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Fractal scaling of landslide distribution in the Umbria Region (Italy)

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The application of the fractal theory has made a great contribution to the understanding of surface processes governing landscape evolution. In this study we focus on landslide events, which also have critical implications in Natural Hazard assessment.

Several works have shown that landslides can be described as processes characterized by self-organized criticality. Based on this, the distribution of landslides in the Umbria Region (Central Italy) was analysed by means of fractal techniques. Statistical self-similarity in space was investigated by applying the box-counting method and the Grassberger-Procaccia algorithm to the inventory map of landslide trigger points. Results showed the existence of fractal scaling and provided an estimate of the Capacity Dimension (D_0) and Correlation Dimension (D_2) of the sample, the latter expressed as the mean regional value. The characteristic minimum distance of landslides was extrapolated from the lower scaling limit for D_0.

In order to investigate the spatial pattern of landslides, artificial point maps were generated. Three different distributions were imposed on the points: i) uniform distribution, ii) random distribution and iii) cluster distribution. The box-counting method was applied to each distribution and the calculated Capacity Dimensions were compared with that of the natural sample. Results showed that landslides in the Umbria Region display spatial clustering. In addition, the D_0 measured for the uniform distribution, lower than 2, highlights that the statement that a D_0 equal to 2 indicates a uniform distribution of points in a 2-dimensional space must be carefully considered on a case by case basis, since the shape of the embedding space strongly affects its value.

Additional analyses were carried out to address the problem of the “edge effect” in the computation of D_2, which results in the underestimation of its value and may lead to incorrect interpretations of the statistical distribution of points. We propose a GIS-based approach to estimate correlation among points in terms of density. This approach enables us to efficiently treat also points near the boundaries, thus avoiding the loss of information. By applying this method, a scaling behavior was identified in the variation of the density of landslides in their neighborhoods.