NERC Steering Committee on the Hydrological Applications of Weather Radar

Third Report

September 1989 – September 1991

Institute of Hydrology

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March 1992

Natural Environment Research Council

Institute of Hydrology
Crowmarsh Gifford
Wallingford
Oxon
OX10 8BB

Chairman's Preface

This is the last report of the Steering Committee, which has now handed over to the Inter-Agency Committee with a wider membership.

The Committee was established to maintain a British impetus in the development of weather radar for hydrological applications. Looking back over the 6 years that the Committee has been in existence, it is clear that much progress has been achieved. Members of the committee have from time to time expressed their concern at the rate of progress and expressed a wish to see greater funding of research. These concerns led to a review of the committee and to its reincarnation as the Inter-Agency Committee.

I have been supported by an enthusiastic membership, dedicated to their beliefs in the role that weather radar can play in improving flood forecasting and other aspects of river catchment and water management for the benefit of the public at large. Nowhere is this more apparent than in the forecasting of flooding when the devastating impacts of water in a home can be reduced by a few hours advance notice.

Vince Collinge was a very active member of the committee and had been a champion of weather radar since the days of the Water Resources Board almost 30 years ago. His sudden and tragic illness was a shock to us all. The committee will miss his contributions and wise counsel.

During the life of the committee, the radar network has expanded from England to cover all parts of the United Kingdom, its output is now seen almost daily on BBC-TV weather forecasts and 9 out of the 10 NRA regions receive weather radar data round the clock for use in their flood warning systems. Members of the committee have in a variety of different ways played their part in supporting and achieving progress in these as well as in many other ways.

A particularly significant contribution has been the prominent role of many members in European developments. Bob Moore from the Institute of Hydrology has coordinated applications and reporting for a cooperative research programme with 6 partners in Europe under the auspices of the European Community. The late Vince Collinge from the University of Lancaster chaired the working meetings of the European research partners. Chairmanship of the COST 73 work to produce a European network was undertaken by Chris Collier of the Meteorological Office.

Three major textbooks has been edited by committee members and a major international symposium was organised almost single-handedly by Prof. Ian Cluckie at the University of Salford.

Members of the committee individually and cooperatively have achieved much during the life of the committee and I thank them for their support during the 3 years that I have been its Chairman. Many, but unfortunately not all, will continue to support the development of weather radar as members of the new committee. Those who could not join the new committee will, I know, continue to further the cause of weather radar in other ways.

Dr Peter D Walsh

Contents

1. Introduction

This is the third and final report of the NERC Steering Committee on Hydrological Applications of Weather Radar. The Committee was initiated in March 1986 by the Institute of Hydrology's Director, then Dr J S G McCulloch, at the request of NERC's Chairman, then Mr H Fish. Dr J C Rodda served as Chairman until 1988, when his departure from IH to WMO, left the position vacant. Dr P D Walsh, NRA North West Region has served as Chairman since that time. The main aim of the committee was to create a forum for the exchange of ideas on the hydrological use of weather radar in research, in applications and for commercial exploitation. Appendix A provides the full terms of reference of the Committee and Appendix B gives details of its Membership.

The period under review has seen further expansion of the UK radar network, beginning with the official opening of the Dyfedd radar in south west Wales in September 1989. October 1990 heralded the release of the FRONTIERS national radar rainfall forecasting product on a trial basis to the North West and Thames regions of the National Rivers Authority. Three new radars serving Scotland are to become operational in December 1991. On the horizon, for 1992, is the first UK operational Doppler radar at Cobbacombe, near Tiverton in Devon, the siting of which follows on from the unsuccessful planning application for a radar on Exmoor in north Devon. Figure 1 shows the location of these radar within the UK.

The Committee has met at 6 monthly intervals over the two year period. Its main activities have been to monitor research progress, to formulate a strategy for basic research, to publish a bibliography of UK research and to convene a research workshop. These activities are reported in greater detail in the following sections.

Perhaps most importantly, the Committee has reviewed its terms of reference with NERC. This review has lead to the emergence of the Interagency Committee on the Hydrological Use of Weather Radar as a successor to the Committee with a widened membership and new terms of reference. Consequently this is the last report of the NERC Steering Committee on Hydrological Applications of Weather Radar.

2. Overview of Activities

Reports on Research Progress

The Committee has continued to monitor research progress through its six-monthly reporting system. This involves the production of short written progress report by active research groups reinforced by brief oral presentations at Committee meetings. The report format has been revised to be more project based: Appendix C provides a set of the reports received, which includes both new and old style reports.

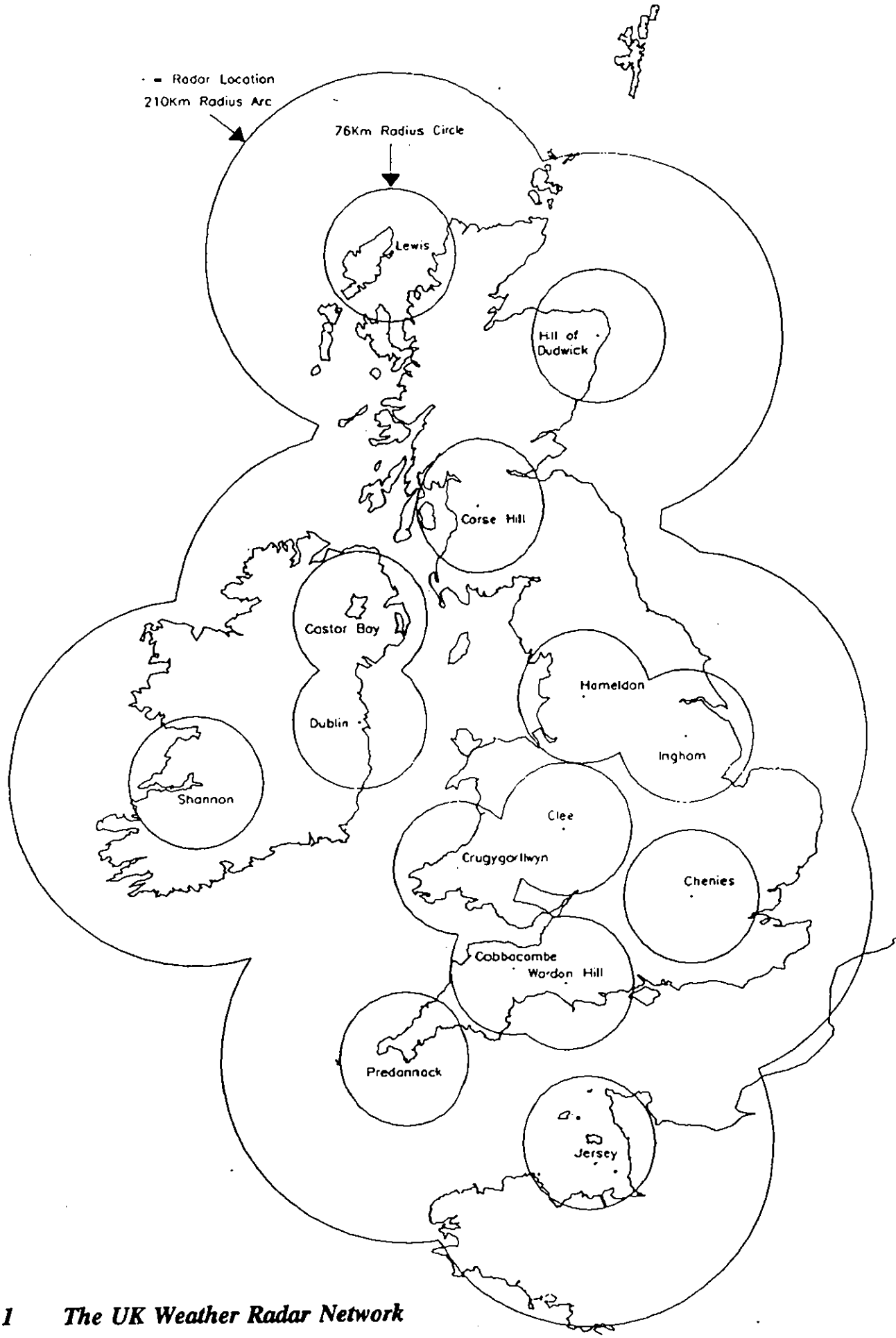

Figure 1 The UK Weather Radar Network

Radar Research Workshops

The value of holding regular research workshops, at intervals of one or two times a year, to complement the administrative responsibilities of the Committee was recognised . This lead to a very successful two-day workshop at the University of Lancaster in September 1991. The fact that no written papers were required helped to generate an informal atmosphere with an exciting exchange of research findings and ideas from invited contributors.

UK Bibliography of Radar Research

A bibliography of UK radar research papers and reports relevant to the hydrological application of weather radar was published by the Institute of Hydrology, on behalf of the Committee, in October 1990. Its purpose is to publicise the considerable amount of research and development that has already taken place in the UK. A notable inclusion in the Bibliography, published within the period under review, is the book by the Meteorological Office representative on the Committee: C.G. Collier (1989), Applications of Weather Radar Systems - A guide to uses of radar data in meteorology and hydrology, Ellis Horwood. Copies of the Bibliography are available on request from Celia Kirby at IH. The Interagency Committee is to take over production and plan to update its contents at regular intervals. Contributions for inclusion are invited.

3. Membership

The split of the Water Authorities into water service companies and the National Rivers Authority, together with developing interests in Northern Ireland and Scotland, required a review of the membership. This review resulted in four existing authority members being reinstated as NRA members and Mr J Tyson, North West Water, being appointed to represent the Water Services Association. Whilst representation from Northern Ireland and Scotland continued to be pursued, Dr G Shepherd, States of Jersey Regional Resources Board was invited to represent the interests of the Channel Islands. It is the responsibility of the Institute of Hydrology to provide the secretariat and in 1990 Mrs E J Stewart was succeeded by Miss D S Hotchkiss.

It was with great sadness that the Committee heard of Dr V K Collinge's untimely death in early August 1991. Dr Collinge will be sorely missed as a liked and respected colleague and for his great contribution to the Committee's activities and to radar hydrology research, development and application for over 25 years.

4. Research Activities

Research Reporting

The progress of research reported in Appendix C indicates that projects at the interface between radar meteorology and hydrology continue to be undertaken at three main centres: the University of Salford, the University of Lancaster and the Institute of Hydrology. Financial support for this research comes particularly from the NRA and MAFF with smaller amounts from the Commission of the European Communities (CEC) and NERC. A welcome addition is a growing interest in the relevance of dual-polarisation radar for hydrological use shown by Dr Illingworth's group at UMIST; this research has been stimulated by CEC funding. The Meteorological Office continue to be very active in the rainfall measurement field of radar research supported by in-house funding; however, a change to agency status in April 1990 marks a shift towards greater support from external funding sources in the future.

Research Strategy Document

A major activity of the period under review was the formulation of a strategy giving greater emphasis to basic research on the use of weather radar in hydrology. The requirements for research were studied through the formation of four sub-committees: (i) Precipitation Measurement, (ii) Hyrological Forecasting, (iii) Urban Applications and (iv) Radar Archiving and Climatology; these were chaired by Dr Collinge, Mr Moore, Professor Cluckie and Mr Collier respectively reporting to the Committee Chairman, Dr Walsh. This work identified both basic and applied research topics in need of funding. A strategy document covering (i), (ii) and (iv) was produced and published by the Institute of Hydrology, on behalf of the Committee.

NERC Special Topic Submission: HYREX

The review of requirements for basic research was used by the Committee as the basis of a Special Topic submission to NERC. Special Topics provide a vehicle to support a focussed area of research through a pool of research grants bid for by the research community. The review revealed the need for a radar hydrology facility which would complement the operational radar network with a dense raingauge network, experimental radars - including mobile vertical pointing and low-cost scanning radars - and a variety of hydrometeorological sensors. A set of community experiments could be planned, initially focussing in one area and later extending to other areas, for example to investigate orographic effects on radar rainfall measurement. This community concept was termed the Hydrological Radar Experiment, or HYREX. Application for support to NERC was sought during 1991 and has resulted in approval of NERC funds over the next three years of £720K, subject to support from other interested parties being demonstrated.

5. International Links

1st International Symposium on Hydrological Applications of Weather Radar

The First International Symposium on Hydrological Applications of Weather Radar was held at the University of Salford during August 1989. The proposal for the symposium was discussed and supported by the Committee in 1986 following on from the success of the symposium "Weather Radar and Flood Forecasting" held at the University of Lancaster in September 1985 (see V.K. Collinge and C. Kirby (eds), Weather Radar and Flood Forecasting", J. Wiley, 1987). Dr John Rodda, then chairman of the Committee, invited Professor Ian Cluckie to convene the symposium. Sponsorship was gained from the British Hydrological Society, NRA units in the Water Authorities, the CEC, IAHS, IH, the UK Meteorological Office, and the universities of Salford and Lancaster. The symposium was an outstanding success attracting participants from 18 countries and providing a balanced representation from the hydrological and meteorological communities. A total of 57 papers were presented and published in: I.D. Cluckie and C.G. Collier (eds), Hydrological Applications of Weather Radar, Ellis Horwood, 1991. Much of the success of the symposium was due to the hard work of the symposium organiser, Professor Ian Cluckie, and his team in the Water Resources Group at the University of Salford.

CEC Projects

The four year CEC project entitled "Use of Weather Radar for the Alleviation of Climatic Hazard" came to an end in September 1991. This project involved partners from France, Italy, Portugal and The Netherlands. An International Workshop on Radar Hydrology has been convened for November 1991 in Lisbon to mark this event. A Specialist Workshop on Urban/rural Application of Weather Radar for Flow Forecasting was also held in Wageningen, The Netherlands in December 1990.

A second CEC project within the EPOCH programme was awarded for the period January 1991 to December 1992. The five country consortium was extended within this project to include seven countries, with the addition of a partner from Greece and Germany. The project is called "Weather Radar and Storm and Flood Hazard" and allows the European Radar Hydrology Group to continue and add to its research programme. Parallel financial support from the National Rivers Authority to the universities of Lancaster and Salford and to the Institute of Hydrology has significantly strengthened the research programme. This project has initiated a Specialist Workshop on Rainfall Measurement and Forecasting in Athens, Greece in June 1992 together with the 2nd International Symposium on Hydrological Applications of Weather Radar in Hannover, Germany in September 1992.

Application for a third CEC project under the Environment programme entitled "Storms, Floods and Radar Hydrology" has been made. A Spanish partner has been incorporated as a sub-contract within this submission. If successful, this project may provide a 6 month overlap with the EPOCH programme and will extend to two years initially with the opportunity to seek an extension to four years.

6. The New Interagency Committee

An uncertain relationship between the Committee and its "sponsor", NERC, together with an unsuccessful application to NERC for Special Topic funding (see section 4.) in 1990 promoted a need to review the terms of reference of the Committee. This culminated in an ad hoc meeting being convened with NERC, which included representation by its Chairman Professor Knill, the Director of the Terrestrial and Freshwater Sciences Directorate Dr Tinker, and the Director of IH Professor Wilkinson. At this meeting the idea of an Interagency Committee was promoted by Professor Knill, since the scope of the Committee's activities spanned across the interests of many agencies including the Science and Engineering Research Council (SERC). At its meeting in March 1991 members of the Committee supported the establishment of the new Committee and the winding up of the old Committee in September 1991. The creation of the "Interagency Committee on the Hydrological Use of Weather Radar" was supported by all the agencies invited by Professor Knill to participate, with the exception of the Water Division of the Department of the Environment, whose membership of the old Committee had been limited to receiving papers. Its inaugural meeting in September 1991 was planned to coincide with the Lancaster Workshop (Section 2), and included representations from SERC and the Scottish Development Department. Dr Walsh continued to serve as Chairman to this new Committee and Dr Acreman of IH appointed as its new secretary.

APPENDIX A

TERMS OF REFERENCE OF THE NERC STEERING COMMITTEE ON HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

1. To identify, in association with users, the main features of a prospective research programme for the application and development of weather radar data for hydrological purposes and to co-ordinate its implementation.

2. To seek funding for research on hydrological applications of weather radar and to use this to increase support.

3. To provide a forum for the exchange of ideas and information and to foster closer links between research on weather radar, its application for hydrological purposes and its commercial exploitation.

4. To review the existing system for the collection and archiving of weather radar and other data for hydrological uses and to advise on developments to meet research purposes.

5. To promote and establish international contacts with other organisations concerned with the hydrological application of weather radar.

6. To report on its work annually to NERC, MAFF, DOE and the Met. Office and the Water Industry generally.

APPENDIX B

LIST OF MEMBERS

Dr P D Walsh	NRA, North West Region (Chairman)
Mr R Buckingham	Ministry of Agriculture, Fisheries and Food
Prof I D Cluckie	University of Salford
Mr C G Collier	Meteorological Office
Mr R Brown	Meteorological Office (Deputy)
Mr V K Collinge	University of Lancaster
Mr R C Goodhew	NRA, Severn Trent Region
Mr C M Haggett	NRA, Thames Region
Mr R W Hatton	NRA, South West Region
Mr R J Moore	Institute of Hydrology
Dr G Shepherd	States of Jersey Regional Resources Board
Mr J M Tyson	North West Water
Mr C E Wright	Department of the Environment
Mrs E J Stewart	Institute of Hydrology (Secretary to end of 1989)
Miss D S Hotchkiss	Institute of Hydrology (Secretary)

APPENDIX C

PROJECT PROGRESS REPORTS

Research Organisation: METEOROLOGICAL OFFICE
SHORT-PERIOD FORECASTING DIVISION

Nowcasting and Satellite Applications

Project Title: *Improvements to the accuracy of Radar Measurements (orographic factors)*

Project Contacts: M Kitchen
R Brown

General Description:

Improvements to the accuracy of real-time radar data are sought by making allowance for orographic effects. Even at modest ranges from the radar, there can be significant growth of precipitation beneath the radar beam over hills due to the seeder-feeder mechanism. This occurs when strong winds and high low-level relative humidity lead to the formation of a capping cloud over the hills. As rain from pre-existing frontal cloud falls through the capping cloud, the drops grow by accretion, enhancing the rainfall rate by up to 5 or 6 mm^{-1} in extreme cases.

Objectives:

(i) Devise improved ways of determining rain types.

(ii) Assess the applicability of existing domain boundaries and re-define as necessary.

(iii) Assess the applicability of, and update/re-define as necessary, the detailed orographic scaling factor due to variations of wind speed and humidity.

(iv) Determine optimal sites for orographic raingauges (with regard to areas of maximum orography and taking into account variable wind drift) and derive ways of using such gauges (whether in or upwind of areas of interest) to determine in real time the appropriate orographic scaling factor.

Progress Report:

At the end of the reporting period work commenced on evaluating the corrections applied to the radar data in the FRONTIERS precipitation nowcasting system to correct for orographic enhancement missed by the radars.

Funding Agency: Meteorological Office

Approximate Cost:

Project Duration:

cc Dyke

Research Organisation: METEOROLOGICAL OFFICE
SHORT-PERIOD FORECASTING DIVISION

Nowcasting and Satellite Applications

Project Title: *Improvements to the accuracy of Radar Measurements (non-orographic factors)*

Project Contacts: M Kitchen
R Brown

General Description:

Improvements to the accuracy of real-time radar data are sought. In particular, the accuracy of radars decreases with range as the beam height increases, leading to growth or evaporation of the precipitation between the measurement level and the surface. Corrections can be made semi-empirically based upon assumptions about the vertical reflectivity profile or using long-range gauge data.

Objectives:

(i) Devise ways of increasing accuracy at long range using (a) estimates of the type and vertical extent of the rain system, and (b) long-range gauge measurements, to derive range normalization appropriate to each occasion.

(ii) Derive procedures for ensuring that radar calibrations are biased in favour of the hydrologically more important areas of heavier rain.

Progress Report:

A key problem in using gauges both for calibration and evaluation is one of representativeness. Because the radar produces a series of instantaneous areal averages which are summed to produce an accumulation over a period, whilst a gauge makes continuous measurements at a point, even if the radar measurements yielded perfect area averages, there would be scatter in R/G totals. An estimate of the scatter has been formed for convective cases by a new analysis of the data from the late fifties Cardington rainfall experiment, where a dense gauge network was deployed over a 5 x 4 km area. Areal averages over 10 km^2 of 2 minute totals were used to simulate perfect radar estimates, which were sampled at 6 or 15 minute intervals to form hourly totals for comparison with individual gauge totals. The 15 minute sampling, as used by FRONTIERS, was found to produce a significant increase in RMS difference between radar and gauge totals, compared to 6 minute sampling which is close to the 5 minutes employed by PARAGON. A statistical bias was also found such that low hourly radar totals were underestimates on average. A similar feature was found in actual radar/gauge comparisons from FRONTIERS.

Funding Agency: Meteorological Office

Approximate Cost:

Project Duration:

Research Organisation: LANCASTER UNIVERSITY
INSTITUTE OF ENVIRONMENTAL AND
BIOLOGICAL SCIENCES
DIVISION OF ENVIRONMENTAL SCIENCE

Project Title: *The accuracy of C band radars in convective storms*

Project Contacts: Dr V K Collinge
Ewan Archibald
Jutta Thielen

General Description:

Numerous studies have been made of the performance of weather radars for measuring rainfall in convective storms. By their very nature those storms cover relatively small areas, and so the alternative to radar of telemetering rain gauges can at best give only limited information in such storms and may give none at all. The advantage of radar is offset by the conversion of radar signals to rainfall rates, which has particular difficulties, and calibrating gauges are not a viable option. Even if such a gauge is in the right place, using it for calibration can easily increase the errors in the estimated rainfall.

Objectives:

(i) To investigate the parameters influencing the accuracy of C-band radars when measuring rainfall in severe local (convective) storms.

(ii) To develop a model for the transformation of signals from C-band radars into rainfall rates in severe local storms incorporating appropriate parameters identified in achieving objective (i).

(iii) To track the movement of individual rainfall cells within severe storms and correlate this movement to upper air wind observations.

Progress Report:

Some work has been carried out under the programme funded by the CEC from 1987 to 1991, but is reported here for convenience.

A study has been made of a severe convective storm which took place on the 19th May 1989 over the Pennines in northern England, causing damage amounting to several million pounds in the Halifax area. The storm was very close to the Hameldon Hill radar and so radar data on a 2 km grid was obtained. Unfortunately only one recording raingauge received significant rain. The maximum ground truth observation of 193 mm is above the PMP for the area and not accepted by the Met. Office.

This work is now being extended to data from storms on the 24 May 1989, including data from the Chenies radar covering parts of the Thames Valley.

Funding Agency: CEC plus NERC (partial support of one research student)

Approximate Cost: £90,000

Research Organisation: INSTITUTE OF HYDROLOGY

Hydrological Applications of Weather Radar

Project Title: ***Regional and national radar rainfall forecasting systems***

Project Contacts: **R J Moore**
D S Hotchkiss
D A Jones

General Description:

The Study was motivated by recognising that the Frontiers product for nation-wide radar rainfall forecasting would not meet the water industry's specific requirement for frequently updated very short-term rainfall forecasts of high resolution in space and time. Such forecasts are needed particularly for forecasting flooding in urban and smaller rural catchments. The Study focusses on developing a regional rainfall forecasting system using the London Weather Radar for testing and implementation. Forecast accuracy is to be compared with the Frontiers product.

Objectives

(i) To develop a regional rainfall forecasting system based on weather radar and to deliver the system for operational use within the NRA Thames Region Flood Warning System.

(ii) To evaluate the accuracy of the regional forecasting system along with the Frontiers system over the Thames Region.

Progress Report

A rainfall forecasting system has been developed based on an underlying advection model of rainfall field movement. This employs a novel shrinking-grid search procedure combined with interpolation in the rainfall and forecast error fields to infer the storm velocity: inference and generation of a 2 hour forecast takes 27 cpu seconds on a VAX3400. Accuracy is consistently better than a persistence forecast at all lead times and the technique also outperforms a binary-coded pattern matching approach. The operational system software has been delivered to the NRA and integration and on-line operation is planned for March/April 1991. Database access routines for the Frontiers data have been written and the forecast evaluation software is under development.

Funding Agency: NRA Thames Region contract with some additional input from MAFF and the CEC.

Approximate Cost: £78K

Project Duration: 2 years (October 1989 to September 1991)

Publications

Moore, R.J., Watson, B.C., Jones, D.A., Black, K.B., Haggett, C.M., Crees, M.A. & Richards, C. (1989) Towards an improved system for weather radar calibration and rainfall forecasting using raingauge data from a regional telemetry system, in New Directions for Surface Water Modelling. Proc. Baltimore Symp., IAHS Publ. no. 181, 13-21.

Moore, R.J., Hotchkiss, D.S., Jones, D.A. & Black, K.B. (1989, 1990) Progress Reports for Steering Committee on Local Rainfall Forecasting using Weather Radar, 1st Report, 16pp, December 1989; 2nd Report, 24pp, March 1990; 3rd Report, 19pp, July 1990. Contract Reports to NRA Thames Region, Institute of Hydrology.

Moore, R.J., Hotchkiss, D.S., Jones, D.A. & Black, K.B. (1990) London Weather Radar Local Rainfall Forecasting Study: Annual Report, 73pp, October 1990, Contract Report to NRA Thames Region, Institute of Hydrology.

Moore, R.J., Jones, D.A. & Hotchkiss, D.s. (1991) Regional Systems for Weather Radar Calibration, Rainfall Forecasting and Basin-wide Flow Forecasting, Abstract, European Geophysical Society XVI General Assembly, Wiesbaden, April 1991.

Research Organisation: INSTITUTE OF HYDROLOGY

Hydrological Applications of Weather Radar

Project Title: *Variation of extreme rainfall events in upland areas*

Project Contacts: **E J Stewart**
N S Reynard
Dr D W Reed

General Description:

The study of spatial and temporal variations in rainfall has particular implications for the structuring of design storms for reservoir flood estimation. The project explores the combined use of radar and raingauge data to develop an improved understanding of spatial and temporal variability of extreme rainfalls. The main study region is an area of 10,000 km^2 centred on the Hameldon Hill radar station, with additional analysis being carried out on recording raingauge data from the Upper Dee catchment in North Wales. The project has been divided into two phases, the first of which has been concerned with providing an improved description of spatial variations in extreme rainfall through an analysis of areal reduction factors. The second phase of the project commenced on 1 April 1989 and aims to develop more realistic design storm profiles for upland areas.

Objectives:

(i) To demonstrate the usefulness of radar data in design applications.

(ii) To assess the applicability of the areal reduction factors currently in use in the UK to upland area.

(iii) To develop realistic design storm profiles for upland areas for a range of durations.

Progress Report:

An extensive analysis of observed temporal rainfall profiles has been carried out. The variation of the shape characteristics of the profiles with duration, season, return period and areal extent has been investigated. Design profiles for a range of durations from one hour to several days have been derived using a variety of techniques and the resultant profiles have been compared with those recommended for design in the UK. Final results and recommendations will be presented in the contract report (due 31 March 1991).

Funding Agency: Department of the Environment Reservoir Safety Research Commission.

Approximate Cost: Phase I £60k
Phase II £77.5k

Project Duration: 4.5 years (start date 1 October 1986; completion date 31 March 1991).

Publications:

Reed, D.W. & Stewart, E.J. (1989) Weather radar and rural storm hazard. In: Weather Radar and the Water Industry, BHS Occasional Paper No. 2, 76-85.

Stewart, E.J. (1989) Areal reduction factors for design storm construction: joint use of raingauge and radar data. In: New Directions for Surface Water Modelling (Proc. Baltimore Symp., May 1989). IAHS Publ. No. 181, 31-40.

Stewart, E.J. & Reynard, N.S. (1989) Variability of heavy rainfall events in North West England: an analysis of spatial structure. Proc. International Symp. on Hydrological Applications of Weather Radar, Salford, August 1989, 10pp.

Research Organisation: NATURAL ENVIRONMENT RESEARCH COUNCIL
INSTITUTE OF HYDROLOGY

Project Title: *Small Catchment Response Times*

Project Contacts: D W Reed
D C W Marshall
A C Bayliss

General Description:

The estimation of floods on small catchment often gives cause for concern in drainage design. Existing gauged catchments having an area within the range 0.5 to 20 km^2 are almost exclusively upland, having an impermeable geology and high mainstream slope. Good quality data from small, lowland permeable catchments are rarely available. Consequently it has thus far been difficult to formulate techniques that are able to predict accurately the magnitude of floods on such catchments. A particular problem lies in the estimation of catchment response times, to which derived flood estimates are sensitive through the choice of design storm duration. The particular requirement to compute the temporal centroid of the flood producing rainfall, allows, with care, the use of uncalibrated radar signals.

Objectives:

(i) To revise existing methods of estimating the delay between rainfall and peak streamflow on such catchments.

(ii) To demonstrate the feasibility of low-cost/labour instrumentation to monitor the response to rainfall of small (0.5 - 20 km^2) catchments having a variety of geology and land use types.

Progress Report:

Fifteen water level recording sites were implemented during the period September 1989 - March 1990. All the sites were chosen such that their catchments fell within the 75 km range of high resolution data from the Chenies weather radar. By October 1990, the sites had generated a median number of 38 flood events. Programs to analyse the uncalibrated Chenies rainfall radar, compute rainfall centroids and generate rainfall volume-duration storm profiles have been completed.

In association with the Field Drainage Experimental Unit at Cambridge, a note describing the project and its objectives - and seeking information relating to the techniques currently employed in the estimation of floods on small catchments and to possible new sources of good quality data - has been circulated to relevant UK agencies.

Funding Agency: Ministry of Agriculture, Fisheries and Food.

Approximate Cost: £45k (1989/90)
£49k (1990/91)
£52k (1991/92)

Project Duration: Start 1 April 1989, Phase I ends 31 March 1992.

Research Organisation: UNIVERSITY OF SALFORD
DEPARTMENT OF CIVIL ENGINEERING

Project Title: *Anglian Radar Information Project*

Project Contacts: K Tilford
Prof. I D Cluckie

General Description:

The utilisation of precipitation estimates provided by weather radar continues to increase as the benefits afforded by the data are recognised. At present, radars provide high intensity resolution estimates of precipitation within a radius of 75 km of the radar (quantative data) with lower intensity resolution (qualitative) data available to up to 210 km. Increasingly, attention is being paid to the 'accuracy' of precipitation estimates derived from weather radar, direct comparison with ground truth data provided by raingauges frequently revealing large discrepancies between the two at given points. The local calibration of weather radar is seen as a means of extending the quantitative range of the radar (particularly relevant in an authority as large as Anglian, where coverage will still be limited despite the installation of the Lincoln radar)whilst improving accuracy. This will effectively extend areal coverage enabling utilisation of the data in areas previously not covered whilst facilitating (by virtue of increased accuracy) multifunctional use of the radar data.

Objectives:

(i) To develop techniques for the integration of radar rainfall data with Divisional telemetry systems.

(ii) To develop techniques to produce locally calibrated radar rainfall data suitable for a wide range of multifunctional uses.

(iii) To employ the calibrated data in real-time flow forecasting models which fully utilise the advantages of radar rainfall data.

Progress Report:

A calibration procedure employing local telemetering raingauge network data has been developed. All aspects of local calibration have been investigated, considerable attention being paid to physical processes such as orographic influences. Particular attention has also been paid to other aspects of data resolution e.g. spatial and temporal, with regard to the identification, calibration and operation of real-time flow forecasting models. Where appropriate, flood forecasting models were derived and the accuracy of flow forecasts using radar-derived rainfall as an input assessed.

During the project, techniques enabling th integration of radar data with other telemetry data were developed. The design featured a sophisticated man-machine interface to display information in an attractive, user-friendly and unified manner negating the requirement for a number of separate display devices. This device has been fully commissioned in the Wessex Region of the NRA as WRIP (Wessex Radar Information Processor).

Funding Agency: NRA Anglian region.

Approximate Cost: £83,000

Project Duration: 3 years (start date: Q1 88, completion date: Q4 90).

Publications:

1987 Anglian Radar Information Project: Preliminary Design Study. Internal Report to Anglian Water Authority, Anglian Radar Information Project Report No. 1, Department of Civil Engineering, University of Birmingham, 79pp (including appendices).

1988 Anglian Radar Information Project: Preliminary Design Study. Internal Report to Anglian Water Authority (re-issued with amendments), Department of Civil Engineering, University of Birmingham, Anglian Radar Information Project Report No. 1, 81pp (including appendices).

1988 An evaluation of the influence of radar rainfall intensity resolution for real-time flood operational forecasting. Anglian Radar Information Project Report No. 2, Department of Civil Engineering, University of Birmingham, 111pp (including appendices).

1989 Transfer-function models for flood forecasting in National Rivers Authority, Anglian Region. Anglian Radar Information Project Report No. 3, Water Resources Research Group, Department of Civil Engineering, University of Salford, 57pp (including appendix).

1989 Software Profile: A User Manual for TFFOR. Software Profile No. 1 in a series of Technical Reports produced by the Water Resources Research Group, Department of Civil Engineering, University of Salford, 65pp (including appendices).

1989 Software Profile: A User Manual for TFCAL. Software Profile No. 2 in a series of Technical Reports produced by the Water Resources Research Group, Department of Civil Engineering, University of Salford, 58pp (including appendices).

1990 Software Profile: A User Manual for TFUH. Software Profile No. 4 in a series of Technical Reports produced by the Water Resources Research Group, Department of Civil Engineering, University of Salford, 90pp (including appendices).

1989 Cluckie, I.D., Tilford, K.A. & Shepherd, G.W. Radar rainfall quantisation and its influence on rainfall runoff models. Proc. Int. Symp. on Hydrological Applications of Weather Radar, University of Salford, UK.

1989 Cluckie, I.D., Yu, P.S. & Tilford, K.A. Real-time forecasting: model structure and data resolution, Proc. COST-73 Seminar on Weather Radar Networking, Brussels, Belgium.

1989 Cluckie, I.D., Tilford, K.A. & Han, D. The influence of radar rainfall quantisation on flood forecasting. Proc. Int. Workshop on Precipitation Measurement, St. Moritz.

1990 Cluckie, I.D. & Tilford, K.A. Hydrological utilisation of weather radar data in the United Kingdom. Proc. Int. Symposium on Remote Sensing of Precipitation and its Application to Hydrology, Sao Paulo, Brazil.

1990 Tilford, K.A. & Cluckie, I.D. Weather Radar: Past, Present and Future. Paper presented to Meeting of the North-Western and North-Wales Branch, Inst. of Water and Environmental Management,

(to appear in Journal of Inst Water and Environmental Management).

1990 Cluckie, I.D., Tilford, K.A., Han, D. & Austin, G. Quantisation of analogue radar reflectivity data: consequences for radar meteorology and hydrological applications, in preparation (to be submitted to Water Resources Research).

1990 Local Re-calibratin of weather radar data in the Anglian Region, Anglian Radar Information Project Report No. 4, Water Resources Research Group, Department of Civil Engineering, University of Salford.

PROGRESS REPORT TO NERC STEERING COMMITTEE ON THE HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

Project A1

Project Title: Assessment of accuracy of rainfall measurements and diagnosis of errors

Report Period: August 1989 to March 1990

Introduction

The Advisory Services Branch of the Met. Office has continued to produce the radar data assessment report (RDAR). Comparison of rainfall totals from radar and gauges has continued. Identification of anaprop prone areas for each radar has commenced. An investigation of the benefit of adjusting hourly radar data using daily gauge information is underway.

Progress:

The latest RDAR covers the period April 1988 - June 1988. Annual maps of comparison of 'unadjusted' and 'adjusted' radar rainfall data from the PARAGON archive with climatological daily gauge data for 1986 - 1988 have been used to identify geographical variations in the quality of radar performance. Comparison of daily catchment totals from radar, and climatological gauges has been used to investigate the effects of range on Ingham radar data quality. Statistical tables, maps and histograms are used to summarize the result. Data have been processed from October 1988 - August 1989 in connection with the work of the Lincoln Long Range Calibration Study (LORCS).

Problems:

The need to reduce the number of assessment gauges per site due to the increased size of the radar network and changes in the Met. Office hourly gauge archive have delayed production of the RDAR.

Financial Aspects:

Costs are included in the FRONTIERS project and the Advisory Services Budget.

Reports Prepared or due:

Papers describing progress on the hourly adjustment and the Ingham radar investigations were presented at the Hydrological Symposium on Hydrological applications of weather radar, Salford 1989.

A paper describing the techniques of investigating persistent geographical variations in radar quality was presented at the COST73 Seminar, Brussels 1989.

Regular progress reports have been prepared for LORCS.

Progress report submitted by: C G Collier (MO) Date: May 1990

PROGRESS REPORT TO NERC STEERING COMMITTEE ON THE HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

Project A3

Project Title: Improvement of accuracy of radar measurements (taking into account non-orographic aspects)

Report Period: to December 1990

Introduction

Objectives:

(i) Derive ways of increasing accuracy at long range using (a) estimates of the type and vertical extent of the rain system, and (b) long-range gauge measurements, to derive range normalization appropriate to each occasion.

(ii) Derive procedures for ensuring the radar calibrations are biased in favour of the hydrologically more important areas of heavier rain.

Progress:

A key problem in using gauges both for calibration and evaluation is one of representativeness. Because the radar produces a series of instantaneous areal averages which are summed to produce an accumulation over a period, whilst a gauge makes continuous measurements at a point, even if the radar measurements yielded perfect area averages, there would be scatter in R/G totals. An estimate of the scatter has been formed for convective cases by a new analysis of the data from the late fifties Cardington rainfall experiment, where a dense gauge network was deployed over a 5 x 4 km area. Areal averages over 10 km^2 of 2 minute totals were used to simulate perfect radar esitmates, which were sampled at 6 or 15 minute intervals to form hourly totals for comparison with individual gauge totals. The 15 minute sampling, as used by FRONTIERS, was found to produce a significant increase in RMS difference between radar and gauge totals, compared to 6 minute sampling which is close to the 5 minutes employed by PARAGON. A statistical bias was also found such that low hourly radar totals were underestimates on average. A similar feature was found in actual radar/gauge comparisons from FRONTIERS.

Four cases from the new FRONTIERS radar analysis (2 frontal, 2 convective) have been evaluated, with emphasis on the performance of gauge calibration initially. No statistically significant difference was found between Remote site, FRONTIERS and uncalibrated data, when the results were averaged over all SREWS gauges. This seems to signify that the radars were performing well and that local improvement or deficiencies due to gauge calibration averaged out.

Reports prepared or due

Kitchen, M. & Blackall, R.M. (1990) Representativeness errors in comparison between radar and gauge measurements of rainfall. To be submitted for Publ.

Progress report submitted by: C G Collier (MO) Date: December 1990

PROGRESS REPORT TO NERC STEERING COMMITTEE ON THE HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

Project A2

Project Title: Improvement of accuracy of radar measurements (taking into account orographic aspects)

Report Period: to May 1990

Within the FRONTIERS system, a new analysis procedure has been implemented which introduces two main changes:- a) the calibration of radar derived rainfall using gauges now takes account of estimates of the orographic growth of precipitation unseen by the radar, and b) a simplified bright-band correction procedure allows the operator to truncate spurious excessive rainfall rates.

Limited verification of the new radar analysis has taken place comparing both the FRONTIERS and RADARNET analyses with hourly gauge data. The comparisons showed FRONTIERS and RADARNET analyses to be of similar quality overall. Radar data from pixels surrounding the gauge site was smoothed in an attempt to reduce collocation errors. However, the smoothing produced no significant improvement in the comparison results compared to using the single radar pixel in which each gauge was situated.

Work is now underway to investigate why the improved parameterizations in the FRONTIERS analysis do not appear to significantly improve the analysis on average. Limited verification against hourly gauge data will be continued in support of this work. Studies contrasting expected bright-band intensities with those actually observed for some anomalously intense cases are being written up for publication. The most likely explanation is the melting of giant snowflakes which have grown by aggregation in a deep isothermal layer occurring where the 0°C isotherm intersets a warm frontal surface.

Reports prepared to due

Warner C 1989. Real-time adjustment of radar fields of precipitation by raingauges, allowing for orographic enhancement near the surface. Preprint Vol., Int Symp on Hydrological Applications of Weather Radar, 14-17 August, University of Salford.

Progress report submitted by: C G Collier (MO) Date: May 1990.

PROGRESS REPORT TO NERC STEERING COMMITTEE ON THE HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

Project A2

Project Title: Improvement of accuracy of radar measurements (taking into account orographic aspects)

Report Period: to January 1990

Introduction

Objectives:

(i) Devise improved ways of determining rain type.

(ii) Assess the applicability of existing domain boundaries and redefine as necessary.

(iii) Assess the applicability of, and update/redefine as necessary, the detailed orographic scaling factor due to variations of wind speed and humidity.

(iv) Determine optimal sites for orographic raingauges (with regard to areas of maximum orography and taking into account variable wind drift) and derive ways of using such gauges (whether in or upwind of the areas of interest) to determine in real time the appropriate orographic scaling factor.

Progress:

A method of determining orographic enhancement using the average annual value was abandoned. The values it gave for SW winds were in broad accord with the case studies, but other wind directions required too much subjective and detailed adjustment to produce sensible patterns and magnitudes. A very simple scheme relating enhancement to slope and distance downwind from previous ridges was devised. The patterns and magnitudes so obtained were similar (but NOT identical) to those already installed in FRONTIERS over Great Britain for all wind directions. Using the case study data already to hand for SW winds, tests were made over Wales and NW England. The existing corrections were better, but not by much. With this encouragement the new scheme was used to provide a new table of corrections for Ireland for ALL wind directions.

Progress report submitted by: C G Collier (MO) Date: May 1990

PROGRESS REPORT TO NERC STEERING COMMITTEE ON THE HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

Project A4

Project Title: Investigation of the man-machine interface

Report Period: to January 1990

Introduction

Objectives:

(i) Develop methods of manual intervention leading to improved accuracy of rainfall analyses and forecasts, develop automated procedures to supercede these where and when practicable, and keep under review the optimal balance between the two types of approaches.

(ii) Undertake a user survey to identify the relative importance of timeliness and accuracy with regard to both actual and forecast (1, 3 and 6 hours) rainfall.

Progress:

The achievement of the first objective is being sought within the framework of the FRONTIERS Project in the Meteorological Office. Progress over the last 6 months is outlined.

The investigation of the satellite rainfall diagnosis techniques was extended from frontal situations to 10 cases of cold-air convection and 5 mesoscale convective systems. The results have been summed to produce aggregate tables for each synoptic type. The key difference is that precipitation is associated with warmer cloud tops in the case of cold-air convection, probably because the cloud-top temperature of small-scale convection is underestimated. The aggregate tables have been used to improve the formulation of the Universal (predefined) Tables within the FRONTIERS system.

A study has been made of the accuracy of the satellite/radar correlation technique. The use of a fixed visible or infra-red threshold produced a small reduction in the average value of the evaluation statistics but a significant increase in the standard deviation, indicating large errors on a few occasions.

Some skill has been found in delineating areas of heavy precipitation in convective cases where such precipitation is widespread, by using correlation tables stratified by rainfall rate. Unless the heavy precipitation is widespread statistical uncertainty precludes sensible answers.

An on-line forecast evaluation scheme has been set up. Six forecast sequences are evaluated each day by comparison with radar actuals. The results can be presented in a variety of graphical forms, stratified by synoptic type and available the next day if required. Baseline statistics are being acquired for comparison with the new forecast scheme described below.

To improve the realism of the short-period forecasts produced by advecting radar and satellite precipitation fields, in particular to allow for rotational motion, a scheme has been devised for FRONTIERS to produce a selection of forecasts by advecting the precipitation areas with the Mesoscale

Model wind field at various heights. The forecaster's role will be to choose the best wind-based forecast or decide that the current method of tracking radar echoes should be used. A new workstation has been acquired for this task, which is also powerful enough to allow the real-time computation of rainfall accumulations. A basic version of the new scheme is under development.

Progress report submitted by: C G Collier (MO) Date: May 1990.

PROGRESS REPORT TO NERC STEERING COMMITTEE ON THE HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

Project A2

Project Title: Orographic rainfall enhancement in North West England from surface and radar data

Report Period: October 1988 to May 1990

Introduction

This is a project being undertaken by a postgraduate research student, Mr K R Brown, working for a PhD. It is funded by NERC. Duration October 1988 to September 1991 (3 years).

Progress:

Seven rainfall case study events have been selected on the basis of widespread, heavy rain incident over the Hameldon Hill weather radar area from a variety of wind directions. This allows the assessment of enhancement position and magnitude.

A comprehensive field programme, including 11 additional, strategically placed, tipping bucket raingauges is in operation (October 1989 - September 1990). These data will supplement existing gauge information to determine frequency and magnitude of orographic enhancement, under various wind directions throughout the year.

Problems:

Problems have been encountered when selecting the rainfall case studies. Events have been selected where there was widespread rain over the majority of the 75 km radius radar image lasting more than about 5 hours. Too frequently the radar developed a fault, producing a break in the continuous data record. Such events were discarded, as were events containing periods of bright band.

Financial Aspects:

Research studentship fully funded by NERC. Some additional support (equipment, computing facilities) from the University.

Reports Prepared to date:

None

Progress Report submitted by: V K Collinge Date: May 1990

PROGRESS REPORT TO NERC STEERING COMMITTEE ON THE HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

Project A2, A3, A6

Project Title: The use of meteorological data for calibrating a weather radar used for rainfall measurement and forecasting

Report Period: Up to May 1990

Introduction

Research at the University of Lancaster has been in progress since January 1988 under the following fundings:

Funding agency	Duration	Principal Investigator	Research staff
NERC (research grant)	April 1986 March 1988		James Buxton (up to April 88) Ewan Archibald (from October 88)
NERC/CEC	October 1987 September 1990	V K Collinge Prof P C Young	plus technician (part-time)
North West Water	May 1988- March 1989		

Progress:

(i) Identification of anomalies in Hameldon Hill data (sector from 270° to 005° only). Method for correcting errors developed and implemented.

(ii) Time series technique for forecasting AF values at calibrating sites developed.

(iii) Influence of physical/meteorological parameters on Assessment Factors now extended to examine influences on radar/raingauge transformatin. Report due shortly.

(iv) Study of radar observations of a major convective storm (Halifax, 19th May 1989) completed. Paper submitted for publication.

(v) Similar study of convective storms on 24th May 1989 also completed.

Problems

Anomalies in Hameldon Hill data in sector 005° to 270° need to be corrected. Poor quality autographic charts only slowly being replaced by solid state logger systems. NERC research student has left (for personal reasons).

Financial Aspect:

NERC	£26,000 (over 2 years) (plus University support for equipment = £10,000 approx)
NERC/CEC	£17,000 (over 3 years)
NWW	£20,000 (over 1 year)
	(Academic staff costs are not included in the above figures)

Reports prepared or due:

Final report to NERC	- September 1988
Annual reports to CEC	- October 1988/October 1989
Final report to NWW	- May 1989

Progress report submitted by: V K Collinge Date: May 1990

PROGRESS REPORT TO NERC STEERING COMMITTEE ON THE HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

Project Title: Small catchment response times

Report period: April 1989 - April 1990

Introduction:

Since the publication of the UK Flood Studies Report (FSR) in 1975, it has become clear that small catchments form the majority of cases in which the FSR methods are used. However,because of a lack of small permeable catchments in the original data set, the FSR is less accurate in predicting floods on such small catchments than on larger ones. This project aims to obtain better flood predictions by using weather radar and water level recorders, with high temporal accuracy, to estimate the delay between storm rainfall and resulting peak water levels. The lag times will be used to derive an improved relationship with catchment characteristics. Fifteen water level recording sites have been instrumented, having catchment areas of between 0.8 and 22 km^2, located within 75 km of the weather radar at Chenies. Sites to the west and north west of London were selected and are within the 2 km x 2 km grid high definition data area of the transmitter.

Progress:

The 15 water level recording sites were implemented between 4 September 1989 and 6 March 1990 and have been operating satisfactorily. Surveys of those catchments having an urban element have been carried out. A database has been implemented on an IBM-PS2 and associated software written. The catchment areas have been digitised. Software which makes use of digitised catchment boundaries to compute the temporal centroids of (radar) rainfall has been written. The interval at which water level data are recorded is 1 hour during dry weather but reduces to 1 minute during events.

Problems:

Two sites experienced initial difficulties with the pressure transducers used to detect water levels.

Financial Aspects:

The project is funded by the Ministry of Agriculture, Fisheries and Food.

Phase 1		Phase 2
1989/90	£49K	Under consideration. (Emphasis may shift to more general analysis of small catchment flood data held by IH and cooperating organisations).
1990/91	£49K	

Reports prepared or due:

Phase 1 report due 31 March 1991

Progress report submitted by: D C W Marshall (IH) Date: May 1990

PROGRESS REPORT TO NERC STEERING COMMITTEE ON THE HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

Project No: A3, A6, B1

Project Title: Local calibration of weather radar

Report period: January 1988 - June 1989

Introduction:

This project forms a contract with Thames Water and also includes strategic research commissioned by MAFF and will also be reported to the CEC. The aim is to develop techniques for combining telemetering raingauge data with radar data to obtain a better estimate of the rainfall field at the current time.

Progress:

Software to decalibrate the at-site radar data was installed on TW's VAX computer in December 1988, a total prototype system for recalibration delivered on 1 March 1989, and following system integration by TW staff became operational on 14 March 1989. The recalibration procedure is based on fitting an extended form of multiquadric surface to calibration factors defined at each 15 minute time-frame, and then applying this calibration surface to the decalibrated radar field to obtain a recalibrated rainfall field. Analysis of historical data for 19 storm events indicate that the product is 22% more accurate than the at-site calibrated product, on average. Operational constraints suggest that the actual average accuracy will improve by between 22 and 13%. The use of a continuous surface rather than domains and the procedures independence of rainfall type also mean that the new product is free of spatial and temporal discontinuities. A procedure to estimate the rainfall field from raingauge data alone was delivered to Thames Water in June 1989: this is to be used operationally to complement the recalibrated radar product and to substitute for it when radar data are unavailable.

Problems:

Timing errors in the archived raingauge data have required extensive quality control of data prior to analysis (these errors are not present in more recent data).

Financial Aspects:

The NRA contract was for£30K per annum over two years ending 1 October 1989.

PROGRESS REPORT TO NERC STEERING COMMITTEE ON THE HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

Project Nos: B2, B3

Project Title: Regional and national radar rainfall forecasting systems

Report period: January 1988 - May 1990

Introduction:

This project forms a contract with the NRA Thames Region and also includes strategic research commissioned by MAFF and will also be reported to the CEC. The aim is to develop techniques for short period, high resolution, rainfall forecasting. New techniques will be compared with the Met. Office FRONTIERS product.

Progress:

An automatic rainfall forecasting procedure has been developed which incorporates removal of anomalous values from the radar field. The procedure is based on a linear advection model with the storm direction and speed estimated by minimizing a root mean square error criteria when advecting a previous radar field forwards in time to forecast the current radar time-frame; this model is then used to forecast future rainfall fields up to 2 hours ahead. Variants of this procedure, including incorporating acceleration and using a zero/one threshold field, have not performed so well. Improved performance relative to a "persistence" forecast and an "average field" forecast has been demonstrated.

Problems:

Shrinking of the field that can be forecast using the current radar field as the lead time increases is currently a problem: this will be overcome by incorporating 5 km data, available for a larger area, into the procedure. The CPU requirement of 14 minutes on an IBM 4381 is a problem for the current NRA operational VAX 11/750 computer.

Financial Aspects:

Preliminary work was undertaken as part of the London Weather Radar Local Calibration Study. A new contract with NRA Thames Region, worth £39K over one year, began on 1 October 1989.

Reports prepared or due:

(1) Report prior to October 1989 are referenced in the Local Calibration of Weather Radar Study. (A3, A6, B1).

(2) Progress Report for 1st Steering Committee Meeting on Local Rainfall Forecasting using Weather Radar, 4 January 1990, Institute of Hydrology, 16pp

(3) Progress Report for 2nd Steering Committee Meeting on Local Rainfall Forecasting using Weather Radar, 4 April 1990, Institute of Hydrology, 24pp.

Progress report submitted by: R. J. Moore (IH) Date: May 1990

PROGRESS REPORT TO NERC STEERING COMMITTEE ON THE HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

Project Nos: B5, B7, A5, B4

Project Title: Real-time forecasting of river flows

Reporting period: July 1989 - May 1990

Introduction:

This project form IH's strategic research programme on real-time flow forecasting commissioned by MAFF and includes the flow forecasting component of the CEC project. Research focusses on developing improved modelling, updating and input specification techniques. That which relates specifically to radar includes radar calibration (reported elsewhere), the development of grid-square models for use with radar data, the use of GIS techniques with radar data for model input specification, the evaluation of radar data for flow forecasting, and gauge/radar network design implications.

Progress:

A grid-square rainfall-runoff model based on the weather radar grid has been implemented on the River Wyre catchment. A simple storage conceptualisation of runoff production is used within each grid square and the isochrone concept used to translate runoff to the basin outlet. The problem of parameterisation is overcome using the contours and the river network of an Ordnance Survey map to derive times of travel and to infer storage capacity as a function of slope. Radar data for a one month period has been used for model testing, and this has allowed continuous soil moisture accounting to be maintained over this period. Further work is required to comment in detail on the performance of the model.

Problems:

Lack of financial support. The study catchment is known to be badly affected by areas of radar anomaly.

Financial Aspects:

MAFF commission funding assigned to radar related research (including radar calibration) is £30K pa. CEC funding is £10K pa for 3 years which includes urban applications and calibration components, project management, travel, etc.

Reports prepared or due:

(1) CEC Weather Radar and Climatic Hazard 2nd Annual Report, November 1989.
(2) Annual Report to MAFF, February 1990.

Progress report submitted by: R. J. Moore (IH) Date: May 1990.

PROGRESS REPORT TO NERC STEERING COMMITTEE ON THE HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

Project Nos: A6

Project Title: Variation of extreme rainfall events in upland areas

Reporting period: August 1989 - May 1990

Introduction:

The project is being undertaken at the Institute of Hydrology, commissioned by the Department of the Environment Water Directorate. The study of spatial and temporal variations in rainfall has particular implications for the structuring of design storms for reservoir flood estimation. This project explores the combined use of radar and gauge rainfall data to develop improved representations of areal and temporal profiles. The 10,000 km^2 study area is centred on the Hameldon Hill radar station. The first phase of the project was concerned with spatial variations of extreme rainfalls, focussing particularly on the re-assessment of the areal reduction factors given in the Flood Studies Report. The second phase commenced in April 1989 and is using raingauge and radar data to develop more realistic storm profiles for upland areas.

Progress:

Experimental profiles have been extracted using a peaks over threshold approach for the shorter durations and annual maxima for durations of greater than one day. Shape characteristics of observed temporal profiles are being compared for different durations, season and return periods. A number of different methods of deriving design profiles are being investigated, of which the Australian "average variability method" shows most promise.

Problems:

The radar dataset under analysis is not continuous, consisting only of selected heavy rainfall events. However, results obtained using the Dee high resolution raingauge data suggest that this limitation may not be too serious.

Financial aspects:

The project is funded by the DoE Reservoir Safety Commission Total budget for Phase II £77.5K

Reports prepared or due:

Stewart, E. J. & Reynard, N.S. (1989) Variability of heavy rainfall events in North West England: an analysis of spatial structure. International Symposium on Hydrological Applications of Weather Radar, Salford, August 1989, 10pp.

Project extended in time, Final Report now due March 1991.

Progress report submitted by: E.J. Stewart/D.W. Reed (IH) Date: May 1990.

PROGRESS REPORT TO NERC STEERING COMMITTEE ON THE HYDROLOGICAL APPLICATIONS OF WEATHER RADAR

Project B6

Project Title: Weather radar and alarm procedures for flood warning

Report Period: January to June 1990

Introduction

The project is being undertaken by NRA - Thames Region with the aim of improving the detection of heavy rainfall, in particular convective storms, in and around London. A two stage alarm procedure is envisaged making use of 2 km radar data from the Chenies installation received by the Region's VAX 11/750 telemetry computer. A stage 1 alarm will initiate automatic interrogatin of the telemetry network every 15 minutes bringing on-line archives up-to-date. The regional radar recalibration system will be activated (as described in project A6) as will the operation of flood forecasting models. A stage 2 alarm, based on locally calibrated radar data, will warn flood duty staff of heavy rainfall approaching subcatchments in and around London. The feasibility of passing warnings to outside agencies will be evaluated.

Progress:

Various criteria for the generation of radar data based alarms have been considered. As a prototype it has been decided to treat a network of 2 km radar cells a pseudo-raingauges. A stage 1 alarm will be generated if a particular grid square registers 7 mm of rain in 1 hour (short-term) or 15 mm in 8 hours (long-term). The initial network consists of selecting 1 grid square every 10 kms in either direction.

Results of the prototype criteria will determine whether a denser or more sparse network is required and if the rainfall alarm settings give warnings of sufficient lead time and frequency.

Problems

(i) Work on this project has been shelved for the time being until a necessary staff vacancy has been filled. Revised timescales are not available at this time.

(ii) Insufficient processing power on the Authorities' VAX 11/750 computer is restricting syst4em enhancements and only priority schemes are being implemented. The alarm procedure is unlikely to be advanced until an upgraded computer system is in place.

Financial Aspects

The project will be funded by the NRA - Thames Region making use of a software consultant.

Reports prepared or due:

A report will be prepared at the end of the project.

Progress Report submitted by: C M Haggett, NRA Thames Region Date: May 1990