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INVESTIGATING LOST MEDIEVAL VILLAGES USING SATELLITE AND AIRBORNE LASER SCANNING: THE CASE OF YRSUM IN BASILICATA (SOUTHERN ITALY)

1. Introduction

In this paper, we present the results obtained from our investigations carried out near the medieval village of Monte Irsi or Yrsum, located in the Basilicata Region (Southern Italy). These investigations were performed using historical documentation along with data from non invasive remote sensing technologies, such as satellite imagery, aerial photos and LiDAR survey.

Literature references are available for Monte Irsi (Janora 1901) due to the rich presence of archaeological remains (Small 1976), but comprehensive studies focused on the transformation of the territory as well as systematic investigations focused on the medieval settlement have not yet been adequately addressed. For example, the question of the existence of a medieval settlement has been under debate among some archaeologists over the last decades, but nothing is yet known about the foundation, development and abandonment. Yrsum was located on a hilly plateau in the northeast of Basilicata (Fig. 1). Its strategic location, overlooking the confluence of two rivers, favoured a long and intensive human activity as testified by archaeological investigations performed in the last forty years (Cherry *et al.* 1971; Small 1976; Small *et al.* 1998).

As regards the Middle Ages, documentary sources mention the existence of Yrsum in the early decade of the 12th century. The site was identified for the first time in 1966 from an aerial image published by Dinu Adamesteanu in 1974 (Adamesteanu 1974). Yrsum achieved its maximum expansion in the 13th century with more than 500 inhabitants. It was deserted probably around the late 14th century, but very little is known about the reasons. Yrsum represents an emblematic study case of the phenomenon of the lost villages and hamlets which took place all over the Europe during the late Middle Ages, due to a variety of causes, such as economic slump, demographic decrease, plague, famine, wars, climate and environmental change (AA.VV. 1970; Driver 2008; Muir 2009).

In Basilicata the phenomenon was also linked to the general economic and political situations as well as to other specific factors, such as environmental degradation and military devastations. For example, the abandonment of the Vitalba Valley – between the towns of Avigliano and Melfi – was due to a political choice of the Angevin government which in 1330 encouraged the inhabitants to abandon their homes and hamlets to found the new town of

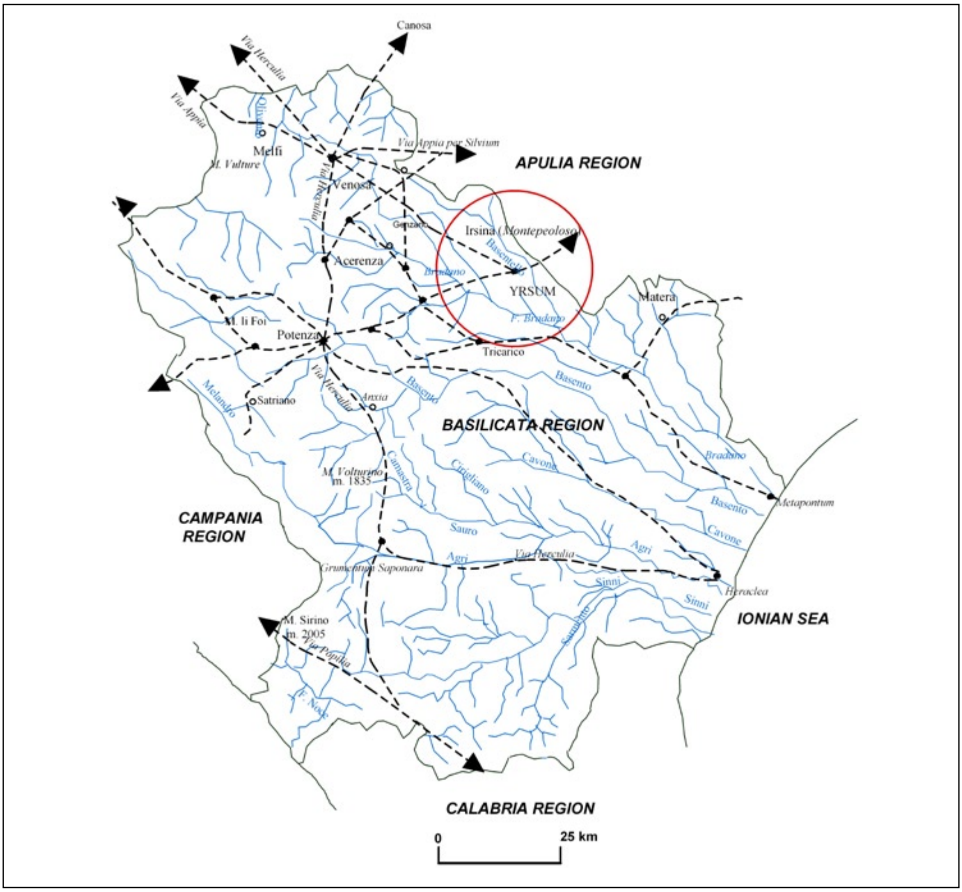

Fig. 1 – Study area location.

Atella (Masini 1996). Landslide events caused the desertification of *Ugianum* whose population moved to the new town of Ferrandina (Province of Matera) in the 15th century. Lastly, different concurrent causes, such the bubonic plague in 1413, looting and destruction by soldiers of Queen Giovanna II around 1430, as well as a devastating earthquake in 1456, caused the abandonment of the ancient *Satrianum* in the second half of the 15th century (Masini, Pellettieri, Potenza 1998).

As regards Yrsum, in order to cast new light on its history, from the early settlement to its abandonment, systematic investigations, based on the use of Earth Observation (EO) techniques (Lasaponara, Masini 2006; 2007a), have been carried out by the same group of Authors of this paper since 2005.

The scientific literature of the last ten years shows that space and airborne remote sensing based on active and passive sensors can be fruitfully applied in archaeology to investigate larger areas, to obtain accurate quantitative information on ancient landscape and to detect archaeological features in a more rapid manner compared to traditional survey techniques[1]. The currently available satellite sensors such as IKONOS (1999), QuickBird (2001) WorldView-1 (2007), GeoEye-1 (2008), and WorldView-2 (October 2009) offer images with a spatial resolution comparable to those from aerial photos. This has extended the use of EO from landscape investigations to the detection of archaeological sites and buried structures. More recently, some studies have examined the possibility of using LiDAR Airborne Laser Scanning (ALS) for archaeological investigations to detect and map earthworks which may be indistinguishable on the ground, to penetrate vegetation canopies and identify archaeological features even under dense vegetation cover (Devereux *et al.* 2005; Doneus *et al.* 2008.).

With regard to Yrsum, the analysis based on remote sensing carried out from 2005 and 2007, using satellite QuickBird imagery, allowed us to identify archaeological crop marks and micro-relief, on the basis of which we roughly depicted the medieval urban fabric (Lasaponara, Masini 2006; 2007a) and identified geomorphological features. Many other questions should be addressed and answered. Among them, the most stimulating and fascinating are the follows:

– Is the castle the oldest nucleus of the medieval settlement?
– Were there several phases of "urban" expansion?
– What about the medieval landscape and the relationships between the site and its landscape?

To answer these questions, we need to collect additional information, as the following:

– a detailed reconstruction of the medieval urban fabric;
– a digital terrain model (DTM) which should enable us to discriminate natural and man-made features, to distinguish micro-relief linked to geomorphology from those linked to shallow archaeological structures;
– the identification of archaeological features linked to man-made transformation of the territory from a site level up to a landscape perspective.

[1] For the knowledge of methods, technologies and fields of application of remote sensing for archaeological research and the cultural resources management, see De Laet, Paulissen, Waelkens 2007; Lasaponara, Masini 2007b; Trier, Larsen, Solberg 2008. See also the Proceedings of the 2nd International Conference on Remote Sensing in Archaeology (Campana, Forte 2006); the Proceedings of 1st International EARSeL Workshop on Remote Sensing for Archaeology and Cultural Heritage Management (Lasaponara, Masini 2008); Parcak 2009 and the Special Issue n. 10S of «Journal of Cultural Heritage» (Lasaponara, Masini 2009b).

In order to address the above-said questions and collect additional information, an ASL was carried out. Archaeological remains were further investigated by aerial LiDAR based to capture micro-topographic relief variations unseen from the optical data set. The detailed DTM obtained from the LiDAR survey allowed the identification of small relief produced by surface and shallow archaeological remains and, in turn, the detailed reconstruction of the urban fabric. Historical documentation and maps have been used as a source for information about past landscape.

Starting from the studies carried out by using satellite imagery dataset, this research, based on the careful analysis of archaeological records, historical documentation and LiDAR data, enabled us to enrich and improve our results obtained from previous investigations. In particular, the ASL survey provided: a detailed characterization and interpretation of earthworks related to the medieval urban fabric, the identification of micro-relief related to landslide phenomena, and the detection of cultural earthworks hidden by wooded areas, with dense canopy and understory.

2. Study area

2.1 *Geographical and geological setting*

Monte Irsi is a hilly plateau, near the confluence of the Bradano and Basentello rivers, in the territory of the Irsina municipality. From the geological point of view, it is located in the Bradanic Foredeep (or Bradanic Trough), a wide depression between the southern Apennines to the west and the Apulian foreland to the east. From a geodynamic point of view, the origin of the Bradanic Trough is to be found in the deformation sustained by Apulia and caused by the elastic bending of the lithosphere (Royden, Patacca, Scandone 1987). The protraction of the tectonic processes led to the enlargement of the depression and the start of a Quaternary sedimentation, characterized by a high depositional rate (Doglioni 1993). These deposits, made-up of clays, sands and conglomerates, cover up the allochthonous thrust front of the Apennines.

From the hill of Irsi it is possible to overlook a wide landscape characterized by three strategic roads: the first road follows the Bradano river in northeastern direction and it ends at the Ionian coast; the second road crosses in northwestern direction valleys and apparently flat grounds up to the slopes of Lucanian Apennines; finally, the third road axis connects Monte Irsi to Venosa up to the Tavoliere (in the Apulia Region).

2.2 *Historical context*

The strategic location of Yrsum favoured a long and intense human activity from the Paleolithic to the Middle Ages, as testified by the several archaeological findings unearthed during the excavation campaigns and field work carried out by Cherry and Whitehouse (Cherry *et al.* 1971) and Alaistair Small (Small 1976) since 1970.

The archaeological records put in evidence an important human activity in the Late Iron Age (6th-4th century B.C.), when the hill was probably settled (Small *et al.* 1998), in the late hellenistic period (in particular dark ceramics were found: Small *et al.* 1998, 345) and in the imperial Roman Age (Small 1976) with some traces still present in the Roman villa unearthed by Small, near the Church of S. Maria d'Irsi (Tataranno 2007).

As regards the historical studies, according to tradition there was a Byzantine settlement which was destroyed by the Saracens in 988 (Janora 1901, 1-2). Nevertheless, there is no evidence or reliable historical sources about this Byzantine settlement (Lasaponara, Masini 2007a), except a treasure of coins, dated back to the 9th-10th century, which was found in the surrounding of the hill (Siciliano 1984).

During the Middle Ages important fights took place on the Bradano river close to Yrsum. One of the most important fights, the "Battle of Montepeloso" fought in 1041, represented the start of the Norman supremacy over the Byzantine empire.

The first documentary source available for Yrsum dates back to the 12th century. It is the bull of Pope Callisto, issued in 1123, which refers to a settlement, named *castrum Ursum* belonging to the diocese of Montepeloso (today Irsina). In 1133 after the famous siege of Montepeloso (Falconis Beneventani 1724, 151; Masini 2006) by King Roger II, *Castrum Ursum* (named also Yrsum in other documents), was given to the Benedectine Priorate of S. Maria dello Juso (Panarelli 2007a).

The historical documents also inform us about the *feudus* of Irsi which was quite wide and important. In fact, as reported by *Catalogus Baronum*[2], it contributed to the royal army with a significant number of knights and soldiers, around 10 and 50, respectively (the near *feudus* of Montepeloso contributed with only 5 knights, whereas the important episcopate of Tricarico contributed with 20 knights and 50 soldiers).

The first information on the demographic consistency and the urban fabric features is dated back to the Angevin Age (13th-14th century). The census of the year 1277 recorded 114 families, corresponding to around 700-900 inhabitants, a significant population compared to the surrounding villages[3].

[2] *Catalogus Baronum* (Catalogue of Barons) is an early 12th century record, a list of all the Barons in the southern regions of the Italian Peninsula. In the Catalogue information related to military service is included (Jamison 1972; Cuozzo 1984).

[3] 114 families is a small number if compared to 458 families assessed in the near town of Montepeloso, however it is significant if compared to the number of families in other near villages, such as Genzano, Banzi and Tolve, respectively equal to 54, 28 e 132 (Minieri Riccio 1877).

Fig. 2 – QuickBird panchromatic image of Monte Irsi. A and B indicate the investigated settlement and the artificial mound related to the documented castle (*Castrum Ursum*), respectively; C and D denote the church of S. Maria d'Irsi and the Roman villa, respectively.

At that time Yrsum was in decadence, as testified by the Prior of S. Maria dello Juso, who described the state of poverty of the people living in the village in a letter to the King dated 1272. The only information on the medieval urban fabric date back to 1288. A deed of sale for a house in Yrsum refers to the presence of a church, two houses and a *platea puplica* (public square) (Lasaponara, Masini 2007a). This document offers a sketch of the centre of the urban fabric. Unfortunately, no documented information about the presence of a monastery is available. It may have been in the structures of the partially conserved baroque church (Tataranno 2007), located at 200 m on the southeast side of the urban perimeter (see C in Fig. 2).

At the end of the 13th century, the decadence of Yrsum was increasing so that, in 1294, it obtained an exemption from the tax payment from the King (Janora 1901, 158-159). The tax exemption did not free the village from poverty, as testified by the 1320 census which recorded a decrease of population[4].

[4] Respect to the 1277 Census, a decrease of 12 families in 1320 was recorded (Minieri Riccio 1877, 177-180).

The narration of historical events shows a close link between Yrsum and the near town of Montepeloso and the Benedectine Priorate of S. Maria dello Juso. In fact, after the dramatic siege of Montepeloso in 1133, Yrsum became a property of the "extramoenia" monastery of S. Maria dello Juso. Lastly, between 1370 and 1376, the people of Montepeloso, with the moral support of the Duke of Andria, Francesco del Balzo, first looted the monastery, then devastated all its properties, among which the territory and the village of Yrsum (Panarelli 2007a). Such devastations marked the end of Yrsum, which is thought to have been abandoned not long afterwards.

3. Satellite based investigation

3.1 *Preliminary field survey*

A field survey was carried out in August 2004, approximately a month after the acquisition of the satellite image. At the North side of the investigated area, the survey put in evidence the presence of a mound enclosed by a ditch (Fig. 2, B). The mound, partially artificial, is linked to the castle (*Castrum Ursum*) which the document refers to (§ 2.2). Inside the ditched enclosure, half meter walls and foundations appear on the surface, between dry grass, heap of stones and fragments of tiles and earthenware. In the southern sector (Fig. 2, A), micro-relief are visible out of the ditch.

The complex geomorphology of this area along with the presence of erosive phenomena make the discrimination of archaeological relief from geomorphological features very difficult, with the exception of a few earthworks along the western border of A2, where fragments of tiles and heaps of stones have been found.

3.2 *Satellite data analysis: methodological approach and results*

The Satellite images used for this study were acquired by QuickBird (QB) sensor in July 2004. QB offers panchromatic and multispectral imagery; with spatial resolutions of around 0,62 m, and of 2,48 m, respectively. The panchromatic sensor has a bandwidth ranging from 450 e to 900 nm. The multispectral sensor acquires data in four spectral bands from blue to near infrared (NIR)[5] band.

Fig. 2 shows the satellite panchromatic image of the investigated area. It displays the medieval settlement (A), the artificial mound (B) related to the documented castle, the church (C), which is the only preserved building, and the Roman villa (D).

[5] Both panchromatic and multispectral sensors provide data using 11 bit (2048 grey levels) resolution.

The multispectral QB imagery was processed with the aim of emphasizing features caused by archaeological deposits and detectable thanks to changes in soil moisture content, soil variations and difference in the height and/or colour of vegetation. Such features are commonly known as damp, soil and crop marks, respectively (Dassie 1978; Wilson 1982; Piccarreta, Ceraudo 2000; De Laet, Paulissen, Waelkens 2007; Lasaponara, Masini 2007b; Trier, Larsen, Solberg 2008). Other marks which typically characterize earthworks or shallow structures (as in the case of Yrsum) are the shadow marks. They can be seen in the presence of micro-topographic relief that can be visible by shadowing in low sunlight angle conditions during early morning or late afternoon.

The methodological approach (Lasaponara, Masini 2007a), adopted for the enhancement and extraction of archaeological marks, has been based on the use of data fusion (or pan-sharpening)[6] and edge detection algorithms[7] in order to exploit the high spatial resolution of satellite QB panchromatic image and the multispectral properties of the four spectral channels.

The presence of vegetation covering the micro-relief suggested us to compute vegetation indices that are spectral combinations of different bands. Such indices are quantitative measures, based on vegetation spectral properties, that attempt to measure biomass or vegetative vigour. Vegetation indices are mainly derived from reflectance data from the red and Near-Infrared (NIR) bands. They operate by contrasting intense chlorophyll pigment absorption in the red against the high reflectance of leaf mesophyll in the near infrared. For the Yrsum investigation, among the diverse available vegetation indices, we used the Normalized Difference Vegetation index obtained by using the following formula:

$$NDVI = [NIR-Red]/ [NIR+Red]$$

The reconnaissance of marks linked to buried structures was performed by analyzing the results obtained from the edge detection algorithm applied to panchromatic, pansharpened multispectral band (blue, green, red and NIR) and NDVI map (Figs. 3a-b, 4, 5). The results from single channel processing showed only a small number of features visible from blue, green and red channels (Fig. 3b). Whereas, panchromatic image (Fig. 3a) and the NIR data

[6] Pan-sharpening is a branch of data fusion that is receiving an ever increasing attention from the remote sensing community, since the availability of new-generation space-borne imaging sensors operating in a variety of ground scales and spectral bands provides huge volumes of data with complementary spatial and spectral resolutions. Thus, it is desirable to perform a spatial enhancement of the lower resolution multi-spectral data or, equivalently, to increase the spectral resolution of the data-set having a higher ground resolution, but a lower spectral resolution; as a limit case, constituted by a unique panchromatic image bearing no spectral information (Aiazzi *et al.* 2008).

[7] The edge detection was performed by applying a multiscale approach based on the scale-space theory (Lindeberg 1998) that uses Gaussian smoothing kernels. The selection of scale was performed by keeping in mind that, in our case, it was necessary to focus on structures having small sizes and signal amplitudes as expected in the case of surface anomalies due to buried walls, buildings and roads.

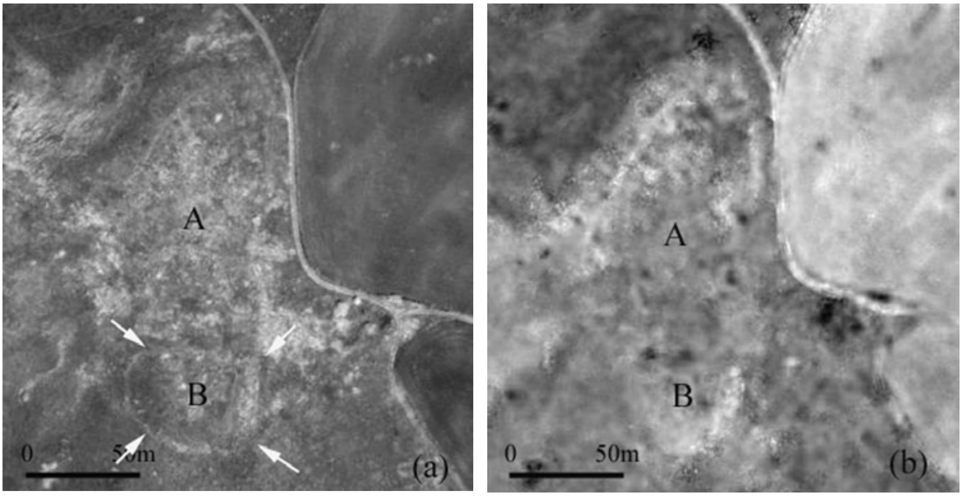

Fig. 3 – Investigated area. (a) QuickBird panchromatic image; (b) Red pansharpened band. A and B indicate the investigated settlement and the artificial mound related to the castle, respectively.

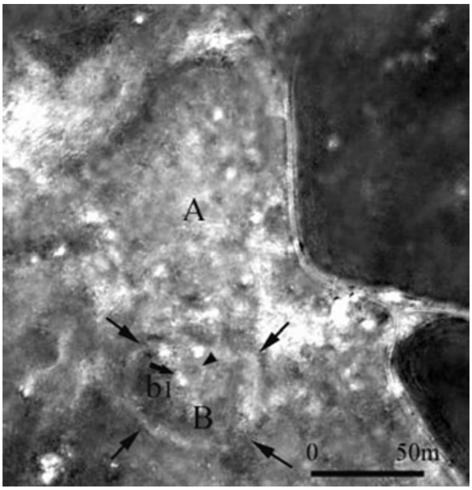

Fig. 4 – NIR pansharpened band. A ditched enclosure (B) and traces of surface walls of the castle (b1) are evident.

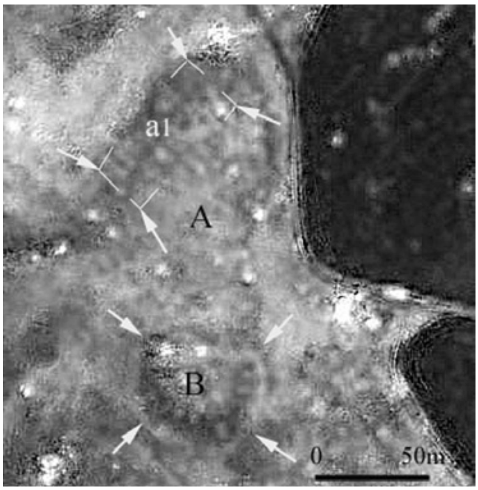

Fig. 5 – NDVI map which puts in evidence not only the defence system but also a urban sector (a1) sited along the western border of the hilly plateau.

fusion product (Fig. 4) provided better results, in particular in the ditched enclosure and in detecting surface walls of the castle (Fig. 4, b1). The best results are obtained from NDVI (Fig. 5), not only in the ditch (Fig. 4, B) but also in a sector along the western border (Fig. 5, a1) where rectilinear micro-relief related to shallow structures are visible. As a whole, these anomalies compose an urban fabric of 70×30 m oriented in SN-WN direction and bounded from the border of the western slope.

4. LiDAR based investigation

4.1 *Data and processing*

Airborne Laser Scanning (ALS) is an active remote sensing technique which provides direct range measurements between a laser scanner and the Earth's surface. These distance measurements are mapped into 3D point clouds.

There are two different types of ALS: conventional scanners based on discrete echo and full-waveform scanners. The conventional or discrete echo scanners detect a representative trigger signal for each laser beam, whereas the full-waveform (FW) laser scanning systems permit one to digitize the complete waveform of each backscattered pulse, thus offering improved capabilities especially in areas with dense vegetation cover and/or characterized by complex morphology as in the case of Monte Irsi.

The LiDAR survey of Monte Irsi was carried out by GEOCART s.r.l. on the 18th November 2008 using a full-waveform scanner, RIEGL LMS-Q560 on board a helicopter to obtain a higher spatial resolution.

The flight was operated with a share around 400 m, a speed 25.7 m/s, and an opening angle at 60°. The scanner acquired data in the direction SN-EW, with a divergence of the radius 0.5 mrad, and a pulse repetition rate at 180,000 Hz. The average point density value of the dataset was about 30 points/m2. The accuracy was 25 cm in xy and 10 cm in z (altitude).

The workflow for processing airborne laser data (LiDAR) was divided into five major steps:

– initial setup and data calibration;
– classifying points;
– processing images;
– validating positioning;
– creating delivery products.

The initial setup involved importing all the necessary raw data into the processing software, applying coordinate transformations and calibration, which is based on the comparison of the laser data produced by different flight passes which overlap each other.

For archaeological investigation, a high quality DTM has to be derived from the ALS data. This demands a detailed and reliable separation of on-terrain and off-terrain points while maintaining a high point density. The separation of terrain and off-terrain points is generally called classification, and can be obtained using the diverse laser measurements and information

(Lasaponara, Masini 2009b), such as: height; intensity; and echo width. Herein, we will focus on the elaboration performed using both height, obtained from the 3D point clouds, and ortophoto acquired at the same time as the ALS survey.

Due to its efficient data sampling capabilities, FW-LIDAR is capable of detecting microtopographic relief with an altimetrical resolution of <0,1m. To achieve this level of resolution, it is necessary to process the ALS point cloud using appropriate numerical filters. For this case study, the Gaussian Pulse Estimation algorithm was used as implemented in the commercial software TerraScan (Terrasolid: http://www.terrasolid.fi/).

TerraScan classification is based on a parametric approach and it develops according to an orderly sequence of stages decided by an operator. In this case study, the classification of laser data was performed using a strategy based on a set of "filtrations of the filtrate". Appropriate criteria for the classification and filtering were set to gradually refine the intermediate results. The workflow can be summarized as follows:

– low point classification;
– isolated points classification;
– ground classification;
– classification of points below surface;
– classification of points by class;
– classification of points by height from ground for different heights.

The data classification process starts by including all the point cloud in to a single class, called the default class, which becomes the reference for the next processing. The elimination of outlier points is performed through two classification algorithms: "low point" and "isolated points". The first finds single points or groups of points which are considered to be below the ground, whereas the second routine identifies isolated points such as points present in the air (for example, birds, etc.).

The next processing step uses the Axelsson TIN model (Axelsson 2000) in an attempt to define a "ground" surface. To accept or reject points as being representative of the "ground", it is necessary to define some geometric threshold values which prescribe possible deviations from the average topographic surface. For example maximum building size of largest buildings. The algorithm looks for the so-called "key points", i.e. the lowest point that will define a first ground surface made up of very large triangles. A triangle of the primary mesh is progressively densified by adding a new vertex to a point inside it.

The "classification of points below surface" allows the identification of points under the surface level, such as wells or similar. The latest two classifications identify and classify points according to a given class or heights, respectively. Finally, the DTM was created using TerraModeler on the basis of the classification of terrain and off-terrain objects performed.

4.2 *Results*

Beginning from the results obtained from satellite image data processing and interpretation, the DTM derived from LiDAR survey, allowed us: to improve the characterization of micro-topographic relief related to the shallow archaeological structures of the medieval settlement; and to identify features of geomorphological interest.

Fig. 6 shows in (a) the LiDAR DTM obtained after the classification of ground and off-ground points, in (b) the orthophoto taken at the same time as the LiDAR survey with a spatial resolution at 30 cm. The orthophoto mosaic of the study area shows the herbaceous cover, which was still present in November. Low vegetation generally limits the detection of micro-topographic relief; in our case, the accurate removal of this kind of vegetation enabled us to obtain an effective classification of ground points as visible in the DTM (Fig. 6a, and 6c).

Fig. 6c shows the 3D view of DTM. In order to emphasize micro-topographic relief, we used different illumination (hill shading) views and finally selected the most adequate values of azimuth and altitude of light direction, displayed in Figs. 6.

The hill-shaded DTM together with the profiles (Figs. 7-8) allowed us to reconstruct the urban fabric of Yrsum. The morphological interpretation of the micro-relief pattern puts in evidence four different sectors (A1, A2, A3 and B, shown in Fig. 7) not clearly visible by VHR satellite imagery (in particular, see the NDVI map in Fig. 5). Sectors A1, A2 and A3 are related to the urban fabric of the village. The most extended sector is A2 which shows a radiocentric pattern (see also Fig. 9) of features which develop on the top of the hill according to the altitude level curves. The high resolution (30 points/m^2) and accuracy (25 cm in xy and 10 cm in z) of DTM makes it possible to appreciate differences in height ranging from 40 to 90 cm which characterize the micro-relief in this sector (see profile y-y' in Fig. 8).

This allowed us to map the perimeter of single buildings (Fig. 9) and internal roads which define a urban shape characterized by alignments in the SE-NW direction. The total area is about 0,65 ha and includes around thirty buildings with an area ranging from 45 and 120 sqm. It is interesting to note the flat area (A2 in Fig. 9) of about 20×25 m characterized by the absence of micro-relief which suggest that it may be the *platea puplica* cited in the document issued in 1288 (Fig. 7).

The analysis of sector A1 must be joined with the near sector B, which is enclosed (Fig. 7) by a ditch (m 1) and preserves low walls already seen in the satellite scenes. It is related to the castle which was built on an artificial earthwork (motte) as was common during the Norman Age (11^{th}-12^{th} century) in Basilicata and Southern Italy (Masini 2006). Between the motte of the castle and the sector A1 we observe a different morphological pattern of micro-relief, indicated with letter A2 in Fig. 7. It is more regular respect to A1, and it seems to be the result of a distinct building phase. The altitude profile (see profile x-x' in Fig. 8) shows variations in height around 0,5 m. These variations clearly identify the external perimeter of the single buildings and even the internal divisions which were less visible from both the QuickBird image (Figs. 2-6) and the orthophoto mosaic (Fig. 6b). A mark (m2) divides the two sectors A1 and A2, each other. As a whole, sectors A2 and B are likely referable to a fortified typology common in the early Middle Ages, composed of a motte (B) linked to a lower enclosed courtyard, also known as a bailey.

The fourth sector (A3) is located on the west side of the castle. It is likely referable to a subsequent urban expansion of the village. The DTM puts clearly in evidence the presence of a landslide (Fig. 4) which is well visible in its typical components (crown, scarp and debris). It is an ancient landslide, which suggests to carry out additional investigations to understand its possible role in the abandonment of the village.

5. Conclusions

The phenomenon of lost villages in the late Middle Ages is a topic as complex as it is stimulating for historians and archaeologists. It puts a lot of questions regarding the causes of the abandonment. To answer these questions, systematic studies are required along with a detailed survey of the investigated areas in order to detect lost villages and to understand the relationships between sites and landscapes. In this context many problems arise, among them, for example, the detection and discrimination of anthropogenic and geomorphological features. This is quite a difficult task especially for complex areas and settlements built on the top of hills and mountains, as in the case of Yrsum.

In this paper, we approached a comprehensive study of Yrsum settlements based on the use of Earth Observation techniques. The integration of different Earth Observation techniques (aerial, VHS satellite imagery and airborne laser scanning) represents an invaluable data source to capture archaeological remains and traces of ancient landscapes which can enable us to cast new light on the urban history as well as on the relations between environmental transformation and human frequentation.

In Monte Irsi, field work, the study of historical sources, the processing and interpretation of VHR satellite imagery and DTM derived from Lidar survey, allowed us to reconstruct the urban shape of the village in its differ-

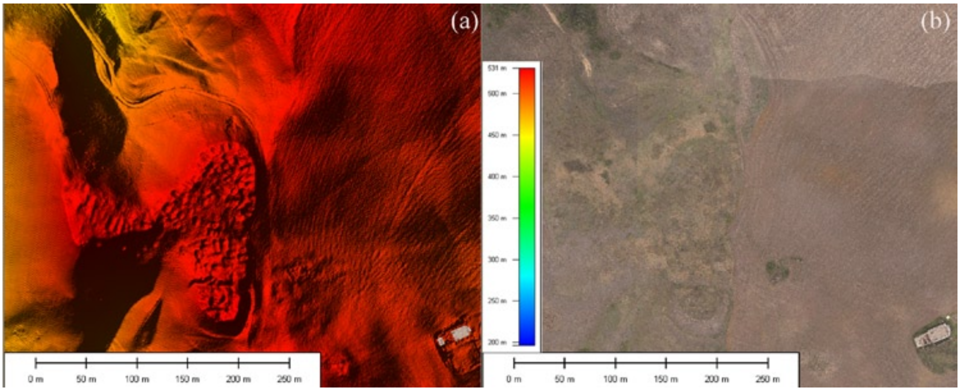

Fig. 6 – 3D view of DTM: a) DTM of the medieval settlements and surroundings, b) orthophoto acquired at the same time as LiDAR survey, c) zoom of medieval settlements.

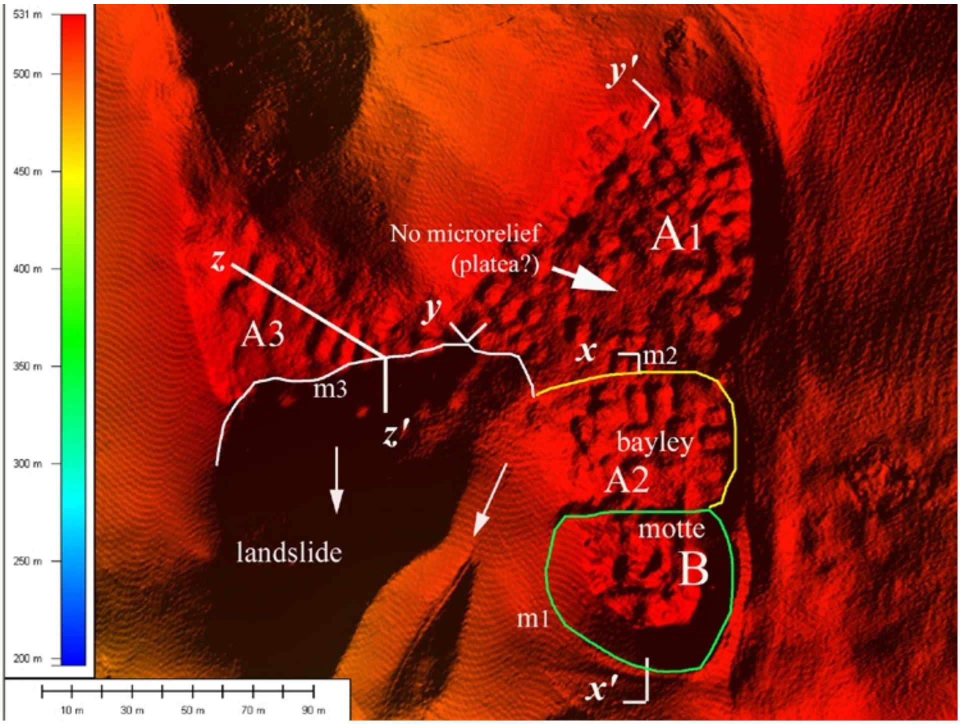

Fig. 7 – Interpretation of DTM for the medieval settlements.

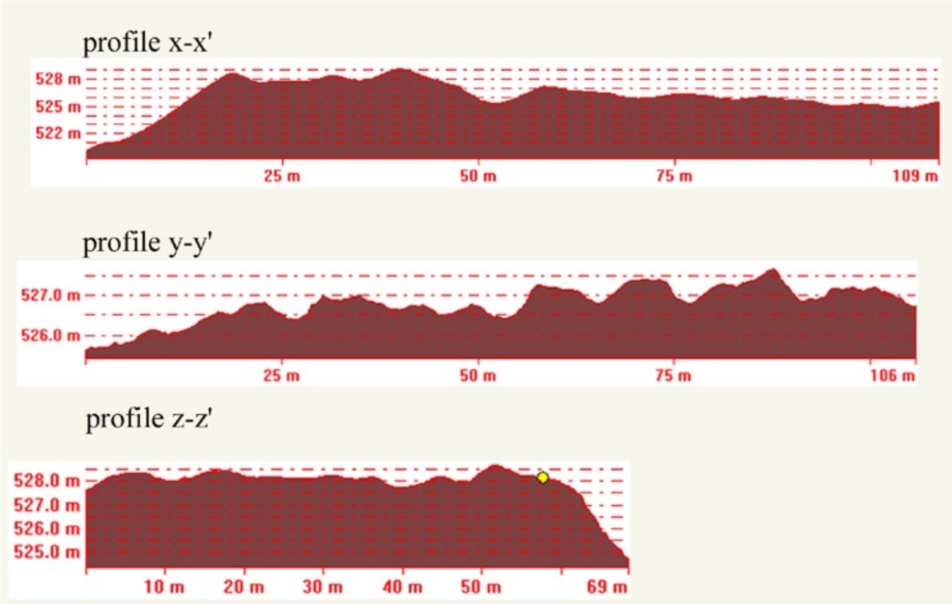

Fig. 8 – Altitude profiles for area indicated in Fig. 7.

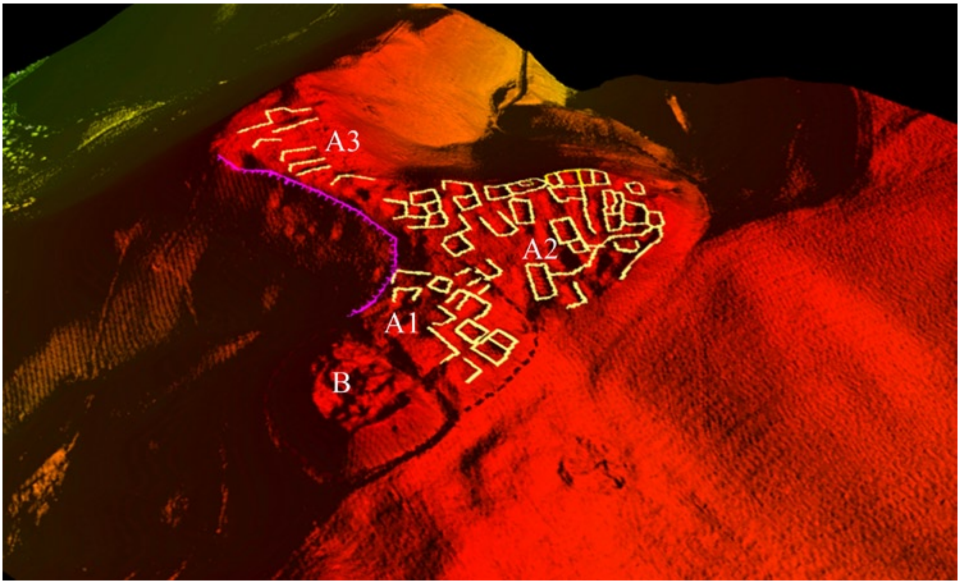

Fig. 9 – Detailed reconstruction of the urban fabric.

ent functional and spatial components as well as to identify features linked to a geomorphological pattern. This opens new investigation perspectives for both the assessment of hazard of the cultural site and the study of the factors which caused the abandonment of the emblematic study case of Yrsum.

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ABSTRACT

The phenomenon of lost villages in the late Middle Ages is a topic as complex as it is stimulating for historians and archaeologists. It raises many questions regarding the causes of the abandonment. To answer these questions, systematic studies are required along with detailed surveys of the investigated areas in order to detect the lost villages and to understand the relationships between sites and landscapes.

In this context many problems arise, among them, for example, the detection and identification of anthropogenic and geomorphological features. This is a difficult task, especially for complex areas and settlements built on the top of hills and mountains, as in the case of Yrsum, located in the Basilicata Region (Southern Italy).

In Yrsum, field work, the study of historical sources, the processing and interpretation of satellite imagery and DTM derived from Lidar survey, allowed us to reconstruct the urban shape of the village in its different functional and spatial components as well as to identify features linked to geomorphological pattern. This opens new investigation perspectives for both the assessment of endangerment of the cultural site and the study of the factors which caused the abandonment of this emblematic study case.