

RECESSION ANALYSIS AND HYDROGRAPH SIMULATION OF THE HUPSELSE BEEK CATCHMENT, THE NETHERLANDS

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1. INTRODUCTION

Linear reservoirs are often used as components of parametric rainfall-runoff models, but nonlinear relations may often be closer to reality and more suitable for that purpose. Kirchner (2009) introduced a method to determine nonlinear reservoir coefficients and to implement them in a simple model. The objective of this study is to examine whether this approach is applicable to the 6.5 km² Hupselse Beek experimental catchment, where soil physical processes play a more important role in the rainfall-runoff process than in catchments where the method has been applied originally.

Large parts of this abstract are copied from a manuscript that we have submitted to Hydrological Processes [2].

2. RECESSION ANALYSIS

Recession coefficients were obtained with a method described by Kirchner (2009), in which the recession rate $-dQ/dt$ is supposed to be a function of discharge Q when there is no precipitation and evapotranspiration:

$$-\frac{dQ}{dt} = a \cdot Q^b$$

Results show that the rainfall-runoff process in the Hupselse Beek catchment behaves strongly nonlinearly ($a=0.20$, $b=1.77$). The recession exponent b obtained from summer data is larger, which might be explained by the occurrence of by-pass flow and air inclusion during severe storm events. Variation in obtained recession coefficients is significant, with values of b ranging from 1.7 to 2.5.

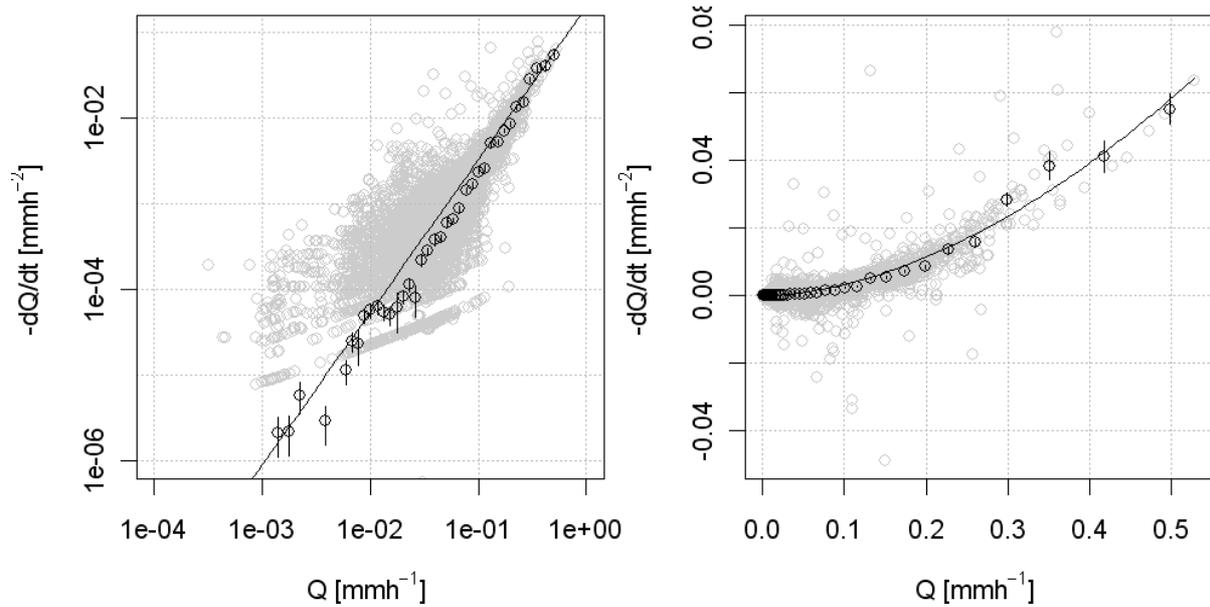


Figure 1. Gray: recession plot from all points with $P=0$ and $ET=0$ ($\Delta t=1h$) on double logarithmic (left) and linear axes (right). Black: mean and standard deviation of all points in a certain bin.

3. RAINFALL-RUNOFF MODEL

The obtained recession coefficients have been employed in a simple rainfall-runoff model (Kirchner, 2009). Unfortunately this did not yield satisfactory results, especially during dry periods: peaks are overestimated, discharge drops too quickly after peaks and the model collapses when evapotranspiration is larger than modeled storage volume (see Figure 2).

Two modifications have been made to the model: (1) a step to compute effective precipitation as input for the model and (2) seasonally varying recession coefficients. Both led to slightly better results.

Three possible explanations for inadequate simulations are given: (1) Processes in the unsaturated zone influence discharge generation. Percolation and capillary rise are not incorporated in the model and the delaying influence of the unsaturated zone is therefore not included, leading to instantaneous reaction of discharge to a rain event. (2) The storage-discharge relation is assumed to be unique. In reality hysteresis and seasonal effects play a role. (3) Capillary rise introduces errors in the recession analysis, which propagate into the model.

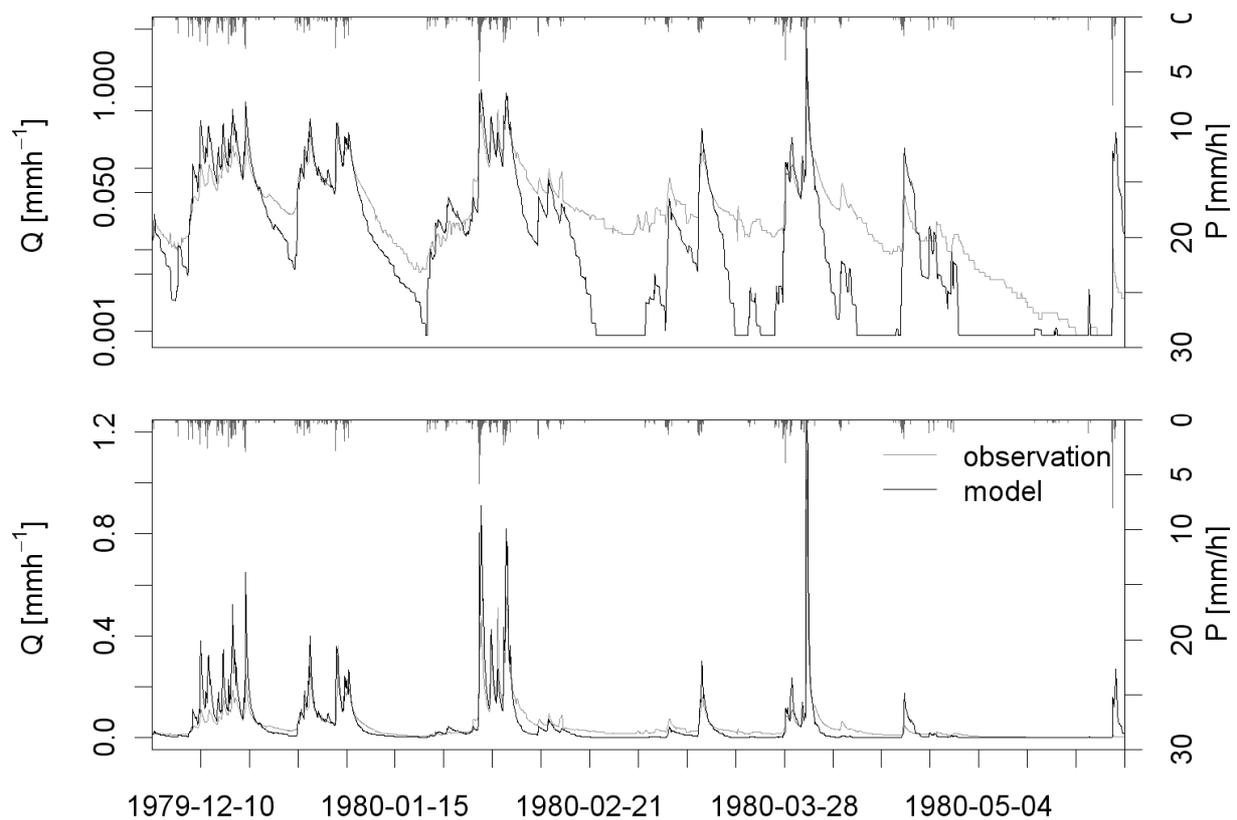


Figure 2. The best model fit: December 1979 - May 1980. Observed and modeled discharge on logarithmic (top) and linear axis (bottom).

4. CONCLUSIONS

These results imply that the modeling approach presented by Kirchner (2009) is not applicable without modification to every catchment. Hydrograph simulation fails in the Hupselse Beek catchment, where soil physical processes play an important role in the rainfall-runoff process. Taking into account the issues encountered during this research, we still think the described method is promising for certain catchments. We found that, like for many other rainfall-runoff models, problems occur when initial moisture conditions in the catchment cannot be ignored.

Perhaps with some alterations this method can be made applicable to more catchments. A next step to improve this method may be to incorporate a soil moisture reservoir, which may lead to a better transformation from precipitation to effective precipitation. Effective precipitation can then be transformed to discharge with the original model and the simplicity of the method would largely be retained.

REFERENCES

Kirchner, J., 2009. Catchments as simple dynamical systems: catchment characterization, rainfall-runoff modeling, and doing hydrology backwards. *Water Resources Research* 45, W02429.

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