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Normal fault activity in response to dynamic surface uplift in the central Italian Apennines: Insights from thermo-mechanical modelling

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In the seismically active central part of the Italian Apennines, extensional faulting and devastating earthquakes occur within a narrow (<100 km wide) zone along the crest of the mountain range. A systematic correlation between spatial and temporal variations in extensional strain rates and the distribution of topographic elevation suggests that active extension and surface uplift are driven by the same mechanism. While the exact mechanism is still highly debated, it seems generally accepted that enhanced elevations in the central Apennines cannot be explained by crustal thickening. Instead high topography in combination with active surface uplift and extensional faulting over the last ca. 3 Myr seem to be related to dynamic, mantle-driven processes. One mechanism that might explain the combination of extension and uplift is the removal of mantle lithosphere. By using a 2D thermo-mechanical model we investigate the impact of mantle lithosphere removal on the evolution of faulting and topographic development. Our model generates surface uplift dynamically by the progressive convective removal of dense mantle lithosphere (triggered by a small thermal anomaly) and replacement by hot less dense sub-lithospheric mantle leading to isostatic uplift. Faults (predefined weak fault zones), in turn, respond dynamically to both topographic uplift (gravitational effect) and rheological changes. In general, our model demonstrates the large impact of mantle dynamics on both topographic development and normal fault activity, confirming previous work. More specifically, we observe in the model changes in the spatial pattern of fault slip rates over time and in the degree of strain localisation. We evaluate over what time scales these different developments occur and what the relative contributions are of faulting and regional uplift for topographic development. Overall, we constrain our model and evaluate our results using observational data from the central Apennines.