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CAS-HYDRO: An Object Orientated, Hydrological and Water Quality Model: Design and Assessment

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The CAS-HYDRO model has been designed to simulate the movement of water and nutrients through a catchment. The model has a fully distributed spatial structure and runs on a continuous temporal representation. This detailed level of representation make the model suitable for the simulation of the catchment hydrological response to changing rainfall and temperature patterns, such as predicted future climates.

The model has been implemented using an object orientated design in C++. This design approach has resulted in a model that is simple to maintain, debug, adapt and extend. There are two key types of objects in the design: the water object and the cell object. The water object represents a parcel of water with its associated solutes that can be moved through the environment. This water object may be split or merged with other water objects. This ensures that the solutes are moved with the water and that it is simple to add additional solutes to the model. The cell object represents the environmental processes occurring at a point in the landscape. A collection of these cell objects are held within the model with each instance of the object representing a different section of the landscape.

The simulation of environmental processes has been split into two domains, the terrestrial and the aquatic. In the terrestrial domain, the model simulates the movement of water through the vegetation, surface storage, infiltration, overland flow, through flow, percolation to groundwater and the connection with the aquatic domain. At each cell in the terrestrial domain, the nitrogen cycling processes of ammonification, nitrification, denitrification ands vegetation uptake are simulated. The nitrogen is able to move between cells and into the aquatic domain. Within the aquatic domain, water and nutrients are moved between the different reaches of the river channel network. Within each reach both nitrogen and oxygen processes are simulated. The nitrogen processes

simulated are ammonification, nitrification and denitrification. The oxygen processes simulated to maintain the in-stream oxygen balance include re-areation, biochemical oxygen demand and oxygen used by the nitrification process.

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, with an area of 177 km2. The model has been subjected to multi-parameter sensitivity analysis and multi-objective model assessment. The multi-objective model assessment was based on both the Nash-Sutcliffe Model Efficiency (NSE) and the Mean Absolute Error (MAE) statistics. This combination of statistics ensures that the behavioural model parameter sets are able to perform for both the high and low flow sections of the hydrograph. Using the behavioural parameter sets, the average NSE value was 0.700 +- 0.018 and the MAE was 0.285 +- 0.019. This shows that the model is capable to accurately re-producing the measured discharge hydrograph. Further testing and assessment of the water quality sections of the model are still required. However, the initial stages of the water quality model assessment have shown that the model is capable of producing a time series of nitrogen concentrations that relate well to the measured data.