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Integrating 3D geological information with a national physically-based hydrological modelling system

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Robust numerical models are an essential tool for informing flood and water management and policy around the world. Physically-based hydrological models have traditionally not been used for such applications due to prohibitively large data, time and computational resource requirements. Given recent advances in computing power and data availability, a robust, physically-based hydrological modelling system for Great Britain using the SHETRAN model and national datasets has been created. Such a model has several advantages over less complex systems. Firstly, compared with conceptual models, a national physically-based model is more readily applicable to ungauged catchments, in which hydrological predictions are also required. Secondly, the results of a physically-based system may be more robust under changing conditions such as climate and land cover, as physical processes and relationships are explicitly accounted for. Finally, a fully integrated surface and subsurface model such as SHETRAN offers a wider range of applications compared with simpler schemes, such as assessments of groundwater resources, sediment and nutrient transport and flooding from multiple sources. As such, SHETRAN provides a robust means of simulating numerous terrestrial system processes which will add physical realism when coupled to the JULES land surface model.

306 catchments spanning Great Britain have been modelled using this system. The standard configuration of this system performs satisfactorily (NSE > 0.5) for 72% of catchments and well (NSE > 0.7) for 48%. Many of the remaining 28% of catchments that performed relatively poorly (NSE < 0.5) are located in the chalk in the south east of England. As such, the British Geological Survey 3D geology model for Great Britain (GB3D) has been incorporated, for the first time in any hydrological model, to pave the way for improvements to be made to simulations of catchments with important groundwater regimes. This coupling has involved development of software to allow for easy incorporation of geological information into SHETRAN for any model setup. The addition of more realistic subsurface representation following this approach is shown to greatly improve model performance in areas dominated by groundwater processes. The resulting modelling system has great potential to be used as a resource at national, regional and local scales in an array of different applications, including climate change impact assessments, land cover change studies and integrated assessments of groundwater and surface water resources.