science summary

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Risk-based probabilistic fluvial flood forecasting for integrated catchment models

Science Summary SC080030/SS

Robust forecasts are vital in providing a comprehensive flood warning service to people and businesses at risk from flooding. For fluvial flood forecasting, rainfall–runoff, flow routing and hydraulic models are often combined into model cascades and are run automatically in the Environment Agency's National Flood Forecasting System (NFFS). However, it is widely known that the accuracy of flood forecasts can be influenced by a number of factors, such as the accuracy of input data, and the model structure, parameters and state (initial conditions). Having a sound understanding of these modelling uncertainties is vital to assess and improve the flood forecasting service that the Environment Agency provides.

This report describes the findings from Phase 1 of the project 'Risk-Based Probabilistic Fluvial Flood Forecasting for Integrated Catchment Models', whose main aim is to develop and test practical probabilistic methods to quantify and, where possible, reduce uncertainties around fluvial flood forecasts from sources other than predicted rainfall. The project started in November 2008 and will complete in late 2010. The main objectives of Phase 1 were to perform the following tasks in order to better define the methods and case studies to be investigated during Phase 2 of the project:

- Task 1.1 – To review current Environment Agency (regional and national) and international experience in addressing uncertainties associated with fluvial flood forecasting and consult key stakeholders to refine user requirements.
- Task 1.2 – To review and investigate which additional sources of uncertainty should be considered to gain a fuller (quantified) understanding of uncertainties in the flood forecasting process and to define in which situations/scales this may be beneficial. Particular focus should be placed on the aspects other than rainfall uncertainty, such as uncertainty associated with rainfall–runoff, routing and hydraulic components.
- Task 1.3 – To recommend and test suitable techniques for the probabilistic treatment of the most important sources of uncertainty and combine them into a high-level unified, scalable framework for integrated catchment models.
- Task 1.4 – To investigate the requirements, possibilities and benefits of real-time/state updating of probabilistic hydraulic/hydrological models and the value of different types of data (historical and real-time) in constraining uncertainties.

The consultations took place during December 2008 and January 2009 and involved more than 25 regional and national staff. More than 20 catchments were suggested as potential case studies for the project, and the discussions suggested that the key sources of uncertainty which it would be useful to consider include catchment averaging of raingauge data, the validity of rating curves, and the calibration of rainfall–runoff models. Much useful background material was also obtained on recent experience with integrated catchment models, and ongoing regional and national studies into model uncertainty.

Based on the review and consultations, and a workshop held on 16 March 2009, this report sets out the key proposals for Phase 2 of the project, including the proposed uncertainty framework, and the methods to be developed and tested on the case studies. The high-level version of the framework, which is described in this report, uses the following seven items as key decision points in selection of an appropriate uncertainty estimation technique: level of risk, lead time requirement (linked to catchment response time), types of models, sources of uncertainty, data assimilation, operational requirements, and model run times. The detailed version of the framework, to be developed during Phase 2, will consist of flowcharts, decision trees and other formats. The project also has the scope to investigate up to four case studies, consisting of two integrated catchment models, and two simpler models which form the basic building blocks of more complicated models.

The following four catchments have been selected for study during Phase 2:

- Upper Calder (rapid response catchment)
- Lower Eden (flow routing reach)
- Ravensbourne (integrated catchment model)
- Upper Severn (integrated catchment model).

The test configurations for these catchments will be trialled on the Environment Agency's NFFS, using the following uncertainty estimation techniques:

- Forward Uncertainty Propagation – specification of a range, or ensemble, of values.
- Data Assimilation – Kalman Filter/Data Based Mechanistic, Ensemble Kalman Filter.
- Conditioning – post-processing of outputs using quantile regression and Bayesian Model Averaging.

The following four approaches to reducing model run times were also reviewed (and will be investigated further during Phase 2): increased computing power, hydrodynamic model reconfiguration, statistical sampling and model emulators. The Lower Eden case study will be used as a test bed for some of these studies, and will also be used for a short investigation into probabilistic inundation mapping using the existing mapping functionality in NFFS.

Phase 1 of this project is now complete and provides a sound basis for phases 2 and 3 which will apply the selected methods to operational forecasting situations and provide practical guidance for their use.
This summary relates to information from Science Project SC080030, reported in detail in the following outputs:-

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