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MORPHOMETRIC ANALYSIS FOR GEOARCHAEOLOGICAL RESEARCH: FROM TESTING DIFFERENT METHODS TO RESULTS VERIFICATION IN THE ROMAGNA PLAIN[1]

1. Introduction

Geomorphological factors always had a relevant role in determining prehistoric and historic settlement choices. This is particularly true within alluvial plains, where flooding risk has always been a major factor in determining their suitability for human exploitation. In these types of environments, ancient human communities often looked for areas raised above the surrounding landscape, like fluvial ridges. These phenomena driving settlement choices have been studied for different periods and different areas within the Po Valley in Italy, especially for its southern part (e.g. for Bronze Age: Balista 1997; Cremaschi 1997; Cattani 2008; for the Roman period: Franceschelli, Marabini 2004; for the Middle Ages: Ficara 2006; Mancassola 2012; Brandolini, Carrer 2020).

On the other hand, since the 60s-80s geomorphology was recognized as a fundamental variable in landscape archaeology, which deeply influences the research results (e.g. Vita-Finzi 1969; Ammerman, Bonardi 1981; for the area of interest: Cavalazzi 2020). The most common reaction to this awareness was to increase the intensity of the research, while the attention was less frequently focused on the quantification and correction of this kind of bias (Nance 1983; Terrenato 2000; Van Leusen 2002; Casarotto *et al.* 2018).

One of the possible approaches to gather geomorphological insights is through the use of morphometric analyses on Digital Elevation Models (DEMs), which were developed since the second half of the 20th century. During the last twenty years, more and more archaeological studies are implementing these methods within their tools to reach a deeper understanding of historical phenomena, but also to better assess existing geopedological

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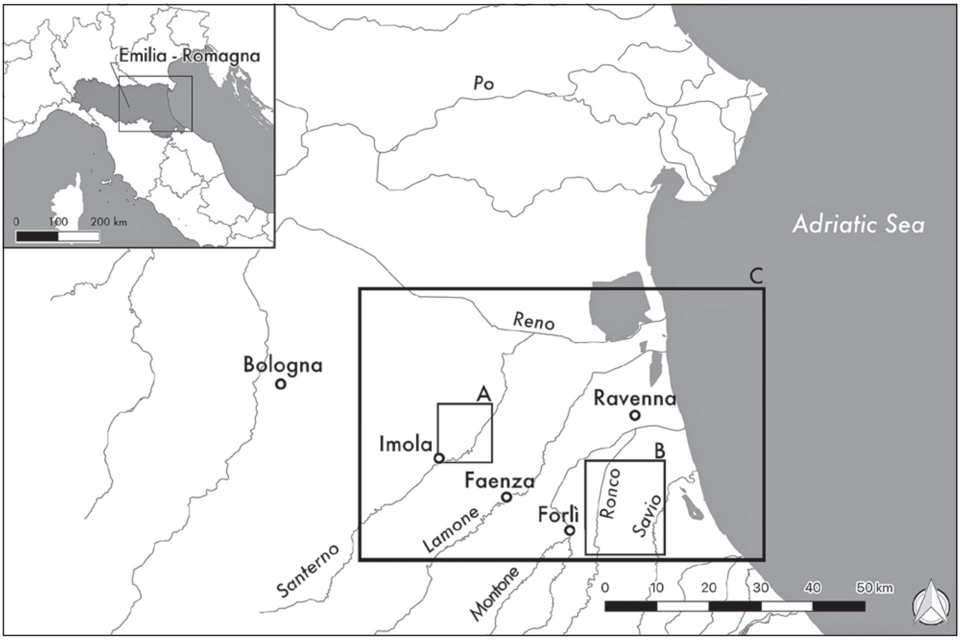

Fig. 1 – Area of interest with major cities, rivers, two case studies (A-B), and the extension of the processed DEMs (C).

biases. Among the methods used, we find the Topographic Wetness Index or TWI (Andresen 2008; Citter, Patacchini 2017; Schmidt, Werther, Zielhofer 2018; Mertel, Ondrejka, Šabatová 2018), but also the Topographic Position Index or TPI, often used together with the Deviation from mean Elevation or DEV (De Reu *et al.* 2013; Argyriou, Teeuw, Sarris 2017; Mertel, Ondrejka, Šabatová 2018). Recently, a new algorithm has been developed by Hector Orengo and Cameron Petrie (2018) for the visual interpretation of landforms using DEMs.

The Multi-Scale Relief Model or MSRM is based on the same approach of pyramidal representations used in computer graphics. The algorithm creates multiple images using different low pass filters and then compares the results, to highlight features as ridges, bluff lines and dune fields. According to the authors, «MSRM aims to extend microrelief detection applications to multiscale features and by incorporating the use of multiscale DTMs, including those of global scope, to the interpretation of geomorphological features» (Orengo, Petrie 2018, 1362). However, despite the use of morphometric algorithms for archaeological purposes is increasing, this is rarely followed by on-field evaluations.

Therefore, the first aim of this paper is to compare the performance of the novel MSRM algorithm to the most used methods in the literature, that are TWI, TPI and DEV (section 5). The study area to test these methods is the Romagna plain (Italy), the south-eastern part of the Po Valley (Fig. 1, C). The second aim is to compare the application of these methods to a global DEM such as the Shuttle Radar Topography Mission (SRTM) and a local DEM based on Ground Control Points (GCP) (section 5). While the first represents one of the free and ready-to-use global dataset available, the second was created interpolating thousands of GCPs, in a time-consuming procedure. However, the second dataset offers the advantage that modern artificial features have been already removed. Finally, since all results depend on the algorithm or sampling strategy used (Pike, Evans, Hengl 2009), we selected two smaller case studies for geoarchaeological verification of the most graphically-clear results (Fig. 1, A-B). We consider this step essential to evaluate the significance of the results and check if they can contribute to geomorphological and archaeological questions (sections 6.1 and 6.2).

2. Case study: the Romagna plain

The study area chosen to test these different morphometric algorithms is the Romagna plain, which covers a large part of the eastern half of the Emilia-Romagna region, in Italy (Fig. 1). The area stretches from the Apennines mountain range to the S, the Reno river to the N and the Adriatic Sea to the E. It is crossed by several rivers and major streams, respectively from W to E: Sillaro, Santerno, Senio, Lamone, Montone, Ronco, Bevano, and Savio. Naturally, these watercourses tend to build up levees raised over the landscape. Furthermore, natural and anthropic induced avulsions created palaeochannels that can have preserved their microrelief also in later periods.

The transformations of the local river network have been intensively studied since the last century, initially using mainly geological data, historical cartography and written sources analysis. A precocious example is the work of Pietro Zangheri (1927) on the river Montone near Forlì or the more complete study by Lucio Gambi (1949) on the whole Romagna, followed by several more localized researches (Roncuzzi, Veggi 1968; Veggiani 1973, 1975, 1976, 1990, 1995). In the last decades, other scholars have re-studied the area with a geomorphological approach, based on the interpretation of contour lines (Cremonini 1994, 2003; Franceschelli, Marabini 2007; Marabini, Vai 2020). In general, the palaeohydrography has been reconstructed satisfactorily for the Modern period and the Late Middle Ages, thanks to the abundance of written and cartographic sources, while it is less clear for earlier periods due to decreasing data availability (Abballe 2021).

3. Data acquisition and preprocessing

For the morphometric analysis, two different elevation datasets have been used. The first one is represented by the SRTM 1 Arc-Second Global, at 30 m resolution[2]. The second dataset was created interpolating GCP manually recorded by the Emilia-Romagna region[3]. The downloaded dataset, composed of almost 400,000 points, still included modern artefacts such as artificial fluvial banks as well as the highway, streets and railroads. Therefore, all elevation points not classified as "isolato al suolo" (i.e. recorded on the bare soil) were removed. The resulting 160,000 points dataset was then interpolated using the Inverse Distance Weighting method (Mitas, Mitasova 2005), to create a local DEM at 10 m resolution devoid of modern interferences. This DEM should represent the most precise reconstruction of the original topographic surface of the study area and it will be used to make comparisons with the results of the SRTM, which still contains modern artificial features.

4. Methods

The first three methods were performed using SAGA, a Free Open Source Software (FOSS) GIS, that can produce a large set of DEM-derived variables (Conrad *et al.* 2015)[4]. To apply the novel MSRM algorithm, we used Google Earth Engine (or GEE), a web-based geospatial computing platform created by Google (Gorelick *et al.* 2017)[5].

4.1 *Topographic Wetness Index (TWI)*

TWI quantifies the potential soil humidity and it is calculated using the logarithm of the ratio between the Catchment Area (CA) and the tangent of Slope (Beven, Kirkby 1979). Anyhow, we chose the method proposed in Hjerdt *et al.* (2004) to compute it, i.e. the Specific Catchment Area (SCA), instead of the CA, and the Downslope Distance Gradient (DDG), instead of the Slope[6]. We used the Flow width and Specific Catchment Area (Gruber, Peckham 2009) and the Downslope Distance Gradient (Hjerdt *et al.* 2004)

[2] Tiles "n44_e011" and "n44_e12" were downloaded on 24th April 2018, from the website https://earthexplorer.usgs.gov/ (accessed on 27th December 2020).

[3] These data were retrieved on 21st December 2018, from https://geoportale.regione.emilia-romagna.it/download/download-data (accessed on 27th December 2020).

[4] The official site of the project is available at http://www.saga-gis.org/en/ (accessed on 27th December 2020).

[5] The platform is available upon registration at https://earthengine.google.com/ (accessed on 27th December 2020).

[6] In SCA we chose the Multiple Flow Direction (MDF) method, while in DDG module we set the vertical distance to 5.

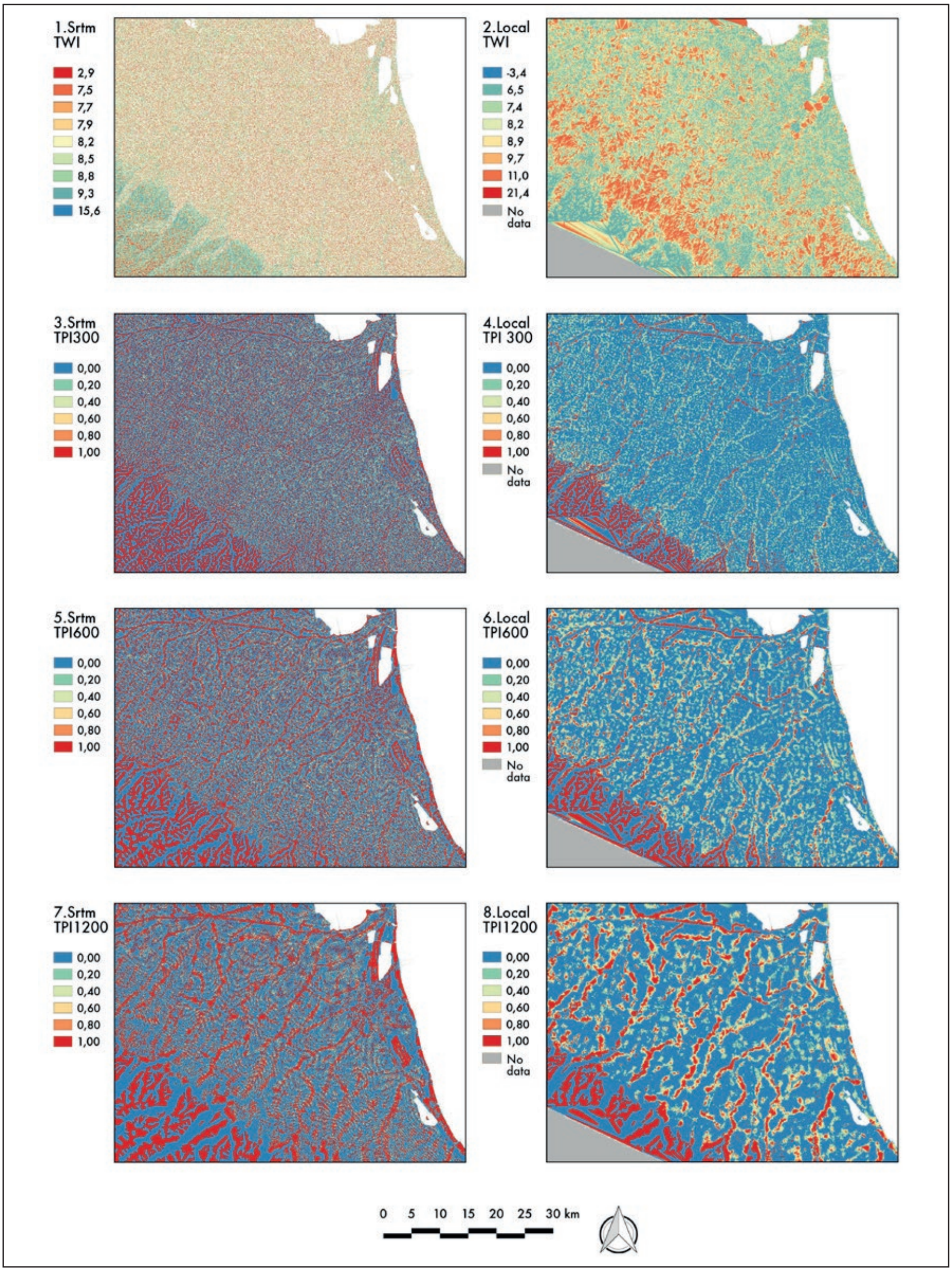

Fig. 2 – Elaborations of TWI (nos. 1-2) and TPI (nos. 3-8) at 300 m (TPI300), 600 m (TPI600), and 1200 m (TPI1200) for both SRTM (left) and Local DEMs (right).

modules to obtain the SCA and the DDG. Finally, we computed the TWI for both SRTM and Local DEMs (Fig. 2, 1-2).

4.2 *Topographic Position Index (TPI)*

The TPI algorithm compares the cell value of a DEM with the mean of its neighbours (Guisan *et al.* 1999; Weiss 2001). The neighbourhood is settled by the user, choosing the inner and outer radius (*R*) of an annulus area of research (Scale Factor). If the TPI value is major than 0, the point elevation is higher than the mean elevation of the neighbourhood (a ridge); vice versa it happens when the TPI value is minor than 0 (a valley). Values near 0 identify flat areas or with a constant slope (Weiss 2001, fig. 2a). The TPI depends by the scale of analysis: what it is flat at a fine-scale could be different at a smaller scale (Weiss 2001), and big *R* values identify only major landscape units, while a lower *R* value detects also smaller geomorphological elements, like ridges and valleys (Grohmann, Riccomini 2009; De Reu *et al.* 2013, 42). We present here the results of the TPI application to the SRTM and the Local DEMs (Fig. 2, 3-8), using no distance weighting and three different annuli (inner and outer *R*): 150-300 m (TPI 300); 300-600 m (TPI 600); 600-1200 m (TPI 1200).

4.3 *Deviation from mean Elevation (DEV)*

DEV measures the relative topographic position of the central point within a predetermined neighbourhood, based on the TPI divided by the standard deviation (SD) of elevation (Wilson, Gallant 2000, 74-75). If the results from DEV are positive, the central point is situated higher than its average neighbourhood, while they are negative when the central point is situated lower than its average neighbourhood. To compute SD we chose three windows with an annulus shape; the inner and outer radii were: 150-300 m; 300-600 m; 600-1200 m. Each TPI raster has been divided with the related SD raster, by pairing the same radius measure (e.g. SD 150-300 m with TPI 150-300 m). We present here the results of the DEV application to the SRTM and the Local DEMs, with these three different scales (Fig. 3, 1-6): 150-300 m (DEV 300); 300-600 m (DEV 600); 600-1200 m (DEV 1200).

4.4 *Multi-scale relief model (MSRM)*

The MSRM algorithm was the last method being tested using the original code made available by the authors (Orengo, Petrie 2018, Supporting Information), which was slightly changed to focus on the Romagna region. Other options that need to be defined are the maximum and minimum filters values (f_{max} or f_{min}). For both DEMs the use of a f_{min} close to the resolution of the raster has been chosen to include the smallest features of the landscape,

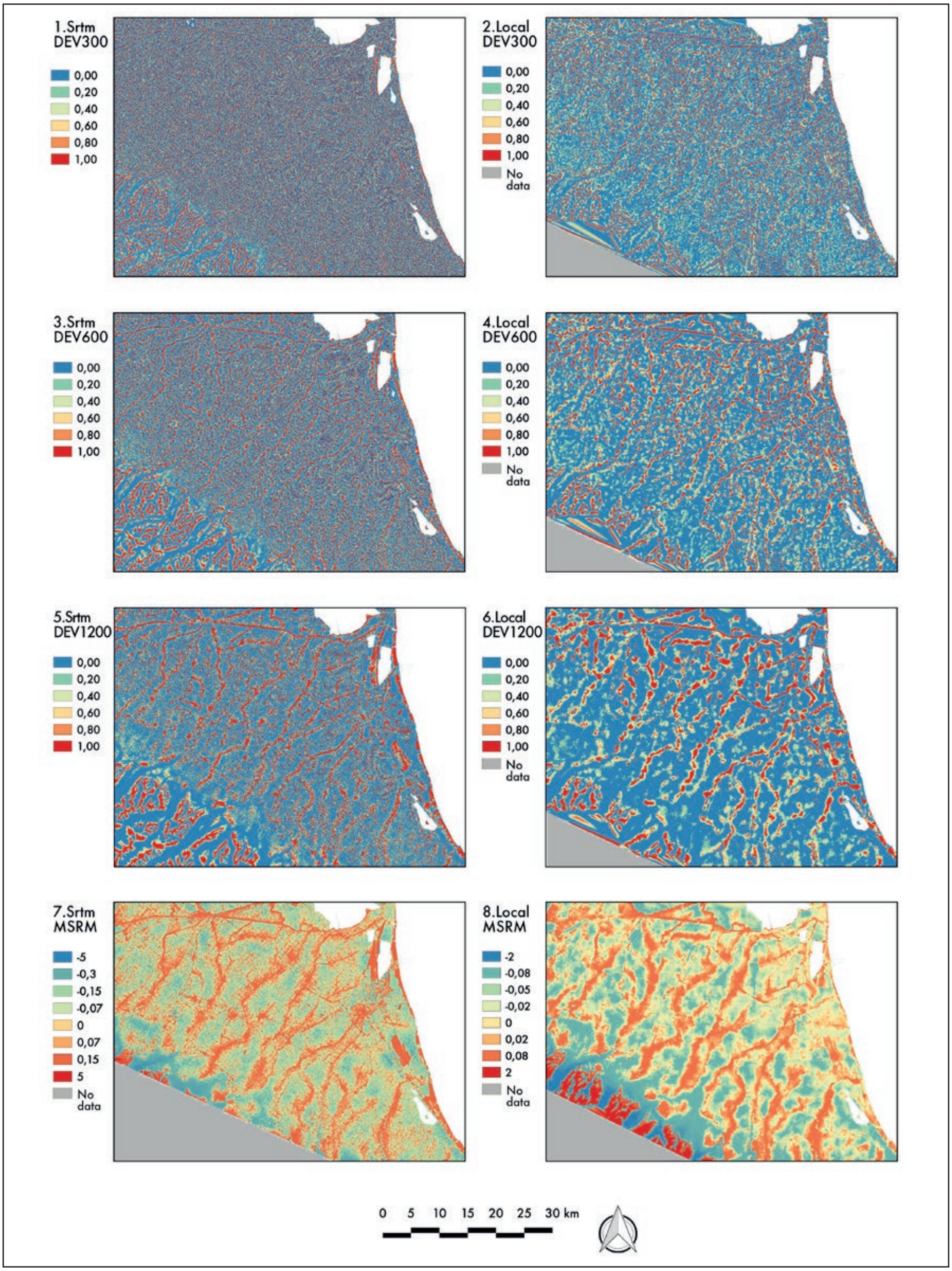

Fig. 3 – Elaborations of DEV (nos. 1-6) at 300 m (DEV300), 600 m (DEV600), and 1200 m (DEV1200) and MSRM (nos. 7-8) for both SRTM (left) and Local DEMs (right).

while the f_{max} was set to at least 5000 m, to include also large rivers, and possibly palaeochannels. Here, we present the two most significant results of the application of the MSRM algorithm applied to the SRTM DEM with the settings f_{min} 31, f_{max} 6000, rr 31m, and to the Local DEM using the settings f_{min} 12, f_{max} 5000, rr 12 m (Fig. 3, 7-8).

4.5 *Geoarchaeological methods*

To evaluate the meaningfulness of the results produced, two specific areas have been chosen for targeted research (Fig. 1, A-B), mostly relying on a desktop-based analysis of freely available aerial and satellite images[7]. The aim was to confirm if these landforms were indeed created by rivers, considering that their traces are often recognizable as crop and soil marks in the agricultural fields. Furthermore, due to the lack of pre-existing historical and archaeological data, targeted fieldwork was required for one of the two areas (Fig. 1, A). We specifically focused around Cavassona (Imola, BO) where several crop and soil marks were identified, likely to be interpreted as a moated settlement. The method used was a non-systematic artefact survey, walking at 1 m distance between surveyors and recording the finds with a manual GPS.

5. Comparing different morphometric methods

Among the four methods used, the TWI analysis gave back the poorest results (Fig. 2, 1-2), not being able to show realistic fluvial ridges within the study area. Comparing the SRTM and Local TWIs, the increased resolution of the latter assured a better result. This is not surprising since this method has been often applied to LiDAR-derived DEMs which have even a finer resolution (Citter, Patacchini 2017).

Regarding the DEVs, since they are computed including the TPIs, the respective results are quite comparable, with just minor differences (Fig. 2, 3-8; Fig. 3, 1-6). Both methods managed to highlight tens of possible fluvial landforms in the hinterland and beach ridges near the coast, proving to be suitable for geomorphological analysis also in areas with low variability like the Romagna plain. In particular, DEV is more capable to differentiate minor changes within a single landform. This is very clear in the southern parts, where the edges of the Appennine are more characterized and this could turn out to be very useful for further analyses, like to model human settlement choices in hilly areas. Another necessary remark regards the benefits of using

[7] Ministero dell'Ambiente e della Tutela del Territorio e del Mare or MATTM (1988, 1994, 2000, 2006, 2012); Agenzia per le Erogazioni in Agricoltura or AGEA (2008, 2011); Consorzio Telerilevamento Agricoltura or TeA (2014, 2017); Microsoft Bing (2018-2019); Google Earth 2003-2020; Esri satellite 2017-2018.

the Local DEM at a finer resolution, which assured good results even using the minimum radius. On the other hand, landforms start to be recognizable for SRTM elaborations only from a radius of 300-600 m.

The last results to be discussed derive from the application of the novel MSRM algorithm (Fig. 3, 7-8), which proved to be very successful in showing up both fluvial ridges and palaeodunes. Also in this case, the result produced from the processing of the Local DEM is clearer than the one obtained using the SRTM. Additional limitations of the latter are the presence of small linear features within the depressed areas, likely connected to artificial streets and channels, and higher values for urbanized areas such as small towns. On the other hand, the SRTM MSRM shows better the ancient coastlines northern and southern of Ravenna, but this is likely due to the existing pinewoods, which were not completely filtered out in the original DEM.

In our opinion, the best result in terms of readability was given by the Local MSRM (Fig. 3, 8), since it creates large continuous landforms that can facilitate their interpretation. Indeed, the MSRM algorithm seems more effective in homogeneous landscapes, like our study area, while showing more limits in more heterogeneous ones (Orengo, Petrie 2018). However, all these comparisons show how the results are very dependable on the starting DEMs, the methods used and their settings, clearly indicating the need for verification.

6. Assessing the results through targeted geoarchaeological research

Based on the results of the Local MSRM (Fig. 3, 8), we chose two smaller study areas for targeted research. The first is located NW of the city of Imola and western of the Santerno river (Fig. 1, A; section 6.1), while the second is located NW of the city of Forlì and eastern of the river Ronco (Fig. 1, B; section 6.2). For these two areas, previous studies had left a series of open questions that our researches have helped to answer.

6.1 *A pre-historical course of the Santerno river*

In the plain NE of Imola, the MSRM algorithm clearly shows a possible fluvial ridge departing from the actual course of the river Santerno around San Prospero (Fig. 1, A; Fig. 4). This ridge crosses the plain moving northwards and can be followed with confidence for 5 km, up to Fluno, where a ridge created by the Sillaro makes the interpretation more difficult. The existence of this older ridge of the Santerno has been recently hypothesized also by S. Marabini and G.B. Vai (2020, 60, 68-69) based only on differences in elevation nearby Chiusura. Available archaeological data could suggest a Bronze Age date for this ridge (CRA-CI, nos. 133 and 248) or even a Neolithic one (CRA-CI, no. 155.), but more data are necessary.

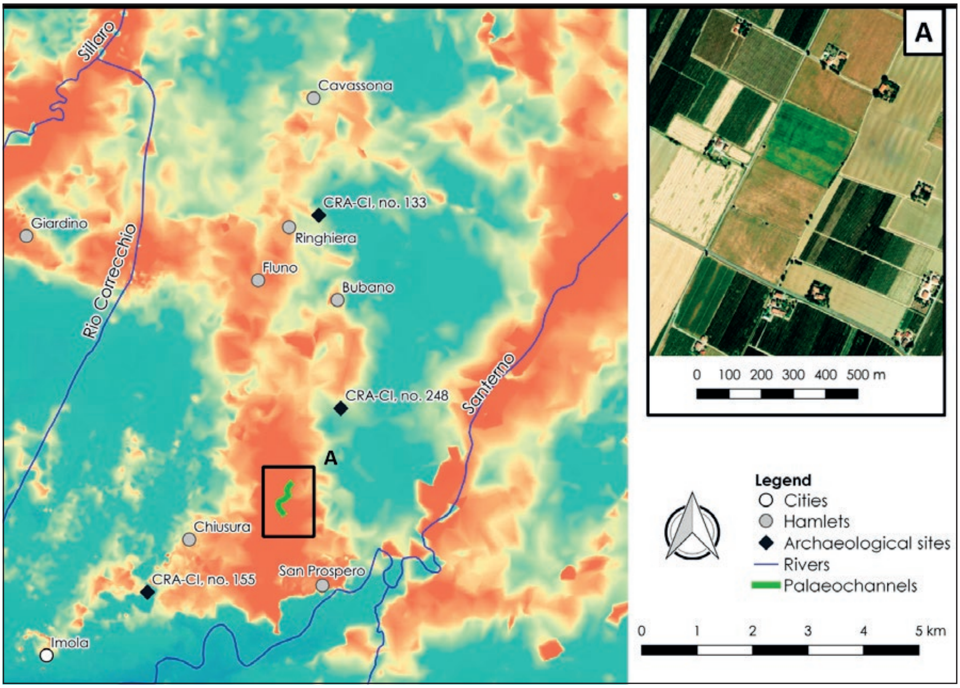

Fig. 4 – Santerno case study: MSRM result with palaeochannel (A).

The first proof that we present in favour of this hypothesis is the possible palaeochannel that could have created this ridge, considering that this evidence lies within the landform highlighted by the MSRM algorithm (Fig. 4, A). Indeed, a large crop mark has been identified in an Esri satellite image from August 2017. This measures between 35-50 m and has a sinuous shape, and it could testify the existence of an older meandric channel of the Santerno river, W of its present course.

The second set of evidence instead had been collected further N, around Cavassona. Here, G. Chouquer (2015, 134-135) already identified several crop marks visible in a Google satellite image from 2003. The main feature is represented by a large rectangular shape (Fig. 5, A), measuring around 85×50 m, which is interpretable as a nucleated settlement of around 0,4 ha. Visible in many other images, this feature is always characterized by a darker colour compared to the rest of the field, as result of a higher content of organic matter in the soil due to human activities. Another important crop mark is instead a possible defensive feature circa 8 m wide, interpretable as an embankment, levelled by now (Fig. 5, B). From the same image, two ditches seem to be

Fig. 5 – Moated site in Cavassona (from Chouquer 2015, 134-135): images modified to highlight the main features (A-D).

present on both sides of the embankment, making this structure c. 18 m wide in total. This element surrounds almost half of the possible settlement, towards the northern side. Prior literature was silent about this possible site, mentioning only "Roman" bricks discovered in the 19th century (CRA-CI, no. 355). A targeted artefact survey carried out in September 2020 has made it possible to document an important medieval settlement likely abandoned around the 12th/13th centuries CE, with the finds mostly concentrated within the rectangular feature (Abballe, under review)[8].

However, in this paper we want to focus on a small number of "residual" finds that could testify the occupation of the site also in protohistoric times. Some flints were indeed recorded together with sherds of impasto and grey pottery (Fig. 6) that could be related to an earlier occupation of the area, dating at least to the Early Bronze Age. Post-depositional processes could have played a role in the discovery of such old finds, although another possible explanation could be the presence of a ridge. Indeed, the site is located along the continuation of the landform highlighted by the MSRM algorithm and, in the 2003 satellite image, a possible palaeochannel around 20 m wide can be seen just flowing eastern of the modern building (Fig. 5, C).

The discovery of so old traces of human occupation questions the current view of this area being poor of archaeological data as the result of intense alluvial sedimentation occurred during the last millennia. Indeed, these findings

[8] The authorisation for the fieldwork was granted by the Soprintendenza Archeologia, Belle Arti e Paesaggio per la città metropolitana di Bologna e le province di Modena, Reggio Emilia e Ferrara (no. 14787-A).

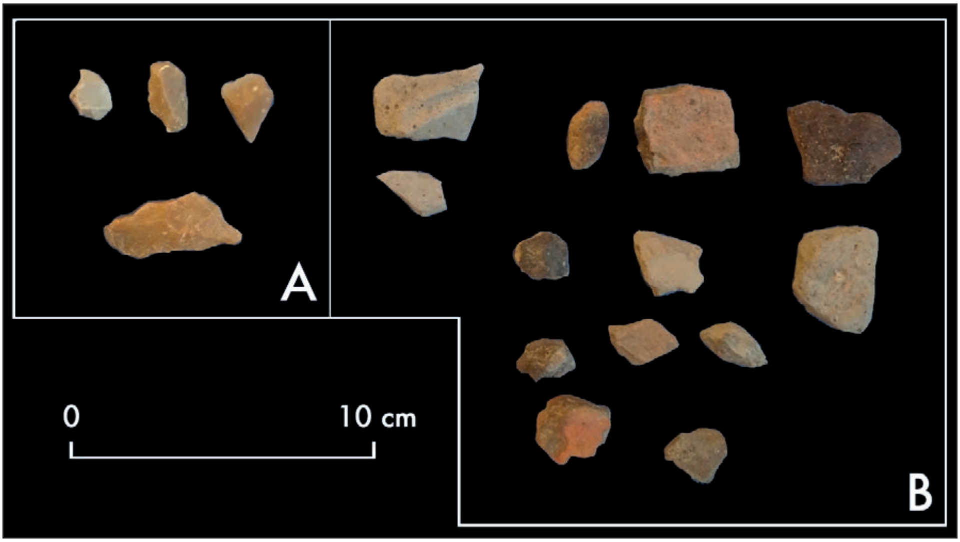

Fig. 6 – Protohistoric finds from Cavassona: a) flint and b) pottery.

open new questions as well as the presence of a possible smaller channel (Fig. 5, D), which seems to connect the palaeochannel of Cavassona to the external ditch of the embankment. Clearly, only further investigations would prove if the ditch-and-embankment feature is older than the medieval site identified through artefact survey or if the palaeochannel deactivated only in the Late Middle Ages or later.

6.2 *The evolution of the Ronco river*

The second area chosen for verification analysis is located at the border between Forlì and Ravenna (Fig. 1, B). The main river of the area is the Ronco, which changed course around the beginning of the 12th century, after leaving the preexisting one between Carpinello-Castellaccio-Massa-San Pietro in Vincoli (Veggiani 1980; Bottazzi 1993). The precise chronology of the latter and possible previous courses have not been identified (Abballe 2021).

Analysing the result of the MSRM algorithm, two different landforms can be recognized E of the present course of the river Ronco and N of the town of Forlimpopoli (Fig. 7). Several crop and soil marks were identified systematically analyzing all aerial and satellite images, to confirm the fluvial origin of these possible ridges. Thanks to the identification of various palaeochannels, we can at least recognize two meandering courses that fit within the two ridges highlighted by the algorithm: an eastern one (Fig. 7, A-C) and a western one (Fig. 7, D-F).

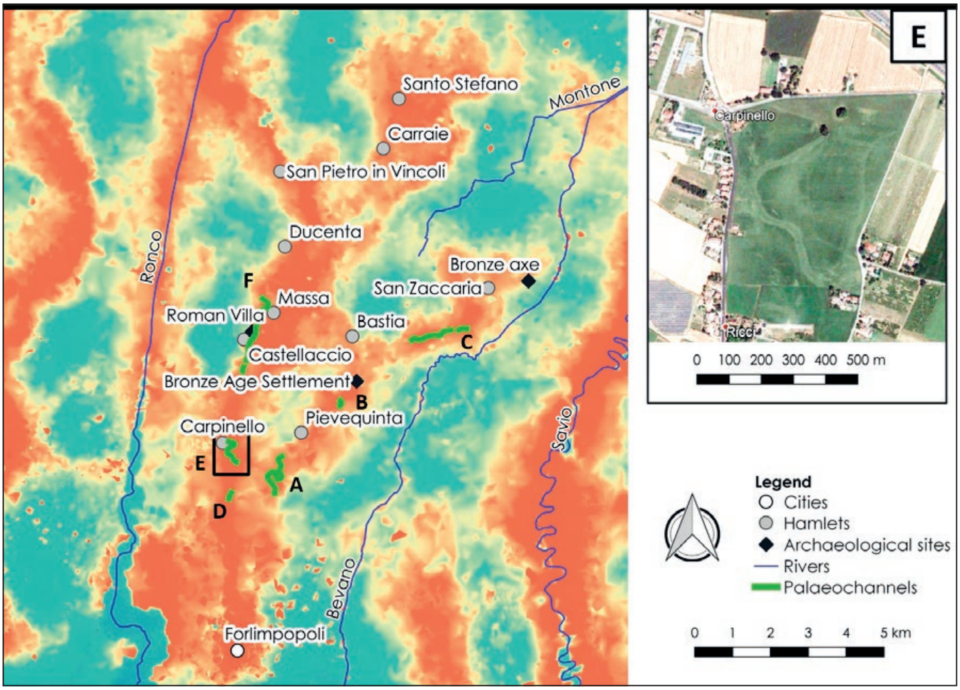

Fig. 7 – Ronco case study: MSRM result visualization with palaeochannels (A-F).

In particular for the eastern one, the oldest archaeological evidence available in the area date to the Bronze Age. The first finding is a single bronze axe with median wings discovered near San Zaccaria, Ravenna (Bermond Montanari, 1990, 36). A more consistent discovery comes from the excavation in 1984 of the Canale Emiliano Romagnolo (CER) in via Petrosa, Bastia, Ravenna (Bermond Montanari 1990, 36). Although the stratigraphy was heavily destroyed by later agricultural activities, the richness in finds of some preserved archaeological layers allowed the interpretation of this site as a Bronze Age settlement. During the analysis of aerial/satellite data, we discovered large crop marks visible in Google Earth on the 8th of July 2017, located between via Petrosa and via Acquara Superiore, Ravenna (Fig. 8).

Although no fieldwork has been carried out yet to confirm the nature of these marks, these are likely connected to the Bronze Age settlement discovered in the 80s in Bastia. The main features recognized are two palaeochannels, ca. 20 m wide (Figs. 8, A and 8, B) that seem to define a square area of about 10 ha. The western palaeochannel is associated with a likely palaeomeander (Fig. 8, C), which attests to the antiquity and stability of this watercourse. If

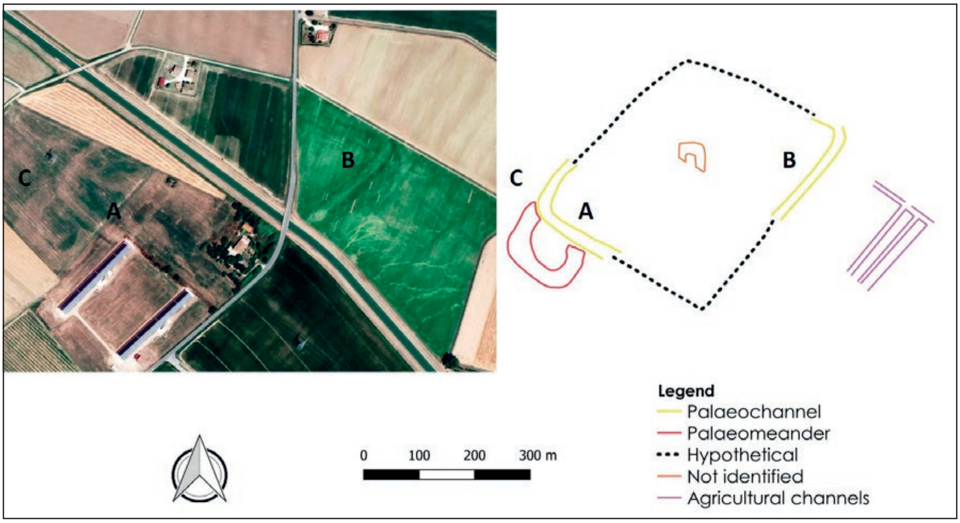

Fig. 8 – Crop marks visible around a Bronze Age village in Bastia, likely interpretable as contemporary fluvial traces (A-C).

this is true, the eastern paleochannel may have been excavated to surround the village (Fig. 8, B). Settlements bordered on all sides by a combination of natural and artificial channels are quite common in Emilia for this period within the Terramare culture (e.g. Terramara of Santa Rosa di Poviglio (RE), Cremaschi *et al.* 2005; Terramara of Podere Pradella (MO), Cattani 2009). However, no comparable sites were surely recognized in the Romagna plain, so further field research is definitely needed, including on this site. However, we believe that the data presented here are sufficient to link the formation of the Pievequinta-San Zaccaria ridge (or Paleodosso di Pievequinta-San Zaccaria) to the Bronze Age course of the river Ronco.

Later on, between the Bronze Age and the Roman period, the Ronco must have changed its course since a new ridge developed W of the previous one, between Carpinello and Ducenta. Indeed, the excavation of a Roman villa and adjacent necropolis in Castellaccio di Massa Forese, during the construction of the CER in 1984, seems to suggest the formation of this ridge at least before the 1st century BCE (Maioli 1990, 263-265; Montevecchi 2003, 107). Furthermore, western of this possible course, remnants of centuriation of the town of *Forum Livii* (Forlì) were already recognized (Bottazzi 1993), strengthening the dating of this ridge before the Roman period.

Northern of Ducenta, the MSRM algorithm shows a likely bifurcation: an eastern one towards Carraie-Santo Stefano and a western one towards San Pietro in Vincoli. The scarce archaeological data do not allow us to suggest

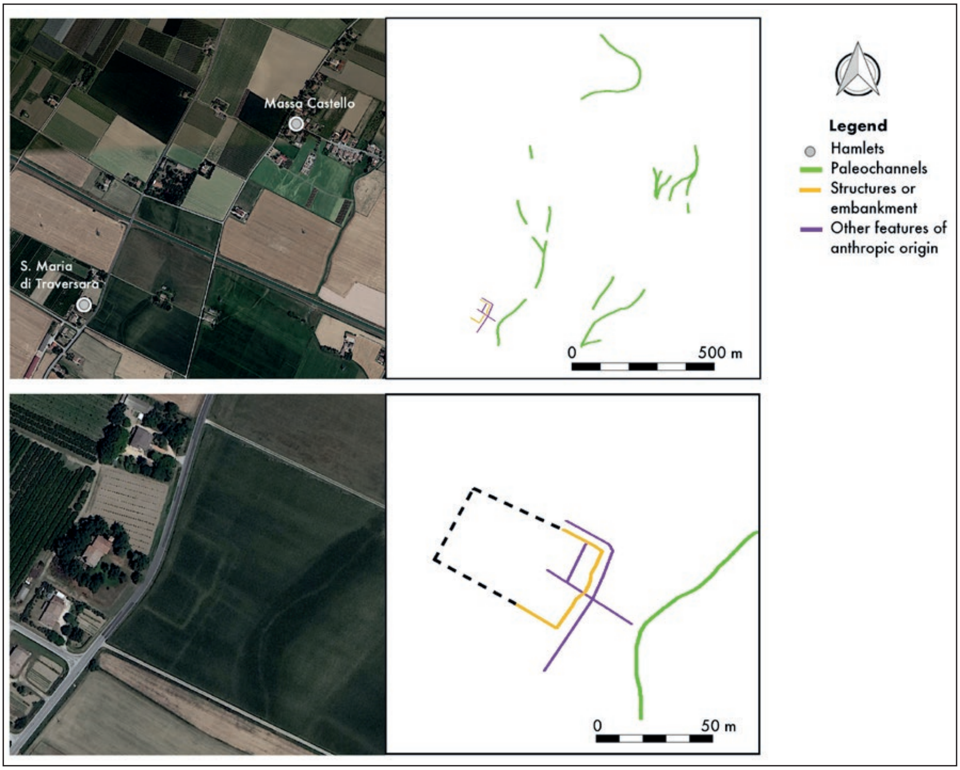

Fig. 9 – The archaeological site of Castellaccio di Massa: original and interpreted images.

which one could have formed before or later, so this is an area where future research should focus. In addition, here our analysis brought to light evidence of another possible archaeological site. Just in front of the Church of Santa Maria in Castellaccio (or in Traversara), a Google Earth image of the 8th of July 2017 shows the presence of several crop marks (Fig. 9), many referring to an ancient meandric course of the Ronco river, oriented N-S (Fig. 7, F). However, a rectangular trace between the church and the palaeochannel is more likely anthropic: it is ca. 3-4 m wide and measures 80×40 m in total. It seems to be related to a buried structure or an embankment. Other linear traces could also have an anthropic origin, probably roads or paths. This site has to be referred to the castle of Traversara, the main centre of the homonymous county since the 10th century, later destroyed in the 13th century (Vasina 1970, 117). Archaeologically, the site was never clearly identified (Augenti, Ficara, Ravaioli 2012, 174), but these evidences can be crucial to direct future research.

7. Conclusions

In conclusion, both TPI/DEV and the novel MSRM algorithm proved to be useful tools for the morphometric analysis of an alluvial landscape like the Romagna plain, while TWI showed limitations due to the resolution of the DEMs used. These could be potentially overcome using models with finer resolution, like LiDAR-derived DEMs, which are not available at the moment for the study area. At the same time, the comparison of sixteen different DEM-derived products showed how these results can be validated only with targeted (field) research. Firstly, this approach allowed us to map several palaeochannels likely responsible for the formation of the selected ridges, that can direct future investigations. Secondly, the analysis of existing archaeological data allowed us to propose possible chronological ranges to date these ridges. Thirdly, during this research new archaeological evidence has been identified that will be the object of future verification.

More in general, our work provides further evidence for the importance of geomorphology within geoarchaeological and landscape research, especially considering the strict relationship that ancient settlements had with the river network. Obviously, in floodplains like the Po Valley, changes in the topography have been quite significant during the last millennia and approaches that aim towards the modelling of palaeotopography are essential (for a review, Schmidt, Werther, Zielhofer 2018; an example for the study area is in Abballe 2020). Thankfully, this line of research has been growing more and more in the last decade, decisively contributing to a better comprehension of the evolution of alluvial landscapes and their historical phenomena.

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ABSTRACT

The Multi-Scale Relief Model (MSRM) is a novel algorithm developed for the visual interpretation of landforms. This was tested within the Romagna plain, the south-eastern part of the Po Valley (Italy), to establish whether it was able to detect fluvial ridges within this alluvial landscape. Since the MSRM is not the only method to carry out morphometric analysis, it was compared with other techniques previously used in landscape archaeology, such as the

Topographic Wetness Index (TWI), the Topographic Position Index (TPI), and the Deviation from mean Elevation (DEV). At the same time, the SRTM 1 Arc-Second Global was compared with a Local DEM based on ground control points. Subsequently, the result of the MSRM algorithm was tested through targeted desktop- and field-based research. This validation phase proved essential to test the accuracy of the DEM-derived products. Furthermore, it allowed us to verify the existence of the detected fluvial ridges, to propose a chronological range for some of them, and, finally, to collect new archaeological evidence.