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Fractal analysis of urban catchments and their representation in semi-distributed models: imperviousness and sewer system

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Land use distribution and sewer system geometry exhibit complex scale dependent patterns in urban environment. This scale dependency is even more visible in a rasterized representation where only a unique class is affected to each pixel. Such features are well grasped with fractal tools, which are based scale invariance and intrinsically designed to characterise and quantify the space filled by a geometrical set exhibiting complex and tortuous patterns. Fractal tools have been widely used in hydrology but seldom in the specific context of urban hydrology.
In this paper, they are used to analyse surface and sewer data from 10 urban or peri-urban catchments located in 5 European countries in the framework of the NWE Interreg RainGain project (www.raingain.eu). The aim was to characterise urban catchment properties accounting for the complexity and inhomogeneity typical of urban water systems. Sewer system density and imperviousness (roads or buildings), represented in rasterized maps of 2 m x 2 m pixels, were analysed to quantify their fractal dimension, characteristic of scaling invariance.
It appears that both sewer density and imperviousness exhibit scale invariant features that can be characterized with the help of fractal dimensions ranging from 1.6 to 2, depending on the catchment. In a given area, consistent results were found for the two geometrical features, yielding a robust and innovative way of quantifying the level of urbanization. The representation of imperviousness in operational semi-distributed hydrological models for these catchments was also investigated by computing fractal dimensions of the geometrical sets made up of the sub-catchments with coefficients of imperviousness greater than a range of thresholds. It enables to quantify how well spatial structures of imperviousness are represented in the urban hydrological models.