Geophysical Research Abstracts
Vol. 21, EGU2019-5261-1, 2019
EGU General Assembly 2019

Hydrological green roof modeling under various climate conditions and building practices

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One of the major effects of the rapid urbanization in many cities around the world is the dramatic increase of sealed surfaces. The green infrastructures, particularly green roofs represent a valid solution allowing nature to return in the urban areas. Beyond the ecological advantages, the implementation of this technology can help to achieve a wide range of benefits including storm water management. Unfortunately, despite a large number of experimental sites, the hydrological behavior of their vegetation layer is still not well-understood and the research in this area is still challenging. In light of this, the current work takes into consideration the daily scale hydrological modelling starting from a conceptual water balance requiring only meteorological data recorded by inexpensive monitoring installations, such as for precipitation and air temperature. The evapotranspiration represents one of the main processes accounted for in the model and it has been estimated a-priori, as a function of meteorological parameters using the Antecedent precipitation index (API) method. To test the model ability in capturing the hydrological behavior of a green roof, the model has been applied to three experimental sites (GR1, GR2 and GR3), located along a European latitude transect. The experimental sites differ in the structural characteristics (types and depths of the layers), the geometry (areal extension and slope) and the climate settings. GR1 is located near Bernkastel-Kues in Western Germany with a temperate climate. It has an area of 22 m2, a depth of 15 cm and a slope less than 5°. The vegetation layer is made of sedum and spontaneous vegetation, the growing medium is a mineral substrate and the water storage/protective layer is a retention Hydrotex membrane. GR2 covers an area of 98 m2, it is located in Tomblaine, north-east of France representing a temperate climate. The sedum cover lies above a substrate of pozzolana and organic media while the drainage layer is made up of expanded clay for a total depth of approximatively 15 cm. GR3 is located in southern Italy and has a surface of 2.5 m2, a depth of 15 cm and a double pitch slope of 1%. The vegetation layer is made up of succulent plants called Mesembryanthemum, the substrate by peat and zeolite, and the drainage layer by modular plastic trays filled with expanded clay. The goodness of fit of the model, applied to the three test plots for long term periods, have been tested comparing the observed runoff values and the simulated ones by means of several statistical indices. Relative errors reach values of 9.14%, 18.18% and 17.21% respectively for GR1, GR2, GR3 confirming the flexibility of the proposed approach, able to predict with a good level of accuracy the hydrological behavior of the three vegetated roofs despite the different configurations and areal extents. Differences appeared in the calibration of the cumulative soil water balance index, which mimics the effect of the evapotranspiration process in restoring the green roofs retention capacity, which appear mainly affected by the areal extent.