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Modification of rainfall stable isotopes by throughfall and stemflow. The case of Scots pine and downy oak forest under Mediterranean conditions.

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In forested ecosystems the isotopic composition of rainfall that reaches the soil either as throughfall or stemflow is modified by processes that take place in the tree canopies. The known factors that can cause a change in the isotopic composition are evaporation, exchange between liquid and atmospheric vapor, and selective canopy storage for isotopically temporal varying rainfall. These processes are still poorly understood, but they have important implications on the heterogeneities of the input water at the catchment scale. Recent advances suggest that equilibrium exchange and selective canopy storage are the dominant processes, even though there is a lack of data to unambiguously identify them. Here, we present the results of an experiment focused on the characterization of the spatio-temporal variability of the isotopic composition of rainfall, throughfall and stemflow in order to identify the main factors affecting its modification.

The study was carried out between May 2015 and June 2016 in a Downy oak (Quercus pubescens) forest and a Scots pine (Pinus sylvestris) forest located in the Vallcebre research catchments (NE Spain, 42º 12'N, 1º 49'E), under Mediterranean climate conditions. The sampling design for isotopic analysis of each stand consisted of one automatic sampler and 10 throughfall collectors distributed within the stand to collect throughfall, and 4 stemflow collectors to collect stemflow. Bulk rainfall was collected with automatic samplers and bulk collectors in two open areas near each forest stand. At each stand, isotopic sampling was combined with hydrometric measurements that consisted of 20 tipping buckets to measure throughfall and 7 stemflow rings connected to tipping buckets to measure stemflow. Moreover, rainfall depth was measured in the two open areas and meteorological variables in the two stands by means of towers located above canopies. In total 36 rainfall events were analyzed.

Our results revealed a high heterogeneity on the isotopic composition of the open rainfall during the studied period. Enrichment occurred for 74% of the throughfall samples and for 91% of the stemflow samples. In general, enrichment was higher for those rainfall events with a more depleted isotopic composition and of lower magnitude, and stemflow was more enriched than throughfall. Despite the structural differences in the canopy and bark of the species, small differences were found in the ^{18}O enrichment between species. Likewise, small differences were found between winter and summer events. Mean differences between $\delta^{18}O$ of rainfall and throughfall were 0.3 $\pm$ 0.3‰ for oaks and 0.5 $\pm$ 0.5‰ for pines; rainfall and stemflow differences were 1.2 $\pm$ 0.7‰ for oaks and 0.9 $\pm$ 1‰ for pines. Even there was a persistence of temporal patterns of throughfall and stemflow volumes in both stands, there was not a clear persistence on the isotopic enrichment.

These results show the complexity of differentiating the processes controlling the isotopic changes of water when passes through the canopies. The analysis of sub-event scale rainfall and throughfall isotopic composition, combined with detailed meteorological data will give us some light on the role of each controlling factor.