The contribution of pattern recognition techniques in geomorphology and geology: the case study of Tinos Island (Cyclades, Aegean, Greece)

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\textbf{ABSTRACT}

Scope of the present work is to apply modern methods of pattern recognition concerning the automatic detection of geomorphological features (curvilinear lineaments and topographic highs), with emphasis on geological faults and to compare the results of the automatic detection with aerial photographs and further geological data collected in Tinos Island. The contribution of this work in the geosciences is multidisciplinary because (a) it proposes to geoscientists a new tool of geomorphological analysis prior to the fieldwork and especially at the stage where published work and already available data are collected, evaluated and reprocessed, (b) it increases the detection accuracy of the geological features both prior and after the fieldwork, (c) it decreases the time of fieldwork and consequently the cost of the entire geological research and (d) it can be applied in digital elevation data. The automatically detected linear-curvilinear lineaments and topographic highs agree in location, shape and orientation with the ground truth data (geological maps, aerial photographs and field measurements). Furthermore, the shape and the orientation of the most prominent topographic high (Tsiknias) seems to be related to the tectonic regime in the wide area of study corresponding to the ENE-WSW, WSW-ESE, N-S and E-W trending normal faults.

\textbf{Introduction}

The increase of the remote sensed images and signals as well as the urgent need for the automatic information extraction and interpretation of such data sets have made the development and application of modern pattern recognition techniques a popular research topic for the last decades (Younan, Aksoy, & King, 2012). A wide range of pattern recognition techniques have been proposed for both traditional application areas such as land cover and land use classification, road network extraction, and agricultural mapping and monitoring, as well as more recent topics such as monitoring of human settlements, management of natural resources, response planning for natural and human-induced disasters, assessment of the impact of climate change and conservation of biodiversity (Younan, Aksoy, & King, 2012). Šîpek and Mlynarczuk (2013) successfully applied four classical pattern-recognition methods (nearest neighbor, k-nearest neighbors, nearest mode and optimal spherical neighborhoods) on the problem of the automatic classification of rock images, taken under an optical microscope under different lighting conditions and with different polarization angles. The classification was conducted with the use of the pattern recognition methods on thin sections of five selected rocks. Grinia, Panagiotakis, and Tziritas (2016) presented a new method for automatic detection of building and road structures using satellite images based on novel image segmentation algorithm and pattern analysis techniques. Additionally, image processing and pattern recognition techniques have been used to map and monitor earthquakes, faulting, volcanic activity, landslides, flooding, wildfire and the damages associated with them (Joyce, Belliss, Samsonov, McNeil, & Glassey, 2009).

The automatic extraction of geomorphological features (Booth, Roering, & Perron, 2009; Dinesh, 2006; Euillades, Grosse, & Euillades, 2013; Iwahashi & Pike, 2007; Kweon & Kanade, 1994; Micheal & Vani, 2015; Miliaresis & Argialas, 1999; Obu & Podobnikar, 2013; Panagiotakis & Kokinou, 2014, 2015, 2017) using Digital Elevation Models (DEMs) belongs to the techniques of remote sensing data processing, that improve our understanding of regional geomorphology and geology prior to the fieldwork. The automatic extraction of geomorphological features...
highly contributes towards a rapid, objective and lower cost geological mapping. Furthermore, remotely sensed data are widely used for geological mapping and a variety of machine-learning algorithms are applied in photo interpretation, automating the feature classification concerning these data sets. For example, Harvey and Fotopoulos (2016) compared four supervised machine-learning algorithms (naive Bayes, k-nearest neighbour, random forest and support vector machines) in order to evaluate their performance for correctly identifying geological rock types in a well previously surveyed area, showing that random forest is the best approach. The application of the pre-mentioned techniques prior to a field-trip helps the geologist to recover all known geological information about a site and it greatly facilitates the fieldwork.

In the context of the present work, recent algorithms (Kokinou, 2015; Panagiotakis & Kokinou, 2014, 2015, 2017) to automatically detect geomorphological features, with emphasis on geological faults, are applied in high resolution (isocountour interval 4 m) DEMs. Furthermore, the results of the automatic detection are verified with data collected from fieldwork in a selected area of study (Tinos Island, Aegean, Greece). Specifically, the purpose of the present work is the geomorphological and geological study of the southern part in Tinos Island (Greece) (Figure 1) aiming to:

(1) Check the efficiency of recent pattern recognition methods on DEMs and to automatically detect the geomorphological features with emphasis on normal faults.

(2) Compare the results of the automatic detection with aerial photographs and geological data provided from fieldwork on Tinos Island, as well as observations from previous research.

(3) Evaluate the results of the proposed methodology.

**Geomorphology**

Tinos (of total 156.5 km$^2$, (Figure 1)) along with 19 other islands belong to the Cycladic Plateau, located in Central Aegean Sea (Greece). The Cycladic Plateau comprises a shallow (up to 250 m in depth) marginal platform, showing a complex geomorphology (Dermitzakis & Papanikolaou, 1981) related to the Miocene climatic conditions (warmer and more humid) and to the Holocene tectonism. Metamorphic and igneous rocks (Hejl, Riedl, & Weingartner, 2002) prevail in the numerous outcropping islands of this plateau, while sedimentary sequences are limited, possibly related with the low fluvial discharges (Poulos, 2009) into the sea. Offshore sedimentological studies (Anagnostou, Sioulas, Karageorgis, Pavlakis, & Alexandri, 1993; Karageorgis, Anagnostou, Sioulas, Chronis, & Papanastassiou, 1998; Lykousis, 2001; Lykousis, Anagnostou, Pavlakis, Rousakis, & Alexandri, 1995), based on side-scan sonar images and high-resolution acoustic profiles, indicated the presence of sandy sediments arranged in the form (thickness 6 m) of sand dunes, ribbons and ripples. Kapsimalis et al. (2009) used acoustic, bathymetric and archaeological data to study the Quaternary stratigraphy and internal structure of the Cycladic shelf aiming to provide information for the archaeological potential of this area. They concluded that submergence and emergence due to the Quaternary sea level changes were the driving mechanisms causing seabed erosion by sub-aerial conditions or paleo-surface burial by thick deltaic/coastal sequences. These mechanisms are also supported by the lack of raised Holocene coastal deposits (Gaki-Papanastassiou, Evelpidou, Maroukian, & Vassilopoulos, 2010) and other morphological features (marine terraces or benches, beachrocks, marine notches, etc.) and the presence of submerged beachrocks (at a depth of about 4 m in Dilos, Fouache & Dalongeville, 2003) in Syros, Andros, Tinos and Naxos.

The climate of Tinos, that strongly affects the geomorphology of this Cycladic island, is characterized by strong winds, intense sunlight and high relative air humidity, factors which enhance the chemical and aeolic erosion, creating Alveoles and Tafoni formations (Evelpidou, Leonidopoulou, & Vassilopoulos, 2010). The modern morphology of

![](Figure 1. Location map showing Tinos Island in Cyclades (Aegean, Greece). The basemap is from the ArcGIS 10 online database. White square shows the study area located in the southeastern part of Tinos Island.)
Tinos is dominated by the presence of three planation levels (A at 600 m, B at 430–450 m and C at 300 m) with Level B presenting the greater extent on the island (Riedl, 1995). Level B is a weathering basal relief of a former peneplain, stretch slopes, torsos of valley heads and kehlal bottoms, developed on a Miocene monzogranite. Furthermore, Tafoni (resembling small caves) formations are among the most prominent geomorphological features of Tinos traced by Theodoropoulos (1974) on actinolith schists and later studied by other authors (Evelpidou, 2001; Leonidopoulou, 2007; Livaditis & Alexouli-Livaditi, 2001; Maroukian, Leonidopoulou, Skarpelis, & Stournaras, 2005).

**Geological setting**

According to Bröcker and Franz (1998), the geological units in Tinos from top to bottom are (1) the Akrotiri unit, (2) the Upper unit, (3) the Cycladic blueschist unit (Kumerics, 2004) and (4) the Basal unit. The Akrotiri unit is present in the southern part of Tinos consisting of amphibolites, paragneisses and minor silicate marbles (Patzak, Okrusch, & Kreuzer, 1994). Previous published work (Avigad & Garfunkel, 1989; Ring, Thomson, & Bröcker, 2003) supports that the Akrotiri unit is separated from the underlying Upper unit by the low angle top to the NE Vari detachment. Brichau et al. (2007) reported the presence of several detachments in Tinos that were active at different periods. Later, Jolivet et al. (2010) presented a synthesis of the northern Cyclades detachments and supported that all these structures are part of a single crustal-scale detachment, called the North Cycladic Detachment System that partly reactivated the Vardar oceanic suture zone. The Upper Unit in Tinos is characterized by greenschist-facies metamorphism, consisting of serpentinites, meta-gabbros, ophicalcites and phyllitic rocks (Melidonis, 1980). The Cycladic blueschist unit consists of marbles, calcschists, siliciclastic metasediments, cherts, basic and acid metavolcanic rocks (Melidonis, 1980) mainly characterized by greenschist-facies corresponding to mineral P-T metamorphism of ~450–500°C and ~4–7 kbar. Bröcker, Kreuzer, Matthews, and Okrusch (1993) found evidences of the earlier high-pressure event corresponding to ~450–500°C and 15 ± 3 kbar. The lower Basal unit is present in the northeastern part of the island, consisting of various metamorphic carbonate rocks (Avigad & Garfunkel, 1989). During the low to medium P-T, metamorphism in the Miocene I- and S-type granites intruded into the units and caused intensive contact metamorphism (Altherr et al., 1982).

According to the Institute of Geology and Mineral Exploration (IGME) map (1:50,000) of Tinos (Figures 2 and 3(a–d)), the geological formations in the southern part (study area) correspond to a wide range of geological ages, from very recent (Holocene) to very old (Permian) (Melidonis & Triantaphyllis, 2003). In specifics, recent deposits

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**Figure 2.** Geological map of the southern part in Tinos Island, according to the IGME map (1:50,000) and field observations. The reference system is WGS84.
are present near the coastline. Gneisses, gneiss-schists and schists cover the majority of the study area. Tsiknias Mountain is located to the northeast, composed of ophiolites, while around this mountain are present greenschists-prasinites. Additionally, marbles, sipolines and gabbrodiorite-diorite cover small areas. Concerning the distribution of the normal faults in the southern part of Tinos, which are also being studied in the context of the present work, four (4) main categories of normal geological faults are indicated (Figure 3(e)), corresponding to E-W, N-S, ENE-WSW, WNW-ESE trending faults, mainly with slopes greater than 60°.

**Methodology**

Digital elevation data, previously published geological data, aerial photographs and field measurements-observations are analyzed and further combined in the present work using MATLAB and ArcGIS platforms.

**Techniques of pattern recognition**

The elevation data (Figure 4(a,b)) were digitized from the topographic maps of isocontour interval 4 m, published by the Hellenic Army Geographical Service (H.A.G.S.). The methodology, concerning the processing of the DEM, has been developed by Panagiotakis and Kokinou (2014, 2015, 2017)) and it has been successfully applied in previous studies (Alves et al., 2015, 2016; Kokinou, 2015; Kokinou & Kopp, 2015). The main steps of this method are:

1. **Input data** are bathymetric/elevation data (.shp format), in the present case elevation data. The first two columns of the input file correspond to the x, y
coordinates. The third column corresponds to the ground elevation. The slope and aspect as well as their derivatives, resulting from the elevation data, are efficiently combined for the computation of the lineament/possible fault enhancement image \( F(p) \) Equation (1), since it holds that abrupt slopes and their associated aspect variations may correspond to lineament possibly related to the presence of a fault.

Calculation of the
\[
F(p) = \left( S^2(p) \ast SS(p) \ast SA(p) \right)^{1/4}
\]  

where
\[
S(p) = \tan^{-1}(|v(p)|)
\]
corresponds to the slope at point \( p \) of the topographic surface \( Z \). \( v(p) \) denotes the plane tangent vector defined as
\[
v(p) = \left[ \frac{\partial Z(p)}{\partial x}, \frac{\partial Z(p)}{\partial y} \right]^T
\]
Slope is measured in degrees with \( S(p) \in [0, 90^\circ] \).

\[
A(p) = \tan^{-1} \left( \frac{\partial Z(p)}{\partial y}, -\frac{\partial Z(p)}{\partial x} \right)
\]
corresponds to the aspect at point \( p \) of the topographic surface \( Z \). Aspect is measured in degrees with \( A(p) \in [0, 360^\circ] \).

\( SS(p) \) is the first derivative of the Slope image.
\( SA(p) \) is the first derivative of the Aspect image (Slope of Aspect).

Estimation of the absolute value-image of the convolution of \( F \) with a zero mean filter \( G(a, w) \) of orientation angle \( a \) and width \( w \) (Panagiotakis, Kokinou, & Sarris, 2011), as follows:
\[
Ig(a, w) = |F \ast G(a, w)|
\]
The resulting image \( Im \) is provided by getting the maximum of the corresponding pixel values of images \( Ig(a, w) \):
\[
Im = \max_{a, w} Ig(a, w)
\]
\( Im \) corresponds to an image showing the automatic detections of the geomorphological features in the study area, with emphasis on geological faults.

Furthermore, the local maxima (topographic tops) of the DEM are computed based on the isocontour approach (Panagiotakis & Kokinou, 2017), in order to automatically detect the most important topographic highs in the study area and further to provide some terrain’s quantitative attributes (orientation, eccentricity, average slope and shape complexity). Additionally, a formal definition of the topographic high is proposed for the first time that is based on volume evolution of isocontours. The novel formulation of a topographic high takes into account the VOlume EVolution of an Isocontour (VOLEI) that starts from the top of a high and grows, as decreasing the altitude level of the isocontour, until a high of higher altitude is reached. This formulation yields to a robust unsupervised algorithm that is sequentially applied to automatically recognize the topographic highs with arbitrary basal shapes. A topographic top is selected if and only if it is the highest top in its neighborhood.

Next, the sequence of isocontours for different decreasing altitude levels of the given DEM is

Figure 4. Elevation data digitized from the topographic maps with contour interval 4 m, published by the Hellenic Army Geographical Service (H.A.G.S.); (a) the distribution of the topographic contours in the study area, (b) a small part of the study area showing the contours with interval 4 m.
computed. During this process, the isocontours are gradually merged providing a topological hierarchy of highs in an inclusion tree structure.

The proposed framework has been tested and compared with the scheme provided by Bohnenstiehl, Howell, White, and Hey (2012) on real and synthetic topographic data, where highs of various orientation, density and size are presented, yielding high performance results. An important parameter, included in the computations, is the MinA, used to define the minimum possible expanded area of a high and to sample the topographic tops that are very close together, in order to reduce the computational cost. Therefore, for each detected high it holds that the corresponding area of the region should be higher than MinA. The parameter MinA influences the detection of the highest tops only if they are very close, so they should be detected as one top, related with the discrimination accuracy of the method.

**Digital elevation model**

The term Digital Elevation Model (DEM) is used to refer to any digital map of a topographic surface and it corresponds to a spatially geo-referenced regular grid of topographic heights. The accuracy of a DEM (Bolstad & Stowe, 1994; Li, 1994; Mashimbye, De Clercq, & Van Niekerk, 2014; Mukherjee et al., 2013; Toz & Erdogan, 2008; Vaze, Teng, & Spencer, 2010) is a key parameter, which depends on elevation data acquisition (such as aerial photographs, satellite imagery, airborne laser scanning-LIDAR, digitization of existing maps), resolution (i.e. distance between the adjacent grid points) and slope of topography. There are many formats to graphically present a DEM such as scattered data points, contour lines, triangulated irregular networks and others.

In the context of the present work, the DEM (Figure 4(a,b)) for the study area in Tinos Island was created by manual digitalization, i.e. scanning, georeferencing, digitizing the contours at 4 m interval and interpolating using “Topo to Raster” interpolation method (Childs, 2004) of the analogue map, published by the Hellenic Army Geographical Service (H.A.G.S.). Furthermore, aerial photographs, provided by the H.A.G.S., were used to evaluate the results of the algorithms (Panagiotakis & Kokinou, 2014, 2015, 2017) of pattern recognition applied on the DEM.

**Geological mapping**

Geological mapping (Marjoribanks, 2010) aims at providing the graphical presentation of geological observations and interpretations for a selected area on a horizontal plane and it is usually implemented in three phases. At the first stage, previous information, concerning already published topographic and geological maps, aerial photographs and satellite images, small- or large-scale geophysical data such as aeromagnetic data, borehole data and any other useful contribution, is collected and evaluated in order to design the most efficient plan of the geological fieldwork (selected traverses across strike, detect horizons or contacts, faults and other geological structures). At the second stage, ground truth data (field observations and measurements excluding noise) are collected. The geologist must be open to all possible ideas, hypotheses and observations (Marjoribanks, 2010). In case the observations do not fit the hypotheses, new models have to be constructed and tested using the field measurements in a repeatable process. At the last stage, a database is constructed including previous and collected in the field measurements and observations in order to construct the geological map at the proper scale.

The field trip in Tinos took part in the beginning of 2016. The collected geological data (Toulia, Kokinou, & Panagiotakis, 2016) have been processed using commercial software ArcGIS and FPTectonics. In general, the time and the financial cost of the geological mapping have been significantly reduced. This is because we selected specific sites for geological research, based on the results of the pattern recognition methods.

The tectonic data, with special emphasis on normal faults, were collected in selected sites, based on the results of the automatic detection and according to the stratigraphic units. In case two generations of normal faults were present in the same site, they were divided prior numerical analysis, based on (a) the criterion of relative overprinting between two generations of striations (e.g. Mercier, Sorel, Vergely, & Simeakis, 1989) and (b) geometric and morphotectonic elements such as the strike, dip and plane of the faults, the presence of recent scree, facets and fault scarps. Fault groups were estimated using the directional histogram for planes, with angle of deviation less than 15°.

**Data analysis and discussion**

**Geomorphological features**

VOLEI method (Panagiotakis & Kokinou, 2017) provides four terrain’s quantitative attributes (Hengl, Gruber, & Shrestha, 2003; Wilson & Bishop, 2013), widely applied in earth sciences (geology, geomorphology, tectonics, hydrology and others). Specifically, the following geomorphological parameters are computed:

- Orientation ranging between 0° and 180°. It corresponds to the angle between the horizontal axis and the major axis of the ellipse having the same second-order moments (Panagiotakis,
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Automatic detection of the topographic highs in 2010

40° (NNE-SSE to Yaros

Average Slope ranging between 0° and 90°, not study area according to the scheme proposed by presents the main orientation (in degrees), Figure 4(a

Yaros sheet,

Shape Complexity is positive and normally less plexity of the three topographic highs in the south-
eccentricity, average slope (in degrees) and shape com-

Figure 6

Panagiotakis and Kokinou (2017)). Furthermore, Figure 7(b

tectonic field measurements (see rose diagrams in Figures 2

Ramasso, Tziritas, Rombaut, & Pellerin, 2008) as the detected topographic high region.

- Eccentricity ranging between 0 (circle) and 1 (line). It is defined by the ratio of the distance between the foci of the ellipse having the same second-order moments as the detected topographic high region and its major axis length.

- Average Slope ranging between 0° and 90°, not affected by local shape variations. It is computed by the basis angle of the cone having the same relative elevation of the topographic high and the circular basis area. The relative elevation is provided by the difference between the elevation of the topographic top and the elevation of the isocontour.

- Shape Complexity is positive and normally less than two. It corresponds to the ratio of the topographic high area divided by the area of the cone having the same relative elevation of the high and circular basis area.

Figure 5 depicts the results of the automatic detection of the topographic highs in the study area. Generally, the area presents a rough topography, with altitudes ranging between 0 and 697.73 m. Five (5) topographic highs [Figure 5], namely Tsiknias (max. altitude 697.73 m), Kerovouni (max. altitude 599.02 m), Ktenados (max. altitude 507.39 m), Monastiria (max. altitude 481.39 m) and Plagia (max. altitude 499.19 m) are automatically detected in the wide area of study, according to the scheme proposed by Panagiotakis and Kokinou (2017). Furthermore, Figure 6 presents the main orientation (in degrees), eccentricity, average slope (in degrees) and shape complexity of the three topographic highs in the southeastern part of Tinos Island. The most prominent topographic high in this area is Tsiknias Mountain, showing prevailing orientation of 25°–40° (NNE-SE to NE-SW), while the average slope, the eccentricity and the shape complexity generally reveal large values probably due to the fact that this topographic high is tectonically strongly deformed (Avigad and Garfunkel, 1989; Brichau et al., 2007; Jolivet et al., 2010; Ring et al., 2003).

Pattern recognition and verification of the results

Figure 7 presents the results of the automatically detected linear-curvilinear lineaments in the study area, mainly corresponding to the presence of normal geological faults. In our experiments concerning the automatic detection of the previously mentioned structures, we used the DEM corresponding to contour interval of 4 m (Figure 4(a)) aiming to accurately track the linear-curvilinear lineaments. Then, we digitized the normal faults on Tinos from the IGME map (Tinos–Yaros sheet, 1:50,000) and we overlaid the rose diagrams that resulted from the processing of the tectonic field measurements based on the methodology applied in previous works (Kamberis et al., 2012; Kokinou et al., 2015). Based on the results of (a) the automatic detection (Figure 7(a)) of the linear-curvilinear lineaments in the study area, (b) the already available geological information of the IGME map (Figures 2 and 7(b)) and (c) the tectonic field measurements (see rose diagrams in Figure 7(b)); it is concluded that NE-SW to ENE-WSW and NW-SE to WSW-ENE trending normal geological faults characterized by steep slopes (>60°) prevail in the northern sector of the study area. Concerning the southern sector of the same area (Figure 2) the fault groups of the previously mentioned trends and some N-S trending faults are present.

In order to qualitatively assess the results of the applied methodology, we selected some of the automatically detected linear-curvilinear lineaments in the study area (see red numbers in (Figure 7(a))). Initially, we identified them on the IGME map of Tinos–Yaros sheet, 1:50,000 (see red numbers in (Figure 7(b))). Then, we confirmed their presence during the fieldwork in Tinos (see rose diagrams in [Figure 7(b)]). The selection criteria of the geological faults, used for the evaluation, are their location, orientation, slope and spatial extent in the study area. The majority of the normal faults, corresponding to the ground truth data (Figure 7(b)), are also automatically detected and indicated by the same red numbers in Figure 7(a). At this point, we have to refer that during the comparison of the automatically detected linear and curvilinear lineaments with the ground truth data, some differences emerged, mainly concerning the shape of the automatically detected lineaments. This is because the scale of the ground truth data is 1:50,000 while the scale of the DEM used for the pattern recognition is 1:5000, which

Figure 5. Automatic detection of the topographic highs in the study area according to the scheme proposed by Panagiotakis and Kokinou (2017).
means that the linear and curvilinear geological elements are detected with higher accuracy using topographic data 1:5000. So, differences are expected to arise during the comparison between ground truth data and automatic detections concerning the location, orientation, slope and spatial extent of the structures.

Furthermore, we selected the most prominent topographic high (Tsiknias Mountain) in the study area, aiming to provide more evidence on the robustness of the applied methodology. Tsiknias Mountain is limited by the faults with numbers 7 and 17 (Figure 7(a,b)). Then we traced these faults in the aerial photograph (302639_2013_15000_359_BW of Figure 7(c)), provided by the Hellenic Army Geographical Service (H.A.G.S.). The location, shape and orientation of the faults with numbers 7 and 17 in Figure 7(a,b) is very similar with the faults traced in the aerial photograph (Figure 7(c)).

Conclusions

In the context of this work, the linear and curvilinear lineaments and the topographic highs in the southeastern part of Tinos Island (Aegean, Greece) are identified and further evaluated, using both modern techniques of pattern recognition and traditional methods (geological mapping, aerial photograph interpretation). Major and accompanying geomorphological structures (geological faults and topographic highs) are estimated with high precision concerning their location, shape and orientation. The previously mentioned methodology has been proved successful, yielding high-performance results concerning the study area. In concluding:

- A DEM of isocontour interval 4 m was used to automatically detect the linear and curvilinear lineaments in the study area. Major lineaments in the study area were indicated to be normal geological faults during the geological fieldwork.
- Five topographic highs, with the most prominent to be Tsiknias, were automatically detected in the wide area of study and further confirmed. Their geomorphological features (orientation, eccentricity, average slope and shape complexity) were further examined using the VOLEI scheme. Tsiknias is probably influenced by tectonic deformation.
- The experimental results indicate the reliable performance of the proposed low computational cost framework. Furthermore, the financial cost of the fieldwork has been severely decreased due to the application of the proposed methodology, since prior to the fieldwork-specific geomorphological structures were identified and scheduled to be examined.

Figure 6. The main orientation (in degrees), eccentricity, average slope (in degrees) and shape complexity of the detected highs in the southeastern part of Tinos Island, according to the scheme proposed by Panagiotakis and Kokinou (2017). The orientation of zero or 180° angle is parallel on horizontal plane. A reference grid has been selecting for indexing. The most prominent topographic high in this area is Tsiknias Mountain, showing prevailing orientations of 25–40° (NNE-SSE to NE-SW), while the average slope, the eccentricity and the shape complexity generally reveal large values probably due to the fact that this topographic high is tectonically deformed.
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