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Lithosphere response to erosion: Model and case studies

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Extensive surface erosion may cause sizable lithospheric deformations. The effects are even more remarkable in regions subjected to glacial erosion. The isostatic response shielded by flexurally strong lithosphere is usually wider than localized glacial erosion and causes non-linear local effects. We use erosion backward in time (EBT) to model this process. In our experiments, we numerically fill the eroded voids with crustal material and calculate isostatic response to this added surface load. We assume that these calculations approximate amplitudes of erosion-related processes occurred in nature. Our studies started with considering enigmatic marine Mesozoic sediments stored at the elevation of 1.2 km in central east Greenland, the area free from recent compressional tectonic processes. The location is surrounded by the world's biggest fjord system, Scoresby Sund. Application of the EBT allows us to estimate the unloading by the glacial fjord carving and conclude about a km-scale regional uplift explaining elevated marine sediments. Similar study on the development of the Europe's biggest plateau, Hardangervidda in the southern Norway, demonstrated that glacial erosion caused up to 40% uplift of the plateau. Analyzing the Quaternary evolution of the North Sea, we found that on-shore erosion and off-shore sediment accumulation results in differential vertical motion of the lithosphere of up to 1 km across the sea. Applied to a particular petroleum system, the Troll field, this tilting explains significant oil spilling during the Quaternary.