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LIDAR-DERIVED DEMS FOR GEOARCHAEOLOGICAL INVESTIGATIONS IN ALLUVIAL AND COASTAL PLAINS

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ABSTRACT: Here we present some Digital Elevation Models (DEMs) produced from airborne laser altimetry in the distal sector of the Venetian-Friulian Plain. The research considered some areas where the high detail of the surface landforms allows to evidence the occurrence of some ancient anthropogenic features that normally are not detectable in the present landscape or have been eroded by recent human activity. Case studies are selected from NE Italy, but this work shows the potential of the use of LiDAR data for geoarchaeological and geological mapping in alluvial environments.

KEYWORDS: Holocene, geomorphology, geological mapping, NE Italy

1. INTRODUCTION

The introduction of LiDAR technology (Light Detection And Ranging) significantly changed the resolution and the scale of topographic surveys, with the possibility to analyse the landscape in a detailed tridimensional perspective and over large areas. In the lowland environments laser altimetry has became a fundamental tool for territorial planning and assessment of natural hazards (e.g. Antonioli et al., 2017). The use of LiDAR data for geoarchaeological reconstructions is especially efficient in hilly environments because the possibility of filtering the vegetation cover (e.g. Bernardini et al., 2018), but the use in alluvial plain and urban context is still largely unexploited, even if results are very promising (Ninfo et al., 2011; 2016; Mozzi et al., 2018). With this work we want to highlight the capability of laser altimetry to detect traces, which are almost completely invisible in the field or with the use of other technics for remote sensing.

2. MATERIAL AND METHODS

The areas indicated as a) and b) in Fig. 1 belongs to the alluvial plain of Friuli Venezia Giulia region, where the LiDAR-derived DEMs are characterised by 1 m^2 cell size and a vertical accuracy of ±0.15 m. The data were produced in 2006-2007 by the Protezione Civile of Regione Autonoma Friuli Venezia Giulia, but DEMs can be freely download only since 2015 (www.irdat.fvg.it). The zones c) and d) are part of the Veneto region and the laser altimetry was obtained by the LiDAR survey acquired by the Italian Ministry of the Environment in the framework of the Extraordinary Plan of Environmental Remote Sensing (PST-A) and its extension (PST-A Extension 2008), with 1 m^2 cell size and vertical accuracy of ±0.10 m. In both of the regions the tile covered by a single file has an extent of 2x2 km and, thus, several tiles were mosaicked together for covering the areas to investigate. The elaboration of DEMs was carried out through software ArcMap and was rather simple: it consisted in the production of several DEMs with different elevation palette and color stretching, aiming at highlighting archaeological traces and morphological features. The topographic derivatives of DEM, as hillshading, slope and aspect, were used to evidence topographic variations and anomalies, as boundaries among landforms and depositional units.

3. RESULTS

Here we present some areas where high-detail DEM may improve the interpretation of the past landscape and, in particular, to support the detection of traces of past human activity. In the area west of Aquileia, Fig. 2A clearly evidences the existence of a fluvial ridge that, according to its direction, was built by the Torre River and was directly draining into the Grado Lagoon. Near Ca' Baredi, a major settlement was built on top of the fluvial ridge during the mid-late Bronze Age (Fontana et al., 2017). The new DEM allows to highlight that the innermost part of the site was bounded to the south by the relict channel of the ancient ridge and, probably, an artificial canal was dug on the northern side of the village for isolating it. The trace of the depression related to the abandoned channel is well visible in the middle of the ridge and could be followed almost to the lagoon. These traces of the ancient landscape documented in Ca' Baredi may be useful in interpreting other sites of the Bronze Age which have been discovered along the north-western Adriatic coast but where relict surface morphology has been strongly reworked by modern anthropo-

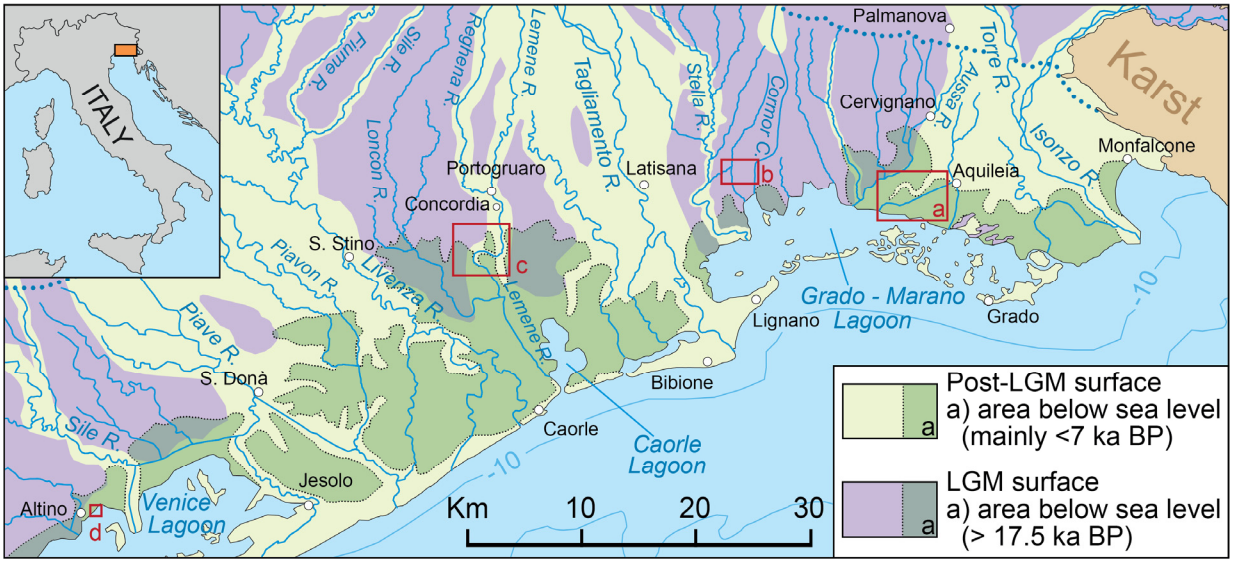

Fig. 1 - Simplified scheme of the alluvial and coastal plain of NE Italy (modified after Fontana et al., 2017) with indication of the studied sites discussed in the text: a) Ca' Baredi near Aquileia; b) Bosco Baredi near Muzzana of Turgnano; c) area south of Concordia Sagittaria; d) ancient city of Altinum, near the airport of Venice.

genic activities.

The area depicted in Fig. 2B is part of the Bosco Baredi of Muzzana del Turgnano, which is the largest semi-natural wood existing in the alluvial plain of northern Italy and it is an important site for wildlife preservation. The wood has not been ploughed since Late Antiquity and this conservative setting allowed the extraordinary preservation of relict landforms. In particular, the DEM highlights the convex topography of the natural levees (#1 in Fig. 2) of the fluvial ridge dated to the final part of the LGM (20.4 ka BP, Hippe et al., 2018), which are 1.5 m higher than the related floodplain and palaeochannel. Throughout the alluvial plain, several other LGM ridges are present, but they have been severely levelled in the last centuries for agricultural practice (Fontana, 2006).

The main features recognised through the detailed elaboration of the DEM is the complex and dense pattern of pathways used by people for moving through the wood. The main directions correspond exactly to the top of the LGM natural levees. This setting could be considered a fossil landscape as, according to archaeological investigations, before the Roman period the main "roads" connecting the lagoon fringe with the mainland used this higher portion of the LGM ridges to avoid swamps and marshes. The original landform is so evident that the main trackway is traditionally called "sentiero Arzarin" (i.e. pathway of the little dyke), even if it is a natural feature.

In the area south of Concordia Sagittaria (Fig. 2C), several pre-Roman sites have been discovered in the last 20 years and the new LiDAR-derived DEM highlights that almost all of them were settled along the scarps limiting an incised landform. This depressed morphology corresponds to a fluvial incision created by the Tagliamento River between Lateglacial and Early Holocene and that was after occupied by lagoon environment since about 7 ka BP (Fontana, 2006). The scarps originally had a height of almost 10 m, but have been progressively lowered by the infill of lagoon and fluvial deposits and currently they are almost invisible in the landscape. The LiDAR clearly shows the continuity of the scarps and allows to plan detailed field survey to look for traces of ancient settlements.

At the NE corner of the Venice Lagoon, where the ancient city of Altinum was present, remote sensing of visible and near-infrared images and geophysical investigations evidenced the exceptional preservation of most part of the urban and productive structures dated at the Roman period, which were mainly built between the 1st century BC and the 2nd century AD (Ninfo et al., 2009; Mozzi et al., 2016). The previous investigations highlighted also the traces related to the Roman harbour and some canals artificially dug in to the LGM deposits. Our DEM analysis evidences the topographic signature of these structures, in particular the depression coinciding with the most inner portion of the harbour (i.e. the "darsena"). This was a basin with a "L" shape, consisting of two segments. These had both a length of 170 m and a width of 25 m and 44 m, respectively. The topographic signature of the ancient harbour structures is rather surprising because the area was reclaimed at the beginning of the 20th century and has been prone to several levelling interventions in the last decades.

4. DISCUSSION AND CONCLUSION

The examples shown in Fig. 2 show that in the areas where archaeological traces are present or probable, the analyses of topography through LiDAR data could be a powerful tool for detecting some faint evidence of past human activity. Moreover, the use of very high detailed DEMs strongly supports the recognition of the morphological factors, which constrained the ancient settlement strategies. Even if large parts of the alluvial and coastal plains of Italy are already covered by LiDAR

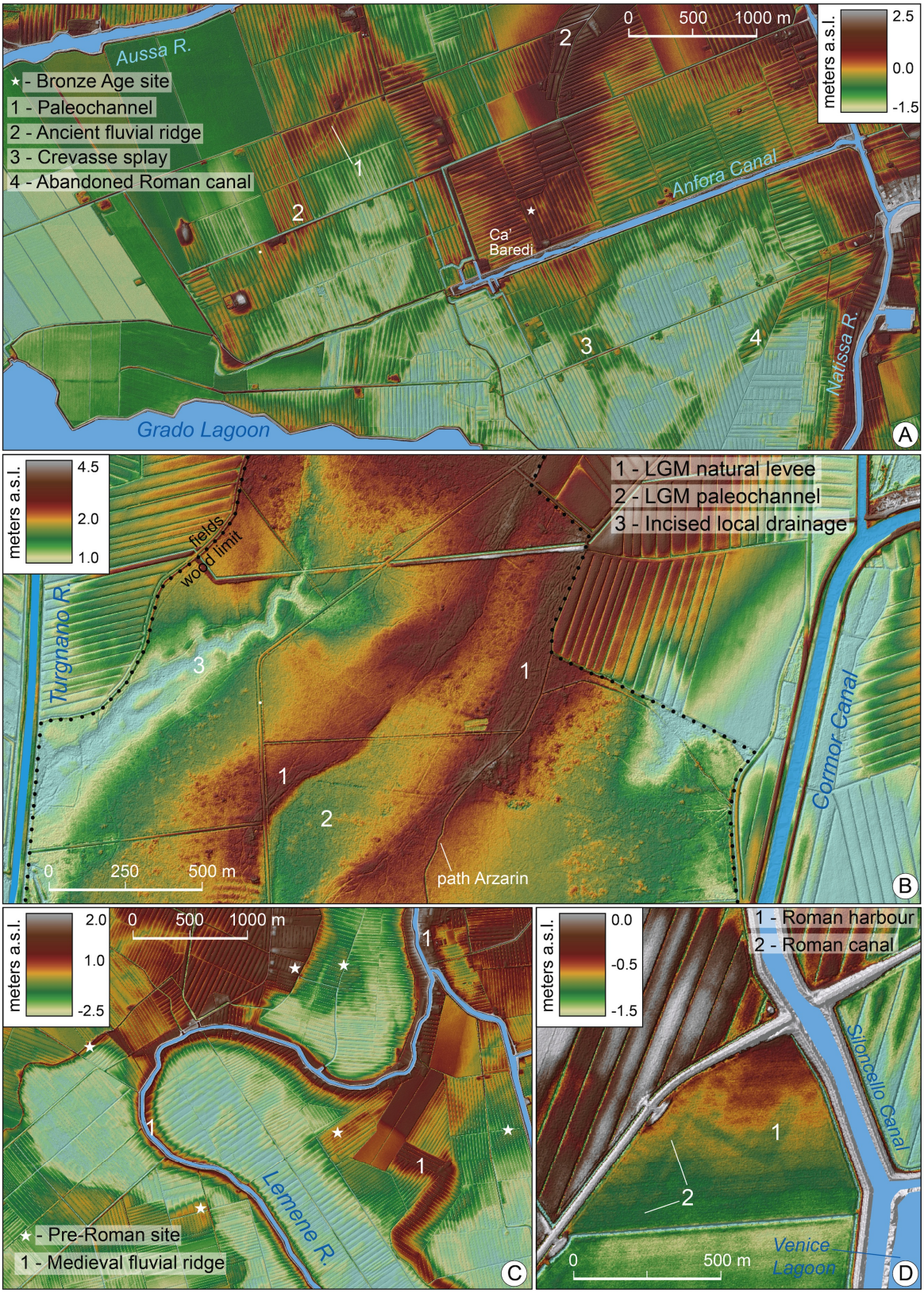

Fig. 2 - Digital Elevation Models (DEMs) of the studied sites. A) Ca' Baredi near Aquileia; B) Bosco Baredi of Muzzana; C) Area south of Concordia Sagittaria; D) Area of the Roman harbour of Altinum.

surveys, unfortunately access to these data is sometimes still not free or difficult to obtain. Notwithstanding, it is likely that in the near future, LiDAR surveys will be easily available and the increasing computational capability will make their processing and analysis fast and more detailed.

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