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A confined–unconfined aquifer model for subglacial hydrology and its application to the Northeast Greenland Ice Stream

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Subglacial hydrology is a key component in ice sheet dynamics as it controls the sliding of ice sheets. Modelling the interaction between ice dynamics and subglacial hydrology is essential for understanding current changes in the system and projecting the future evolution of ice sheets and their contribution to sea-level rise. Models recently have progressed in incorporating multiple components of the drainage systems and are able to reproduce the observed seasonal evolution of an efficient drainage system during the melt season. Subglacial hydrology modelling on a large scale still remains a challenge. Recent approaches represent subglacial channels and thin water sheets by separate porous layers of variable hydraulic conductivity. We extend this concept by using a single layer of an equivalent porous medium (EPM). By using the method of a confined–unconfined aquifer system (CUAS) we prevent unphysical values of water pressure at reasonable computation cost. The evolution of the system is achieved by locally adjusting its transmissivity according to channel and cavity equations. We compared the model to a well-established model and performed sensitivity tests to investigate the effect of different model parameters. We find that the parameters controlling the opening and closure of the system have the strongest influence on the results. We applied the model to the Northeast Greenland Greenland Ice Stream, where we identify an efficient drainage system independent of seasonal water input. Using the effective pressure from the hydrology model as input for the Ice Sheet System Model (ISSM) considerably improved modeled ice surface velocities.