The Application of GEOtop for catchment scale hydrology in Ireland

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Introduction

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) Rigon et al 2006. 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.

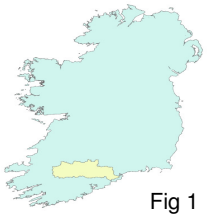

Fig 1

Blackwater Catchment

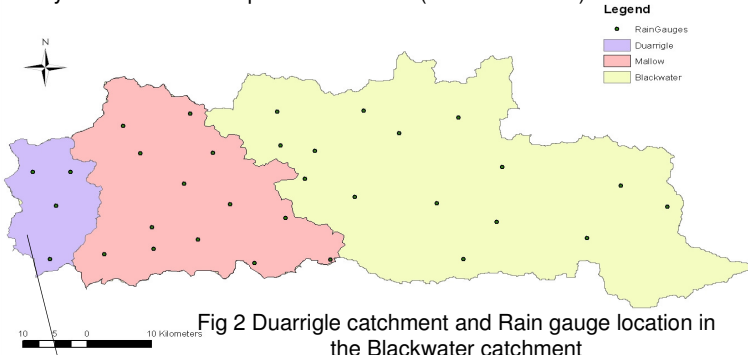

Fig 2 Duarrigle catchment and Rain gauge location in the Blackwater catchment

Study Area

The Blackwater catchment in southern Ireland has a total area of 3324 km^2 and runs in an East-West direction (Fig 1). In 2006 a network of 32 rain gauges was setup in the Blackwater catchment which recorded hourly rainfall values for the full year. This data was as part of a study in to flooding in the Blackwater catchment as a number of town in the catchment regularly suffer from flooding, particularly the town of Mallow. The Rainfall patterns were similar through the catchment but the rain amounts in the west of the catchment were twice that of the east. The annual rainfall in the west were as high as 1600mm while amounts in the east were as low as 770mm.

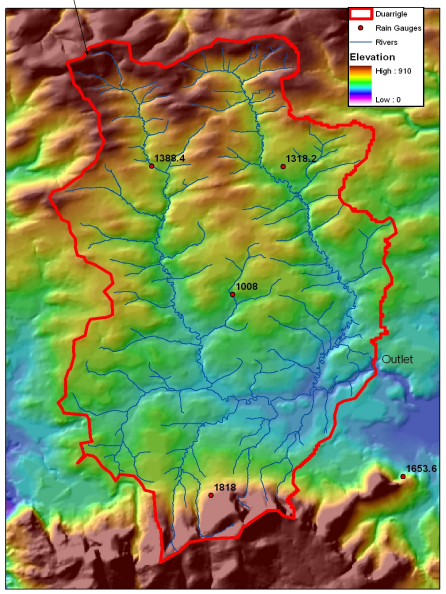

Fig 3 Duarrigle catchment with rain gauge and amounts in mm for 2006

Duarrigle Catchment

For the purpose of modeling we concentrated on the western end of the catchment up stream of the flow station in Duarrigle (245km^2). The center of the catchment is of a lower elevation with higher areas covered in blanket peat to the north and south, see Fig 3. The lower parts of the catchment is grassland with small sections of arable and forestry (see Fig 5) The land used data was obtained from the 2000 Corrine Land use survey. From the 1980 Gardner and Radford soil survey of Ireland we can see that blanket peats and gleys are the dominant soil types (Fig 6).

GEOtop

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. For the purpose of this study we used a cell size of 200 by 200m. The soil type maps must also contain information regarding texture and hydraulic conductivity. This data was obtained from carrying out field tests as described in Lassabatère et al 2006.

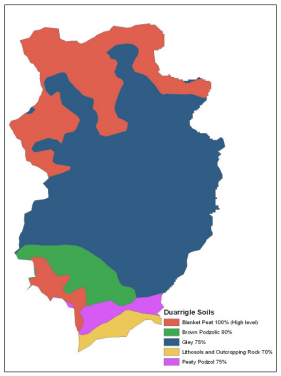

Fig 4 Soil Type

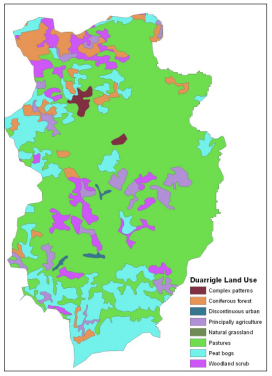

Fig 5 Land use maps

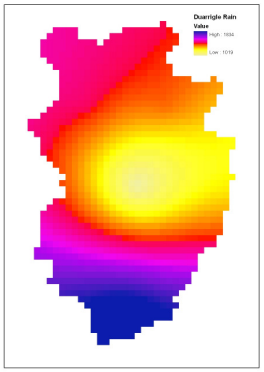

Fig 6 Rainfall

Rainfall

GEOtop has the capability to accept multiple rain gauge data. We used four rain gauges that are located within the Duarrigle catchment. GEOtop then interpolated this data to vary the rainfall in the catchment, see Fig 6.

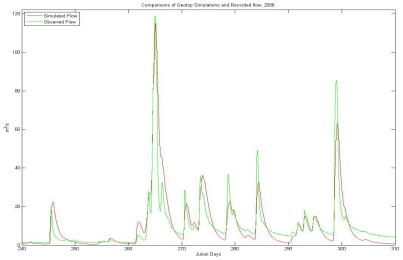

Fig 7 comparison of simulated and observed flows from 28th Aug to 6th Nov 2006

Results

GEOtop has the capability to output many useful parameters such as soil moisture, suction potential and stream flow. Fig 7 shows the simulated and observed flow from the Duarrigle catchment. A number of weeks 'spin up' are required at the start of a simulation, however following a dry period during the summer the model produced some good results (Fig 7).

Fig 8 shows the soil moisture map for the 2nd of July. The areas of high soil moisture correspond to areas of blanket peat in the higher elevations. As it was dry for the previous month many parts of the catchment saw a substantial reduction in moisture content.

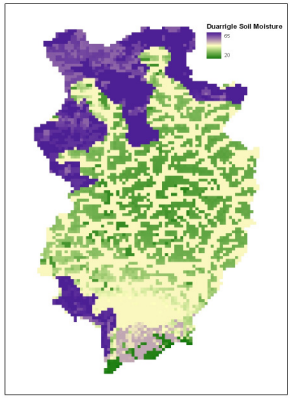

Fig 8 Soil moisture map 2nd July

Discussion

The initial results appear quite promising. The model performs well at times of peak flow but tends to underestimate the base flow. This will require some further study to determine the cause of this. This work forms part of a larger project examining different threats to soil quality in Ireland. Once we are satisfied that the model is working correctly new modules will then be written to help quantify soil quality threats such as soil erosion, compaction, loss of organic matter and landslides.

Acknowledgements

The support of the Irish EPA is gratefully acknowledged.

References

Lassabatère, L., R. Angulo-Jaramillo, J.M. Soria Ugalde, R. Cuenca, Braud, I., R. Haverkamp. 2006. Beerkan estimation of soil transfer parameters through infiltration experiments—BEST. Soil Sci. Soc. Am. J. 70:521–532.

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