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Modelling Nitrogen Cycling Within an Upland Catchment: the Development and Application of the Fully Distributed Model, CAS-HYDRO

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The predicted levels of climate change over the course of this century have the ability to impact the water quality of many temperate river systems. This is due to the changes in the nature of the rainfall effecting the hydrological functioning of catchments and the changes in temperature altering process rates. The key changes which will drive any change in water quality will occur in the terrestrial environment - e.g. changes in soil moisture and temperature effect process rates and the changes in the hydrological connectivity of the landscape and river channel systems. To assess the extent of the potential impacts on the nitrogen section of the water quality, a simulation model capable of responding to the changes in climate is required. To capture these changes the model must operate at the catchment scale and have a detailed spatial representation. For this model to be successful, it must balance the complex nature of the nitrogen cycling process with the available data for large catchments and the ability to parameterise the model at these scales.

The developed model couples the hydrological process representation from the CAS-HYDRO model with an elegant yet simple representation of the nitrogen cycle. To represent the spatial variability of both the hydrological and nitrogen cycling processes, the model is based on a fully distributed grid structure at a resolution of 100 metres. This grid is coupled with a separate river channel network model operating with 100 metre reaches. It is possible to output the model status, in terms of hydrology or nitrogen variable, at each of these modelling elements. This means that the model is able to give both detailed temporal and spatial predictions of the nitrogen and hydrological status of the catchment.

The model represents the nitrogen cycling processes in both the terrestrial and aquatic

environments. In both environments, the processes of ammonification, nitrification and denitrification are simulated. In the terrestrial environment, the uptake of nitrogen by vegetation in the terrestrial environment and the additional of nitrogen from deposition and fertiliser applications are also simulated. The process rates for each process are calculated from rate equations driven by the current soil moisture and temperature. The soil moisture dynamics and the transport of nitrogen are simulated by the hydrological model.

The model has been applied to the Upper Rye catchment, North Yorkshire, UK. This catchment is characterised by a mix of heath land and grassland and covers 177 km2. Although the model is in the initial stages of development, it is able to produce time series of in-stream nitrogen concentrations which related well to the measured data. The Upper Rye catchment has a limited number of nitrogen samples which makes undertaking a full model assessment difficult. The next stage in the model development is to apply the model to an instrumented catchment with a detailed nitrogen concentration time series. This will enable the full model assessment and the undertaking of uncertainty analysis.