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A numerical study of the impacts of climate change on surface hydrological connectivity in an upland environment

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For a surface hydrological connection to be made across a landscape, there has to be a complete transmission flow path from the point of runoff generation to the receiving water. In the case of a saturation excess overland flow driven system, for the flow to be connected to the receiving water, the flow path needs to also be saturated. Therefore, by tracing the flow paths across a map of soil moisture, it is possible to predict which parts of the landscape are connected to receiving waters at a point in time. By considering a time series of soil moisture patterns, a number of indices can be developed that show the spatial dynamics of surface flow hydrological connectivity. The first of these indices relates to the mean amount of time that a point is considered to be connected. This index is important for the total volume of water and associated pollutants, such as fine sediment and phosphorous, that may connect to the receiving waters. The second index relates to the number of connection - disconnection cycles that occurs. This index is important for supply limited processes whereby an increase in the number of connection - disconnection cycles may exhaust the supply. An increase in the number of cycles may alter the annual temporal pattern of water or pollutant delivery to the water course. The spatial patterns of soil moisture have been predicted with the hydrological model CAS-Hydro 1.1. This model is physically based, time explicit and organised on a grid structure. The model simulates the processes of interception, evapotranspiration, infiltration, runoff generation, overland flow, lateral and vertical flow through the soil and river channel flow. The grid structure is coupled with the FD8 multiple flow routing algorithm which allows the complex flow patterns to develop. The physical process basis and detailed flow routing allow spatial soil moisture patterns to develop as a function of the model dynamics. These feature make CAS-Hydro

a suitable model to use in this study. The model has been applied to the Upper River Rye, Yorkshire, UK. This catchment covers 13.1 km2 and the land cover is moor land, grassland and a small area of woodland. The model has been tested against historical rainfall and discharge data and was able to reproduce the observed discharge hydrograph with a Nash-Sutcliffe coefficient of 0.7. The model has been applied to current and a possible future climate. The possible future climate is based on predictions from the HadCM3 global climate model using the medium high scenario for the 2080's. The rainfall was downscaled to daily rainfall using the SDSM weather type approach and to storm rainfall using the Monte Carlo storm rainfall generator in CAS-Hydro. The connectivity indices predict from the model simulation results in an expansion of the areas connecting to the river channel under climate change conditions. A number of new areas connect to the receiving waters that did not previously. The results predict a large change in the number of connection - disconnection cycles with many areas greatly increasing the number of cycles per year. These changes in surface hydrological connectivity have the potential to alter the location of critical source areas for diffuse pollution with previously disconnected areas contributing pollutants to the river channel network.