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Can we upscale short-term to long-term erosion rates?

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The long-term evolution of convergent mountain belts is determined by the interaction of tectonics, climate, and surface processes such as weathering, erosion and sediment transport. Tectonic processes are often viewed as the driving force behind surface uplift and growth of a convergent mountain belt, while climate and surface processes may respond to the changes induced by tectonics, for example through orographic precipitation, river incision, and land sliding on over-steepened hill slopes. However, in recent years more and more researchers have claimed that changes in the climatic system, variations in precipitation distribution, increasing or decreasing glaciation, or variation in vegetation coverage can alter erosion rates in a mountain belt on local or regional scales, and therefore influence the underlying tectonic regime. Various authors have provided arguments and data for and against coupling between climate/precipitation and long term, over millions of years, erosion rates in different orogenic systems (e.g. Reiners et al., 2003; Burbank et al., 2003). The reason why these studies have come to different conclusions is that they compared modern distributions of precipitation with long-term erosion rates determined from low-temperature thermochronology in the Olympic Mountains of the northwestern United States and in the Himalaya. This can be misleading, because when studying the relationships between tectonic and climatic effects, one has to keep spatial and temporal scales in mind. It is still not very well known how fast orogenic systems may adjust to climatic perturbations, and if they do, it is not necessary that the entire mountain belt adjusts at the same time. Long-term erosion rates, over millions of years, determined from low-temperature thermochronology may not be related to modern climate patterns that undergo relatively fast changes, over tens of thousands of years, or even faster as we can currently experience through human induced climate change. In addition, different low-temperature thermochronometers have different sensitivities to upper crustal processes, depending on their closure temperature. The higher the closure temperature, the less sensitive are the systems to changes in erosion rates. On the short term it is evident that the amount of precipitation in a certain area is not a direct proxy for erosion rate because other factors such as lithology and relief, for example, are important. As a result, short-term and long-term erosion rates can be considerably different and highly variable within single mountainous drainage basins, and short-term erosion rates can be several magnitudes higher in certain areas than the long-term average erosion rates of the same area. Or, as Kirchner et al. (2001) have shown for 32 Idaho mountain catchments, the opposite can be the case as well, where long-term erosion rates are 17 times faster than short-term erosion rates estimated from river sediment yield.

Therefore, long-term and short-term erosion rates can be very different for the same drainage area or mountain belt because they are a function of a variety of factors (tectonic regime, climate, lithology, relief, sediment transport capacity etc.) which can change over time. In general, the long and short-term erosion rate estimates are determined by different techniques with different uncertainties and different sensitivities to changes in erosion rates. It is necessary to make observations and to draw conclusions on the same temporal and spatial scales. Extreme caution should be used when attempting to upscale short-term to long-term erosion rates.