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Flood frequency estimation by national-scale continuous hydrological simulations: an application in Great Britain

Giuseppe Formetta, Elizabeth Stewart, Victoria Bell, and Nick Reynard
Centre for Ecology and Hydrology, Wallingford, UK giufor@ceh.ac.uk

Estimation of peak discharge for an assigned return period is a crucial issue in engineering hydrology. It is required for designing and managing hydraulic infrastructure such as dams, reservoirs and bridges. In the UK, the Flood Estimation Handbook (FEH) recommends the use of the index flood method to estimate the design flood as the product of a local scale factor (the index flood, IF) and a dimensionless regional growth factor (GF). For gauged catchments the IF is usually estimated as the median annual maximum flood (QMED), while for ungauged catchments it is computed through multiple linear regression models based on a set of morpho-climatic indices of the basin. The GF is estimated by fitting the annual maxima with the generalised logistic distribution (GL) using two methods depending on the record length and the target return period: single-site or pooled analysis. The single site-analysis estimates the GF from the annual maxima of the subject site alone; the pooled analysis uses data from a set of catchments hydrologically similar to the subject site.

In this work estimates of floods up to 100-year return period obtained from the FEH approach are compared to those obtained using Grid-to-Grid, a continuous physically-based hydrological model. The model converts rainfall and potential evapotranspiration into river flows by modelling surface/sub-surface runoff, lateral water movements, and snow-pack. It is configured on a 1km2 grid resolution and it uses spatial datasets of topography, soil, and land cover. It was set up in Great Britain and has been evaluated for the period 1960-2014 in forward-mode (i.e. without parameter calibration) using daily meteorological forcing data.

The modelled floods with a given return period (5,10, 30, 50, and 100 years) were computed from the modelled discharge annual maxima and compared to the FEH estimates for 100 catchments in Great Britain. Preliminary results suggest that there is a good agreement between modelled and measured floods with a correlation coefficient that ranges from 0.8 for low return periods to 0.65 for the highest. It is shown that model performance is robust and independent of catchment features such as area and mean annual rainfall. The promising results for Great Britain support the aspiration that continuous simulation from large-scale hydrological models, supported by the increasing availability of global weather, climate and hydrological products, could be used to develop robust methods to help engineers estimate design floods in regions with limited gauge data or affected by environmental change.