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Changes in catchment hydrology in relation to vegetation recovery: a comparative modelling experiment

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Mediterranean mountains have been largely affected by land abandonment and subsequent vegetation recovery, with a general expansion of shrubs and forests. Such a large scale land-cover change has modified the hydrological behavior of these areas, with significant impact on runoff production. Forecasting the trend of water resources under future re-vegetation scenarios is of paramount importance in Mediterranean basins, where water management relies on runoff generated in these areas.

With this purpose, a modelling experiment was designed based on the information collected in two neighbouring research catchments with a different history of land use in the central Spanish Pyrenees. One (2.84 km2) is an abandoned agricultural catchment subjected to plant colonization and at present mainly covered by shrubs. The other (0.92 km2) is a catchment covered by dense natural forest, representative of undisturbed environments. Here we present the results of the analysis of the hydrological differences between the two catchments, and a description of the approach and results of the modelling experiment.

In a statistical analysis of the field data, significant differences were observed in the streamflow response of the two catchments. The forested catchment recorded fewer floods per year compared to the old agricultural catchment, and its hydrological response was characterised by a marked seasonality, with autumn and spring as the only high flow periods. Stormflow was generally higher in the old agricultural catchment, especially for low to intermediate size events; only for large events the stormflow in the forested catchment was sometimes greater. Under drier conditions, the relative differences in the stormflow between the two catchments tended to increase whereas under wet conditions they tended to be similar. The forested catchment always reacted more slowly to rainfall, with lower peakflows (generally one order of magnitude lower) and longer recession limbs.

The modelling experiment aims at separating the effect of land cover from other differences (e.g. catchment area, morphology) between the two catchments. This approach allows us to make general statements on effects of land cover, required for future predictions for larger areas. In our modelling experiment, a process-based distributed hydrological model is used for the two catchments. First, we calibrate the model using data from the two catchments until a single set of parameters valid for both is found. With this set of parameters and considering a given meteorological driver (due to their proximity, it can be considered the same for both catchments), runoff at the outlet of each catchment is simulated. Land cover is then swapped between catchments and a new runoff simulation is performed for each "swapped" catchment, using the same set of parameters and the same meteorological driver. The effects of the land cover change are determined by analysing the differences between the first and the "swapped" simulations.

This study is based on an analysis of the hydrological differences of two catchments with different history of land use, and a comparative modelling experiment applied to them. Following this approach, we attempt to advance our understanding of the effects of land-use/land-cover changes in catchment hydrology and, ultimately, anticipate their hydrological consequences under a future re-vegetation scenario.