# Orographic Precipitation and the Form of Mountain Ranges

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Over geologic timescales, patterns of precipitation shape mountain ranges. Since precipitation is influenced by topography, there may be a feedback between evolving topography and patterns of precipitation. At the scale of mountain ranges climatological and geological data show clear evidence of such a feedback when a strong rain shadow is present. Are there similar feedbacks at the scale of individual ridges and valleys?

To investigate this question we analyzed precipitation over the Olympic Mountains of Washington as simulated at 4-km resolution by a mesoscale weather prediction model (the MM5). Model results from individual storms and precipitation totals over two years calculated from twice-daily model integrations show a consistent pattern of precipitation that is closely related to the topography (Fig. 1). On the southwest flank (typically the upwind side), simulated precipitation totals on ridges are consistently 2-4 times those in adjacent valleys in annual totals and individual storms. Rainfall totals for major and moderate storms show remarkably little variability in the patterns of precipitation despite variability in wind speed and direction, and the temperature and humidity of the incoming air.

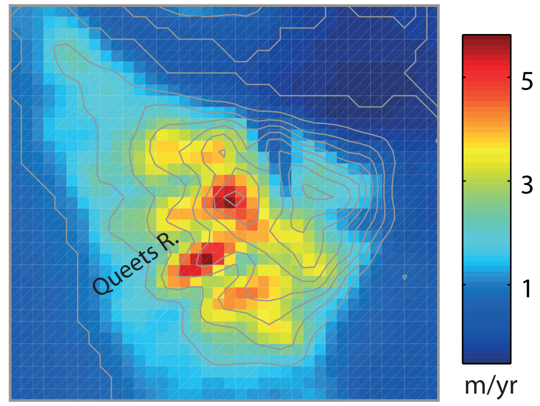


*Fig. 1. The two-year average of MM5 predicted precipitation is shown in m/yr. Topography is contoured with a 200 meter interval in gray.*

In order to evaluate the precipitation patterns predicted by the MM5, we established a rain and snow gauge network in October of 2003 to measure gradients in precipitation across the ridge south of the Queets River. Preliminary results from this network support the spatial pattern of precipitation predicted by the MM5.River networks set the pace of erosion in mountain landscapes. River erosion rates are determined by the slope of the river and the stream flow (i.e., water discharge). Slope and stream flow trade off to maintain a uniform erosion rate along a river profile such as the Queets (Fig. 2). An idealized model of river erosion shows the very large differences between a river profile that evolves with spatially uniform precipitation versus one that evolves with a pattern of precipitation like that predicted by the MM5. If precipitation is concentrated on ridges, the large stream flow high in the river network is balanced by lower slopes in that region. These relatively low slope ridges create a modeled topography with ridges roughly 500 m lower than in a case with uniform precipitation (Fig. 2). We are using more sophisticated, three-dimensional landscape evolution models together with MM5 integrations over the evolving topography to further evaluate the co-evolution of precipitation and topography at these spatial scales.

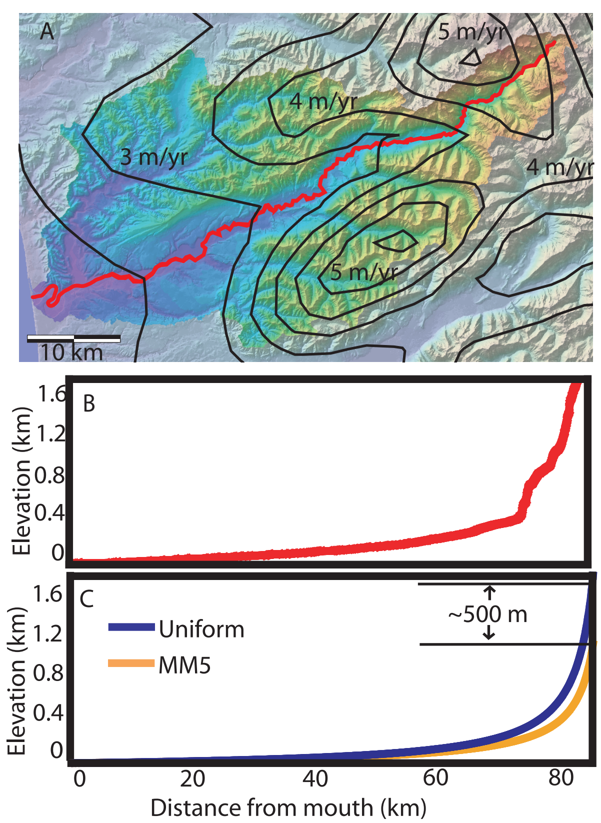


*Fig. 2. Panel A shows the topography in the Queets River basin in shaded relief with contours of MM5 precipitation in black. The main stem of the Queets River is shown in red. Panel B shows the profile of the Queets River. Panel C shows modeled river profiles that evolved under uniform precipitation and MM5-like precipitation. Incorporating the MM5 precipitation pattern reduces ridge elevations by 500 m.*