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Modelling tunnel valley erosion in northern Germany during the first ice-sheet advance (Elsterian, MIS 12) – a conceptual model and preliminary results

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This study, supported by the Bundesgesellschaft für Endlagerung (BGE), presents a computationally efficient model for simulating the formation of tunnel valleys, erosional features carved by subglacial meltwater that offer insights into past meltwater drainage and possible erosion under the future ice sheets. Understanding tunnel valley formation is crucial for predicting future glacial erosion, particularly in areas considered for radioactive waste disposal repositories.

We focus on a region previously glaciated by the Scandinavian Ice Sheet in northern Germany, leveraging geological data and taking the maximum Elsterian ice extent (MIS 12) as the primary erosional event. The ice-sheet thickness and solid Earth deformation are estimated using ICESHEET 2.0 (Gowan et al. 2016) and gFlex (Wickert 2016), assuming a steady-state ice-sheet configuration. The model incorporates both basal meltwater and surface meltwater input via simulated moulins, routed through the subglacial system using the Fastscape landscape evolution model (Benoit & Lange 2023). Erosion and deposition within these channels are calculated based on the Walder & Fowler (1994) model, considering factors like channel shear stress, geometry, and sediment properties.

Preliminary results demonstrate the model's suitability and efficiency for addressing the research tasks. We have tested the model on a 425x625 km grid at a 100x100 m grid resolution (4251x6246) for simulating tunnel valley erosion using generic parameters. The model runs in under 60 seconds per iteration, typically requiring less than 20 iterations to converge, making it versatile and relatively fast considering the grid size.

Future development will focus on incorporating a diffusion equation to enable simulating transitions between sheet flow and channelized flow and allowing for spatially variable hydraulic conductivity and potential coupling with groundwater flow models. A regional-scale geological subsurface model of Lower Saxony will be used in the modelling framework to predict erosion patterns there. The outcome of this model will be compared to smaller-scale high-resolution models to inform about the importance of resolving uppermost strata to high resolution with regards to subglacial hydrology and erosion patterns, rates, and depth limits. This will facilitate investigation into the influence of diverse lithologies and hydraulic parameters on tunnel valley erosion, enhancing the model's predictive capabilities for assessing future glacial erosional impact on the study area.

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Session: *Pangeo workshop: Glacial erosion and deposition*
Keywords: *Tunnel valleys, glacial erosion, numerical modelling, subglacial processes*