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Subglacial lake and meltwater flow predictions of the last North American and European Ice Sheets

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There is increasing recognition that subglacial lakes act as key components within the ice sheet system, capable of influencing ice-sheet topography, ice volume and ice flow. The subglacial water systems themselves are recognised as being both active and dynamic, with large discharges of meltwater capable of flowing down hydrological pathways both between lakes and to the ice-sheet margins. At present, much glaciological research is concerned with the role of modern subglacial lake systems in Antarctica. Another approach to the exploration of subglacial lakes involves identification of the geological record of subglacial lakes that once existed beneath ice sheets of the last glaciation. Investigation of such palaeo-subglacial lakes offers significant advantages because we have comprehensive information about the bed properties, they are much more accessible and we can examine and sample the sediments with ease. If we can find palaeo-subglacial lakes then we have the potential to advance understanding with regard to the topographic context and hydrological pathways that the phenomena form a part of; essentially we gain spatial and sedimentological information in relation to investigations of contemporary subglacial lakes and lose out on the short-time dynamics.

In this work we present predictions of palaeo-subglacial lakes and meltwater drainage pathways under the former European and North American ice sheets during the last glaciation. We utilise data on the current topography and seafloor bathymetry, and elevation models of the ice and ground surface topography (interpolated to a 5 km grid) to calculate the hydraulic potential surface at the ice-sheet bed. Meltwater routing algorithms and the flooding of local hydraulic minima allow us to predict subglacial channels and lakes respectively. Given that specific ice-surface and bed topographies are only known from modelled outputs, and thus contain significant uncertainty, we utilise many such outputs to examine where on the bed that subglacial lakes are likely to have occurred. This includes modelled output of palaeo ice and bed topographies from ICE-5G (Peltier, 2004); CLIMAP (CLIMAP Project Members, 1984); GRISLI (e.g. Alvarez-Solas, 2011); Glimmer-CISM (e.g. Gregoire, 2010); and a Bayesian calibration of a 3D glaciological model against a large set of observational constraints (Tarasov et al., In press). Predictions are also calculated at discrete time-slices throughout the evolution of the sheets thus allowing us to assess the temporal variability and stability of subglacial lakes and drainage networks. These lake likelihood predictions could usefully form targets for detailed field investigations.

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