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Does normal fault propagation and linkage depend on climate and surface processes?

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Initiation and linkage of normal fault segments is a fundamental aspect of tectonics in extensional settings. Despite that, the factors controlling the structural and topographic expression of individual normal faults are still not well resolved. Here, we investigate the impact of surface processes, including both erosion and deposition, on both the dynamics of normal faults and the linkage structure between several propagating individual normal fault segments. We use a fully-coupled 3D model which is based on the landscape evolution model CASCADE and the 3D tectonics code FANTOM. We present results of numerical simulations designed to study the response of viscous-plastic crustal materials subjected to extension and to surface processes. The model uses a constant depth frictional-plastic to viscous transition interface, which can be interpreted as a system at the conductive limit for the crust. This model set-up naturally favors the emergence of low-angle normal faults consistent with a rolling hinge behavior. We focus our study on the evolution in time and space of both the tectonic structures and the surface morphology of the normal fault segments for varying surface process efficiency. At first order, we show that the dynamic lateral propagation of a single normal fault is dictated not only by its rheological properties but also by the efficiency of erosion and sedimentation acting on its surface, which in turn depends on the amount of precipitation. In particular, we demonstrate that increasing the efficiency of fluvial erosion, increases the efficiency of strain localisation on only one shear zone, resulting in a halfgraben like structure. Our results also indicate that the linkage type between two separate normal faults is controlled by both fault offset and erosion efficiency. This illustrates the strong coupling between tectonic and surface processes, and demonstrates that surface processes, by enhancing localization of deformation, have a strong control on normal fault lateral propagation and structural expression. We suggest that our results may have important consequences for understanding the propagation and linkage of normal fault segments for varying climatic conditions in both space and time.