Geophysical Research Abstracts
Vol. 12, EGU2010-14141, 2010
EGU General Assembly 2010

Measuring and modelling storm rainfall and flood response behaviour in a densely instrumented multi-scale catchment experiment

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A deficiency in current understanding of flood response is the variation of flood generation at different spatial scales as a function of spatial and temporal variations in storm rainfall. There is a lack of studies showing the process of transformation from rainfall to stream flow at a range of consecutive scales. This process is complex and varies with catchment size. Hydrological data from an extensive, nested hydrometric network in the predominantly rural Upper Eden catchment, Cumbria, UK, were collected for a range of flood events. Five large storm rainfall events and the resulting flood responses were recorded over varying land use and scales from a small upland catchment (1.1km2) to the basin outlet (616km2). A physically based, spatially distributed hydrological model (SHETRAN) was used to investigate the flood response with various representations of raingauge networks to indicate the importance of accurately representing the spatial and temporal variability of storms for flood forecasting. The raingauge distribution in model simulations ranged from three raingauges to a network of 25 raingauges.

Results from the model showed that a dense network significantly improves rainfall estimates by capturing the spatial variability of the storm. The sparse network performs the worst of all the scenarios. For localised convective events, using the sparse network in the smaller catchments resulted in random peaks forming. This highlights the importance of having a good spatial coverage of rainfall within a fully distributed model. When a synthetic raingauge network was applied to a 69-km2 headwater catchment the model estimates of the peak discharge improved relative to the observed network owing to the more realistic representation of the increased intensity of rainfall at higher elevations where real raingauges are not present.

Uncertainty in the model results and in the input data (due to undercatch at high elevations) is examined.