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Evidence for the occurrence of infiltration excess overland flow in an eroded peatland catchment and implications for connectivity in a changing climate

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Overland flow generation is a crucial process in catchment hydrology and how this varies in space and time is a key influence on connectivity at the catchment scale. In peatlands it has generally been found that overland flow is the most important runoff pathway, particularly during stormflow, and most models suggest that overland flow is almost exclusively produced as saturation excess.

Traditionally, overland flow production in peatlands has been examined by the use of crest-stage tubes. However, as these need to be manually monitored and emptied, the temporal resolution of measurements is necessarily limited. This paper presents a new type of overland flow sensor which is capable of monitoring at high spatial and temporal resolutions. The sensor design utilises electrical resistance technology to detect water between a pair of electrodes, allowing a binary distinction to be made between the presence and absence of overland flow. This has given rise to the collection of an unprecedented high resolution dataset on overland flow production in peatlands.

The sensors were deployed in the Upper North Grain research catchment, an eroded peatland in the south Pennines, UK. Data were collected in two phases. From May to July 2008 a network of 43 sensors was located at the head of an erosional gully. From September to November 2008 a network of 40 sensors was located at a gully edge site. The data collected by the sensors demonstrates that overland flow production is widespread, occurring frequently at both the gully head and the gully side sites. Overland flow is produced via saturation excess at the gully head site following wet antecedent conditions. However, there is significant evidence to suggest that infiltration excess overland flow dominates at the gully side site and is also produced at the gully head site following very dry conditions. This is thought to occur due to drying of the peat by water table drawdown which causes the peat to become hydrophobic to the extent that incident rainfall cannot infiltrate. The relationship between overland flow production and discharge at the catchment outlet is also explored.

The apparent importance of infiltration excess overland flow has hitherto not been widely acknowledged and as such this represents a major advancement in our current knowledge of the dominance of various runoff mechanisms in peatlands. One of the implications of these findings is that flow regimes may be significantly affected by climate change. This could effectively lead to the dominant overland flow process shifting from saturation excess to infiltration excess as expanses of the peat surface become hydrophobic. In addition, the generation of infiltration excess overland flow has implications for the timing of stormflow delivery and may lead to shorter lag times and higher flood peaks. With a focus on the need to understand the behaviour of peatland systems under future climate change scenarios, the high resolution data collected in this study provides a good basis for the development and testing of process based models of peatland hydrology.