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Identifying controls on throughfall variability at the hillslope scale through satellite data and UAV-assisted techniques

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Spatio-temporal variability of throughfall (TF) in forested catchments depends on climatic forcing, forest stand parameters, and rainfall characteristics. Identifying and quantifying these controls is fundamental for a correct analysis and modelling of interception and catchment hydrological response. Despite many studies carried out at the stand and hillslope scale focused on the analysis of controls on TF variability, very little is known about the role of hillslope topography and the associated tree population characteristics in shaping throughfall spatio-temporal variability. In addition to ground-based measurements, satellite and unmanned aerial vehicle (UAV)-data can be explored to obtain a more robust assessment of the main drivers of TF variability. Therefore, this work aimed at i) identifying the dominant factors on throughfall variability in a European beech stand along a steep hillslope; and ii) quantifying forest interception at the hillslope scale and upscaling it at the small catchment scale using ground-level measurements and UAV-derived and satellite observations.

The experimental activities were carried out in the upper part of the Re della Pietra catchment, Tuscany Apennines, Central Italy. The hillslope is roughly 110 m long and 60 m wide, has a mean slope of 30°, and is dominantly covered by European beech trees. The TF experimental plot consists of 126 throughfall collectors divided in two square grids of 144 m^2 with 49 collectors at the bottom and the top of the hillslope, and a transect of 28 collectors from the bottom to the top grid. TF was manually measured from the collectors approximately monthly and compared with gross precipitation. Moreover, five automatic gauges were installed along the hillslope to increase the temporal resolution. Topographic surveys were conducted to measure the main physiological characteristics (diameter, height and age) of the trees in the TF plot. Leaf Area Index (LAI) was estimated using a ceptometer above each sampler in four dates in the dormant and in the growing season.

The 40 manual measurements revealed a large spatial and temporal variability of the TF/precipitation ratio (mean 68%, standard deviation 37%). In the growing period, the TF/precipitation ratio showed higher spatial variability compared to the dormant season (66±29% and 85±31%, respectively), suggesting that the crown expansion can be an important control on TF

variability. Moreover, TF was consistently lower in the bottom plot, characterized by larger tree size compared to the top grid indicating a control by trees size. Event-scale data from the gutter gauges show a rainfall intensity control on TF but showed no correlation between TF and hillslope position.

To corroborate the preliminary observations on crown and tree size, in early March 2023 a UAV survey will be conducted to determine the crown architecture and lateral expansion, and relate this parameters to the observed TF. Furthermore, LAI ground measurements will be compared with LAI data derived from Sentinel-2 data to establish a relation between ground measurements and satellite observations. This relationship will be then use to upscale LAI and its possible associate control on TF variability from the hillslope to the small (0.3 km^2) catchment scale.