EGU24-15751, updated on 16 Feb 2025
https://doi.org/10.5194/egusphere-egu24-15751
EGU General Assembly 2024

3D interaction of tectonics with surface processes explains fault network evolution of the Dead Sea Fault

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Releasing and restraining bends are complementary features of continental strike-slip faults. The Dead Sea Basin of the strike-slip Dead Sea Fault is a classical example of a releasing bend with an asymmetric, deep basin structure. However, the intrinsic relationship to its northern counterpart, the restraining bend that created the Lebanese mountains, remains unclear.

Here, we present 3D coupled geodynamic and landscape evolution models that include both the releasing and the restraining bend in a single framework. These simulations demonstrate that the structural basin asymmetry is a consequence of strain localization processes, while sediments control the basin depth. Local extension emerges due to strength heterogeneities and a misalignment of faults and the overall stress field in an area where regional tectonics are dominated by strike-slip motion. Furthermore, we reveal a crustal thinning and thickening pattern that intensifies with surface process efficiency. Along-strike deformation is linked through coupled crustal flow driven by gravitational potential energy which is opposed by deposition at the releasing bend and enhanced by erosion around the restraining bend. Due to the generic nature of our models, our results provide templates for the evolution of fault bends worldwide.