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Evidence for Late Miocene climate change from the tectonics of the Alps

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Active mountain belts have a response to climate change that is distinct from static landscapes. In a convergent mountain belt, shortening and crustal thickening lead to the formation of critical topography which has a characteristic response to a change in erosional flux driven by climate change. We demonstrate this response through coupled numerical models of crustal deformation and surface process erosion. In our model, erosion is dominated by fluvial incision which depends on climate through precipitation rates. A steady-state landscape that is subjected to an increase in precipitation exhibits the following response: the cross-strike width of the active orogen decreases, abandoning frontal structures as deformation shifts into the orogen interior; sediment yield initially increases, but subsequently decreases towards its original value as a new steady-state is achieved; mean exhumation rate initially increases, then systematically decreases towards a new equilibrium value that is larger than the initial condition. These characteristics are exhibited by the European Alps at the end of the Miocene. Faults of the southern deformation front of the Alps, that had propagated into the present Po basin by the mid Miocene, became inactive between 5 and 8 Ma. Exhumation of the Alps subsequent to 8 Ma has been focused north of the Insubric line, particularly in the external Massifs which comprise much of the highest present topography. Taken together, these indicate a decrease in the actively deforming width of the orogen. This was accompanied by an increase in sediment yield from the Alps to the surrounding basins from the late Miocene to the present. This combination suggests that erosional fluxes have increased relative to the accretionary flux and in absolute value, which is consistent with a more erosive climate. We speculate that this climate change is associated with the onset of glaciation or the formation of

the modern Gulf Stream in the late Miocene.