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Surface control on contrasts in deformation between eastern and western margins of the Central Andes

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The deformation style and climate between the eastern and western escarpments of the Central Andes are strikingly different. The eastern side is in a tropical climate; it receives annual precipitation amounts of >3500 mm and experiences active shortening and thrusting, while the western side is one of the driest places on Earth and is deformed by long-wavelength warping. Indeed, climate is so dry that the western slopes can go decades without recorded rainfall. Here we show that the modern distribution of deformation in the Central Andes can be a result of enhanced orographic precipitation pattern beginning ca. 7-10 Ma (Norton and Schlunegger, 2011). Reduced erosion on the western side would have steepened the orogen, forcing deformation to shift to the east where high precipitation amounts would have enhanced erosion. We support this hypothesis with low erosion rates and a well-defined retreating knickzone in the Western Andes, and likewise by high erosion rates and channel morphologies indicative of transient orographic feedbacks in the east. Indeed, erosion rates as measured by cosmogenic nuclides are < 0.01 mm yr-1 in the west (Kober et al., 2007) and more than an order of magnitude higher, > 0.2 mm yr-1, in the east (Safran et al. 2005). Stream profiles from the Western Escarpment are indicative of slow knickzone retreat in the absence of modern tectonic forcing while streams on the Eastern Escarpment are the product of strong climate-tectonic feedbacks, indicated by steep and strongly concave segments in the orographically-affected reach.
Reconstructions of the accretionary wedge geometry and high angle fault movements between the Miocene and today further support an erosion driven shift in the locus of deformation. In particular, at orogenic scales, critical taper calculations indicate that the near cessation of erosion on the western side ca. 7-10 Ma ago shifted the orogen into a super-critical state where deformation only occurs along the basal décollement, while the eastern margin resided in sub-critical to critical conditions and experienced enhanced orographic rainfall, which promotes thrusting and internal shortening. A fault-scale coupled erosion-deformation model also shows that low erosion rates and steep topographic angles would have forced a migration of deformation from the Western Escarpment to the eastern side. These findings illustrate the strong control of orographic precipitation on the deformation of the Central Andes.

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