mm/yr), where also recent uplift rates are among the highest. From these data, we constrain a total cosmogenic-derived sediment flux leaving the Alpine and the Apenninic source areas of ca. 35 Mt/yr that is notably higher than present-day estimates of sediment export (∼10 Mt/yr at the Po delta) biased by anthropogenic disturbances.

Our results demonstrate that the cosmogenic record of mountain erosion is effectively transmitted from the source areas to the sediment sink, even across a strongly subsiding foreland basin. Cosmogenic nuclides applied to the depositional record of a basin can hence provide a powerful mirror of average mountain erosion from which links between tectonic, climate, and erosion can be further disentangled.

[1] Wittmann and von Blanckenburg, ESR, 2016