Towards Unleashing the Potential of Elevation Data for Archaeological Research

Reviewing Past and Present Applications

Irmela HERZOG, The Rhineland Commission for Archaeological Monuments and Sites, GERMANY

Keywords: *Digital elevation model—GIS—Lidar data—open access*

CHNT Reference: Irmela Herzog. 2020. Towards Unleashing the Potential of Elevation Data for Archaeological Research. W. Börner and CHNT Organization Committee. Proceedings of the 25th International Conference on Cultural Heritage and New Technologies. DOI:xxxxxxx.

Introduction

This paper is about elevation data that was not recorded for archaeological purposes but that was, is and will be used for archaeological purposes. The focus of the first part is on early applications of this data in the 1980s and 1990s. In the second part, some issues concerning the availability of elevation data are discussed. Moreover, recent or current applications of such data in the Rhineland Commission for Archaeological Monuments and Sites are presented, outlining the impact of the early ideas and new developments.

Looking back at the 1980s and 1990s

Before digital elevation data covering large parts of the world at different scales became available, archaeologists used contour lines on analogue maps to identify possible site locations and to assess the risk of erosion for known sites. These are some of the reasons why scanned maps with contour lines at a scale of 1:25,000 were integrated in an information system with a GIS component for archaeological sites in Saxony presented at the predecessor of the CHNT conference in 1998 although more accurate topographic maps without contours were also part of that system (Zeeb, 1999).

An early application of elevation data for archaeological research is presented in the publication by Kvamme (1988). He used elevation data digitized from contour maps in the 1980s with the aim of developing and testing “models of archaeological distributions that have a predictive capacity”. The paper includes descriptions of how to derive slope and aspect from a contour map, and mentions two approaches for comparing aspect measurements in view of the 0°=360° issue. Kvamme also presents key figures for measuring local relief, terrain texture, view quality and shelter. Moreover, he refers to the publication by Ericson and Goldstein for estimating travel time based on slope. So this paper touched many subjects that are important for state-of-the-art archaeological landscape research in hilly or mountainous terrain today.

Kvamme also is an early adopter of GIS software that provides tools for calculating the relevant key figures (Kvamme, 1992). After generating a digital elevation model (DEM) based on digitized contour line data, GIS allowed him to generate viewsheds, 3D visualisations of the terrain also showing the location of finds or sites. In his papers, he also suggests a new DEM based approach for identifying drainage courses.

Subsequently, archaeologists all over the world have adopted, discussed or improved these approaches. An example is the PhD thesis by Axel Posluschny (2002), parts of which were presented at the CHNT predecessor conference in 1999. The thesis presents several analyses based on data derived from a DEM:

preferred ranges of elevation, slope, and aspect are identified for the sites considered; the thesis also discusses site preservation and detection probability depending on the local relief key figure.

Availability of open elevation data

In many countries, it is no longer necessary to digitize contour maps, because high quality elevation data is freely available. In countries without such services, case studies in landscape archaeology often rely on satellite data with limited accuracy and resolution (Herzog and Yépez, 2016). In some countries, digital contour line data presents a viable alternative for archaeological landscape analysis. The resolution of available elevation data increased considerably in the course of the last two decades partly due to new photogrammetric technologies (structure from motion) but mainly due to air-borne laser scanning (ALS) adopted by many ordnance survey institutions. Initially, the ALS point density was only 1 measurement in 36 m² in forests (Zijverden and Laan, 2005), but nowadays about 19 ground points per m² can be achieved in such areas *(<2019-Sep DEM* in Fig. 1). Different visualisation techniques have been developed for ALS data, grey or colour hill-shading is probably still the most popular (centre images in Fig. 1).

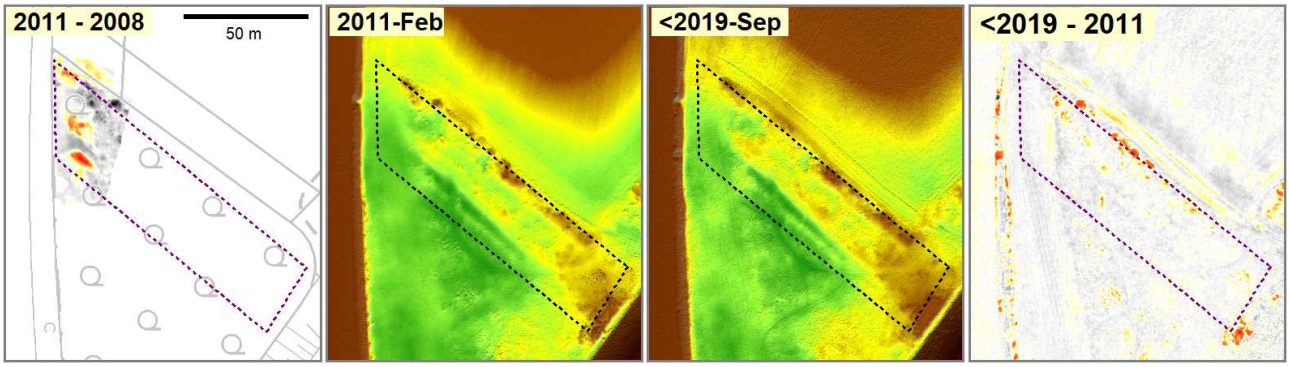


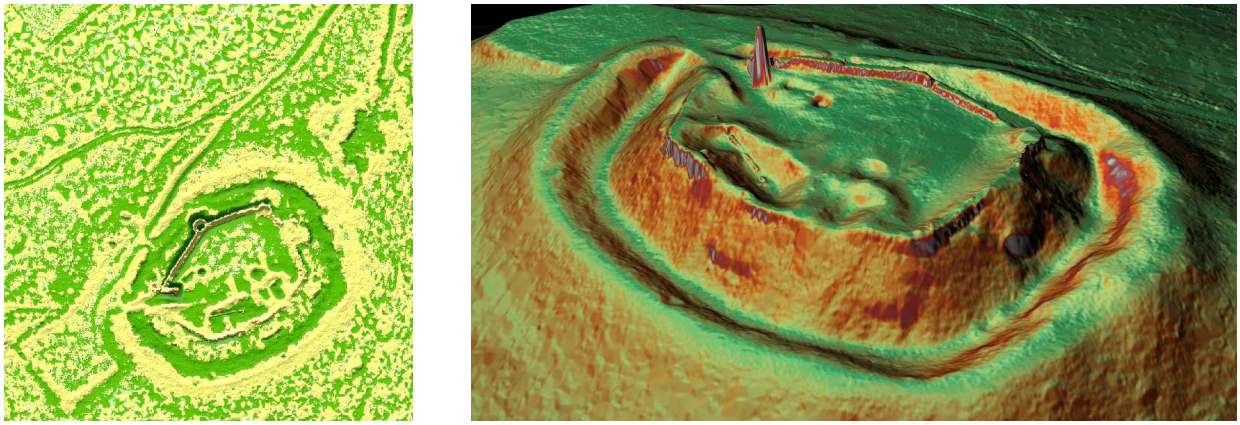
Fig. 1. The dotted line delimits a protected site, i.e. remains of a feature consisting of ramparts and ditches. The elevations of the western part of the site were surveyed manually in 2008 (739 measurements), the image on the left shows the difference to the DEM that was computed from ALS data recorded in February 2011. The red area highlights an elevation minus of about 40 cm. Hill-shading of the DEMs based on the 2011 and later ALS data are depicted in the two centre images. The differences between these two DEMs are shown on the right.
(© Irmela Herzog based on data provided by Geobasis NRW).

The situation in the Rhineland may appear like elevation data paradise for many colleagues: the ordnance survey institution Geobasis NRW provides open access ALS data with classified point data in laz format. Moreover, interpolated raster data with a cell size of 1 m is available, as well as four WMS layers providing grey and colour hill-shading of the 1 m DEM from two different directions. But there are also some drawbacks: the data is updated at regular intervals, and the old versions are no longer accessible. Moreover, the date of the ALS flights are not provided, the file dates serve as a *terminus post quem*. It is for this reason that one of the DEMs shown in Fig. 1 is designated by "<2019-Sep DEM". The earlier DEM dated February, 2011 was delivered as a special favour to the Rhineland Commission for Archaeological Monuments and Sites in 2012, when this data was not yet free of charge. At that time, metadata was provided as well. Another issue is the fact that archaeological landscape analysis often requires DEMs at a lower resolution. It is quite tedious to generate such a DEM from a DEM with a cell size of 1 m. Fortunately, such DEM data was acquired in the "special favour" phase.

Recent or current applications of elevation data in the Rhineland

ALS data has been used in archaeology for detecting sites and identifying features within known sites or for correctly delimiting sites. The need of correcting the boundaries of the protected site in Oberhausen is evident when studying the two ALS visualisations of this site that consisted initially of ramparts and ditches (Fig. 1, two images in the centre). Fig. 1 also illustrates the potential of ALS data sets from different years for monitoring sites. Before computing the differences, the two ALS DEMs considered had to be adjusted in elevation and position. Elevation data on the motorway—which is partly visible in the western part of the images in Fig. 1—was used for assessing the difference in elevation. Artificial sections in north-south and east-west directions helped to identify possible displacements in these directions. The resulting image shows that part of rampart remains were destroyed

In Fig. 2, two ALS data visualisations of a site in the forest near Lindlar-Scheel are shown. A ruin of the tower and some walls are still visible today. Therefore, the corresponding elevation points were classified as non-ground points in the ordnance survey data. To give the full picture, the points on the ruin and the walls had to be selected from the set of non-ground points, that also included a large number of points on trees. Thematic maps of the elevations assisted in the manual selection process. The 3D visualisation benefits greatly from a colour scheme that depends on the slope values.



a *b*

Fig. 2. Visualisations of ALS data depicting the remains of a castle known as Neuenberg a) local relief model; b) 3D view created by Planlauf/terrain (© Irmela Herzog based on data provided by Geobasis NRW).

A master thesis by Sandra Rung (University of Cologne) is currently in preparation with the aim of analysing the relationships between prehistoric fortifications east of the Rhine. The preliminary list of sites consists of 41 entries, one of these is a likely earlier site at the Neuenburg location. Currently, high resolution (20 cm) DEMs are derived from the ALS data for relevant areas surrounding the sites. In a next step, the sites are delimited as precisely as possible, and the remains of the ramparts are digitized. This allows comparing many features of the sites such as the area enclosed by the fortification, the current size of the ramparts, the slope of the surrounding area, and the shape. A lower resolution (25 m) DEM is the basis of investigations into possibilities of communication between the fortifications either by signals or by routes.

References

Herzog, I. and Yépez, A. (2016). 'The impact of the DEM on archaeological GIS studies. A case study in Ecuador', in *Proceedings of the 20th International Conference on Cultural Heritage and New Technologies 2015*. Vienna, 17

pages. Available at: https://www.chnt.at/wp-content/uploads/eBook_CHNT20_Herzog_Yepez_2015.pdf (Accessed: 16 August 2020)

Kvamme, K. L. (1988). 'Development and Testing of Quantitative Models', in Judge, W. J. and Sebastian, L. (eds.), *Quantifying the Present and Predicting the Past*. U.S. Denver: Department of the Interior, pp. 325-428.

Kvamme, K. L. (1992). 'Geographic Information Systems and archaeology' and 'Terrain Form Analysis or archaeological location through Geographic Information Systems', in *CAA 1991, Computer Applications and Quantitative Methods in Archaeology 1991, BAR International Series S577*, pp. 77-84 and pp. 127-136.

Posluschny, A. (2002). Die hallstattzeitliche Besiedlung im Maindreieck. GIS-gestützte Fundstellenanalysen British Archaeological Reports (BAR), International Series 1077, Oxford. https://doi.org/10.17192/z2002.0092

Zeeb, A. (1999). Erste Schritte zu einem Flächenmanagement: Ein GIS in der sächsischen Archäologie, *Proceedings of Workshop 3, Archäologie und Computer 1998*. Vienna: Phoibos Verlag, pp. 85-102.

Zijverden, W. K. van and Laan, W.N.H. (2005). Landscape reconstructions and predictive modeling in archaeological research, using a LIDAR based DEM and digital boring databases, *Proceedings of Workshop 9 - Archäologie und Computer, 3.-5. November 2004*. Vienna: Phoibos Verlag, 8 pages.