A soil-based approach to rainfall-runoff modelling in ungauged catchments for England and Wales

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Abstract:
Hydrological models are powerful tools for the investigation of many hydrological issues. The historical approach for the development of rainfall-runoff models, with regard to the choice of model structure and the calibration of the free parameters, has been to focus on gauged catchments where sufficient data, in particular stream flow data, are available. Applications of models were then extended to the case of ungauged catchments. In recent years, it has become apparent that this approach did not lead to satisfying results in ungauged catchments, and that the main focus should instead be on ungauged catchments for the implementation of new modelling strategies. This thesis demonstrates the potential of a new conceptual, catchment-scale, semi-distributed, integrated rainfall-runoff model as a modelling tool in both ungauged and gauged catchments for the assessment of water resources management, land use change or climate changes at the catchment scale. The review of existing model structures and regionalisation methods has lead to the development of the Catchment Resources and Soil Hydrology (CRASH) model following the top-down modelling strategy. The free parameters of the model are directly related to controlling factors of the hydrological processes in the United Kingdom, i.e. soil and land use. The classification of the soils according to their hydrological behaviour is based on the Hydrology Of Soil Types (HOST) system. CRASH also incorporates a novel rainfall disaggregation scheme for the derivation of infiltration excess surface runoff. A regional set of model parameters has been derived from the calibration of CRASH in 32 catchments throughout England and Wales covering contrasting climatic, soil, geological, and land use conditions. The single-site and regional CRASH models performed satisfactorily according to reviewed performance criteria for gauged catchments and to a scoring system proposed for ungauged catchments. However the quality of stream flow data in the UK which was used for the calculation of the regional parameter set, in particular the widespread unavailability of naturalised flow data, tends to limit the performance of the regional CRASH model for low flows.

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those of watershed characteristics. Watershed characteristics which may be mostly readily compared to estimating the volume of runoff that will result from a given amount of rainfall are soil type and cover, which includes land use. In Palestine, availability of runoff records is very limited compared to rainfall records, especially for medium and small catchments. Since discharge values are necessary for such ungauged catchments for the design of various hydraulic structures such as small dam, some analytical models, such as RFDC_cal, are used for rainfall–runoff modelling in ungauged catchments. Suggestions for improving RFDC_cal. Based on this strong relationship between catchment physical properties and the FDC, one may hypothesise that model calibration against the FDC (referred to as the "FDC calibration" hereafter) can provide parameters that can sufficiently capture actual catchment behaviours. Sugawara (1979) is the first attempt at the FDC calibration, emphasising its advantage to reduce negative effects of epistemic errors in rainfall–runoff data. Likewise, we tested several questions relevant to rainfall–runoff modelling in ungauged catchments using different combinations. In Table 3, we summarise the results of paired t tests for scientific questions that may arise from this study.