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Mechanisms and definitions of coupling and feedback between tectonics, climate and surface processes

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A number of processes and mechanisms have been identified that link tectonics, surface processes and climate. These couplings can be unidirectional, or bidirectional, that is with feedback. We discuss some of the mechanisms proposed for this coupling and identify pathways for feedback. Tectonic processes create or destroy topography which modifies climate by changing patterns of ocean and atmospheric circulation on regional and global scales. Climate modifies rates of surface processes, and thus potentially affects tectonics through several mechanisms, including (1) isostatic adjustment of the lithosphere; (2) reduction of excess topography and therefore of the work needed to be done against gravity; (3) upward advection of heat, thus weakening crustal rock and localizing deformation. These mechanisms operate over different time and length scales and will involve different strengths of coupling between surface processes and tectonics. In some cases, erosion and deposition may be coupled to tectonics without influencing it. In others, one can anticipate coupling involving dynamic feedbacks, leading to self regulation. We demonstrate coupling and feedback through two examples of coupled tectonics and surface processes. First, a convergent orogen which reaches a flux steady-state attains a critical form dictated by the strength of the crust, but in which the uplift pattern responds in a specific manner to spatially non-uniform precipitation. We demonstrate that rock uplift rate is locally forced by precipitation rate and responds much more dramatically than does the topography. In the second example, we demonstrate how the internal deformation and basins associated with an evolving fold-thrust belt respond to temporal variations in erosion rates related to the emergence of an initially submerged orogen above sea level. We show that an increase in the erosive mass flux coinciding with emergence may cause a laterally accreting orogen to narrow as material is rapidly exhumed from subaerial regions

and deposited in the foredeep. Together, these examples highlight the major impact that surface processes can have on the style and evolution of orogens and their related basins.