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Fractal statistics of landslides in the Rif belt (Morocco)

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Landslides exhibit fractal (power-law) frequency-size distributions in different geological conditions, and are generally modelled as self-organized critical phenomena.

We have analysed the frequency-area statistics of landslides in Tetouan region, located in the Rif mountains (northern Morocco), considering an inventory of about two thousands landslides. The data set contains different types: rock falls, flows, slow movements (creeps), simple and complex landslides.

The cumulative frequency-area distribution of all landslides, without consideration of their types, does not show a simple power-law relation, but can be fitted by two linear segments with two exponents (b_1= 0.89 and b_2= 1.87).

The sorting of landslides with regard to the type shows that they correlate well with a single power-law for simple slides, flows, and creeps with an exponent b ranging from 1.44 to 1.57. Complex landslides distribution can be fitted either by a power-law (b=1.30) or by a “bifractal” fit with two exponents (b_1=0.68 and b_2 = 1.72). Rock falls show a low value b =0.77.

Regarding the geology and lithology of landslides, the cumulative frequency-area distributions show different behaviours. Marls correlate very well with a simple power-law with bg=1.42. Limestones (falls in general) can be fitted either by a simple power-law (b =0.82) or by a "bifractal" fit with (b_1=0.47 and b_2=1). Flyschs show often a “bifractal” regime.

There is evidence that for some landslide type and lithology a simple power-low is not sufficient enough to fit the overall frequency-size distribution, and then a “bifractal” regime was observed.

The mean conclusion of this work is that the exponents of observed power-law distributions are subject to considerable variability. The fractal exponent is thus not a unique and universal value, but should depend on the type of landslide, lithology, geological setting, and perhaps on the triggering mechanism. The difference the exponents and the subjective choice of the fit seem to be critical for landslide risk assessment.