Geophysical Research Abstracts,
Vol. 11, EGU2009-9453-1, 2009
EGU General Assembly 2009

From scaling up to scaling down land management impacts on downstream flood risk

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Climate change and land use change have both been hypothesised as responsible for current increases in flood risk. However, scaling up their impacts to large drainage basins (> 1000 km2) remains a methodological challenge, notably for assessing land management impacts, both because of the increase in catchment heterogeneity with scale, and because of the growing number of process interactions that need to be incorporated. Upscaling using traditional physically-based, distributed modelling is a challenge because: (1) the parameters in each model grid cell are rarely known; and (2) as the spatial scale of analysis has to be increased, so the resolution of the process representation has to be reduced, with subsequent impacts on model performance. For this reason, many individual impacts of land management upon flood risk remain unproven and, even then, when the potential scale of management change is larger, we do not understand how to prioritise what to do where. This is particularly important, as land management measures may require considerable resource input (e.g. agri-environment payments), but also they may have counteracting impacts upon hydrological response according to where they are located within the catchment.

In this paper, we present an alternative approach, based upon both data-based and model-based downscaling. This starts with the problem, in this case, a major flood event in the city of Carlisle, River Eden, in January 2005. It then identifies a set of criteria that need to be met for a land management based solution to be adopted: (1) the measure should be robust to different types of climatological event; (2) it should be focused upon the location in the catchment where impacts are greatest; and (3) it should recognise that land management impacts influence both the magnitude and the timing of peak events in sub-catchments which, in turn, will impact upon sub-catchment interaction. The downscaling approach then proceeds by using a mixture of both analysis of historical data and mathematical modelling to identify first the sub-catchments and then the tributaries where change in the hydrological response would deliver flood risk reduction downstream. This leads to identification of a much smaller sample of tributaries which need detailed investigation to identify what land management changes should be explored, where and how to deliver the required hydrological change.

Here, we demonstrate this approach for the River Eden, a 2300km2 catchment in the North-West of England. First, we identify one sub-catchment whose relative timing of peak flow we find exerts a critical influence upon downstream flood risk. Second, we identify the tributaries where manipulation of their hydrological response could lead to a change in sub-catchment response that would generally deliver downstream flood risk reduction. Third, aided by a community-based workshop, we identify the possible land management measures that could be tried in each tributary, assess their likely sustainability and evaluate the extent to which they can be tested scientifically. The result of this approach is a focused and prioritised set of measures that suggest what to do and where to do it, so as to reduce downstream flood risk.