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Experiences with semi-distributed hydrological modelling in a small Mediterranean mountain research basin: TOPMODEL at Vallcebre (South-Eastern Pyrenees).

F. Gallart (1), J. Latron (1), P. Llorens (1), and K.J. Beven (2)

(1) Institute for Environmental Aseessment and Water Research (IDAEA), CSIC, Barcelona, Spain (fgallart@ija.csic.es, +34-93-4110012), (2) Environmental Science/Lancaster Environment Centre, Lancaster University, Lancaster, UK

Research in the Vallcebre basins (0.15-4.17 km2) started 20 years ago with the objective of better understanding the hydrological functioning of Mediterranean mountains that were used for agriculture and extensive grazing in the past and are subject to land abandonment in the last decades.
Two of the sub basins (Cal Parisa and Can Vila) show characteristics adequate for the application of TOPMODEL: topography is sloping, bedrock is water tight, saturated areas appear and are dynamic during wet periods, and the extent of impervious areas prone to Hortonian overland flow is limited. Two major exercises were conducted in these sub basins with TOPMODEL.
In a first application, the spatial pattern of Molinia coerulea patches, a hydrophytic grass which grows in frequently water-logged soils, was compared with the TOPMODEL topographic index map in the Cal Parisa sub basin. Furthermore, a tentative parameterisation of TOPMODEL using flow recession and soil moisture data was performed and observed and predicted basin responses were compared. The results showed that the frequently saturated areas had a bi-modal distribution of topographic index values, one mode attributed to the general topography of the basin and the other (with lower values) to the role of old agricultural terraces. The terraces generate saturated areas in drier situations than those expected by the main topography, causing an increase of saturated overland flow and a decrease of baseflow, in comparison with a non-terraced basin. These results were not validated nor refuted afterwards, although the analysis of the response time of this basin demonstrated a delay of flows when compared with the response times expectable for saturated overland flow in basins of similar size.
The second experience, carried out in the Can Vila basin, consisted of the use of internal basin information (depth to the water table and extent of saturated areas) to gather information on TOPMODEL parameters using the GLUE approach. The results demonstrated that when TOPMODEL was calibrated with flow data, it showed a good performance for simulating total discharge during wet periods, but the predictions for the relative baseflow contribution were extremely uncertain. The use of the internal information meant a strong decrease of the uncertainty of baseflow contribution and a more robust simulation of discharge. Yet the approach is adequate for use in poorly gauged basins as only scattered flow and internal data but no continuous discharge, precipitation and weather records are required.
Although the hydrological functioning of this basin does not fully follow TOPMODEL assumptions (the spatial distribution of saturated areas is partly controlled by sub-grid features such as agricultural terraces, events after the summer are poorly simulated, water table becomes discontinuous and recession flows decline rapidly during dry spells) the overall model performance is satisfactory during the more active part of the year and provides an adequate framework for guiding field observations and further modelling developments.
Consequently, research is in progress on the spatial distribution of water table particularly during and after dry periods (17 piezometers network) and on the development of a model (TOPBAL) that keeps parameter parsimony and the saturated store arrangement of TOPMODEL but expands the simulation of evapotranspiration, allowing different types of vegetation and two-way flows between unsaturated and saturated stores.