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Sensitivity of Pine Island and Thwaites drainage basins to subglacial hydrology

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Subglacial processes in Antarctica are difficult to directly observe and are one of the sources of uncertainty when modelling the response of ice sheets to environmental forcing. Subglacial processes pertain to the type of basal sliding or friction law used, where especially the contrast between viscous (linear) and plastic (Coulomb) sliding makes the latter far more responsive to changes at the marine boundary (Ritz et al., 2015; Brondex et al., 2019; Bulthuis et al., 2019; Sun et al., 2020; Kazmierczak et al., 2022).

Besides the type of sliding, physical basal conditions, such as basal temperatures, bed properties (hard or soft), subglacial water flow and drainage, till properties, and mechanics, also directly affect the ice sheet flow (Clarke, 2005, Cuffey and Patterson, 2010, Kazmierczak et al., 2022), by affecting the effective pressure (Bueler and Brown, 2009, Winkelmann et al., 2011, van der Wel et al., 2013).

In this study, we investigate how variations in effective pressure determines the evolution of the main marine basins of the West Antarctic Ice Sheet (Pine Island and Thwaites glacier) which are currently exhibiting the largest ice mass loss of the Antarctic ice sheet.

For this purpose, we employ different types of subglacial hydrology for soft and hard bed configurations, which we adapt to simulate individual drainage basins of the Antarctic ice sheet at a km-scale resolution, thus allowing for proper migration of the grounding line (e.g., Pattyn et al., 2013). These hydrological representations are included in a generalized basal sliding law (Zoet et al., 2020), implemented in the the f.ETISh/Kori model (Pattyn, 2017; Sun et al., 2020). Results are compared to results from a pan-Antarctic ice sheet model (Kazmierczak et al., 2022) and demonstrate the importance of detailed bed topography influencing the subglacial conditions upstream of the grounding line.