Earth Surf. Dynam. Discuss.,
https://doi.org/10.5194/esurf-2019-57-AC1, 2020
© Author(s) 2020. This work is distributed under
the Creative Commons Attribution 4.0 License.

Interactive comment on "Modelling Bedrock Topography" *by* Nils-Otto Kitterød and Étienne Leblois

Nils-Otto Kitterød and Étienne Leblois

nils-otto.kitterod@nmbu.no

Received and published: 2 March 2020

Thanks to de Beer for a positive and constructive review! Your comments and questions will be carefully considered in the final revision of the paper. We appreciate this opportunity to continue the discussion on the bedrock topography, and we would like to reply briefly on some of de Beers comments. It is true that the spatial distribution of sediment thickness, D(u), and the elevation of the bedrock topography, B(u), play important roles in many practical applications, but from our point of view there is a general lack of attention on how to utilize the large amounts of information that exist in public databases to improve estimates of D(u) and B(u). In this paper we suggest to model B(u) as a stochastic function, and we use a dataset from an area where the B(u) is modified by glacial erosion. It is true, as de Beer indicate, that application of

the Poisson's equation was motivated by the classical U-shaped valleys, which is the result of glacial erosion. It is also true that in areas where B(u) is eroded by other processes (viz chemical weathering; fluvial erosion), the transition between the sediments and the bedrock might be more fuzzy. Still there might be useful to regard B(u) as a stochastic function because the purpose of treating B(u) as a stochastic function is to estimate the most likely surface, not to reproduce a deterministic surface. Exact fit between the observation and the modelled surface can only be achieved where exact observations exists - either as point observations (drillings or boreholes); as line information (geophysical surveys); or as areal information (constructions or excavations). The purpose of the Poisson equation is to test if the largescale trend can be modelled by a simple mathematical function. We suggest to test a similar approach with data from other areas. Poisson-like equations might not be the final solution, but the main challenge is to find robust methods for inverse modelling of the parameters in the equations. We encourage people to explore other options for example deep neural network or other deep machine learning algorithms. The point observations we use for this study were taken from the Norwegian well database called GRANADA (NGU 2020). The exploratory semi-variograms were derived from the global database, and the local study was carried out in a small sub-area called Øvre Eiker (c.f. Fig.2). As de Beer points out, the number of data is increasing every year, and all these data were not included in the current study. The experimental semi-variograms was taken from a previous study which means that all the current observations are not included (Kitterød, 2017). The purpose of this study is to test algorithms to control the problem of preferential sampling and bias in the observation material, not to present up-dated results from the GRANADA database. These problems are discussed in more detail in Kitterød (2017). As de Beer underline, there will always be uncertainties in public data (viz Digital Quaternary Maps, DQM; well databases). A major challenge is uncertainty in the spatial location of interfaces between sediments and exposed bedrock. These uncertainties need to be included as part of the estimation procedure, and not hidden in the result. Extensive use of public data is a call for improving the data quality.

Today it is possible to carry out an independent quality assurance of the DQM by application of LIDAR data and machine learning technology. It is a great encouragement to notice that the quality of the GRANADA data increase with respect to recording of D(u) for boreholes and total depth for sedimentary wells. This comment is a call for further studies and administrative planning should be done to implement estimation of the bedrock topography for greater part of Norway.

References Kitterød, N.-O.: Estimating unconsolidated sediment cover thickness by using the horizontal distance to a bedrock outcrop as secondary information, 2017. Hydrol. Earth Syst. Sci., 21, 4195-4211, https://doi.org/10.5194/hess-21-4195-2017, doi:10.5194/hess-21-4195-2017. NGU: Geological Survey of Norway, GRANADA database, 2020. http://geo.ngu.no/kart/granada/

Interactive comment on Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2019-57, 2019.