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Preliminary study of the hydrologic response of an urban drainage basin at two different scales

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Predicted changes in climate and urban sprawl areas are expected to cause significant modification in rainfall pattern and hydrological regimes. Urbanization can alter the hydrologic response by increasing streamflow, reducing time of concentration, altering soil moisture levels and increasing overland flow, thereby increasing the size, frequency and speed of peak flow responses. However, despite the profusion of works, effective methodologies to investigate the impacts of potential land-use change on how spatial variability of soil moisture and precipitation affect runoff production at a range of scales and on different land uses remain largely undeveloped. This has important implications for flood prediction accuracy.

The main aim of this work is to assess the hydrological response and to understand the influence of different land uses. The study is based on a small urban drainage basin (7 Km2), undergoing rapid urbanization, located in central Portugal: Ribeira dos Covões. It considers a combined approach of field survey and data acquisition to access spatiotemporal dynamics and land uses contributions to surface hydrology, based on drainage basins and small plot scales.

At drainage basin scale, the study is based on three years rainfall and stream flow data analysis (collected through an automatic water level recorder and rain gauges). Rainfall-runoff relationship was assessed over the time and isolated events were studied. To understand land uses on the hydrology, rainfall simulations were conducted at the small plot scale (0.25 m2) during a dry period, in forested and deforested areas, agricultural areas, including tilled and abandoned areas, as well as built-up areas (21 experiments with 1 hour duration, with a rain intensity of 43$\pm$3 mm h-1). During the experiments hydrophobicity was monitored (Molarity of an Ethanol Droplet technique), soil moisture content was assessed every minute, and runoff volume was measured every 5 minutes.

This work has shown the existence of different spatial and temporal variations on hydrological processes. At drainage basin scale, runoff coefficient varied between around 5% of the rainfall for a dry year (2005), to around 15% in a wet year (2007). The hydrological response to rainfall simulation experiments is significantly different according to the land use. In agriculture areas overland flow did not occur or was negligible. However, in forest and clear felled areas the overland flow coefficient ranged between 20% and 80% of total rainfall, while in construction areas the values were higher: 55% and 95%. However, the overland flow didn´t seem to be yielded by saturation. Considering the low moisture content when overland flow started, hydrological response in some plots can only be explained by the hydrophobic soil behaviour registered and/or macrospore collapse.

This research confirms the importance of land use in overland flow processes and points out the difficulties in upscalling hydrologic response of complex urban drainage basins. The differences registered in both scales revealed contradictory results, so rainfall simulation results should be interpreted carefully according with the specific antecedent soil conditions and rainfall characteristics simulated.
The abundance of different overland flow generating sources may increase and decrease depending on previous climatic conditions and land use.