# Network representation of geographical landscape data and their correlation to transportation networks in mountainous Greece

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Our work addresses the problem of how socio-technical networks, such as rural telecommunication infrastructure, grow on the background of spatially variable fields. The method we follow is to analyze both the geo-morphological terrain and the road web as complex networks, using the visibility algorithm that converts the georeferenced points into a graph. Such algorithm has been shown to relate in a unique way properties of the point series to stochastic features of the associated graph, so that fractal series lead to scale-free networks (Ref. 2). Thus, it proposes a novel representation that takes advantage of the analytical tools of complex network theory.

Our data are drawn from the geographical mountainous landscape in the mainland of Greece. Such areas consist of highly variable terrain geomorphology, ranging from high mountain peaks to land plateaus. The population of typical settlements in this region does not exceed a few hundred inhabitants. The rural road infrastructure, which connects the various settlements, follows the complex landscape formation. This road network is the evolution of the existing older routes and excludes modern national highways and motorways.

The terrain data we analyze firstly correspond to the altitude of geographical pixels in a line $\approx 30\,km$ long. We convert these sets to networks, using the visibility tool in an ArcGIS platform. Each terrain pixel corresponds to a network vertex, connected to other vertices of the set with a clear line of sight. We find that the topology of the network does not depend on the specific position, length or orientation of the terrain data set in the mountainous region we examine. Moreover, the degree distribution exhibits a fat tail with power exponent $\approx 1.2$. This characteristic is indicative of an underlying fractality of our terrain data, as it appears in networks associated through the visibility method to fractal series, such as the Conway fractal (Ref. 2). This power law exponent is fairly robust. We find the same form of the degree distribution if, instead of the height of the digital terrain pixels, we analyze the set of profile curvature points.

We finally compare these results to the transportation road data. The degree distribution of the associated network exhibits again a power law with exponent $\approx 1.2$. However, we find differences in other network topological parameters, such as the local clustering coefficient, the closeness and betweenness centrality.

[l] R.V. Donner, F. Johnathan, Acta Geophys. **60**, 589 (2012).

[2] L. Lacasa et al, PNAS **105**, 4972 (2008).

[3] A. Asimakopoulos et al, Int. J. Mod. Phys. B **30**, 1541009 (2016).

[4] D. OSullivan, A. Turner, Int. J. Geogr. Infor **15**, 221 (2001).