# Impact of glacio-isostasy on topography, hydrology and drainage patterns in the southern North Sea

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During the last glacial period, which lasted from approximately 120 000 to 11 700 years ago, the North Sea region was surrounded by ice sheets covering the British Isles (British-Irish Ice Sheet; BIIS) and Scandinavia (Fennoscandian Ice Sheet; FIS). At times of their maximum extent, these ice masses even coalesced over the North Sea, which was largely emerged due to global sea-level lowering in response to the large volumes of ocean water that became stored as ice on land. There is some limited sedimentological evidence suggesting that a proglacial lake existed in this emerged southern North Sea basin south of the ice margin. Because of the assumed importance of proglacial lakes in this area, also during older glaciations for their role in e.g. the opening of the Dover Strait, many attempts have been made to define the extent of these lakes. These hypothesised reconstructions have often ignored the effect of glacio-isostasy. In this study, the bedrock deformation in the North Sea basin resulting from the load of the surrounding ice sheets throughout the last glacial period was modelled by using different ice-sheet reconstructions as input. The modelling was performed by relying on a simple but proven model that considers the two most important involved layers, the lithosphere and the asthenosphere. The results indicate that during the peak glacial phases of the last glacial period – Marine Isotope Stages 2 and 4 – the area directly south of the ice margin in the North Sea basin was deeply depressed, up to almost 100 m of subsidence. The combination of this bedrock deformation together with the already present low-lying topography in the Oyster Ground region created an enlarged basin that could have been filled with water to develop a proglacial lake with a volume of up to 3 000 $km^3$. This basin would only have been completely inundated if sufficient water was delivered to it, but the extensive supply from rivers such as the Elbe and glacial meltwater make this condition not unlikely. It seems implausible that a proglacial lake would have extended beyond our suggested limits, as a larger lake would have spilled over a relatively low topographic barrier into the Axial Channel and further towards the Dover Strait. After disconnection of the BIIS and FIS over the North Sea, the remainder of the lake water likely drained towards the north, potentially as a high-volume Glacial Lake Outburst Flood (GLOF).

Beyond the zone of bedrock subsidence, glacio-isostasy also induced a small region of uplift surrounding the depressed area, i.e. the flexural forebulge. Within the region of interest for this study, the area of maximal uplift was situated at the present-day Netherlands. This forebulge likely slightly tilted this relatively flat area, contributing to the southward shift of the Rhine river course during MIS 3, as was already suggested in previous studies.

Our modelling results provide additional support for the hypothesis that glacio-isostasy has had a profound impact the hydrology and drainage patterns in the southern North Sea basin, during periods of maximum glaciation.

**Keywords**
North Sea; Last Glacial Period; Proglacial Lakes; Modelling; Bedrock Deformation