Geophysical Research Abstracts
Vol. 13, EGU2011-12518, 2011
EGU General Assembly 2011

Modelling the contribution of surface and groundwater flows to runoff in a volcanic tropical catchment in the French West Indies

Lai Ting Pak (1,2), Marc Voltz (3), François Colin (2), and Philippe Cattan (1)

(1) CIRAD, UPR26, Station de Neufchâteau, Sainte-Marie, 97130 Capesterre-Belle-Eau, France (pak@supagro.inra.fr), (2) SupAgro, UMR LISAH, 2 Place Pierre Viala, 34060 Montpellier, France, (3) INRA, UMR LISAH, 2 Place Pierre Viala, 34060 Montpellier, France

In humid tropical regions with volcanic substrata, surface and groundwater flows can both contribute significantly to catchment runoff given the large and intense rainfalls and the soils with high infiltration capacities (Charlier et al, 2008, Hydrological Processes, 22, 22, p.4355-4370). A coupled modelling of surface and groundwater flows is required to model the hydrological behaviour in such regions. In this work we applied and evaluated a simplified approach that simulates the two fluxes and their interactions and that can cope with both the strong heterogeneity of aquifer geometry, due to the randomness of volcanic deposits, and the large spatial variation of land use.

This approach was performed on a catchment of 17.8 ha, cultivated with bananas in the French West Indies. The catchment is characterized by abundant rainfall (4229 mm year-1), very permeable Andosols, and two overlapping aquifers. An extensive experimental survey of rainfall (four bucket rain gauges), runoff (a gauging station at the outlet) and piezometric measurements (five shallow piezometers and three deep piezometers), conducted in 2004, is used for the present modelling approach.

The modelling system was based on linking two models. One is a distributed surface model, MHYDAS (Moussa et al, 2002, Hydrological Processes, 16, 2, p393-412), which simulates infiltration and Hortonian runoff at the field scale and its routing from the fields to the catchment outlet. The other is the three-dimensional finite-difference groundwater flow model, MODFLOW (McDonald and Harbaugh, 1988, USGS Book) which simulates water flow in the groundwater zone and its interaction with the hydrographic network. Two-way interactions are considered, namely surface water on groundwater and groundwater on surface water. The recharge input data in the groundwater model simulation are fixed by the simulated surface water infiltration, whereas stream runoff of the surface model simulation is influenced by the simulated aquifer drainage (from aquifer to network) by the groundwater model. A simple iteration approach ensures the convergence of the boundary conditions and outputs of the two models.

Results showed that the performance of the modelling system was satisfactory for simulating catchment runoff. It accounted for large difference in flood events given the modelling period, from January to December 2004, includes the rainiest storm events since 1952. Noticeably, the simulation of high flooding was accurate; the Nash and Sutcliffe coefficient (NS) of stream discharge was 0.90 during calibration and 0.77 during validation. However, performances of the modelling system were disappointing for underground transfers; the NS of logarithm of stream discharge was 0.64 during calibration and 0.47 during validation. The simulation of the shallow and deep water levels should be investigated to account for the spatial distribution of groundwater levels.

The modelling step helped describing and understanding the hydrological behaviour in volcanic humid tropical regions. The main cropping system on the catchment is banana, a plant with a large stemflow component which promoted runoff production at the plant base. However, the shallow groundwater, which is promoted in such permeable soils under abundant rainfall, was the main contributor to stream runoff.