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Modelling overland flow during extreme precipitation events: influence of precipitation aggregation level, soil development and climate change

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In this study, the sensitivity of overland flow modelling to selected parameters in a small (several km^2) recharge area in the Campine region, northern Belgium, is investigated. In first instance, the amount of overland flow is estimated according to the temporal resolution of rainfall data. In a second step, the effect of soil development and climate change is incorporated in the model as well.

The study focuses on the extreme event of 23 August 2011, when ∼40 mm of rain fell in ∼25 minutes in the investigation area. Precipitation was recorded with a one-minute temporal resolution. The generation of saturation overland flow during this event is simulated with the van Genuchten-Mualem model (using HYDRUS-1D) for a Haplic Podzol typical of the area. The hydraulic barrier eventually causing overland flow is the Bh horizon at shallow depth, characterised by a saturated hydraulic conductivity (Ksat) of 4.5×10-6 m/s.

The sensitivity of overland flow to the temporal resolution used in the model is investigated for daily, hourly, 20-minute and 10-minute time steps. Results show that the aggregation level has a critical influence on the amount of saturation overland flow, ranging from 0 to 4.0 mm.

Landscape and soil evolution studies in the vicinity of the site indicate that cemented podzols may develop in several thousands of years, thus decreasing the Ksat of the Bh horizon by several orders of magnitude. On this time scale, global climate evolution is also expected to have an impact on the precipitation regime, possibly resulting in more severe extreme events for a given return period. These two processes are simulated respectively by decreasing Ksat by one or two orders of magnitude and by increasing rainfall rate by 4 and 16% (and potential evapotranspiration by 13 and 25%, based on the scenarios for the period 2071-2100 of the CCI-HYDR project; Baguis et al., 2009). Results show that in the most defavourable case, overland flow during the extreme event simulated could increase to 29.8 mm (for the 10-minute temporal resolution), due to soil podzolisation and climate change.

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Reference

Baguis P., Ntegeka V., Willems P., Roulin E., 2009. “Extension of CCI-HYDR climate change scenarios for INBO”, Instituut voor Natuur- en Bosonderzoek (INBO) & Belgian Science Policy – SSD Research Programme, Technical report by K.U.Leuven – Hydraulics Section & Royal Meteorological Institute of Belgium, January 2009, 31 p.