Universiteit Utrecht

LOSS
Living on Soft Soils
Subsidence & Society

Kim de Wit MSc
k.dewit@uu.nl

Subsidence and relative sea-level rise due to glacio-isostasy in the Netherlands

Reconstruction of differential subsidence using 3D groundwater level interpolation

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Glacio-isostacy (GIA) in the Netherlands

In the Netherlands, several processes cause long-term natural subsidence. These “background” subsidence factors (Eq. 1) cause subsidence in the order of tenths of millimeters per year, due to which they are best distinguished on longer time scales. During the Holocene, the sea level of the North Sea was rising, and simultaneously the Netherlands was subsiding because of glacio-isostatic movement of the Earths mantle. The glacio-isostatic subsidence is stronger in the North, because it is closer to the former Fennoscandian ice sheet. As an example, the difference in glacio-isostatic subsidence between the German and Belgium coastline is approximately 7.5 m since 8000 yr BP (Vink et al. (2007).

Total subsidence =

$$\overbrace{Compaction + Oxidation + Resource\ extraction +}^{\text{Anthropogenic}}$$
$$\underbrace{GIA + Hydro\ isostasy + Sediment\ isostasy + Tectonics}_{\text{Natural “background” subsidence}} \quad Eq.1$$

Relative sea level rise

Different types of Holocene sediments were deposited under the influence of the rising sea level and the accompanying rising groundwater levels. These deposits now form an archive of the relative sea level rise along the Dutch coastline (Figure 1.a). By comparing groundwater level rise reconstructions at different locations in the Netherlands, it is possible to identify patterns of long term subsidence (e.g. GIA), as long as local influences on groundwater levels are taken into account (Figure 1b&c).

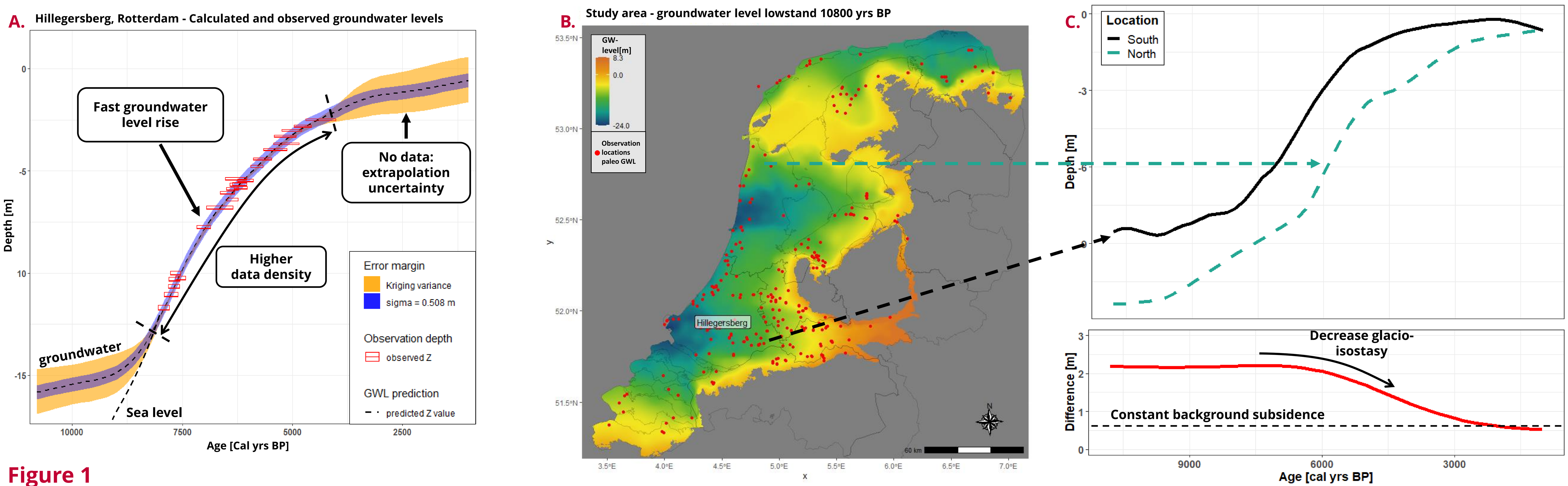

Figure 1
A. Extrapolated groundwater level at Hillegersberg, Rotterdam (black dashed line). Uncertainty margins of the interpolation and kriging are drawn in yellow and blue. Groundwater level observation data from Van de Plassche (1982) (red squares). **B.** Groundwater level at the groundwater level low stand around 10.8 ka BP in the research area. Locations of groundwater level indicators are marked with red dots (source: Van de Plassche (1982), Kiden (1995), Cohen (2005), Koster (2017), Meijles (2018), Hijma & Cohen (2019)). **C.** Difference in depth of calculated groundwater levels through time in the north and the south of the Netherlands.

3D groundwater interpolation

With a 3D interpolation of paleo-groundwater levels in the Dutch delta, it is possible to reconstruct the relative groundwater level rise of the past nine thousand years on a spatial scale (Figure 3).

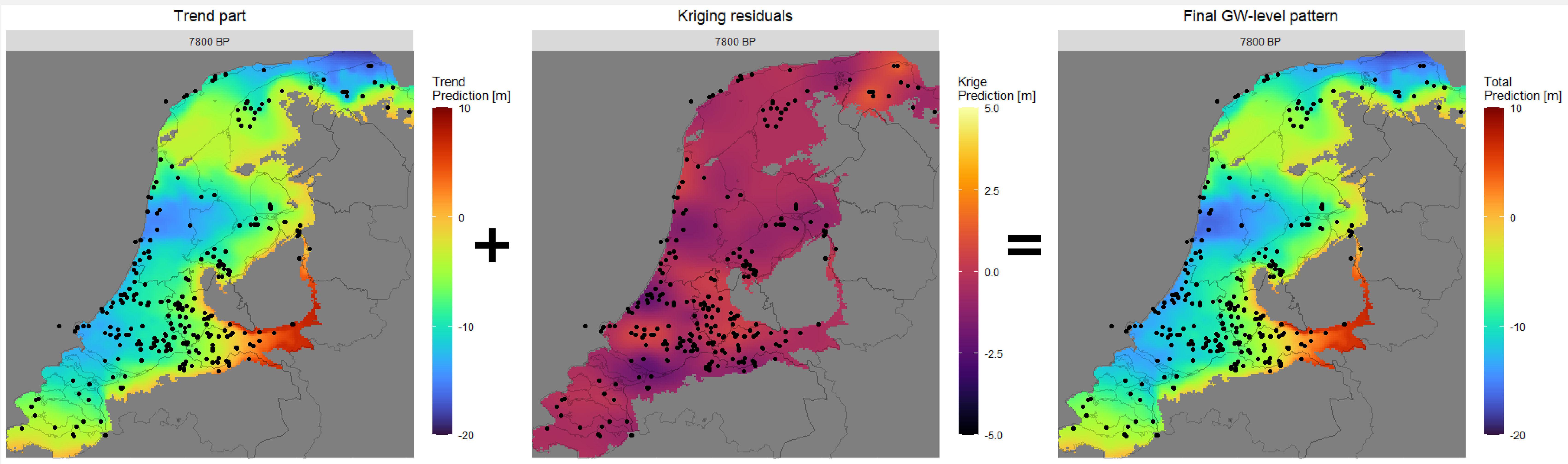

Figure 2
Predicted groundwater level of western Netherlands in 7800 BP. Panel 1: The trend-based calculated groundwater level. Panel 2: The deviation between trend and observation, calculated using kriging interpolation. The residuals that remain after trend fitting are interpolated using kriging to obtain a better reconstruction of the groundwater levels through time. Panel 3: The final groundwater level in 7800 BP, consisting of the trend part and kriging part of the interpolation summed together.

References

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