An integrated approach to reconstruct the Saalian glaciation in the Netherlands and NW Germany

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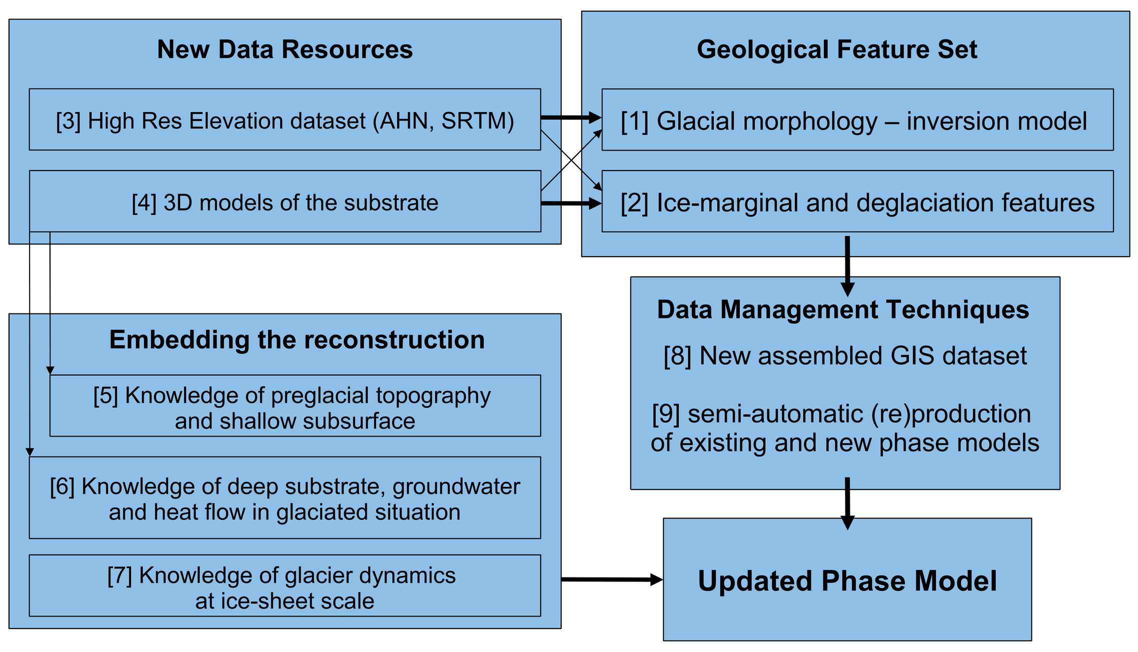
Introduction

In MIS 6, around 170,000-150,000 years ago, large ice masses last covered the Netherlands and NW Germany (Saalian Drenthe Substage). It left many geomorphological features in the landscape, e.g. push moraines, sandurs and glacial basins. Throughout the 20th century extensive research has been done on this geomorphological assemblage and the sequence of glacial events, resulting in glaciation phase models. However, the various phase models each appear biased to specific features, subregions and types-of-data. Besides, new data and insights have risen since the construction of these models.

In this research we newly reconstructed the sequence of events, unifying the evidence in NW Germany with that in the Netherlands. Elements of 'classic' knowledge and new lines of reasoning are each outlined. We collected geological-geomorphological evidence (literature inventory) and new high-resolution elevation data in a inventory GIS. We reviewed conceptual models of the phasing of events and related glaciological processes during the glaciation, responsible for the eventual ice-margin landscape.

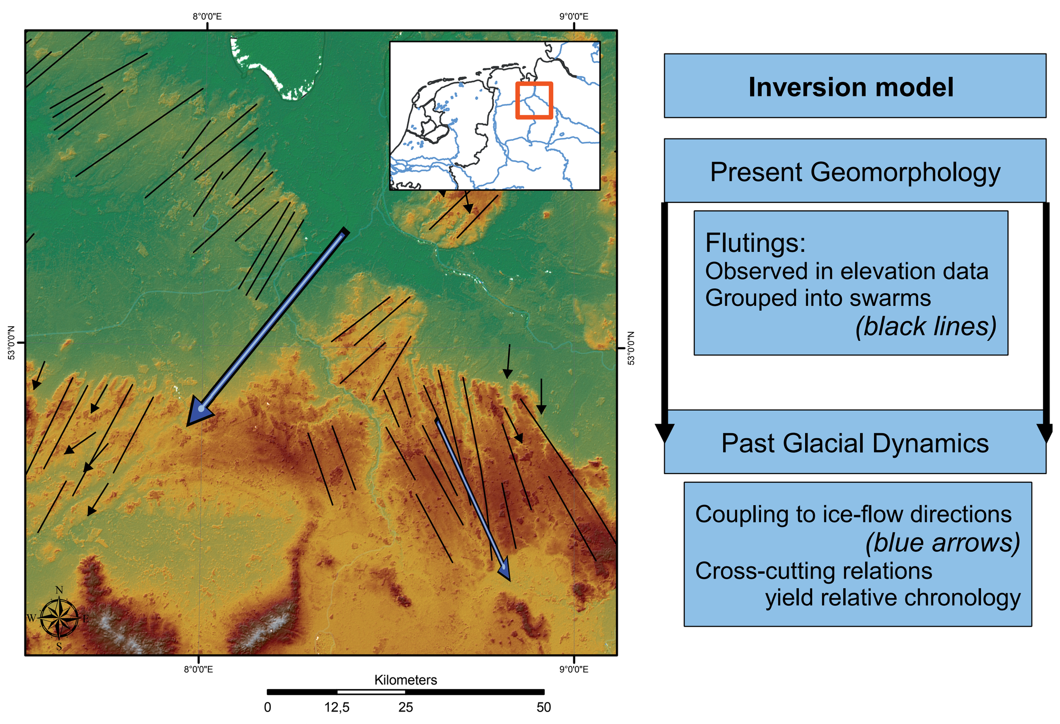
Our newly constructed phase model recognises four phases towards maximum ice-sheet extent, and one complex deglaciation phase. The GIS stores our preferred phase model, as well as earlier interpretations. This poster presents our results as overview maps.

Methods



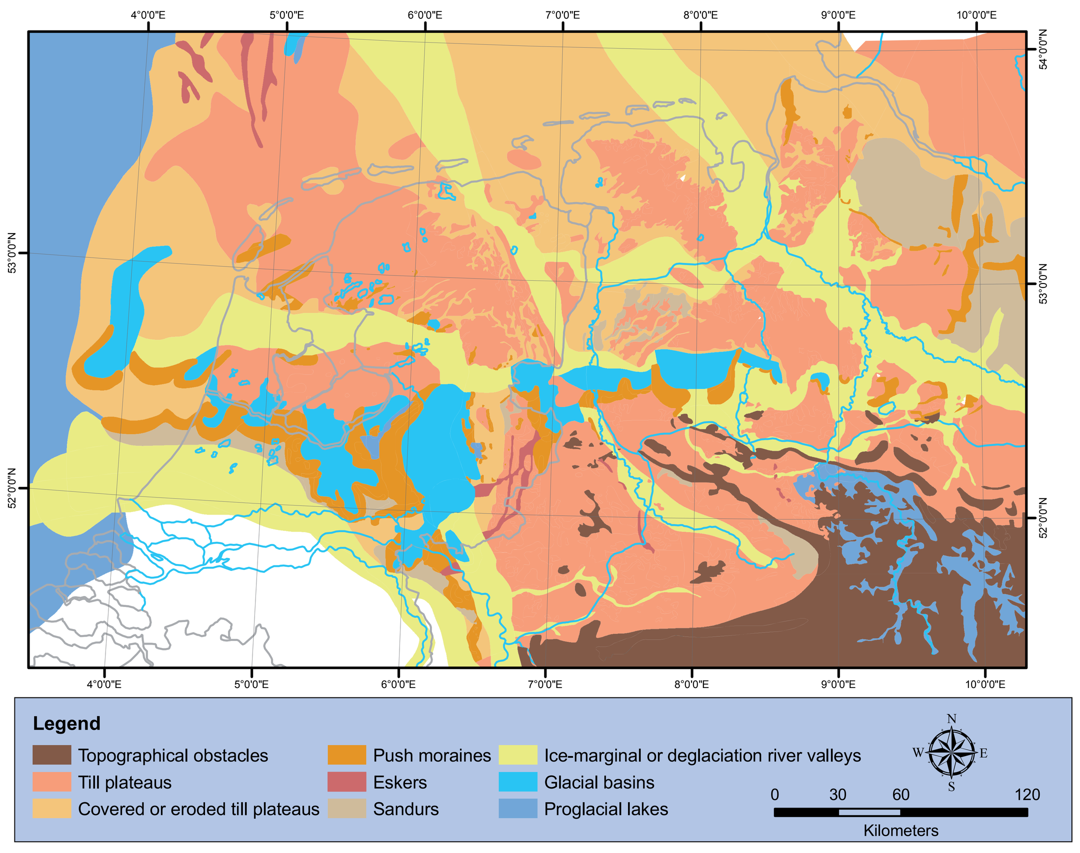
The main sources for the construction of a GIS were existing maps of glacial features **[1]** and associated documented information, such as till stratigraphical information. Also used are recent reconstructions of the proglacial glaciofluvial areas, and deglaciation-related features 'inside' the ice limit (**[2]**; Busschers et al., 2008; Winsemann et al., 2009). High resolution elevation data (**[3]**) are new resources allowing to detail the geological-geomorphological feature sets (see box: inversion model). All the known glacial features are collected in a new assembled GIS dataset **[8]** and their phasing coded to allow to reproduce existing and newly iterated phase models **[9]**.

The use of elevation models and the inversion method [1][3]



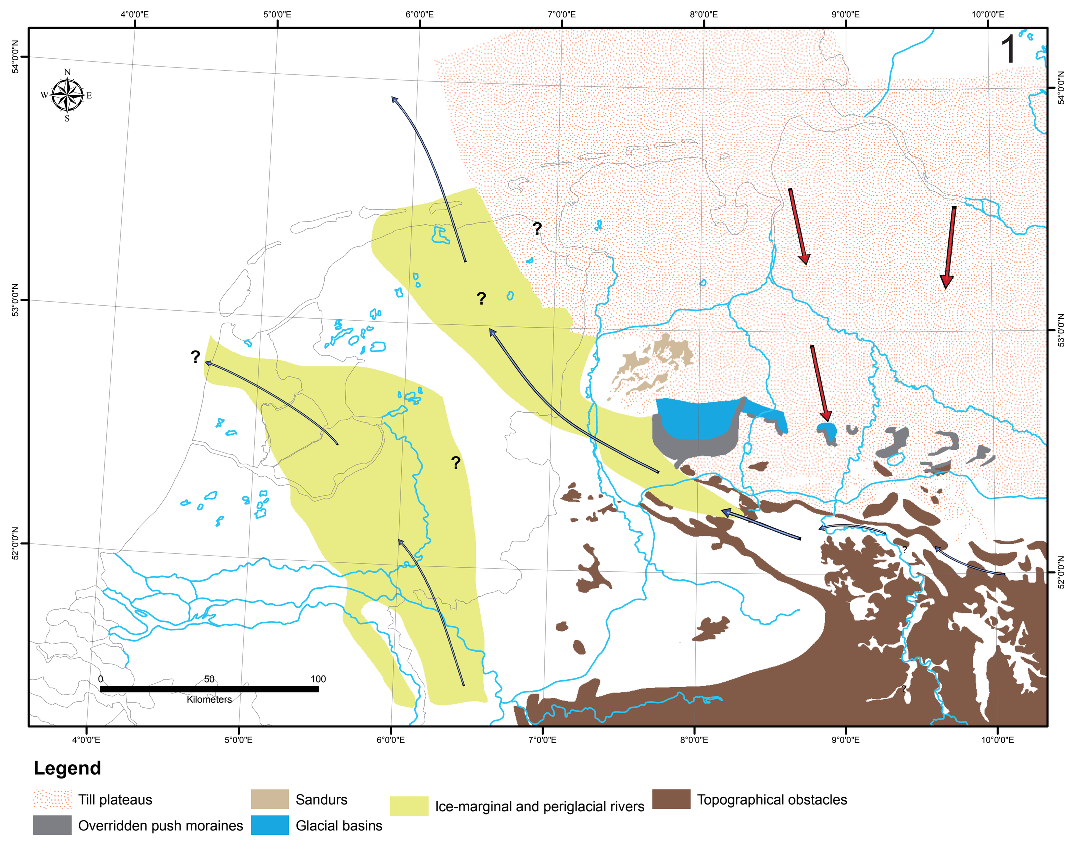
Glacial landforms are traces of past glacial dynamics and can hence be used to reconstruct past conditions of glaciation (the 'inverse method' cf. Kleman et al., 2006). We used digital elevation data and traced swarms of apparent megaflutes and drumlins. The glacial origin is supported by existing field data, but the pattern is much better recognised with the new datasets. The swarms reveal palaeo ice-flow directions (blue arrows) and their cross-cutting chronology, following theory and methods developed and applied by Boulton et al. (2001) and Winsborrow et al. (2010). The black arrows are the directional results from till fabric analyses (Ehlers, 1990). These reproduce the flute directions. It is concluded that the NNW flow in this SRTM image is older than the SE flow.

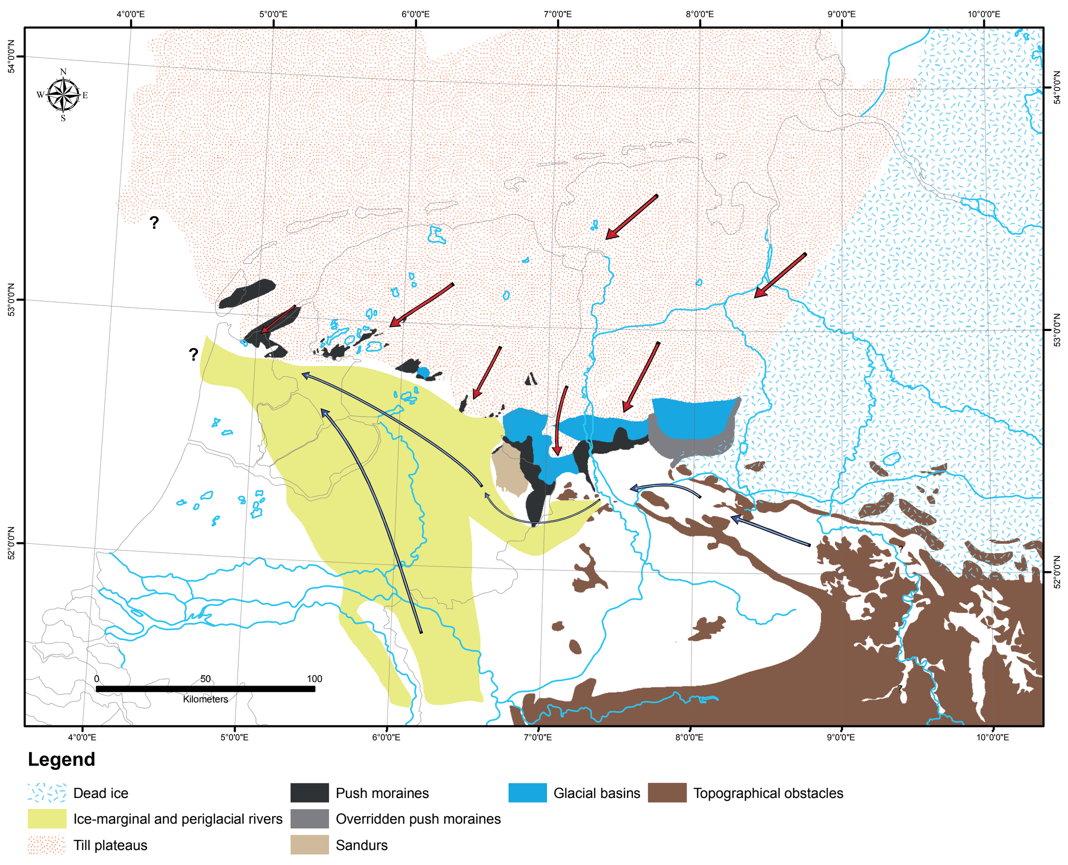
Glacial morphology

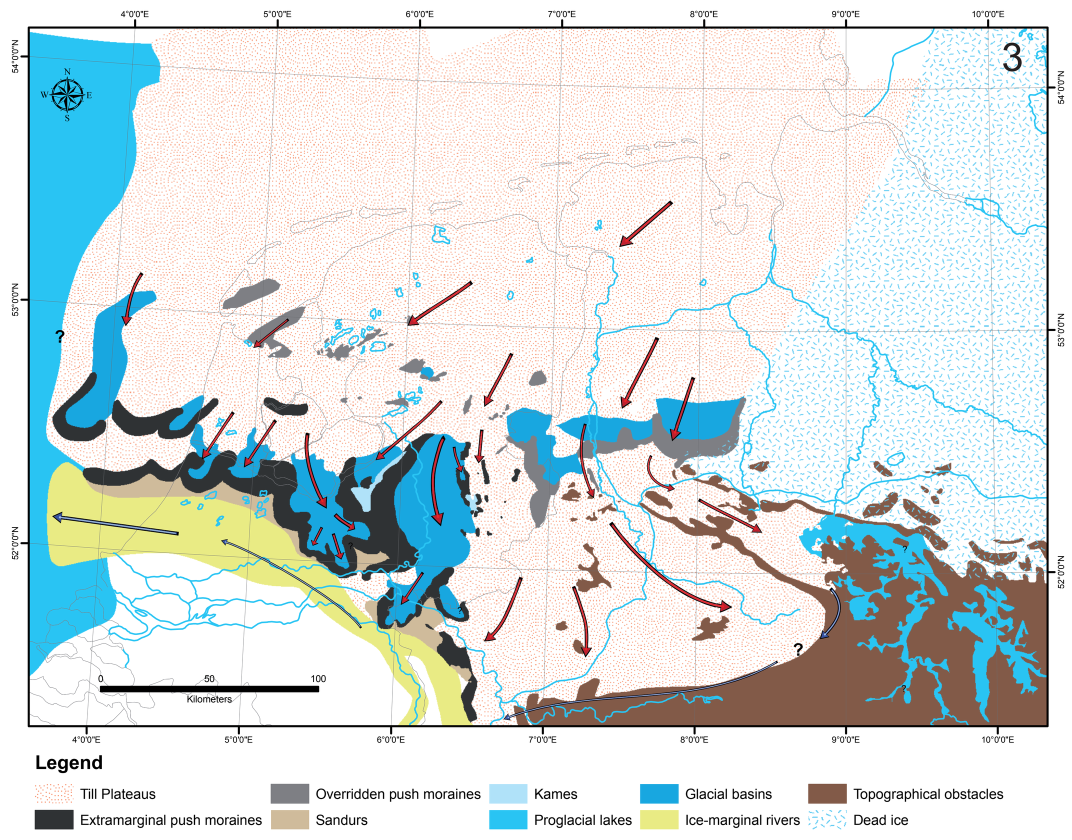


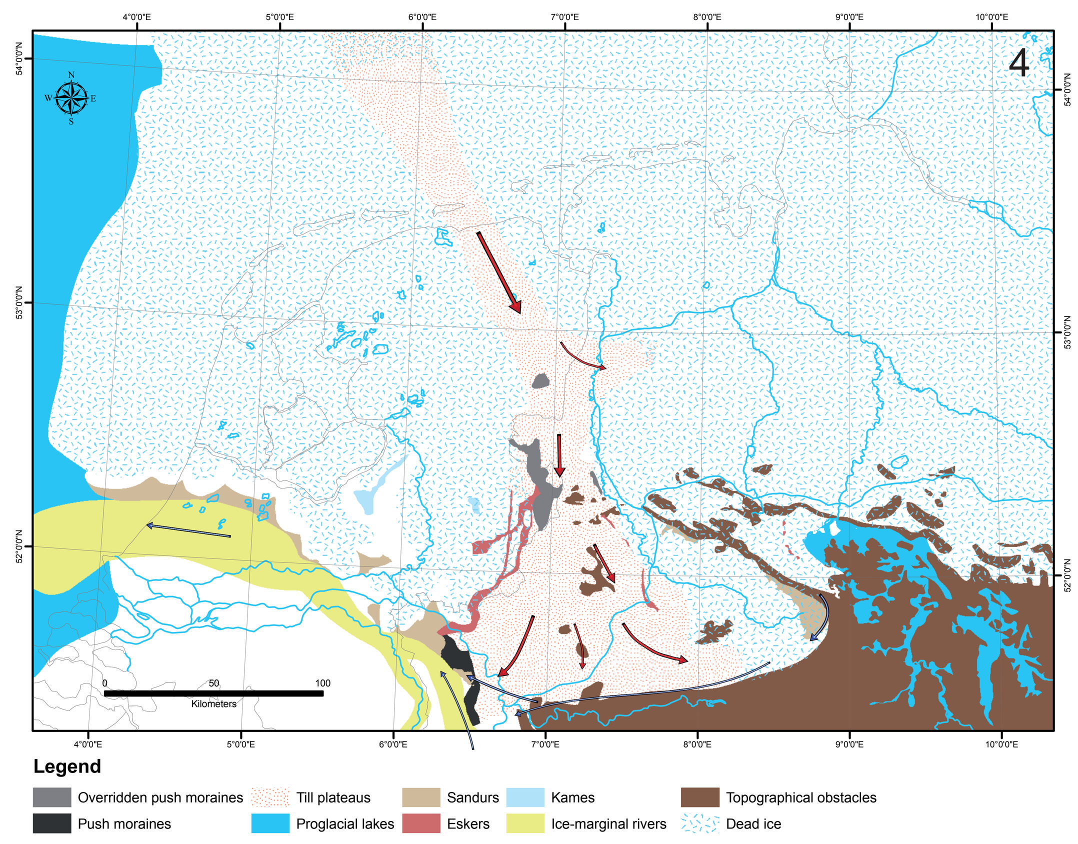
This GIS-generated map shows the main features stored, more or less as they have been preserved (younger strata uncovered and erosion repaired). The extent of larger proglacial lakes in the area are included because of their implications for stages of maximum glaciation and initial deglaciation. The most prominent features are the push moraines surrounding deep glacial basins between 52° and 53°N (Netherlands e.g. Van den Berg & Beets, 1987; Germany: e.g. Meyer, 1987). Just as dominant are the valleys that routed meltwater during the deglaciation (Vecht, Hunze, Weser; e.g. Ehlers et al., 2004; Skupin et al., 1993). They dissect relatively flat till plateau areas, parts of which have been subjected to substantial periglacial erosion and part of which have Holocene cover. A critical area linking Germany and The Netherlands is the Münsterland and the Niederrhein area.

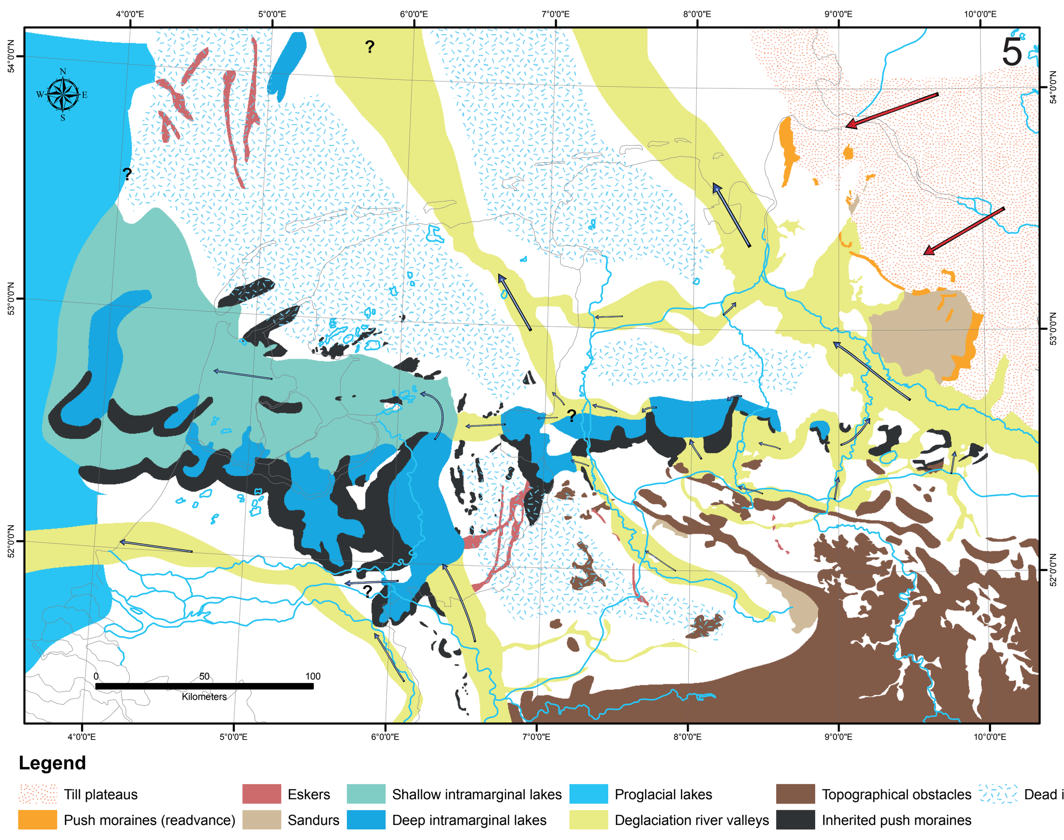
The proposed new phase model

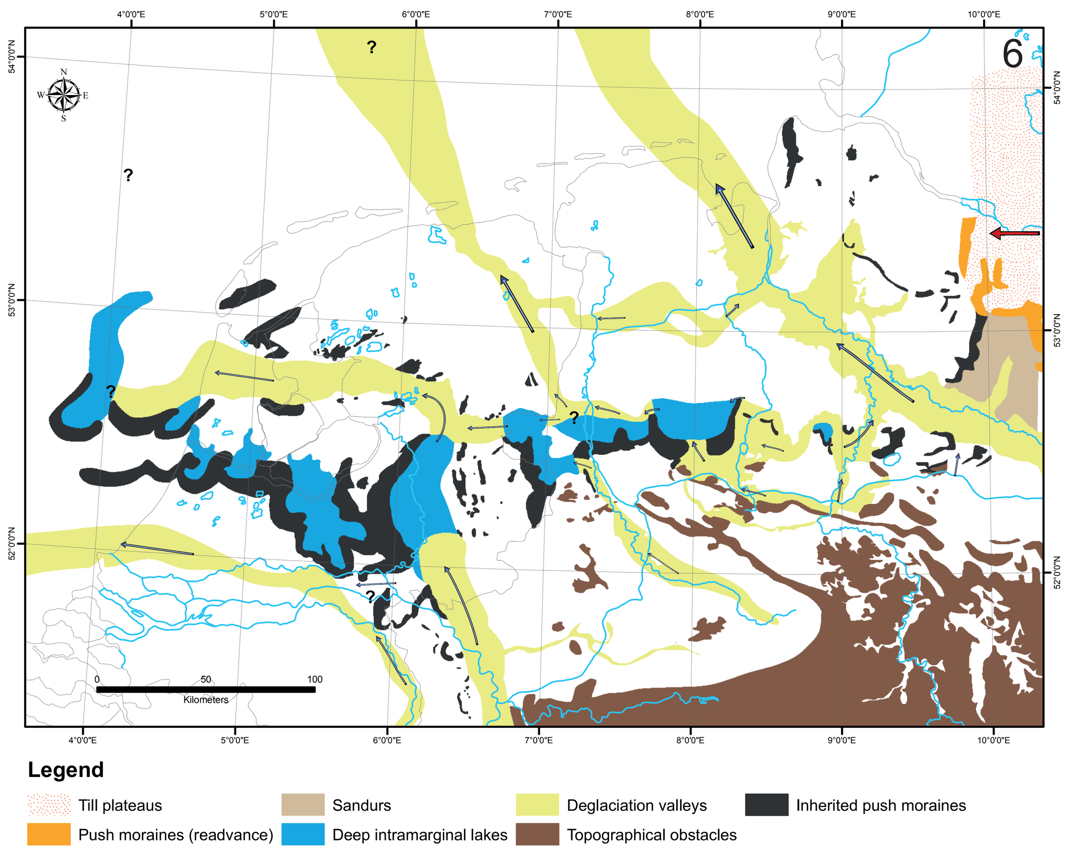












Phase 1 and 2: During the onset of the glaciation the ice first entered the region from the north, later from the northeast. This was probably related to the shift in the ice divide of the Fennoscandian ice sheet. During the onset rivers were deflected towards the west and meltwater deposits were formed in front of the ice (sandurs and ice-marginal rivers) which were overridden by the ice. Causing thick meltwater deposits to be covered by till in large regions of the research area. Push moraines were formed at localities where the conditions of the subsoil favoured their formation (e.g. coarse sediments, presence of faults or dipping hardrock structures). When the ice prograded further, these push moraines were overridden (e.g. Rehburg line).

Phase 3: During the maximal extension on the line Haarlem-Utrecht-Nijmegen-Düsseldorf, sometimes large push moraines were formed along the Peel faults, flanked by sandurs that drained into the Rhine-Meuse ice-marginal rivers, which subsequently drained into the large North Sea proglacial lake. In the Weserbergland the ice caused the formation of the proglacial Lake Weser. This integrates recent results from Busschers et al. (2008) and Winsemann et al. (2009).

Phase 4: When the ice sheet stagnated a single ice flow from the NNW intruded into the Münsterland, forming the Hondsrug flutings in Drenthe. This phase partially reproduces Van den Berg & Beets (1987). It was probably related to a mass surplus of ice in the North Sea that could be drained because of the presence of thermo sources in the subsoil.

Phase 5: During deglaciation large deglaciation rivers formed draining the huge amounts of water from the melting ice sheet. Also, large intramarginal lakes formed, especially in the former glacial basins. In the Elbe-Weser region a readvance of the ice sheet occurred, reflecting the last ice activity of the Drenthe substage, forming small push moraines and thick outwash deposits.

Phase 6: During this phase the North Sea proglacial had stopped to exist (ice no longer coalescent between Scotland and Norway), causing the valleys to incise deeper. In the Elbe-Weser region a second readvance ('Warthe') occured.

Conclusions and recommendations

- Storing spatial data on both glaciation and deglaciation phenomena in a dedicated GIS greatly aided optimalisation and documentation of phase model reconstructions for the last glaciation of our study area.
- Our updated 'new phase model' recognises four phases towards maximum ice-sheet extent, and two deglaciation phases. Initially the ice entered from the north, thereafter, flow was from the northeast. A last single ice stream from the NNW marks the time of maximum glaciation.
- The large glacio-fluvial valleys formed that discharged huge amounts of water released by the retreating ice sheet margin during deglacation, at critical positions in the drainage network (in NL, in GER) were interrupted by deglaciated tongue basin lakes.
- The dataset and integrated, updated, new phase model allow future reseach to focus on mechanisms of interaction of glacial dynamics with substrate processes (waterflow, heatflow) and conditions (lithology, thickness). The area covered by the reconstruction is now large enough to intercompare feature sets that have a comparable substrate setting. The dataset and phase model also serve to focus dating sampling strategies, and vice versa accumulated dating results ('swarms of dates') may help to validate the model.

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