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Response of river networks at active continental margins to aseismic ridge subduction: a 3D finite-element approach

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Subduction of aseismic oceanic ridges causes considerable uplift and deformation of the upper continental plate and may therefore ultimately affect also coastal drainage systems. To investigate the impact of a subducting ridge on the river network of the upper plate, we link a landscape evolution model with 3D finite-element models of ridge subduction. The landscape evolution model includes diffusive hillslope processes and fluvial erosion and deposition. The finite-element model represents a deformable forearc and a rigid oceanic plate, which carries the model ridge beneath the upper plate (cf. Zeumann and Hampel, 2015, 2016). Our model results show that as long as the forearc is unaffected by the ridge, rivers flow more or less straight toward the model coast. Once the ridge tip has arrived at a position beneath the coast, the uplift caused by the ridge changes the flow direction of the rivers. If the slope at the ridge tip exceeds the slope of the forearc wedge, the flow direction of rivers above the ridge crest is inversed, i.e. the rivers flow away from the coast. Once the main part of the ridge (with constant maximum elevation of the ridge crest) has arrived beneath the coast, the rivers inverse their flow direction once more and flow toward the coast again. At this stage, rivers flowing above the ridge flanks are deflected away from the ridge crest. This deflection gets more pronounced during further subduction of the ridge. In case of a stationary subducting ridge, no further drainage reorganization takes place after the ridge tip has passed and the main part of the ridge with its constant crest height has arrived beneath the forearc. For a migrating ridge, further reorganization of the drainage network takes place as the ridge moves along the margin. We compare the modelled deflection of rivers during stationary ridge subduction with the flow direction of rivers in Costa Rica and Panama, which are affected by the subduction of the approximately stationary Cocos Ridge. Our case study for the impact of a migrating ridge on coastal rivers is the Peruvian margin, where the migrating Nazca Ridge is subducted.