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Relative importance of climate and tectonics for landscape evolution in the northern Basin and Range - insights from digital elevation model analysis

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This study uses the relatively simple tectonics of the northern Basin and Range, Idaho, Montana and Wyoming, USA, to address the question of whether relief enhancement due to glaciation and increased erosion drives uplift, or if surface processes respond primarily to tectonic forcing. A series of ranges (the Lost River, Lemhi, Bitterroot, and Teton ranges) have developed in response to extension and normal faulting, with different fault lengths, numbers of segments and offsets producing a range of tectonic histories. Furthermore, these ranges lie at the margins of glaciation, such that only the northern parts of the ranges have been glaciated. Several factors influence landscape morphologies in this region: 1) the extent of glacial erosion and modification of drainage basins, 2) the position of drainage basins relative to range-front fault-segments, and 3) the side of the range that catchments drain with respect to recently-active faulting and orographic precipitation. Using $\sim$10m resolution USGS digital elevation models (DEMs), we compare hillshade, slope, curvature and relief plots, and longitudinal profiles and relief distributions along trunk- and tributary-streams. Glacial erosion incises valley floors, widens valley walls and increases relief. It is enhanced by the orographic effect of snow blowing over the range crest to accumulate preferentially on the leeside, resulting in asymmetric range profiles and drainage divide migration in the windward direction. In partially glaciated ranges, topographic elevations decrease northwards from the southern limit of glaciation at the last glacial maximum (LGM), lending support to the “glacial buzzsaw” hypothesis that glacial erosion limits elevations in glaciated ranges. However, the tectonics also exert an along-strike control on landscape evolution. Catchments that drain close to fault-segment boundaries are often larger than neighbouring basins, show shallower gradients and lower elevations, and are the only basins that may be orientated obliquely to the fault.