Thunderstorm and Deep Convection Warning Project

The prediction of convective storms and other, related severe local weather phenomena has long posed difficulties for the meteorologist and the hydrologist. Whilst the mechanisms underpinning the release of convective instability, and the development of convective precipitation are now reasonably well understood in quantitative terms, reliable, deterministic prediction of convective cell initiation and subsequent behaviour have remained largely beyond the capabilities of meteorologists.

The precipitation accompanying convective storms poses significant problems for flood forecasters. Whilst intensities often exceed 10 mm/hr (values of more than 30 mm/hr are not uncommon over periods of minutes), the spatial and temporal extents of the precipitation are typically very limited - a few square kilometres and a few hours. The difficulties entailed in providing timely flood warnings for such events are exacerbated in small urbanised or semi-urbanised river catchments where their characteristics give rise to very rapid rainfall-runoff responses.

To date, the Agency has employed various rainfall radar, extrapolation based precipitation forecasts to attempt to predict the location and severity of flood producing storms, for example, those produced by the FRONTIERS and Nimrod systems at the Met. Office, and Hyrad, developed by the Institute of Hydrology. These have proven beneficial in forecasting frontal precipitation, but have at times, demonstrated serious deficiencies in their treatment of convective precipitation. Thus, results from a number of Agency - Met. Office collaborative studies (FOAG 1992, 1993) led to the conclusion that the ability of FRONTIERS to " accurately forecast rainfall in ..... convective events .... is generally poor".

This Research and Development Project therefore, was established to explore ways of improving the short range prediction (up to three hours ahead) of heavy convective precipitation, initially in the Agency's Thames Region. The aims of the Project were two-fold:

- to validate an object-orientated conceptual model of convection devised to improve the prediction of heavy convective precipitation

- to provide objective guidance on the most appropriate choice of radar-based precipitation forecast in a range of weather situations.

It was hoped that the work undertaken in these two areas would improve the spatial accuracy and timeliness of flood warnings during periods of non-frontal convection. With this latter goal in mind, the approach adopted in the Project was to develop and trial an automated, convective precipitation nowcasting system - GANDOLF (Generating Advanced Nowcasts for Deployment in Operational Landbased Flood Forecasts). The object-oriented model, which forms the hub of the GANDOLF system, was developed by the Met. Office to specifically address this problem. Peripheral system components were developed to identify and distinguish airmass convection and frontal weather systems, and to measure and predict the relative performance of object-oriented and extrapolation-based precipitation forecast algorithms.

The performance of 15-minute precipitation accumulation forecasts generated by GANDOLF,

Nimrod and Hyrad was assessed over two six month periods spanning the months May to October in 1995 and 1996. The forecast validation area was restricted to 19 flood-prone river sub-catchments in the Thames catchment. When convective precipitation was observed to fall a suite of error statistics were computed for each of the three models over the 19 sub-catchments.

Considered in isolation, the performance statistics generated during this project did not provide conclusive evidence that the object-oriented model outperformed the extrapolation-based approaches during periods of non-frontal convective precipitation. Nevertheless, when these quantitative findings are viewed in combination with the qualitative graphical evidence from key case study events, it is reasonable to conlude that GANDOLF will generally provide superior guidance to that of Nimrod and Hyrad. The main reasons for this conclusion are:

- GANDOLF possesses superior spatial and temporal resolutions to that of Nimrod (2 km versus 5 km spatial resolution, 10 minute versus 30 minute run cycle) and superior temporal resolution to that of Hyrad (10 minute versus 15 minute run cycle). It can therefore provide more reliable early warnings of impending heavy convective precipitation

- in terms of spatial predictive skill, GANDOLF performance is generally superior or comparable to that of the extrapolation models for lead times out to about 60 minutes

- in terms of 15-minute sub-catchment total accumulations, GANDOLF forecasts demonstrate comparable performance, whilst generally affording a positive as opposed to a negative bias at lead times out to about 75 minutes. In some circumstances GANDOLF outperforms the extrapolation models at lead times out to T + 3 hours.

In conclusion, the 1995 and 1996 summer trials of the GANDOLF system were largely successful. They have shown the system to be capable of 24 hour standalone operation. It is recommended that the future of GANDOLF be reviewed following a further trial of the system, and subsequent evaluation by the Agency in a hydrological context. Should this trial confirm the findings of the Met. Office it is recommended that the feasibility of incorporating the various system components into an upgraded version of Nimrod should be explored. This would have the advantage of maintaining a single system for Met. Office quantitative forecast provision to the Agency.

This R & D Technical Summary relates to information from Project 510 contained in the following outputs:-

R&D Technical Report W 103: GANDOLF Thunderstorm Warning Project
Internal Status: Released to Regions
External Status: Released to Public Domain

R&D Project Record W5/i 510/1: GANDOLF Thunderstorm Warning Project
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Copies of documents are available internally and externally from the Agency's R&D Dissemination Centre c/o WRc Frankland Road, Swindon, Wilts SN58YF (Tel: 01793 511711; fax: 01793 514562).

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