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Photogrammetric re-discovery of the hidden long-term landscapes of western Thessaly, central Greece

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This paper introduces a novel workflow for the reconstruction of nowadays disappeared cultural landscapes based on the extraction of morphological information from historic aerial photographs. This methodology has been applied for the first time for the detection, classification and characterisation of upstanding, flattened and buried archaeological sites and various off-site ancient landscape features in the plain of Karditsa, western Thessaly. Although Thessaly has been the focus of prehistoric, and especially Neolithic, research in Greece, since the beginning of the 20th century, western Thessaly has not received as much archaeological attention and its archaeological record remains rather scanty. Moreover, an extensive land reclamation project implemented in the western Thessalian plain during the early 1970s resulted in the flattening of habitation tells and funerary sites of all periods. Thus, recognition of archaeological sites and relict landscape features becomes extremely difficult, whereas standard landscape analysis and application of mainstream Remote Sensing (RS) techniques based on multispectral satellite images are problematic.

Digital photogrammetric reconstruction techniques and the subsequent GIS-based treatment of the results allowed overcoming these challenging limitations: the combined use of pre-1970s aerial pho-tographs with later imagery provided a powerful means to reconstruct the landscape before the land reclamation process, using a workflow designed to highlight photogrammetry-derived topographic differences and multi-temporal imagery analysis.

Hundreds of previously unknown mounded archaeological sites, as well as other ancient landscape traits such as roads, city grids and field systems were detected. More importantly, invaluable insights into the type and character of these archaeological features were gained, which would have been impossible to obtain by conventional RS techniques.

1. Introduction

The pioneering efforts of Tsountas (1908), Wace and Thompson (1912) and Mylonas (1928), and later seminal work by Miloj.cilc (1959), Theocharis (1967, 1973), Chourmouziadis (1971, 1979), Gallis (1992), Kotsakis (1983) and Halstead (1981, 1984) have brought Thessaly to the fore in Neolithic research in Greece (Andreou et al., 1996) and have set the agenda for new excavations, surface surveys, analysis of old excavation data and rigorous theoretical discourse.

Thessaly forms a closed geomorphological environment, bounded by mountain ranges and drained by the river Pineios and its tributaries. To the interior, Middle Pleistocene tectonism created two large basins, the Larissa to the east and the Karditsa-Trikala to the west (Higgins and Higgins, 1996) (Fig. 1). These basins were subsequently filled with alluvial deposits (Demitrack, 1986) and today they form the largest and among the most productive agricultural lands in Greece.

Archaeological and geomorphological research focused on eastern Thessaly, whereas western Thessaly received much less archaeological and palaeoenvironmental attention (see Andreou et al., 1996 for additional references). This is clearly demonstrated by the IGEAN (2015) Neolithic archaeological site inventory that reports 342 documented Neolithic tell-like sites, of

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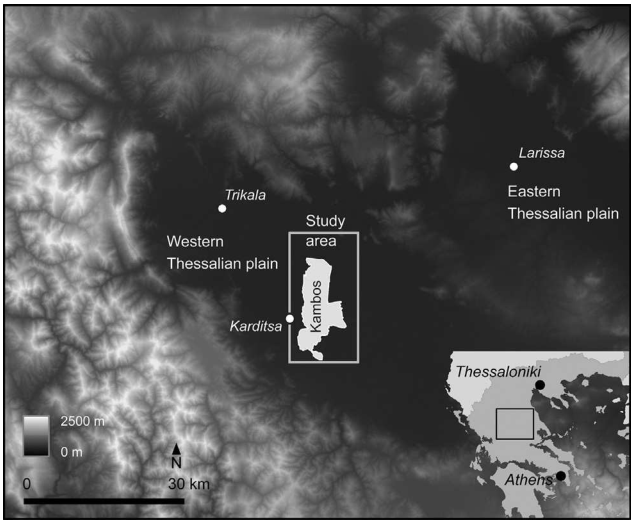

Fig. 1. Location of the study area.

which 288 are located in eastern and 55 in western Thessaly. It is often thought that the striking scarcity of prehistoric presence in Western Thessaly is due to the “hostile” physiography of the area (Andreou et al., 1996: 276). However, lack of intense surface surveys, geoarchaeological and palaeoenvironmental work and final publication of excavation and extensive archaeological reconnaissance results prevent any conclusive argument as to the intensity and character of prehistoric habitation, as well as the nature of land-scape and use of space through time.

In the heart of the Karditsa alluvial plain lies the former municipality (now municipal unit) of Kambos that occupies an area of 90 km^2 (Fig. 1). Between 1970 and 1972, rescue excavations were carried out by G. Chourmouziadis at three Neolithic sites (Prodromos I, II and III) (Chourmouziadis, 1971, 1972). Very few prehistoric and historical sites supplement the arguably poor and sketchy archaeological map of the Kambos area (e.g. Intzesiloglou, 1997, 2000, 2010; Nikolaou, 2004; Chatziaggelakis, 2007; Chatziaggelakis and Karagiannopoulos, 2012).

To further complicate this very tentative picture, a large-scale, centrally planned and executed project to reclaim land for intensive, mechanised, irrigated agriculture was implemented in the Karditsa plain during the early 1970s (from 1970 to 1972). As a result, the landscape was dramatically trans-formed (Krahtopoulou et al. in preparation) (Fig. 2): the flow of major rivers and smaller streams was modified to avoid seasonal flooding, wetlands were drained, an extensive network of irrigation canals was installed, old roads and fields were reshaped, new fields and road networks were created, the land was flattened and soil was locally shifted to fill topographic depressions. Moreover, mounded tell-like habitation sites, locally known as “magoules”, characteristic of the Thessalian lowlands, as well as other types of monuments, mainly tombs, were partially or totally destroyed (Gallis, 1979: 18). Recent low intensity, extensive landscape reconnaissance and informal interviews with members of the local communities indicated that the cultural record of the Kambos area was gravely affected by the land reclamation process and especially by the establishment of a specific irrigation system that required the systematic flattening of the landscape (Krahtopoulou et al. in preparation).

Recent research has employed multispectral satellite imaging in combination with geophysical survey and GIS to locate unexcavated magoula sites in Thessaly with very promising results (e.g. Alexakis et al., 2011; Agapiou et al., 2012, 2013, 2014; Hadjimitsis et al., 2013 73-75). This project introduces a new methodological approach, based on the digital reconstruction of the cultural landscape as it was before the land reclamation process. This novel methodology attempts to overcome the problems posed by the flattening of the landscape in this reclaimed area, which renders impossible the application of previously employed RS methods. Moreover, moving beyond the detection of sites and monuments, this approach provides a more secure identification and a better characterisation of the entire cultural record. This approach is considered of vital importance, since the ultimate goal of this project is to understand and reconstruct the long-term cultural landscapes of western Thessaly.

2. Methodology and sources

2.1. The assemblage of the project's GIS geodatabase

Photo-cartographic material, necessary for the development of this research, was provided by the Hellenic Military Geographical Service (HMGS), the Hellenic Cadastre (Ktimatologio) and the United States Geological Survey (USGS). The HMGS provided the aerial photographs on photographic paper and they were scanned with an A3 photogrammetric scanner at 900 dpi. The calibration parameters of the cameras employed in the pre-1972 flights were provided by the HGMS.

The first sources to be incorporated in the GIS geodatabase were the reference cartographic materials. These were relatively easy to incorporate by a simple georeferencing process in which the coordinate grids of the map series employed, provided in a local coordinate system, had to be reprojected to the Greek Grid (EPSG 2100) used in the development of the project. QGIS Georeferencer Plugin was employed to do this. The sources integrated in the GIS geodatabase were:

- 1963-73 cadastral maps at a scale of 1:5000. They afford high accuracy and large scale. They also provide important information on the second- and third-level trigonometric network. Interestingly enough, they sometimes depict elements of the landscape with topographic relief. Due to the flat morphology of the plain, magoules and tombs often provided ideal places for the construction of these trigonometric points (Fig. 3).
- 1973-75 topographic maps at a scale of 1:5000 produced by the HMGS. These were extremely useful since they contain detailed topographic data including thousands of spot heights that were employed to analyse post-reclamation topographic changes. They also contain many post-1972 trigonometric points (most of those appearing in the pre-1971 maps were destroyed together with the magoula or tomb upon which they were positioned) that were very useful as they could be used as Ground Control Points (GCP) for the photogrammetric ortho-correction and georeferencing of the later aerial photograph series.

Digital photogrammetric block triangulation was considered necessary for the integration of the different series of photographic materials. Two types of outputs were produced using this tech-nique: (1) ortho-photomosaics of the study area for as many dates as pre-1972 (the date by which the land reclamation process was completed) photographic series were available and (2) Digital Surface Models (DSM) of the area. The development of the ortho-photomosaics and DSMs followed the same process of photogrammetric correlation between the different images of each flight. To assist this process and assure the correct georeferencing of the products, a set of accurate GCPs were acquired using the previously discussed projected cartographic material and identified in each image.

Fig. 2. Photograph of the land reclamation process, which flattened the area under study effectively destroying most archaeological remains (Administrative Region of Thessaly, photographic archive).

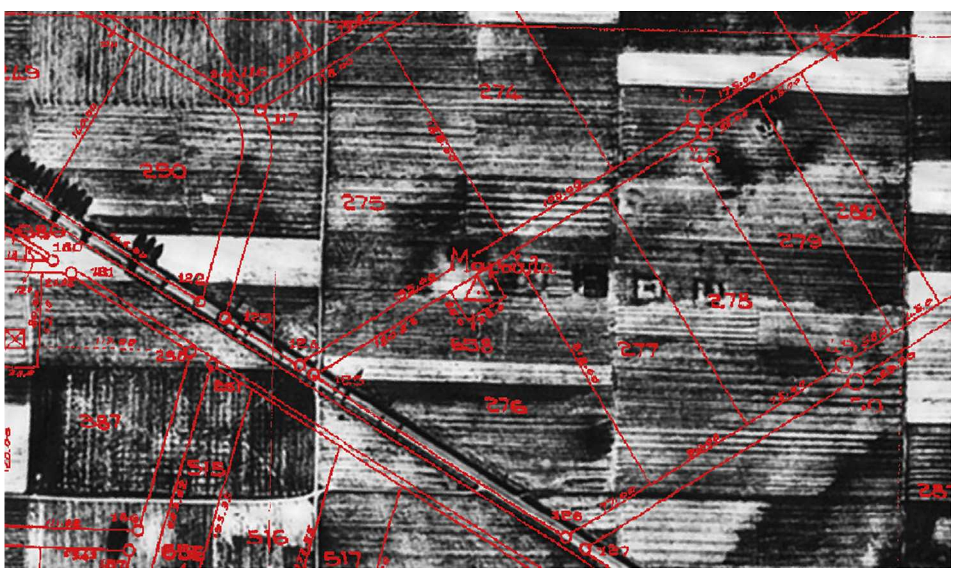

Fig. 3. Georeferenced scanned map (red lines) on top of the 1960 ortho-photomosaic. Towards the center, a trigonometric point (red triangle) rests on top of a nowadays invisible magoula (Magoύla is the toponym).

The different photographic materials of interest for the study area incorporated into the project's GIS geodatabase were:

- The 1945 flight at a scale of 1:42,000 acquired by the Royal Air Force (RAF). Although these photographs could be employed for the visual detection of features, the scale was too small to allow the use of digital photogrammetric techniques for the reconstruction of the area's topography at a significant resolution.
- Two 1960 flights at a scale of 1:15,000 and 1:30,000 acquired by the U.S. Air Force (USAF). The 1: 30,000 photographs offer a good complement to the 1:15,000. Although these cannot be used to produce useful DSMs due to their scale, they can be used for the visual detection of features and increase the number of images available, which is particularly important given the problems of image contrast apparent in the 1:15,000 images (see Fig. 4). The 1960 flight at a scale of 1:15,000 allowed the creation of both an ortho-photomosaic (Fig. 4) and a relatively high resolution DSM. Although these images provided a reasonably high resolution at an early enough date, the evident problems of contrast hindered in some cases the development of DSMs, which showed inconsistencies such as pits or peaks. However, the resulting DSMs still allowed us to reconstruct the topography of now invisible magoules and tombs.
- CORONA analogue satellite imagery was also employed. In the Kambos case CORONA offers excellent image quality and a ground resolution of 2 m. Two strips of CORONA coverage acquired in Jun 1970 were obtained from the USGS, georeferenced, employing the high resolution GCPs, and incorporated into the

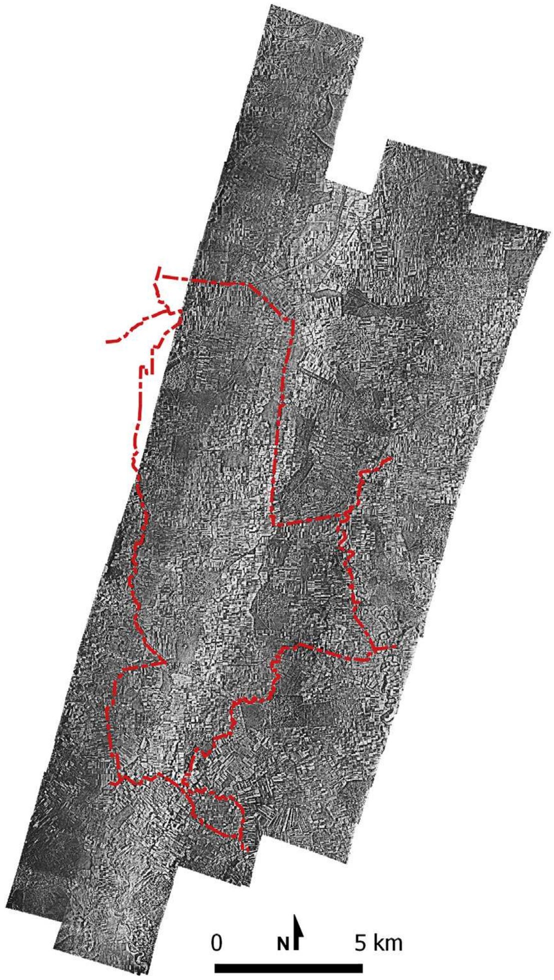

Fig. 4. Ortho-photomosaic developed from the 1960 aerial photographs of the study area. The Kambos sub-municipal unit is delineated in red.

project's GIS. At the date when the CORONA images were taken the land reclamation process was still in progress and some areas, such as the eastern sector of the study area, had still not been reclaimed. Even in those sectors where the land-reclamation process was ongoing some magoules, tombs and older field systems were still visible.

- The digital orthoimages of the Hellenic Cadastre (Ktimatologio) aerial flight (2007e9) were incorporated as a reference base-map. These images reflect the landscape as it is today and allow us to check whether any of the sites located through remote sensing techniques are still standing.

Lastly, two point-vector layers providing important information were incorporated into the project's geodatabase:

- The sites' record database of the Ephorate of Antiquities of Karditsa was integrated into the geodatabase. This database incorporates sites reported in the relevant bibliography, as well as sites discovered by recent extensive reconnaissance of the area (Krahtopoulou et al., in preparation). The coordinate fields X and Y were used to produce a point vector layer from which all information related to the sites could be queried and analysed. The layer attribute table contained information on site name, area, chronology, type of archaeological exploration, if any, and preservation. The layer presents 36 habitation and funerary sites, most of them still upstanding. Although this is a rather modest record, it provides valuable chronological and morphological information that can be related to different types of features but also criteria for the identification of micro-reliefs that have been related to former archaeological sites.
- The first-order trigonometric network of the area was also incorporated into the GIS as a point layer depicting the position of current trigonometric vertices in the area.

2.2. Methodological approaches for the reconstruction of Thessalian hidden landscapes

In order to compensate for the reduction in spectral information with respect to modern multispectral imagery that the use of old monochrome aerials would imply, it was decided to increase the chances of feature detection by employing a workflow (Fig. 5) specifically designed to extract the maximum information possible from old black-and-white aerial photographs. The workflow was based on two methodological approaches:

- Photogrammetric 3D reconstruction. Moving from the sole visual interpretation of features and taking advantage of the stereo-photogrammetric capabilities that old near-vertical aerial photographs offer, digital photogrammetric block triangulation was used for the 3D reconstruction of the landscape as it was before the 1970s. Although this is not a new development, few archaeological applications take advantage of the topographical information enclosed in old aerial and/or satellite imagery stereopairs for the production of DSMs (but see the innovative work of Casana and Cothren, 2008 and Galiatsatos et al., 2008 with CORONA satellite images and, more recently Orengo et al., 2014 with old aerials).

The analysis of topographic change in the area employed the DSMs developed from both pre- and post-1970 aerials. In order to obtain a fast and reliable picture of topographic changes, these two models were compared using a cut-and-fill process. The models did not completely overlap on the Z axis. Small changes in the DSM values due to the interpolation process and the differential availability of GCPs for the different periods were probably responsible and, although changes were still appreciable, these were not as clear and uniform as expected. In order to address this problem in the comparison of models, we used an algorithm developed for the filtering and visualisation of LiDAR data: Local Relief Model (LRM) (Hesse, 2010). LRM produces a raster in which only relative topographic differences are reflected and, in doing so, reducing constant trends in height changes to a flat surface. This technique is particularly appropriate for the comparison of DSMs, since the cut-and-fill between the pre- and post-1970 LRMs will find no difference in the areas where topography is constant in both, and only when there are significant differences in relative (not absolute) height will these be picked up by the cut-and-fill tool. Although some of those differences in height highlighted by the cut-and-fill process were due to pits and peaks generated by the photogrammetric reconstruction process, easily detectable by their morphology and the comparison with the ortho-photomosaic, many corresponded to flattened out mounded sites. The sites located could be further investigated by using the original pre-1970 DSM where absolute measurements could be obtained and their shape analysed.

This novel workflow combining photogrammetric-generated DSMs, LRM and cut-and-fill DSM comparison allows the fast and accurate analysis of recent topographic change, an important capacity since most large-scale anthropogenic topographic changes in the world have taken place during the last 60 years due to urban

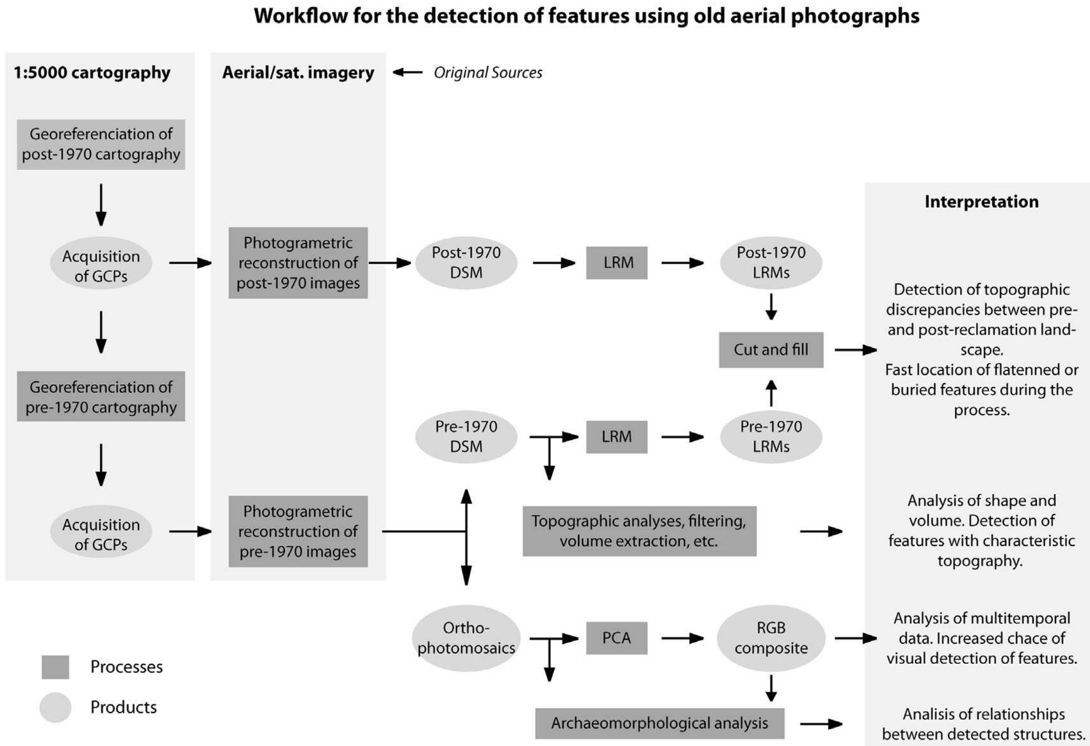

Fig. 5. Scheme of the workflow followed for the photogrammetric-based multi-temporal Remote Sensing (RS) analysis of the study area.

development, the global expanse of mechanised agricultural practises and the use of heavy machinery. In this way it would be possible to detect features flattened out during the land reclama-tion process, such as magoula settlements or tombs, through their characteristic topography.

- Multi-temporal visualisation. The visual detection of features is strongly linked to physical differences in ground conditions, which, at the same time, are bound to sometimes rapidly changing factors, such as time of acquisition, soil moisture, temperature, and so forth. Moreover, multi-temporal data were

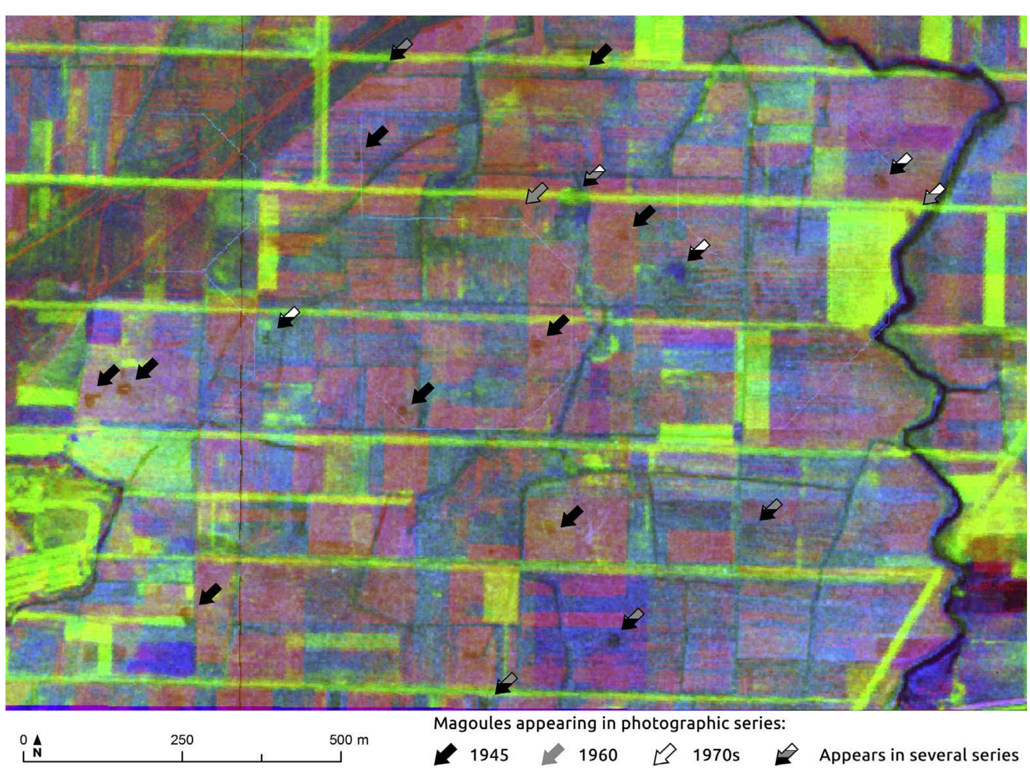

Fig. 6. Multitemporal RGB image generated from the 3 Principal Components of a PCA analysis of the different orthoimages available for the study area.

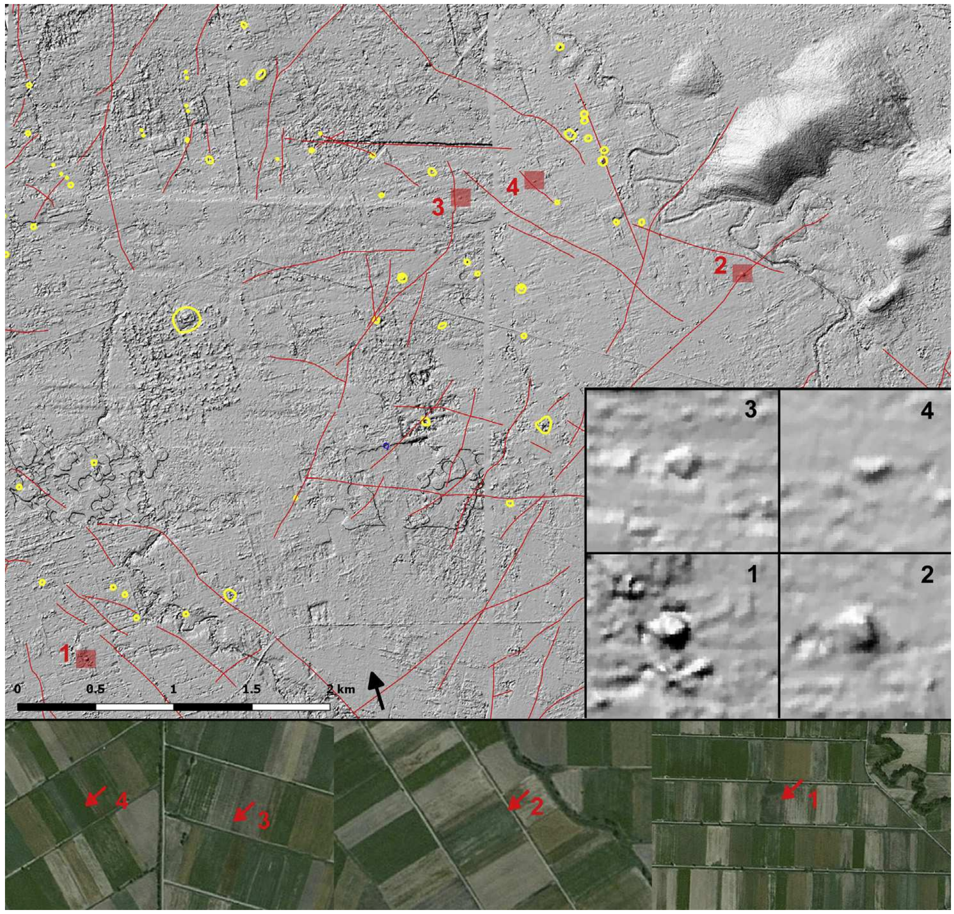

Fig. 7. Examples of mounded sites (yellow lines) detected through topographic reconstruction and RS detected roads (red lines) in the area east of the modern village of Agios Theodoros. Some of those sites identified only as topographic marks are enlarged in the images in the boxes. None of these exist today as shown in the Ktimatologio orthopho-tographs below.

used to increase the chances of feature detection. The photogrammetric 3D reconstruction had a second output besides DSMs: ortho-photomosaics of the different flights employed were produced and then combined in a single multi-temporal image. This image was created using a Principal Component Analysis (PCA), a method available in most GIS software packages, of all ortho-photomosaics. The three principal components were combined in a RGB (Red-Green-Blue) composite (Fig. 6). This composite provided a means to explore the diversity of the data in a simple and efficient way, taking into account variation in environmental conditions, but also in human transformations, which could have caused differential visibility of features.

2.3. RS-based interpretation process

The multi-temporal image together with the 1945 and 1960 ortho-photomosaics provided an excellent tool for the visual inspection of the study area. Their high resolution of 1 m/px, 1.55 m/px and 0.657 m/px respectively, was high enough to allow visibility of the smallest features. Image contrast, however, was in some cases problematic, hindering the identification of many features that had to be identified by using alternative sources to the initial visual inspection.

The analysis of the multi-temporal image followed a systematic approach: a vector grid in which each grid cell was equal to the size of the map window at the 1960s ortho-photomosaic's maximum resolution was created and laid over the study area. To secure a systematic inspection each grid square was visually investigated separately. This operation was repeated for each ortho-photomosaic and the results compared. Although most soil marks were visible in several images, some were only identifiable in one of them, highlighting the importance of employing images acquired in different environmental conditions to increase the chances of feature detection.

Archaeomorphological analysis was also performed following the methodology developed by Orengo and Palet (2010) and Palet and Orengo (2011). Archaeomorphology, a term employed mainly in French landscape studies, refers to the study of ancient human-made structures preserved as part of the modern landscape, such as roads, field systems, channels and irrigation systems, and urban shape and distribution by means of cartographical documents and aerial photography. In the Kambos case, the results were significant as they allowed the ordering of feature morphologies, such as roads, into a relative chronological sequence. Also, road morphology was an important factor in ascribing typologies to mounded sites and/or features according to the location of the site/feature in the road network and its relation to other sites/features inside the network.

The photointerpretation was made in a polyline vector layer. The attribute table linked to this layer incorporated information of the type of feature detected (for example, road, mounded site, wetland, etc.), subtype (for example, different types of mounded sites or roads were given different codes), chronology, when available, the

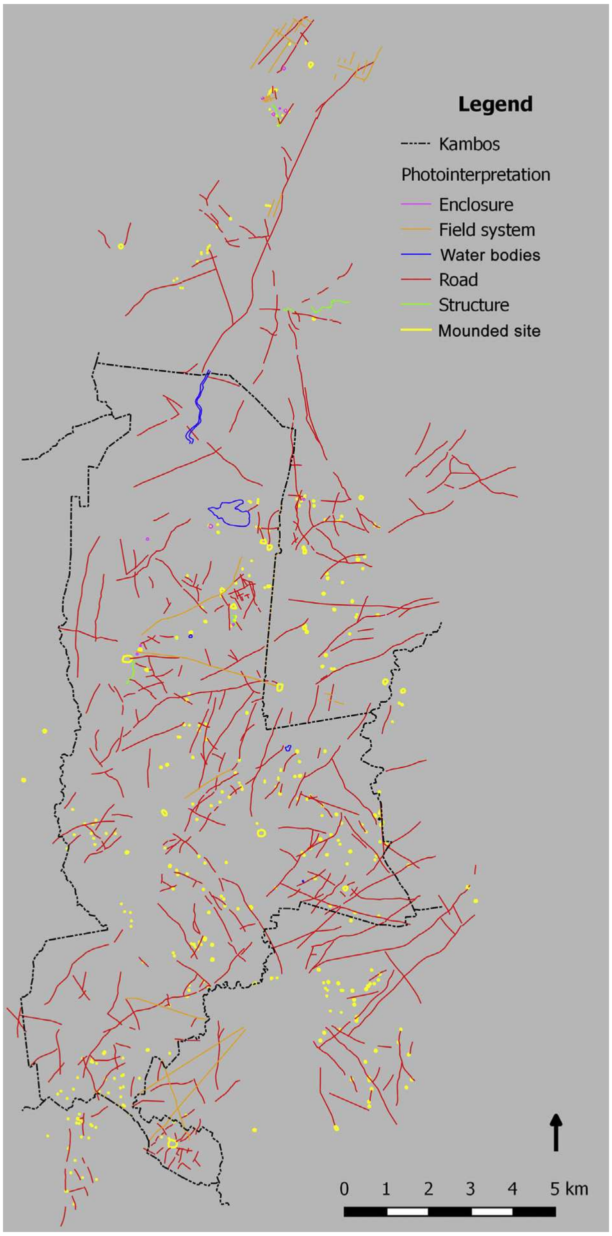

Fig. 8. Results of the photointerpretation and archaeo-morphological analysis.

type of source employed for its detection, the year in which this source was created and finally the degree of security of the identification. This last information was based on the consistency of site/ feature detection. Elements appearing in maps, such as the one shown in Fig. 3 had a high level of reliability, as did those appearing in at least two images and, at the same time, showing characteristic topography in the DSMs. Elements appearing in more than one source had a medium level of reliability, while those appearing in only one source were tagged as low level.

The DSM generated from the 1960 photographs presented a spatial resolution of 1.329 m/cell but, due to the average quality of the images, it presented several deformations in specific areas. These were treated with standard tools but the DSM was not filtered in any way, in order to preserve small depressions, which could reflect actual data. The visual inspection of the DSM made use of different filtering and visualisation methods, from the simple histogram stretch of the height values to more sophisticated techniques initially developed for the visualisation of micro-reliefs in LiDAR datasets. These included Local Relief Model (Hesse, 2010), which, as already mentioned, was incorporated as part of the cut-and-fill production process, and a RGB composite of the 3 principal components of a PCA of multiple shaded relief models (following Devereux et al., 2008). The results not only allowed us to locate mounded sites but, in many cases, to map their topography.

3. Results and discussion

Four types of structures, according to the factors prompting their detection, have been identified:

- Sunken or hollow structures. The most common structures of this type are the so-called “hollow ways” (Wilkinson, 1993). The continuous use of these informal paths by people, animals and vehicles erodes the substrate and forms a depression. The geology of the plain of Karditsa, namely easily erodible Quaternary alluvial deposits, promotes the formation and preservation of such negative relief features. Moreover, the plain forms a large natural basin that retains water perennially. The water table is particularly high and oscillates between 2 and 4 m. Therefore negative relief features, such as hollow ways, ditches, and so on are unusually visible, as they tend to present different moisture content than that of their immediate environment.
- Marks related to differential vegetation growth such as formal paved roads, but also ancient city grids and walls.
Preserved and standing structures (at the moment at which the image was acquired). These are in the majority magoula settlements or funerary sites, which are usually visible in aerial photographs but also detectable through the photogrammetric 3D models developed (Fig. 7). This category also includes structures and landforms located through archaeomorphological analyses, such as field systems or ancient rivers. These last are usually detected using visual identification and a series of morphological factors such as the existence of constant distances between field limits related to ancient measure units, interrelation between structures, or characteristic morphologies.
Structures located through old documents, cartographic analysis and ethnographic work. Fig. 3 offers a good example of one of those.

In total, 891 previously unknown features of archaeological interest were detected. These can be broadly classified as mounded or rounded features (377), road stretches (446), elements of field systems (22) and isolated finds of diverse types (46) (see Fig. 8 for a general map of detected features). This paper focuses on mounded sites and roads, leaving the interpretation of the communication network and the analysis of the area's historical morphology for a second phase of work in which the development of archaeological survey campaigns will provide data to inform the historical interpretation of the detected features.

Our results prove that the Kambos area preserves a much richer, denser and more diverse network of magoules and tombs than previously thought. It is indicative that the IGEAN (2015) archaeological site inventory reported fifty documented Neolithic magoules in the Karditsa prefecture. Only two of those are located in the Kambos sub-municipal unit. Preliminary identification of 377 unspecified mounded sites is thus a sub-stantial improvement of our knowledge of the cultural record of the area.

Comparison of the analysis results with the modern Ktimatolo-gio orthoimages and available archaeological site inventory showed that very few of the magoules and tombs detected are presently preserved. In several cases the DSMs were able to reconstruct the topography of invisible or partly-flattened features (Figs. 7 and 9).

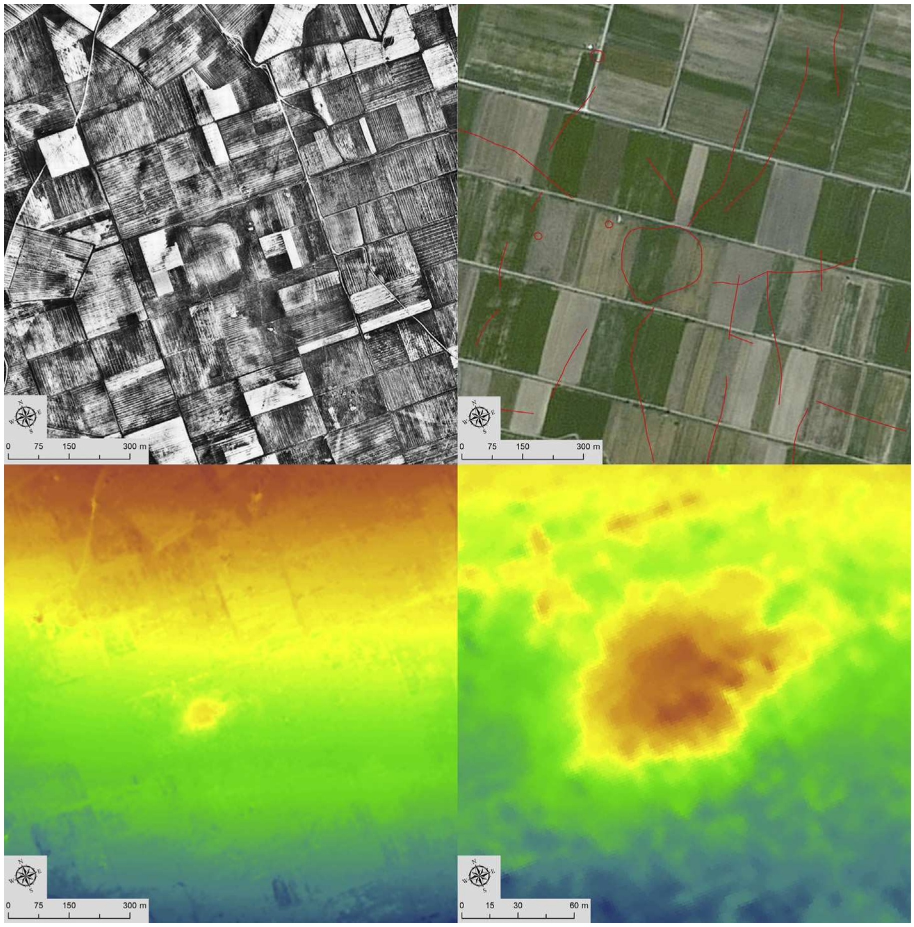

Fig. 9. Topographic reconstruction of the Late Neolithic/Bronze Age Karnomagoula south of the modern village of Pteloupula (zoom-image of the magoula in the bottom right image). Photointerpretation from the 1960s aerials (superimposed on the Ktimatologio orthophotograph in the top left image).

They provide therefore a highly reliable counterpart to the visual identification provided by the multi-temporal image and the 1945 and the 1960 aerial series ortho-photomosaics. More importantly the 3D reconstruction of the topography of the study area as it was in 1960 allowed the detection of magoules and tombs not identified by the aerial photographs' visual photointerpretation process. Initial ground checks seem to verify the results of the landscape analysis. Only nineteen of the flattened sites detected through the analysis have been visited so far (Krahtopoulou et al., in preparation). They all preserve surface archaeological material, thus confirming the huge potential of this methodology.

Our results have gone beyond the simple identification of magoules and tombs. The combination of the detected archaeological features with the results of archaeomorphological analysis and the available archaeological data provided meaningful insights into the character of mounded sites and their chrono-typological ascription. Three main sub-typological groups were detected. The first group includes large magoules, in most cases larger than 30 m in diameter (the larger examples reaching 90 m in diameter), with rounded morphology. These are interpreted as habitation sites. Archaeomorphological analysis shows that some of these are located at the centre of radial road networks. The Late Neolithic-Bronze Age site of Karnomagoula shown in Fig. 9 offers a good example of this type of settlement. The few additional examples for which dates are presently available point to a similar chronological framework. The second group involves large magoula settlements that are joined by a well-developed network of relatively straight roads, perhaps indicating simultaneous occupation. The few presently dated examples imply a historical time framework (Classical to Roman period).

The last sub-group comprises smaller mounded features (5e20 m in diameter with a few larger than 30 m) that lie along roads, are not surrounded by radial hollow way systems and sometimes exhibit small depressions around them. These are interpreted as funerary sites. Available archaeological data from the Kambos area show that tombs of this type have been built from at least the Proto-Geometric to the Roman period (from the 10the8th century BCE to the 4th century AD). In Pieria, Macedonia, northern Greece, cemeteries dating from the Early Bronze Age (3300/3100-2300/2100 BCE) onwards, and isolated tombs, dating to the late Classical-early Hellenistic (4th century BCE) period, were also located along roads (Besios, 2003, 2010; Besios and Athanasiadou, 2014; Besios and Krahtopoulou, 2003; Besios et al., 2003). In the Kambos case, association with excavated examples (e.g. Intzesiloglou, 1995, 2000, 2010) indicates that tombs were placed along roads since at least the Proto-Geometric period (10th-8th century BCE). Some of the tombs detected are surrounded by an excavated ditch (Fig. 4, tombs 2, 3 and 4; tomb 1 and, to some extent, tomb 3 show small depressions around). The erection of tombs involved digging up soil around them (Besios, unpublished data). The soil was then piled on top to create the impressive monuments that once littered the nowadays flat and featureless Kambos landscape.

This project has also developed sub-typologies of roads, namely paved roads, hollow ways and double ditched roads. These buried features were particularly visible due to the combination of their morphology and the geological and hydrological characteristics of the Karditsa plain. A buried formal paved road identified by this project measures up 4012 m in length and leads to the Classical-Hellenistic-Roman site of Kierion. An excavated segment of this road verifies our interpretation and indicates that paved roads were in use at least since the 2nd-1st century BCE, during the Hellenistic period (Intzesiloglou, 2010). Only one example of a double ditched road has been found in the area. It runs in straight stretches for 8700 m, crossing the northern sector of the study area following a N-NW direction. Although no secure chronological ascription can be assumed at the moment, its relation to field systems with a distance between field limits corresponding to multiples of historical measure units, which seem to be aligned to it, might offer a preliminary dating.

Negative relief features known as ‘sunken lanes’ or ‘hollow ways’ (Wilkinson, 1993) are a common indication of ancient informal road systems. Linear and radial hollow way networks are widespread and exceptionally well documented at a variety of scales in the Middle East (e.g., Casana, 2013; Menze and Ur, 2012; Wilkinson et al., 2010). In Pieria, northern Greece excavated linear examples date from the Early Bronze Age to the 14th century AD (e.g. Besios, 2003, 2010; Besios and Athanasiadou, 2014; Besios and Krahtopoulou, 2003; Besios et al., 2003). Pedogenic expression of the fill of a currently excavated hollow way in the Kambos area suggests that this pathway was used during prehistoric times. Completion of the excavation will provide a more secure and close chronology.

4. Conclusions and future work

This paper has highlighted the enormous potential of the application of multiple remote sensing techniques and sources for the analysis, reconstruction and understanding of lost cultural landscapes. The photogrammetric reconstruction of the Kambos area succeeded in locating hundreds of no longer visible or compromised archaeological features dating from the Early Neolithic onwards, clearly proving that existing knowledge on the cultural record of the area is spatially inconsistent, incomplete and misleading. The use of old aerial photographs provided a unique way to undo virtually the ravages of the last fifty years, when land reclamation, urban development and infrastructure projects led to large-scale and often irreversible landscape modifications. This technique was combined with more traditional visual photointer-pretation of the ortho-photomosaics generated during the same photogrammetric reconstruction process. Archaeomorphological analysis offered invaluable new perspectives on the nature of the detected structures, while integration with available archaeological information provided meaningful chronological associations.

Initial targeted surface archaeological work, albeit limited, appears to validate our results. Ground checks will continue rigorously, in order to gather more data and to refine, if necessary, classification and characterisation of the archaeological features detected. Dating of the surface material will establish firm chro-nologies for most identified features. Chronologies will be then securely related to the different morphological types identified during this initial phase of the project. Moreover, trial trenches will provide ground truthing, formation and dating evidence for hollow ways and paved roads recognised by this project. Finally, ongoing geoarchaeological work is expected to elucidate the role of geomorphological processes, mainly alluviation, in the detection potential of the methodology introduced in this paper.

The data gathered by this project have been made available to the local Archaeological Service and they already constitute a unique resource for the protection of the entire cultural heritage, upstanding, buried and otherwise, and for the implementation of archaeological legislation when necessary.

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