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Projecting Future Flood Risk: Highlighting the Impacts on High Value Buildings

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There is now a widely held hypothesis that the hydrological cycle will intensify and become more volatile with future greenhouse-gas induced global warming. There is therefore a requirement for robust and accurate flood estimation procedures to be developed that allow for appropriate mitigation and protection against any potentially heightened flood risk. Research focused on producing future flood risk projections has been receiving considerable effort, with regional climate models (RCMs) emerging as the preferred tool in hydrological impact assessment. Although there has been a significant focus on impact studies there are few that consider impacts at scales that will be applicable to the end user.

This study applies the novel approach of translating climate model projections into the physical effects on the environment at a building scale, outlining the potential risks posed to historical buildings from flooding under future climate change and formally accounting for model uncertainty. The methodology is tested through the use of a study site known to be prone to flooding. A modelling framework was constructed to cascade flows from climate models through to hydrological and hydraulic models. An ensemble of RCMs from the UKCP09 and ENSEMBLES projects were used to directly force the HBV hydrological model. A Monte Carlo procedure was then used to sample from the range of projected changes with the resulting values used to perturb the boundary conditions of a two-dimensional flood inundation model, LISFLOOD-FP. Ranges of possible future conditions were presented as a probabilistic framework, incorporating climate and hydrological model uncertainties. The approach moves away from a deterministic methodology, providing future projections that account for the full range of incorporated uncertainties.

A case site of Tewkesbury in the U.K has been selected. The town has been subject to severe flooding as recently as May 2012, and is an urban location with a particularly high density of historic structures of national cultural significance. The modelling framework was implemented on the site and used to carry out 2D hydraulic modelling under future climate scenarios, which were used to assess risk to individual buildings within the flood plain with an identified vulnerability status. For each building depth of flood and flow velocity was identified at the façade and the dynamic loading conditions were used to analyze the fragility conditions applicable to each structure. Appraisal of multiple discrete examples leads to the development of a site wide appraisal producing failure curves based upon probabilistic future climate conditions.

This approach to the issue of flood induced damage to historic structures and urban sites in this manner leads to detailed knowledge of the risks posed in such situations. Feedback loops which return this information to the impact studies in this area will allow for iterative work to improve our ability to predict the effects of climate change. This in turn will better inform our management of these culturally significant sites, and our ability to protect and conserve irreplaceable structures in a changing future climate.