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Importance of the spatial heterogeneity in the non-linear response of a small Mediterranean catchment

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It is well known that Mediterranean catchments are characterized by a complex hydrological behavior and strong non-linearities (Ye et al., 1998, Piñol et al., 1999). Therefore, modeling hydrology of a small Mediterranean catchment still represents a great challenge for modelers. To this end, the practical superiority of distributed or semi-distributed approaches over lumped ones remains an open question (see e.g. Loague and Freeze, 1985; Michaud and Sorooshian, 1994; Refsgaard and Knudsen, 1996; Loumagne et al., 1999; Zhang et al., 2003). In fact, a variety of earlier studies have inter-compared distributed versus lumped model simulations reaching opposite conclusions.

With the present work, we tried to answer the following research question: Are observed non-linearities due to spatial heterogeneity or to non-linear mechanisms that should be taken into account in a model conceptual scheme? To address these issues the hydrological modeling of the Can Vila catchment (Vallcebre, Eastern Pyrenees, Spain) was carried out. Three hydrological models were considered: two lumped models called LU3 and LU4 (Medici et al., 2008), and a fully distributed model called TETIS (Francés et al., 2007). The TETIS model has the same conceptual schema as the LU3 model at cell-scale and the LU4 model's structure is based on the LU3 model, but it splits the aquifer storage in two tanks: shallow aquifer and deep aquifer. Percolation to the deep aquifer occurs only when soil water content exceeds a threshold value. So, the difference between the LU3 model and the TETIS model is the incorporation of the spatial heterogeneity and the difference between the LU3 model and the LU4 model is an additional strong non-linearity with the threshold which actives the deep percolation.

The graphical comparison with the observations and the goodness of fit indexes employed showed that: (1) the LU3 model could not reproduce reasonably well the wet and dry period with the same set of parameters while (2) the LU4 and the TETIS model gave similar results and much better than the LU3 model's results. However, a multi-criteria analysis was done and the concept of Pareto Optimal (Bastidas, 1999) was employed to determine which model (LU4 or TETIS) was more suitable to represent the observed behavior of this small Mediterranean catchment. This analysis showed the higher capability and robustness of the distributed model to reproduce the complex hydrological behavior observed in this catchment.