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Provenance analysis using Raman spectroscopy of carbonaceous material: A case study in the Southern Alps of New Zealand

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Detrital provenance analyses in orogenic settings, in which sediments are collected at the outlet of a catchment, have become an important tool to estimate how erosion varies in space and time. Here we present how Raman Spectroscopy on Carbonaceous Material (RSCM) can be used for provenance analysis. RSCM provides an estimate of the peak temperature (RSCM-T) experienced during metamorphism. We show that we can infer modern erosion patterns in a catchment by combining new measurements on detrital sands with previously acquired bedrock data. We focus on the Whataroa catchment in the Southern Alps of New Zealand and exploit the metamorphic gradient that runs parallel to the main drainage direction. To account for potential sampling biases, we also quantify abrasion properties using flume experiments and measure the total organic carbon content in the bedrock that produced the collected sands. Finally, we integrate these parameters into a mass-conservative model. Our results first demonstrate that RSCM-T can be a powerful tool for detrital studies. The relative ease of data acquisition allows for a robust statistical provenance analysis with a high spatial resolution. Second, we find that spatial variations in tracer concentration and erosion intensity have a first-order control on the RSCM-T distributions, even though our flume experiments reveal that weak lithologies produce substantially more fine particles than do more durable lithologies. This result implies that sand specimens are good proxies for mapping spatial variations in erosion when the bedrock concentration of the target mineral is quantified. The modeling suggests highest present-day erosion rates (in Whataroa catchment) are not situated at the range front, as might be expected from the long-term metamorphic rock exhumation pattern, but about 10 km into the mountain belt. This closely matches the pattern of maximum rain fall and highest short-term (contemporary) inter-seismic uplift.