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Patterns of erosion and deformation in two-sided frictional mountain belts

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Observations and inferences of spatial patterns of erosion, deformation, topography and precipitation are important for understanding the possible interactions between tectonics, erosion and climate. However, the theoretical framework in which to interpret these observations is often lacking in many tectonic settings, such that correlations (or decorrelations) between, for instance, precipitation and erosion rate are generally assumed to imply coupling (or decoupling) between climate and tectonics. In this work, we use a coupled tectonic-erosional numerical model to investigate two-sided frictional mountain belts and develop a framework to explain how erosion and deformation rates vary spatially in the absence and presence of spatial variations in precipitation rate. We consider isostatically-compensated orogens, which exhibit a strong large-scale topographic asymmetry, under three precipitation scenarios: uniform precipitation, a rainshadow pattern of precipitation, and highly-localized precipitation. In all cases, we find that the large-scale topographic form is nearly invariant of the pattern of precipitation. Under uniform precipitation, erosion and deformation rates are non-uniform: rates increase towards the main topographic divide and are generally higher on the steeper side of the orogen. A rainshadow pattern of precipitation results in higher erosion and deformation rates on the side of the orogen receiving more precipitation. Highly-localized precipitation leads to localized deformation and rock uplift responses, the scale of which is determined by the crustal thickness and the orientation of major faults. Overall, our results suggest that non-uniform erosion and deformation can arise without climatic forcing and that correlations between erosion, deformation and precipitation do not necessarily imply coupling between climate and

tectonics.