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Automated reconstruction of drainage basins and water discharge to the sea through glacial cycles

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Over glacial cycles, ice masses and their geophysical impacts on surface topography dramatically changed drainage patterns and river discharges. These changes impacted meltwater discharge to the ocean, geomorphology, and climate. As the river systems—the threads that tied the ice sheets to the sea—were stretched, severed, and rearranged during deglaciation, they also shrank and swelled with the pulse of meltwater inputs and proglacial lake dynamics. Here I present a general method to compute past river flow paths, drainage basin geometries, and river discharges. I automate these calculations within GRASS GIS to take advantage of rapid solution techniques for drainage networks in an open-source and compute-cluster-ready environment. I combine modern topography and bathymetry with ice sheet reconstructions from the last glacial cycle and a global glacial isostatic adjustment model to build digital elevation models of the past Earth surface. I then sum ice sheet mass balance with computed precipitation and evapotranspiration from a paleoclimate general circulation model to produce grids of water input. I combine these topographic and hydrologic inputs to compute past river networks and discharges through time. These paleodrainage reconstructions connect ice sheets, sea level, and climate models to fluvial systems, which in turn generate measurable terrace and sedimentary records as they carry physical, compositional, and isotopic signatures of ice sheet melt and landscape change through their channels and to the sea. Therefore, this work provides a self-consistent paleogeographic framework within which models and geologic records may be quantitatively compared to build new insights into past glacial systems.