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Hydrological flood forecasting for permeable catchments using extended rainfall-runoff models

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A groundwater model component is formulated for use as an extension of existing rainfall-runoff models so as to improve flood forecasts for permeable catchments. It accommodates common hydrological features that many rainfall-runoff models do not represent: ephemeral streamflow, pumped abstractions, external spring flows and underflows beneath the river gauging station. It also supports simulation of well levels in addition to river flows. Here, the utility for real-time flood forecasting of the groundwater model component is assessed by using it as an extension of the PDM (Probability Distributed Model), a rainfall-runoff model employed operationally in many countries. Two catchments on the Chalk Downs of southern England are used as case studies. A major challenge when introducing the new functionality for permeable catchments is to enforce mass balance in a conceptually meaningful way, paying special attention to the specification of the model inputs. Sensitivity analyses on the forms of model input to use operationally are performed, which quantify the impact of factors such as varying the combination of raingauges used and their weighting, the value of radar rainfall, and the choice of potential evaporation and abstraction records to employ. An emulation of the real-time application of the model in forecast-mode demonstrates its potential to forewarn of the rapid rise in river flow during the onset of major flood events. Model performance assessments highlight the benefit the extended PDM could have for flood warning and advance operation of flood alleviation facilities for permeable catchments.