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A coupled model of glacier-ice dynamics, bed-hydrology and bedrock groundwater flow including heat-transfer

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Within the modelling framework of Elmer/Ice we have existing model components to compute the thermo-mechanical ice flow problem, using a full-stress approach as well as several model approaches for the bedrock hydrology, for instance the Glacier Drainage System model (GlaDS - Werder et al., 2013). Further, a thermodynamically consistent groundwater model including freezing (permafrost) and thawing of the pore-water and the stress-induced deformation of the rock skeleton is implemented in Elmer. The real challenge lies within coupling those three components with mutual feedback, both, in mechanical and thermal aspects that mutually depend on each other, e.g. through a temperature and water-pressure dependent sliding law. The fact that all equations are implemented in the same Finite Element framework enables a consistent coupling of the equations solved on different domains (ice, water-sheet and sediment), in case of weakly coupling being able to use the residual to transfer loads. Along the lines of a synthetic glacier setup, we highlight the workflow of such a coupled simulation and point out the challenges of such a highly complex process model.