Hydrological modelling using convective scale rainfall modelling – phase 1 & 2

Project Summary SC060087/S1

Hydrological models have the capability to provide useful river flow predictions and flood warnings. Scientists from the Centre for Ecology & Hydrology (CEH) at Wallingford in Oxfordshire and Deltares at Delft in the Netherlands have investigated which models and associated computational methods would allow best use of the latest Met Office developments in numerical weather prediction (NWP) to predict severe weather events leading to flooding.

High resolution NWP using STEPS (Short Term Ensemble Prediction System) and a new system for longer term numerical weather prediction called MOGREPS (Met Office Global and Regional Ensemble Prediction System) could open the door to the use of probabilistic flood forecasting in the UK. But research into their operational application is necessary to realise their potential benefits for the national flood warning service. Ensemble prediction systems provide a practical tool for estimating how the uncertainties and approximations associated with numerical models affect the forecast.

The three-phase project is concerned primarily with:

- how to use high resolution (convective scale) rainfall forecasts effectively for flood forecasting;
- how to incorporate information from MOGREPS into the Environment Agency's National Flood Forecasting System (NFFS) on an operational basis.

The project has three phases:

- Phase 1 Inventory and data collection
- Phase 2 Pilot
- Phase 3 Verification and synthesis.

This science summary is concerned with the progress made in Phases 1 and 2.

The project paid particular attention to 'distributed forecasting' which, in terms of the project, means the use of a spatially distributed (grid-based) hydrological model to forecast 'everywhere'.

This contrasts with current hydrological model networks that comprise a connected set of (normally) lumped rainfall-runoff ('catchment') models feeding into hydrological and hydrodynamic river models that only provide forecasts at specific locations.

Phase 1 involved:

- examining the suitability of three recent severe storm events as the pilot case study for Phase 2;
- obtaining detailed numerical weather predictions from the Met Office's Joint Centre for Mesoscale Meteorology (JCMM) in Reading;
- compiling an inventory of hydrological models (primarily rainfall-runoff models) suitable for predicting runoff generated by severe storm events;
- configuring and calibrating four models for transformation of high resolution rainfall predictions into accurate flood forecasts;
- selecting two Environment Agency Regions (North East and Thames) to act as pilots for ensemble forecasting in NFFS;
- examining the use of high resolution NWP forecasts and the generation of 'pseudo' ensembles;
- determining the procedures and indicators for assessing model and ensemble performance.

The extreme weather event at Boscastle in north Cornwall on 16 August 2004 was selected as the pilot case study for Phase 2.

In Phase 2, three hydrological models (one lumped and two distributed) were applied to the Boscastle catchments:

- Probability Distributed Moisture (PDM) model;
- physical–conceptual Grid-to-Grid (G2G) model;
- physics-based Representative Elementary Watershed (REW) model.

The three models were configured and calibrated for three of the catchments (Ottery, Tamar and Camel) where gauges are in place to collect rainfall data. Raingauge-adjusted radar rainfall data produced using HyradK were used as model input.

This phase also coupled the latest Met Office high resolution NWP products with the distributed hydrological model developed by CEH and considered the potential of ensemble convective scale rainfall predictions for flood forecasting.

Ensemble forecasting was configured in a test NFFS system for Thames and North East Regions set up at Deltares as part of the Delft Flood Early Warning System (Delft-FEWS). This test system receives MOGREPS forecasts direct from the Met Office. Particular attention was given to the effect on system performance as it is necessary to repeat the forecast workflow 24 times when running the hydrological models in ensemble mode.

Phase 2 demonstrated that a distributed hydrological model (set up using a digital terrain model) can be operated on the National Flood Forecasting System platform with short enough run times for use in real-time forecasting. The performance of the G2G model was considered particularly promising.

For Phase 3, the research team recommended:

- testing an extended G2G model incorporating soil/geology datasets;
- undertaking a more ‘regional assessment’ based on an area of the Midlands affected by the summer 2007 floods;
- utilising raingauge data in combination with radar data to improve rainfall estimation as model input for this assessment;
- carrying out more detailed analysis for the selected case study area (including use of high resolution NWP pseudo ensembles);
- continuing the MOGREPS trial.

At the end of Phase 3, overall conclusions will be drawn on the general benefits of using high resolution NWP as input into a hydrological model for flood forecasting. A possible approach using the hydrological models will also be formulated.

The results of this research will help the Environment Agency to make best use of the latest Met Office developments in numerical weather prediction for improved flood forecasting and flood warning within the framework of its National Flood Forecasting System.

This summary relates to information from project SC060087, reported in detail in the following output(s):

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