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Combining measured and visually observed granulometric characteristics in updatable voxel models of seabed sediment

S. van Heteren

The challenge of making accurate seabed-sediment maps suitable for decision making connected to sustainable marine sediment extraction lies in using as much data, information and knowledge as possible and in providing associated measures of uncertainty. A key deliverable of ongoing transnational work to develop a tool for integrated long-term strategy for the exploitation of marine sand and gravel resources in Belgium and the Netherlands (project TILES) is a state-of-the-art seabed-sediment map. For the southern Dutch part of the North Sea, a new, easily updatable map was generated through geostatistical subsurface modeling. As part of this process, measured and visually observed data points were weighted before knowledge-influenced interpolation, with weights dependent on methodological strengths and weaknesses.

Strengths of measured grain-size data (distribution curves) include their quantitative nature and internal consistency. Some weaknesses concern the representativeness of commonly small subsamples analyzed, and a lack of inter-method calibrations needed to harmonize the results of numerous methodologies and of models translating physical measurements into percentages of grain-size classes. Strengths of visual descriptions include the possibility to address the contribution of outliers such as large clasts in a fine matrix, and of sublayers/inclusions that cannot be assessed individually but do have a significant cumulative effect. Major weaknesses are its subjective nature and the difficulty of expressing qualitative estimations as semi-quantitative figures.

Combining these two vastly different types of data in geostatistical models resulted in artefacts that needed to be reduced on the basis of additional information and expert knowledge. Water depth, for example, turned out to be a useful surrogate for grain size, improving interpolations when used as an auxiliary predictor. Expert knowledge was indispensable when comparing and choosing among different model results, although care was taken not to dismiss unexpected patterns too easily. By working with subsets of the total database, it was possible to quantify the interpolation-related uncertainty of each model, and thus to select the best modeling protocols for specific areas. Using a single protocol, however attractive for efficiency purposes, was not possible. Instead, subareas modeled with different optimized protocols were merged to generate the final seabed-sediment map.

Although the merits of this new map in extraction-related decision making still need to be quantified, inclusion of uncertainty is of clear added value. Many of the negative impacts of marine sediment extraction are related to presence of fines. Knowledge on the influence of sampling, subsampling, description, analysis, classification, interpolation and interpretation on mud content used as model input is crucial. Incorporating this knowledge into modeled output requires proper weighting, as well as quantification of all known uncertainties.

Contact author: Sytze van Heteren, Geological Survey of the Netherlands, sytze.vanheteren@tno.nl