Geomorphological mapping of the Belgian seabed and its submerged landscapes

Lars Kint[1]*, Maikel De Clercq[2,3] & Vera Van Lancker[1]

[1]Royal Belgian Institute of Natural Sciences (RBINS), Operational Directorate Natural Environment (OD Nature),
[2]Ghent University, Renard Centre of Marine Geology (RCMG), [3]Jan De Nul Group
*lkint@naturalsciences.be

Abstract

Digital Terrain Models (DTMs) of varying resolutions are available as interoperable gridded data layers and data products. These bathymetry data, together with increasing availability of various terrain analysis tools, give new impetus to a more uniform geomorphological mapping of the marine realm. To test approaches in sandy shelf areas, multi-scale analyses are performed on bathymetric data from the Belgian part of the North Sea (BPNS) using the Benthic Terrain Modeler (BTM) in ArcGIS and other GIS-related raster tools that analyse the topography of the seabed. Resulting geomorphological features were sand banks and crests, valleys and depressions, and sandwave fields. A similar approach was tested on the depth-converted structure map (DCSM) of the Top-Paleogene surface at a 1:250,000 scale (De Clercq et al. 2016). Palaeovalleys and –ridges, from 120,000 to 100,000 years ago, were delineated semi-automatically, though more in-depth procedures are needed to distinguish less prominent features such as planation surfaces, escarpments and slope breaks. The geomorphological mapping products contribute to EMODnet-Geology's work packages on geomorphology and submerged landscapes.

Introduction

EMODnet-Geology is a pan-European initiative for harmonised mapping of marine geology. As such, collated geomorphological maps of the European seabed and its submerged landscapes are included. The Belgian contribution focuses on developing **(semi-)automated procedures** applicable to bathymetric grids (as inspired by Verfaillie et al. 2007) and using **standard vocabularies** on geomorphological features, as available for the North Sea (Dove et al. 2016).

Methodology

The **Bathymetric Position Index (BPI)** (Lundblad et al. 2006), part of the BTM toolbox in ArcGIS, is a marine modification of the Topographic Position Index (TPI) developed by Weiss (2001) for terrain classifications on land. The algorithm is based on relative comparisons of elevations of grid cells within a landscape within a user-defined inner and outer radius of a rectangle, annulus or circle. Using negative bathymetry data, a cell lower than its neighbouring cells gets a negative BPI (valleys); a cell higher than its neighbouring cells a positive BPI (ridges). This results in a map with geomorphological features like constant slopes and flat areas (zero BPI), i.e. first order derivatives; and crests (+ BPI) and depressions (- BPI), i.e. second order derivatives. A broad-scale BPI (B-BPI) results in the delineation of larger geomorphological structures; a fine-scale BPI (F-BPI) in smaller features. For the standardisation of the raw BPI, both B-BPI and F-BPI are needed. Bathymetric data tend to be spatially autocorrelated (i.e. locations that are closer together are more related than locations that are farther apart), allowing classifications against a defined dictionary of fine- and broad-scale BPI values, slopes and depths on almost any scale (Weiss 2001).

Preliminary results

Submerged landscapes

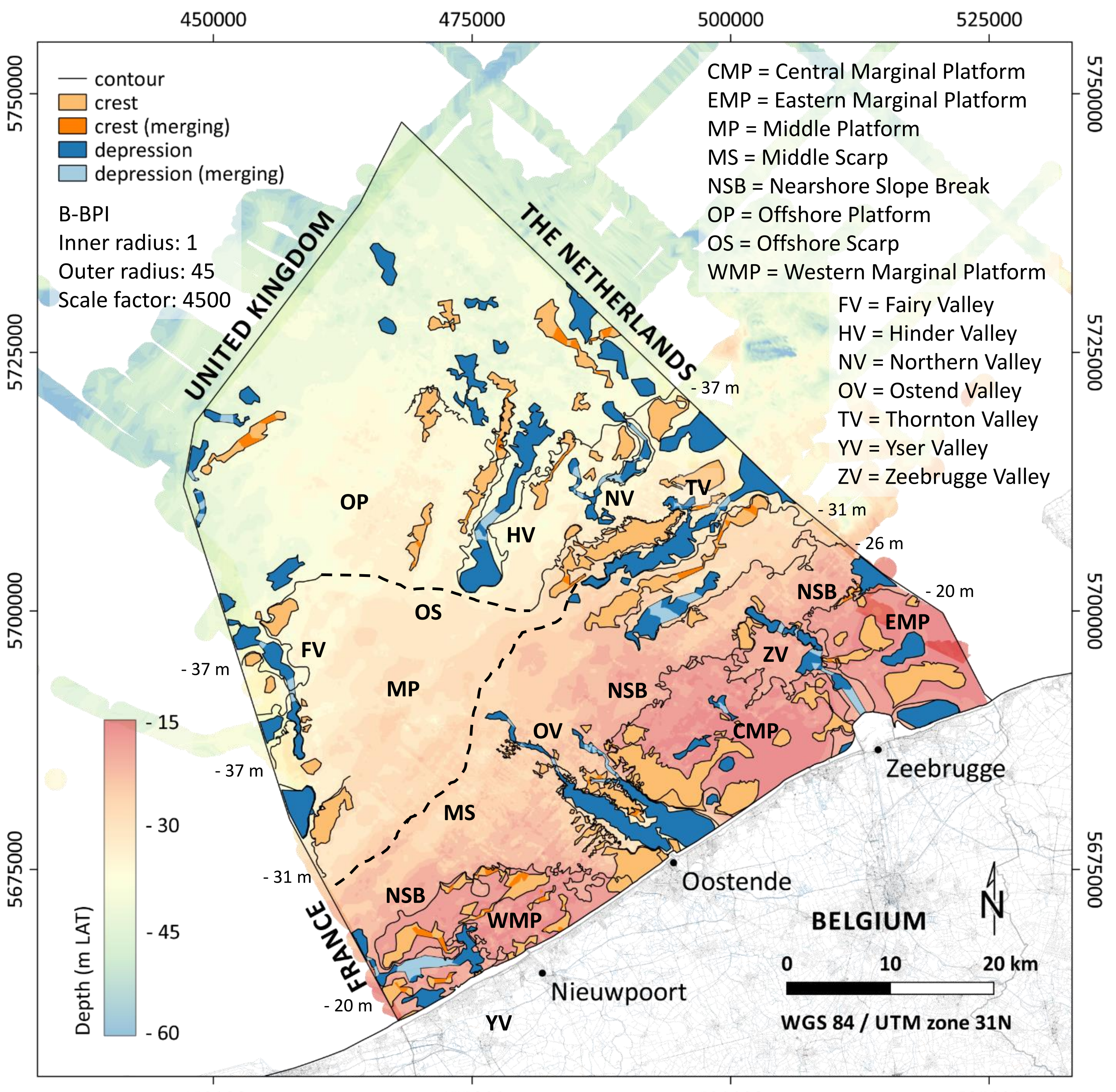


Figure 5. Semi-automated delineation of elongated ridges and depressions, indicative of the submerged palaeovalleys in the Top-Paleogene surface as identified in De Clercq et al. (2016). Major slope breaks and escarpments (- -) were added manually.

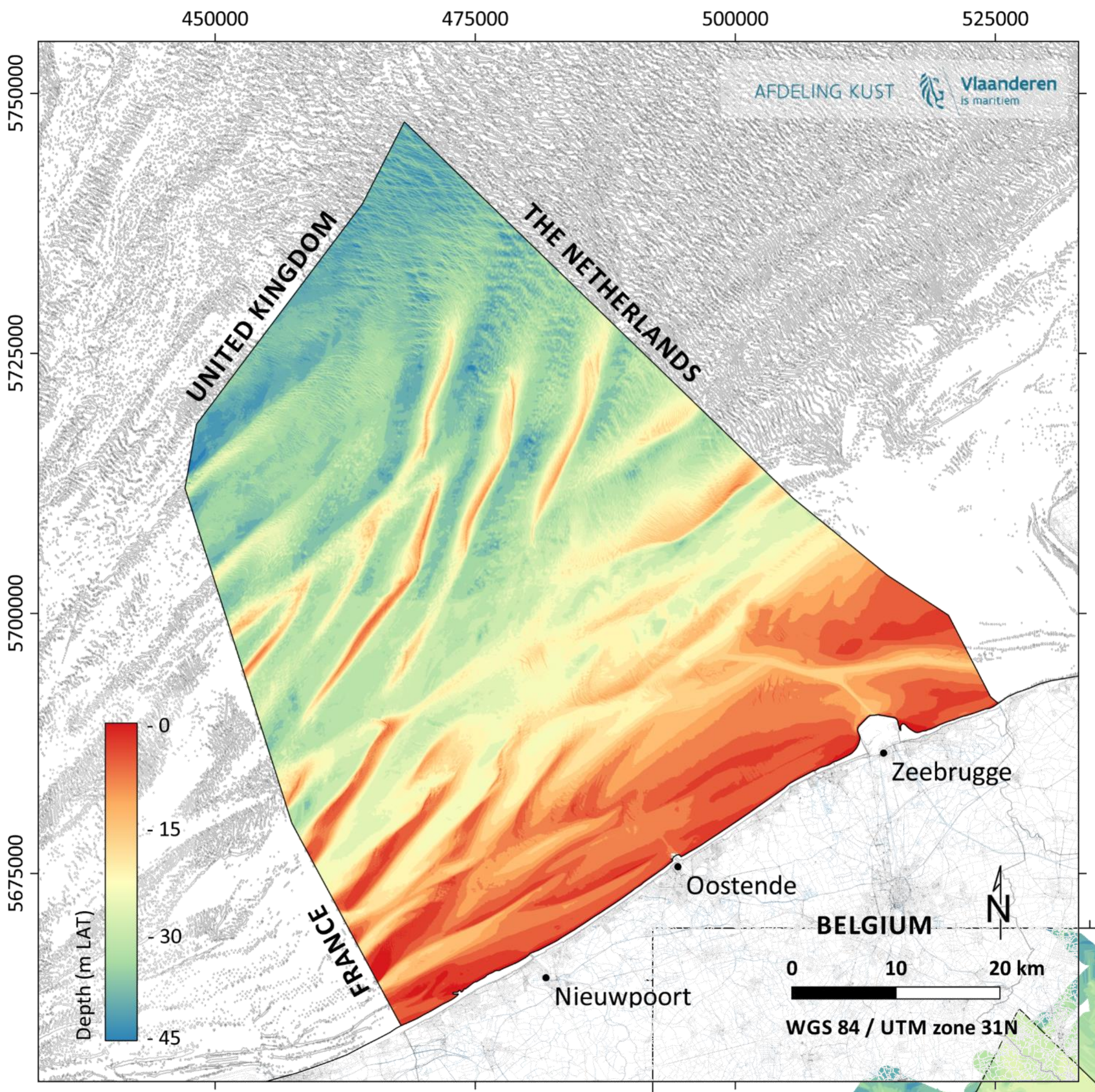


Figure 1. Flanders Hydrography provided a DTM of the BPNS at a grid resolution of 20 by 20 meters, combining single beam (2004-2010) and more recent multibeam (post-2010) echo sounding data.

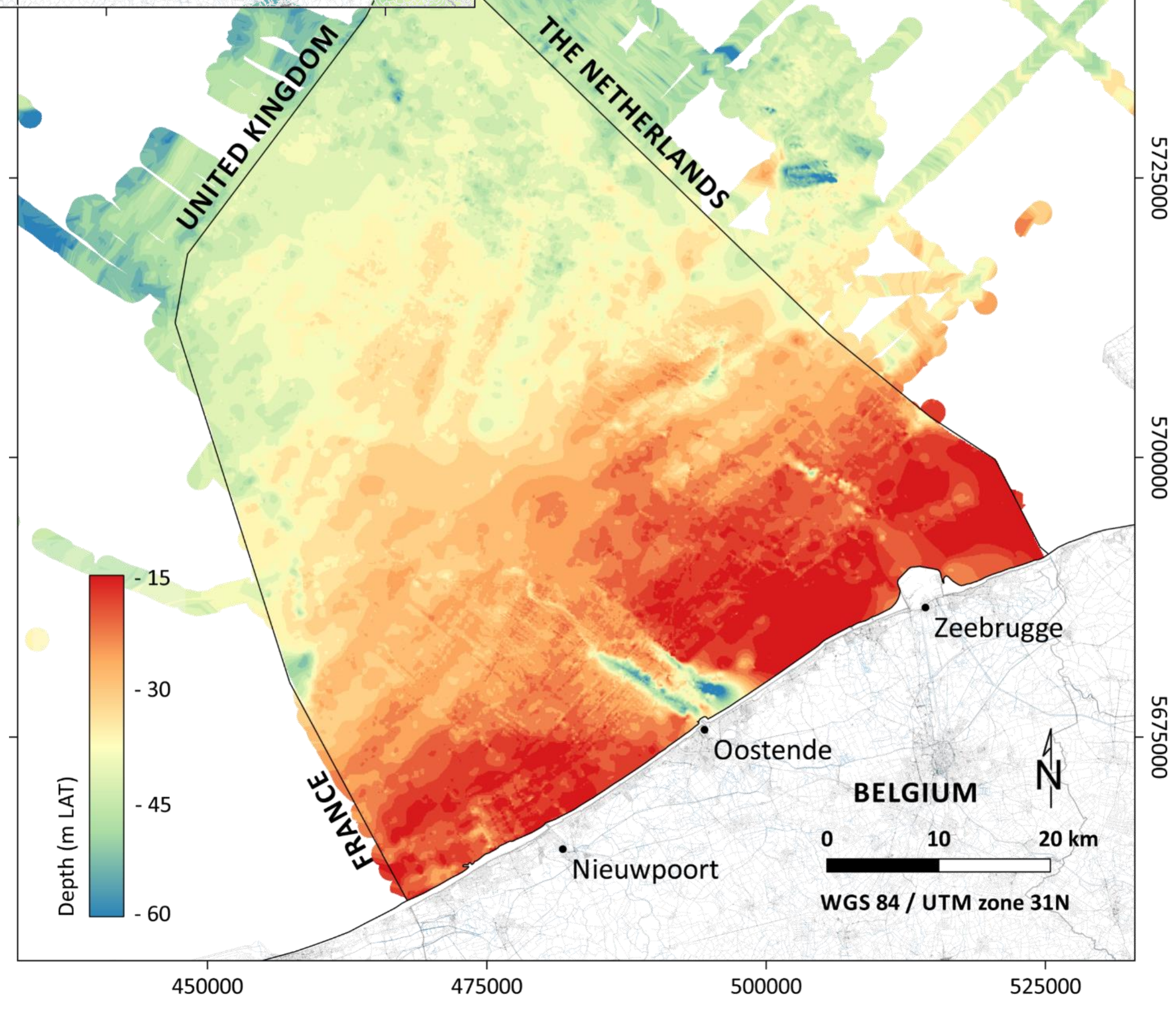
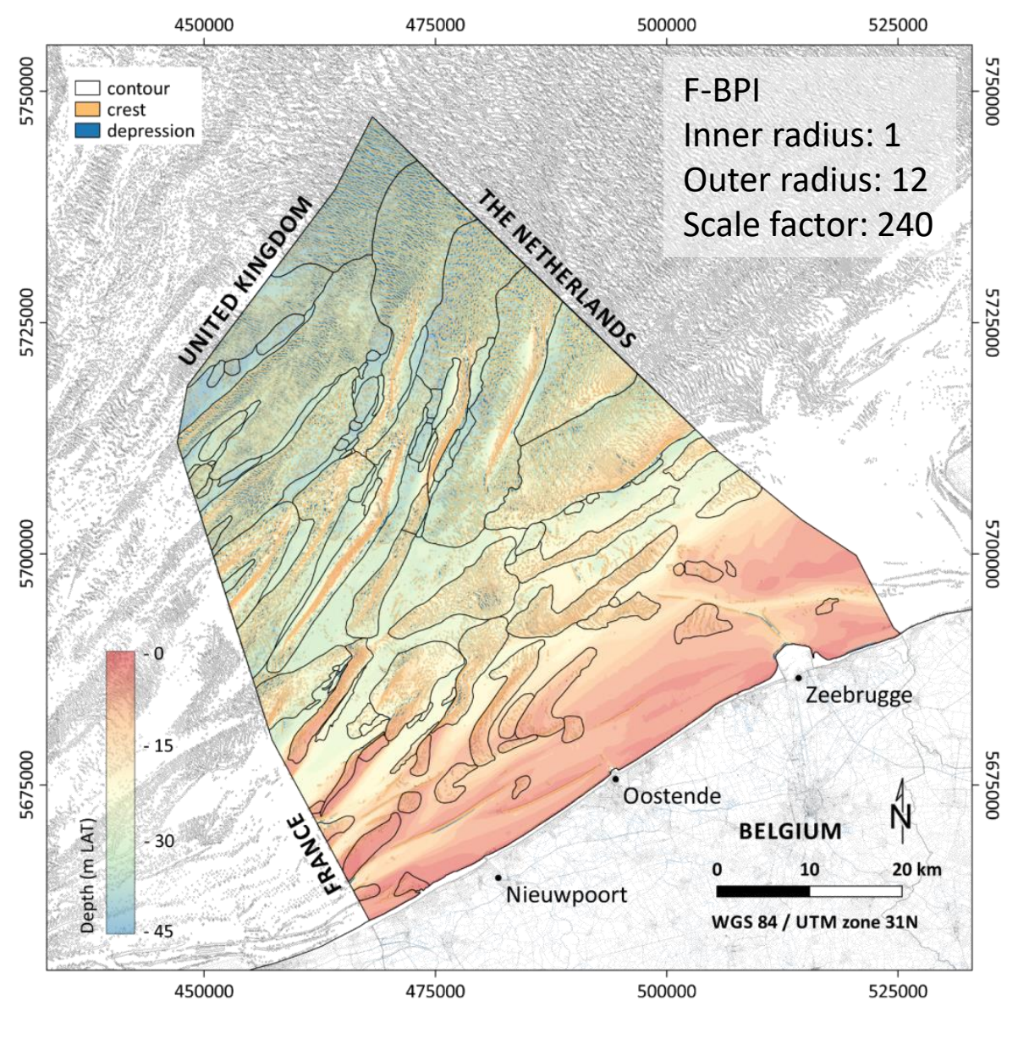


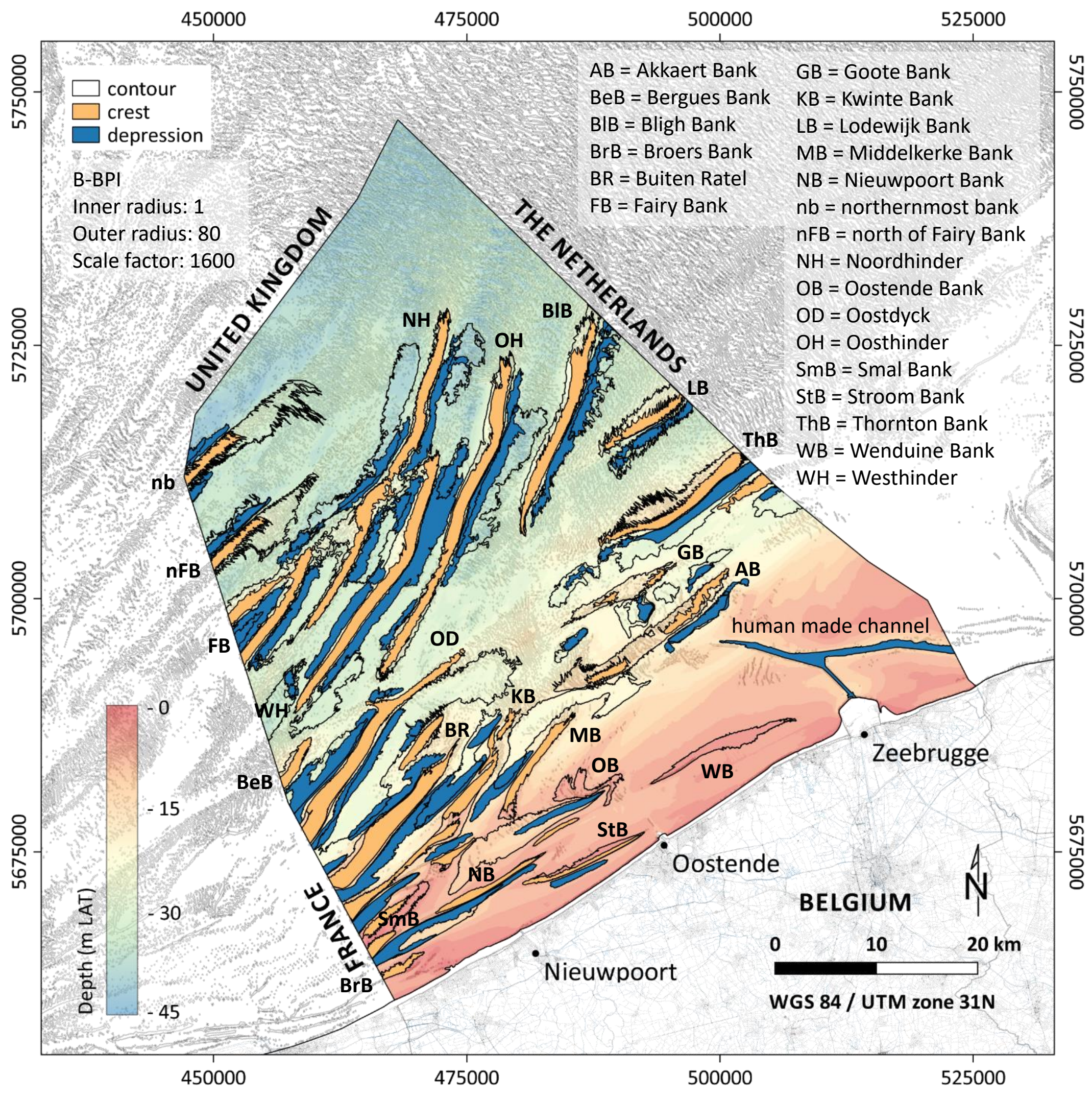
Figure 2. Ghent University constructed a high-resolution (1:250,000 scale) DTM of the Top-Paleogene surface at a 100 by 100 meter resolution (De Clercq et al. 2016). It is based on in-depth processing and re-interpretation of 130 boreholes, in conjunction with a quality-controlled digital dataset of 6670 km of seismic records.

Seabed geomorphology

Figure 3. Large-scale geomorphological features are sand banks (+ crests) and shallow marine valleys (+ gullies).

Figure 4. Fine-scale bedforms are mostly sand waves, here grouped into sandwave fields.





Some thoughts for discussion…

- Broad-scale BPI proves successful in delineating large bedforms on the seabed (e.g. sand banks, shallow marine valleys) and of submerged landscapes (e.g. palaeovalleys, elongated ridges), though complementary analyses of contour lines and slopes are best applied to improve the results. Furthermore, extra manipulations are needed to eliminate smaller trivial features, and to merge larger dominant bedforms to improve feature consistency. Individualizing slope features (e.g. slope breaks, escarpments) is difficult given their limited geometry, or their amalgamation in a network of slopes crossing the entire marine area.
- Fine-scale BPI, allowing distinguishing crests and troughs of sand waves remains complex. Grouping of features is more meaningful (e.g. sand waves in a sandwave field). Not applicable for the submerged landscapes.
- Standardised procedures and vocabularies are needed for harmonised mapping across the European seas.

References

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