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The application of GEOtop for catchment scale hydrology in Ireland

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GEOtop represents the new generation of distributed hydrological model driven by geospatial data (e.g. topography, soils, vegetation, land cover). It estimates rainfall-runoff, evapotranspiration and provides spatially distributed outputs as well as routing water and sediment flows through stream and river networks. The original version of GEOtop designed in Italy, includes a rigorous treatment of the core hydrological processes (e.g. unsaturated and saturated flow and transport, surface energy balances, and streamflow generation/routing). Recently GEOtop was extended to include treatment of shallow landslides. The GEOtop model is built on an open-source programming framework, which makes it well suited for adaptation and extension. GEOtop has been run very successfully in a number of alpine catchments (such as Brenta) but has not been used on Irish catchments before.

The cell size used for the spatially distributed inputs varies from catchment to catchment. In smaller catchments (less than 2000ha) 50 by 50m cells have been used and 200 by 200 for larger catchments. Smaller cell sizes have been found to significantly increase the computational time so a larger cell size is used providing it does not significantly affect the performance of the model. Digital elevation model, drainage direction, landuse and soil type maps are the minimum spatial requirements with precipitation, radiation, temperature, atmospheric pressure and wind speed been the minimum meteorological requirements for a successful run. The soil type maps must also contain information regarding texture and hydraulic conductivity.

The first trial of GEOtop in Ireland was on a small 1524 ha catchment in the south of Ireland. The catchment ranges from 50 to just over 200m, the land use is predominately agricultural grassland and it receives on average 1400mm of rain per year. Within this catchment there is a meteorological tower which provides the meteorological inputs, soil moisture is also recorded at this location. GEOtop was run from the end of April 2006 to December 2007. A comparison of measured and simulated values of soil moisture showed some good results and proved that the model could be successfully be used in Ireland.

Following initial success in modelling soil moisture in a small catchment GEOtop was then used in the much larger 115,000 ha Blackwater catchment. The variation of soil type within the catchment was obtained from a national soils database while Landuse data was obtained from the national Corrine Land use database. Hydraulic properties were estimated by carrying out on site infiltration experiments. As GEOtop can accept multiple rainfall inputs and it was known that the rainfall varies substantially within in the catchment it was decided to make use of a rainfall study on the Blackwater catchment. A total of 21 rain gauges were deployed around the catchment for year 2006. The data from these 21 rain gauges were then added to the inputs which GEOtop interpolated the rainfall using the kriging method.

Continuous flow is recorded at the outlet of the Blackwater catchment and as GEOtop simulates stream flows we were able to see how well GEOtop modelled the hydrology of the catchment. Comparisons of simulated versus real flow showed that GEOtop was providing us with satisfactory results. Once we were satisfied that GEOtop was successfully modelling the catchment we were able to see the effects of varying rain fall and land use on many different hydraulic parameters such stream flow, soil suction potential, soil moisture content etc.

When this process has been carried out for other parts of the country it is planned to use GEOtop study potential threats to soil quality such as erosion, surface sealing, compaction, landslides and loss of organic matter. New modules will be develop for GEOtop to help understand and quantify these threats. The model will also be used to help understand the interactions between soil hydrology, land use and climate change (with climate projections from the IPCC fourth assessment). These outputs will be combined with Irish geo-spatial data to develop a GIS-

based risk assessment tool to predict impacts on soil quality based on hydrology, land use and climate change.