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Green roofs implementation in European cities – A fractal analysis

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Green roofs have become relatively commonplace over the last 20 years, representing a market of several tens millions of m2 implemented every year in Europe. Considered as Blue Green Solution (BGS), green roofs are particularly efficient to reduce the potential impact of new and existing urban developments by making the city "greener" and more resilient. Indeed, they provide several ecosystem performances, particularly in stormwater management, urban heat island reduction, and biodiversity conservation.

Fractal analysis and the computation of a fractal dimension are tools widely used in geophysics to characterize spatial fields exhibiting strong heterogeneity over wide range of scales. They have also been employed to analyse land cover distribution and the effect of urbanization over landscape. Such fractal analysis is performed here to characterize the spatial distribution of green roofs in urban centres. For this purpose, the space filled by geometrical features (green roofs) in its embedding space is characterized across scales. Initial data at 1 m resolution is used. This study has been conducted in various European cities (London, Amsterdam, Geneva, Lyon) where GIS database containing the location and geometry of implemented green roofs is available. It has been carried out within the framework of the French ANR project EVNATURB (https://hmco.enpc.fr/portfolio-archive/evnaturb/) that aims to assess the ecosystem performances of BGS.

The results show that every studied city depicts similar behaviour with the definition of three distinct scaling regimes. The first corresponds to the inner scales of standard green roofs (between 1 and 16 m). It is characterized by a fractal dimension approaching 2 simply, reflecting the 2D nature of green roofs. The intermediary one (between 16/32 and 512/1024 m) characterizes not only single roofs but their distribution in space which is what we are interested in. Hence it is the most relevant scale range to assess green roof implementation and the focus of this paper. Here the fractal dimension is the most variable, ranging from 0.5 to 1.1, and increasing with the green roofs density. The boundary of the scale range of this regime seems also to be an indicator of green roof distribution. The last regime (between 512/1024 and 16.384 m) exhibits a high fractal dimension, ranging from 1.5 to 1.8. It characterizes the space filled by the green roofs at very large scales.

This analysis should be extended to additional European cities in the future. Such a characterization of the urban environment can then be useful to simulate the distribution of green roofs across scales. It is particularly relevant in environmental modelling to simulate the impacts of spatial distributions of green roof regarding the previously mentioned ecosystem performances.