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Large-scale groundwater modelling of the UK : creation of return period-based groundwater surfaces

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Large-scale groundwater modelling of the UK: creation of return period-based groundwater surfaces

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Abstract: Groundwater flooding in the UK affects 100,000s of properties and in the winters of 2000/1 and 2013/14 caused widespread disruption. The groundwater flooding which occurred during these winters affected transport links for many weeks or months as well as threatening water supply and waste water treatment infrastructure. Groundwater flooding as a phenomena is mainly related to the chalk outcrop in southern England. To predict how groundwater flooding affects properties with respect to increased flood risk a methodology that creates groundwater surfaces with given return periods has been developed. Its basis is a numerical groundwater model of the chalk aquifer for England, stretching from Yorkshire down to Dorset (525 kilometres). Given the model size, the hydraulic conductivity (K) distribution is parametrised using a relationship between distance to river and size of river (mean flow). A relationship is developed for K and distance to river as well as mean flow based on two parameters. These parameters are calibrated using pumping test data and river geometry / flow summaries for four areas of the chalk outcrop.

The groundwater flow model is then calibrated for the period 1962 to 2014 against groundwater hydrographs. Annual maxima are used to create head vs return period relationships at every model node at the chalk outcrop. Various approaches, i.e. Gumbel are chosen depending on the best fit with the annual groundwater head maxima. Groundwater heads at each model node for the requisite return period (30, 75, 100, 200, 250, 500, 1000 years) are then used to create groundwater surfaces. These surfaces are then combined with a surface water model to simulate overland flow, for which flooded extent is modelled. The modelling workflow from recharge model driving the groundwater model through to creating the return period defined surfaces is described and results presented. It is believed that this is the first large-scale groundwater model to simulate groundwater flooding and so the challenges overcome during the process are summarised.

Keywords: Groundwater; flooding; return period; model; United Kingdom