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Towards understanding the dynamics of environmental sensitivity to climate change: introducing the DESC model

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The DESC model seeks to explore the interactions that exist between Earth systems at a range of spatio-temporal scales by coupling current landscape evolution modelling technologies to a host of new geo-processing modules. DESC currently uses the well established CAESAR model (Coulthard and Van De Wiel, 2006) as its kernel; a two-dimensional cellular automaton landscape evolution model which has a modular design and great versatility in the range of simulated spatio-temporal scales. Initial research focused on the loose coupling of CAESAR to the groundwater flow model ZOOMQ3D, investigating the role of groundwater on sediment transport at the catchment scale. The Eden Valley (Cumbria, UK) was selected as a test bed for the coupled model and results suggest that although the volume of sediment transport through the catchment is not altered, the distribution of sediment erosion and deposition in the simulation is perturbed by the interplay of baseflow conditions and storm intensity and frequency.

In order to reduce processing time, the groundwater module was replaced by a cellular, distributed, coupled surface-subsurface water flow model. The updated hydrological model has decreased data storage needs and a simulation time in the region of two orders of magnitude faster than the original, whilst continuing to calculate a range of hydrological parameters at individual nodes. The surface model was developed by simplifying and improving a single layer soil moisture water balance model (FAO, 1998) to simulate surface runoff and groundwater recharge. Spatially distributed soil types, vegetation types, near surface soil moisture, evapotranspiration, and distributed rainfall are considered in calculating the soil water balance, and a new method was developed to simulate the surface runoff and groundwater recharge. The latter two are based on baseflow indices (for different soil types), ground surface slope and rainfall intensity, and are used to identify excess water where soil reaches saturation. The groundwater model component was established using an explicit macroscopic cellular automata modelling technique that passes water between adjacent cells based on Darcy's law. The groundwater model is linked to the surface water model through the recharge and baseflow components.

With the completion of DESC it is envisaged that a variety of climate-derived, looped feedback research can be undertaken at daily to centennial timescales. Initial research will investigate sediment transport in the Eden Valley and compare this to the work undertaken using the coupled ZOOMQ3D-CAESAR model. With the increase in hydrological variables available from implementing the updated model, improvements are being made to the way landslides and vegetation are handled by the code. A finalised version of DESC will act as a base from which a variety of climate-derived, looped feedback research can be undertaken at daily to centennial timescales.