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Flood risk and flood forecasting - the state-of-the-art in EU research

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FLOOD RISK AND FLOOD FORECASTING - THE STATE-OF-THE-ART IN EU RESEARCH

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Abstract
Flooding causes damage and distress wherever it happens and in the worst cases can devastate communities and countryside. The scientific understanding of the processes involved has made great progress in recent decades, with substantial contributions from European researchers in hydrology, flood forecasting, river basin, estuary and coastal hydraulics and the engineering of defence infrastructure. At the same time the understanding of the social and economic impacts of floods and the management of emergencies has also improved. These advances have challenged the traditional notion of flood "defence", a design paradigm that has given way to the concept of flood risk management. This change offers an opportunity for harmonisation by identifying all factors that contribute to the flood risk at any location and the effectiveness of different mitigation measures in reducing the impact of floods on the environment, people, property and businesses. This paper provides an overview of some of the 100 European Commission financed projects on hydrological risk from the 1980s.

1. Introduction

In Europe flash flooding poses the most frequent risk to life, particularly in mountainous areas, but millions of people also live close to large rivers and on coastal plains where their security often depends upon dykes and embankments. The potential for flood damage is increasing arising from social and economic development bringing pressures on land use within the flood plains of rivers. It is essential to recognise that floods are part of the hydro-meteorological cycle and may be characterised as:

- Flash floods in small, steep or urban catchments with little warning and of short duration
- Plains floods in large rivers with typically a slow build-up and long duration
- Tidal and marine floods caused by surges, waves, which again have predominantly a short duration

Heavy rainfall may trigger other hazards such as landslides and mudflows with their attendant generation and transport of debris. In severe events there may be considerable damage from failure of infrastructure such as dams, dikes, sluices and bridges, with consequent damage to buildings and businesses. Flooding also may liberate and transport pathogens and pollutants leading to contamination of water supplies and land with subsequent physiological and psychological effects on the population affected.

There is currently concern that flooding may be increasing in frequency and severity, induced by changes in the earth's climate. Sustainable flood management combines an acceptable degree of protection by physical infrastructure combined with alternative means of risk reduction against the most severe floods, using methods which are

technically feasible, economically and environmentally sound and sustainable.

2. Flood forecasting and warning

It is important to recognise the difference between flood forecasting and flood warning. Flood forecasting covers the prediction of the nature and extent of a flooding hazard at some time in the future. Many scientific and technological advances have improved the quality and timeliness of flood forecasts and the projects described in this paper concentrate mainly on the science and technology for forecasting. Flood warning, however, deals with the public face of flood management during an event. The relevant authorities (e.g. river basin authority, local or regional government, civil protection authority) take information from flood forecasts and transmit appropriate information to those at risk. Many factors influence the effectiveness of the flood warning as tabulated below.

Table 1 Steps in achieving a response to a flood forecast and warning

Step	Issue
Awareness of a warning	Is the warning received before flooding occurs?
Availability to respond	Can the property owner reach the property to take action?
Ability to respond	Is the owner physically capable of mitigating flood damage?
Effectively respond	Does the owner know what to do and act effectively?

There is a need to present the warning information in a manner that can be readily understood by the intended recipients and is specific to the locality at risk. The full benefits of advances in knowledge in the science and technology of flood forecasting can only be achieved in combination with appropriate institutional and social systems to mediate the forecast into actions which reduce and mitigate the flood impacts. Thus the implementation of a flood forecasting system must be accompanied by:

- local warning dissemination plans,
- identification of the areas at risk (even for low levels of hazard),
- building public awareness of the extent of flood hazards and risks, the type of flood warning issued and actions to take on receipt of a warning
- means of issuing general broadcast warnings and specific alert warnings to identified communities

3. EC Research Actions

The European Commission (EC) Research Directorate General (formerly DG XII) has funded research on many issues in the science and management of flooding since the early 1980s. The number and scope of the projects has increased in the past decade, driven partly by the need to address the real and apparently increasing needs of the citizens of Europe for protection from floods. This research has been set mostly within a broader programme of science on understanding natural hazards and hydrogeological risks. In all 100 projects have been funded through a variety of specific programmes and mechanisms with a total Commission funding in excess of €90 Million; access to summary information on most of these projects is possible through the EC research server http://www.CORDIS.lu.

Table 2 EC funded research project related to flood risks

Framework Programme	Project Start Dates	Number of Projects
FP2 and earlier	1990 and earlier	9
FP3	1991 to 1994	19
FP4	1995 to 1998	34
FP5	1999 to 2003	38

These project have covered a diversity of topics including:

- Remote sensing of weather conditions
- Radar-hydrology coupled to numerical weather prediction for flood forecasting
- Climate impact on floods and paleoflood assessment
- Flood risk identification and socio-economic factors in flood management
- Hydrological and hydrodynamic model integration - for planning and forecasting
- Debris and sediment movement in high energy rivers
- Dam failure and consequent flooding
- Exploitation of Telematics in the management of flood risks

The state-of-the art for project in FP3 and FP4 is well documented for river flooding hazards in the end-of-project reports of the FP4 and FP5 Concerted Actions: RIBAMOD, RIPARIUS and MITCH and Masters at the University of Birmingham (Table 3). The latter report, Ashton *et al* [1], identified projects and summaries from CORDIS and other sources. This report includes some statistics on the participation in the EC research on flood risks, showing that four countries (Italy, France, the UK and Germany) account for over half the partners in all the projects and nearly three quarters of the project co-ordinators. This concentration of the research activity however appears to follow approximately the extent of the flood problems in these countries as documented in the CRED database, see Table 4.

Table 3 Links to project reports

Project	**Link**
RIBAMOD	http://www.hrwallingford.co.uk/projects/RIBAMOD/index.html
RIPARIUS	http://www.nwl.ac.uk/ih/www/research/briparius.html
MITCH	http://www.mitch-ec.net/news_events.htm
Birmingham University MSc Report	http://www.actif-ec.net/library/review_EU_flood_projects.pdf

Table 4 Participation in EC research from Ashton *et al* [1]

National participation as Partners in EC flood related research projects 1980 – 2002		National proportion of major floods in EU countries during* 1980 – 2002		Approximate national proportion of total EU flood losses* 1980 – 2002	
Italy	21 %	France	22 %	Germany	28 %
France	14 %	Italy	17 %	Italy	25 %
UK	13 %	UK	12 %	UK	15 %
Germany	9 %	Greece	10 %	Spain	15 %
Spain	7 %	Spain	9 %	France	6 %

Data taken from disaster databases, Centre for Research on the Epidemiology of Disasters. http://www.cred.be/emdat/intro.htm

4. Some Fourth Framework Programme Projects

4.1 Flood Risk Management - the RIBAMOD principles

In 1995 the EC organised an expert workshop to discuss the current state-of-the-art and research needs in the area of river flood management; this led to the funding of the Concerted Action on River Basin Modelling, Management and Flood Mitigation, RIBAMOD. The severe flooding on the River Oder in the summer of 1997 occurred just prior to the third of the RIBAMOD scientific meetings. At that meeting a series of principles of holistic flood defence were developed (see Kundzewicz and Samuels [2] and Samuels [3]). These are a sequence of pre-flood activities, operational flood management and post-flood activities, which are broadly applicable across all scales of flood management.
The pre-flood activities include:

- Flood risk management for all causes of flooding
- Disaster contingency planning to establish evacuation routes, critical decision thresholds, public service and infrastructure requirements for emergency operations.
- Construction of flood defence infrastructure, both physical defences and implementation of forecasting and warning systems,
- Maintenance of flood defence infrastructure
- Land-use planning and management within the whole catchment,
- Discouragement of inappropriate development within the flood plains, and
- Public communication and education of flood risk and actions to take in a flood emergency.

Operational flood management includes:

- Detection of the likelihood of a flood forming (hydro-meteorology),
- Forecasting of future river flow conditions from the hydro-meteorological observations,
- Warning issued to the appropriate authorities and the public on the extent, severity and timing of the flood, and
- Response to the emergency by the public and the authorities.

The post-flood activities may include (depending upon the severity of the event):

- Relief for the immediate needs of those affected by the disaster,
- Reconstruction of damaged buildings, infrastructure and flood defences,
- Recovery and regeneration of the environment and the economic activities in the flooded area, and
- Review of the flood management activities to improve the process and planning for future events in the area affected and more generally, elsewhere.

4.2 Flood Risk Assessment – FLOODAWARE and EUROTAS

The FLOODAWARE project was coordinated by Cemagref. The project proposed a European methodology for vulnerability and risk mapping, to aid decision-making in flood management and damage mitigation. The project was set up to address the need to move the development environmental policies from the prevailing qualitative approach to a more objective one, taking into account the importance of the relationships between climates, hydrological regimes and land use. The project integrated environmental constraints (including ecology) and socio-economic factors with synthetic hydrological models of flood-frequency coupled to hydraulic modelling. The research topics included hydrological regionalisation for rainfall, estimation of extreme rainfalls and discharges, including the effects of reservoir management rules. The methods were also tested within the EC FRAMEWORK project on the Alert Prototype System in mountainous catchments in NW Italy. The “QdF” (discharge-duration-frequency) hydrological approach developed at Cemagref and the agricultural

damage and vulnerability models were later extended and validated during the EUROTAS project coordinated by HR Wallingford.

The EUROTAS project partners developed and demonstrated the use of integrated catchment modelling based upon an open-systems integration of standard models

- To address the structural and non-structural issues of flood management at a catchment scale and
- To explore future scenarios of climate and land-use change from local, national and regional socio-economic policy.

The EUROTAS project led to several advances and achievements including:

- Demonstration of the integration of several existing hydrological and hydrodynamic simulation models within and open-systems catchment scale framework
- Development of and demonstration of a land-use change scenario builder
- Development of a methodology for downscaling precipitation scenarios at the catchment scale from General Circulation Model (GCM) simulations
- Illustration of the sensitivity of flood flows to urbanisation, land-use change and climate change at a variety of scales and European climatic zones
- Illustration of the uncertainty in flood risk assessment based upon observations and the need for improved confidence in GCM simulations before firm conclusions can be drawn on the impact of climate change on flood risks.

By coupling hydrological and hydrodynamic modelling with spatial information on land use and flood vulnerability, future policy and planning of flood defence strategies can be based upon best available, sound science. This will contribute to overall sustainable flood management as discussed by Samuels [4]. In particular, the approaches demonstrated within FLOODAWARE and EUROTAS can now inform and influence the decisions on the allocation of land for development within the national spatial planning process. The completion of the research was particularly timely as the knowledge and the approach, potentially, can find application within the EU in the generation of the flood risk information in the forthcoming Basin Management Plans required by the Water Framework Directive (WFD). In addition the approach to model integration is under development, more broadly to all the water management issues under the WFD in the HARMON-IT project.

5. Fifth Framework Research on Flood Forecasting

5.1 The CLUFF cluster of Fifth Framework research on flood forecasting

In mid 2002, an overview cluster arrangement was established for all the active FP5 projects relating to flood forecasting. The projects in the **CLUFF** cluster, coordinated at the University of Salford are delivering their scientific results and advances over from 2003 to 2005. These FP5 projects are covering a variety of topics including:

- innovative technologies for space-borne and ground-based monitoring;
- data assimilation from a variety of sources
- new and improved modelling techniques;
- the linkage between meteorological and hydrological models;
- spatial recognition and indicators for current state of natural hazards;
- improvements in the dissemination of forecasts and warning;
- practices for emergency awareness, preparedness and operations at both the institutional level and with the individual citizen.

5.2 The European Flood Forecasting System

The EFFS project is coordinated from WL Delft Hydraulics. The overall objectives of the project are to employ currently available numerical weather prediction information to produce reliable flood warnings, beyond the

current flood warning period of approximately three days, in a European Flood Forecasting System (EFFS). The EFFS project produces flood forecasts from the European Medium-Range Weather Service forecasts of conditions four to ten days ahead. EFFS provides daily information on potential floods for the large river basins of the Rhine and Oder as well as flash floods in small basins. The demonstration of EFFS uses the LISFLOOD model developed at the EC Joint Research Centre (JRC) at Ispra. The framework of EFFS enables the incorporation of both detailed models for specific basins as well as a broad scale for entire Europe. This new system can produce flood forecasts for regions where at present flood forecasts are unavailable.

5.3 CARPE DIEM

The CARPE DIEM project is coordinated by ARPA-SMR (Bologna) and commenced in 2002. It is directed at the better estimation and prediction of rainfall for the management of floods and other hydro-geological risks. The main objectives are to:

- Process atmospheric parameters to transfer data to numerical weather prediction (NWP) algorithms, compatible with the atmospheric state
- Improve the techniques for assimilation of radar data in NWP models, with emphasis on the forecasting of flooding events and on nowcasting
- Improve the quality of radar products using NWP results
- Improve the quality of radar rain retrieving techniques
- Establish quality control procedure for filtering raw data
- Improve the quality of the rainfall field inputs to hydrological models
- Assess the sensitivity of hydrological models to input data and
- Improve the useful lead-time and reliability of flood forecasts.

The project involves test sites in several Member States and end-users are actively engaged in the definition and assessment of project outcomes.

5.4 EURAINSAT

The EURAINSAT project, coordinated by CNR-ISAC (Bologna), is researching the use of Earth Observation (EO) technologies for flood management applications and this research has attracted interest from other institutions worldwide. The key objective of the project is the development of algorithms for rapidly updated satellite rainfall estimations at the geo-stationary scale. The channels now available from the new METEOSAT Second Generation "SEVIRI" radiometer in the visible and infrared (VIS/IR) portion of the spectrum will provide insight into the microphysics and dynamic structure of precipitating clouds thus allowing a more precise identification of precipitation levels. Microwave (MW) radiometers on board polar orbiting satellites will be used because of their information on the clouds vertical structure. The method will work by:

- Characterising the microphysics of precipitating clouds from VIS/IR sensors;
- Creation of microphysics and radiative databases on cloud systems using cloud model outputs and aircraft observations;
- Tuning MW algorithms on the different cloud types (convective etc);
- Combining data from the different algorithms and applying them in a rapid update cycle using different sensors at the geo-stationary scale.

5.5 MANTISSA

The MANTISSA project, coordinated by the University of Salford, takes advantage of the natural attenuation of microwave links in rain to derive spatial-temporal rainfall data to improve the performance of operational flood forecasting systems. The end application is to mitigate flash flooding in steep urban and rural catchments and water quality degradation from sewerage overflows. The MW frequencies of interest in MANTISSA are used by the mobile telecommunications industries across Europe. Data covering most of Europe can therefore be readily collected in the event that this research is successful. The project is combining information from

MW and radar sources and is examining how MW attenuation measurements can be used as the basis of comprehensive and flexible tools to manage the entire rainfall-runoff system. The MANTISSA project is undertaking a series of field measurement exercises as well as developing methods for hybrid estimation of rainfall and state-updating of hydrological models.

5.6 MUSIC

The MUSIC project, coordinated at the University of Bologna, has two main aims, which are to improve:

- The reliability of the rainfall estimation techniques based on radar and METEOSAT, by combining them with the traditional rain-gauge observations; and
- The communication and the dissemination of results to the authorities involved in real-time flood forecasting and management.

The project is developing improved precipitation estimation algorithms for each sensing technology, assessing their uncertainty and combining the output data of the three independent data sources to provide a more reliable short term flood forecasting system together with a measure of its uncertainty. The system will improve considerably the forecast reliability and precision for flash flood and will shorten the time required to detect events, which lead to catastrophic flood events. The system is applicable to small as well as to medium size catchment areas and can be used for very short term (one to six hours) forecasting systems and, in combination with a Local Area Meteorological Model, for forecasts up to two days ahead.

5.7 FLOODMAN

The main objective of the FLOODMAN project, which is coordinated at NORUT-IT and commenced in 2003, is to develop, demonstrate and validate an information system for cost effective near real-time flood forecasting and management using earth observation (EO) data. The project aims to:

- Develop improved methods for near-real time continuous monitoring of flood extent from EO data, in particular space borne synthetic aperture radar (SAR) data
- Develop methods for utilising EO and in-situ data in distributed hydrological and hydraulic models
- Develop a generic, distributed and scalable prototype information system for water management, which integrates EO, in-situ and model data
- Validate and demonstrate the information system operationally.

The prototype system will provide near real-time information on the flood situation and improve flood prediction, for better management of rivers and their catchments, including hydropower production planning.

5.8 FLOODRELIEF

FLOODRELIEF is coordinated by DHI Water and Environment and commenced in 2003. The aims of the project are to develop and demonstrate a new generation of flood forecasting methodologies which will advance current capabilities and accuracy and to make then forecasting information and results more readily accessible both to flood managers and those threatened by floods. This will be achieved by exploiting and integrating different sources of forecasting information including improved hydrological and meteorological model systems, databases, radar, advanced data assimilation procedures and uncertainty estimation. A decision support system (DSS) will be demonstrated on regional forecasting systems in the UK and in Poland. Work packages include weather forecasting, dynamical downscaling, radar-based quantitative precipitation forecasts (QPF), hydrological and hydraulic modelling, forecast uncertainty tools and the development of the real-time DSS.

5.9 ACTIF

A final Accompanying Measures project, ACTIF, coordinated by HR Wallingford, commenced in early 2003 to draw together

the results of this cluster of FP5 projects as European best practice papers on:

- Understanding and reducing uncertainty in Flood Forecasting using information from many sources,
- The requirements of flood forecasters for the preparation of specific types of warnings, and
- The integration and assimilation of data from a variety of sources including Earth Observation.

In addition a fourth workgroup in ACTIF will examine how data from experimental measurements and field test sites should be stored in the long-term. This will enable other researchers to benefit from intensive and detailed measurement programmes that are a part of several EC funded to derive more value from the research funding. This workgroup will report as early as possible so that the recommendations can influence the arrangements for long-term availability of data from the current round of RTD projects. The project web site http://www.actif-ec.net/ gives links to the other FP5 forecasting projects in the cluster.

6. Areas for Research

Despite progress in research and practice, however, significant scientific gaps still remain in understanding the processes that generate floods as well as socio-economic developments in flood-prone areas. These gaps contribute significant uncertainties to flood risk assessments and reduce the effectiveness of some measures intended to reduce flood risk. In addition, a significant challenge lies in bringing together these various strands of scientific, engineering and socio-economic knowledge and using it to support integrated flood risk management, taking into account that inherent uncertainties cannot be taken away and so must be adequately tackled in management decisions. Amongst the topics for research are

- Use of remotely sensed data (as part of the GMES initiative)
- Generation and forecasting of flash floods on catchments less than 500 km^2
- Improvement of NWP, QPF and coupled hydrological models
- Simulation of flooding in urban areas and quantification of risks to people
- Influence of climate change, land-use change and river restoration on flood risk
- Integrated risk assessment which includes reliability of structures, maintenance regimes, emergency management, public resilience, common safety standard

7. Discussion and Conclusions

The research projects funded by the EC have led in several cases to prototype implementations within the timeframe of the project, which has continued after completion, demonstrating that technological advances can give practical benefits. The projects have identified:

- There is a need to understand and adapt to changing flood regime
- Flood risk management mixes technical, social and economic factors
- The importance of public awareness and preparedness in mitigating flood losses with the need to tackle warning and response
- The need to plan and regulate use of the flood plain as part of flood risk management
- Flood forecasting can be effective in mitigating flood damage and ensuring public safety
- Opportunities to use technological advances especially in EO for public benefit
- That flood forecasting potential on a global scale

However, the difficulty with identifying the information on the EC funded projects from the CORDIS server (compiling the list took many days effort) indicates that there is a strong need to improve the dissemination of and access to RTD project results. This needs to be tackled both at the level of DG Research and almost certainly within the national programmes in many countries.

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References

Ashton V, Aziz H, Keith S and Smith T (2003), *Review of EU Flood R&D Projects*, unpublished MSc Management Project Report, School of Civil Engineering, University of Birmingham, B15 2TT, UK

Kundzewicz Z & Samuels P G (1997), *Real-time Flood Forecasting and Warning - Conclusions from the Workshop and Expert Meeting*, Proceedings of the Second RIBAMOD Expert Meeting, Published by DG XII, European Commission, Luxembourg, ISBN 92-828-6074-4

Samuels P G (2000), *Integrated River Management and Flood Risk*, Proceedings of the first EU-MEDIN workshop on Natural and Technological Hazards, Eds Fabbri K and Yeroyanni M, European Commission DG Research, Office for Official Publications of the European Communities, L-2985 Luxembourg, ISBN 92-894-3578-X pp 148-155

Samuels P G (2000), *A New Tool for Sustainable Flood Defence Planning*, Proceedings of the first EU-MEDIN workshop on Natural and Technological Hazards, Eds Fabbri K and Yeroyanni M, European Commission DG Research, Office for Official Publications of the European Communities, L-2985 Luxembourg, ISBN 92-894-3578-X, pp138-147

Appendix List of Projects and EC contract numbers

Project Title	EC contract Reference
A comprehensive forecasting system for flood risk mitigation and control	EPOC0023
Weather radar and storm and flood hazard	EPOC0026
Flood hazard control by multisensors storm tracking in Mediterranean areas	EV5V0167
Genesis and Impact of Tsunamis on the European Coasts	EV5V0175
Flooding risks in mountain areas	EV5V0462
Climate Change and Extreme Events: Altered risk socio-economic impacts and policy responses	EV5V0391
Storms, Floods and radar hydrology	EV5V0182
Relative sea-level changes ad extreme flooding events around European Coasts	EV5V0266
Climate Change and Coastal Evolution in Europe	EV5V0445
Slope instability; erosion and solid material transport in steep mountain catchments: laboratory and field experimentation	EV5VOI79
Genesis and Impact of Tsunamis on the European Coasts	CIPD925067
Slope instability; erosion and solid material transport in steep mountain catchments: laboratory and field experimentation	CIPD930031
Storms, Floods and radar hydrology	EV5V0182
Applied Research on a transferable methodology, devoted to flood awareness and mitigation, helping the decision and negotiation processes, adapted to a changing environment, and respecting water resources	ENV4960293
Flash flood risk assessment under the impact of land use changes and river engineering works	ENV4960297

Genesis and impact of tsunamis on the European coasts: Tsunami warning and observations	ENV4960297
Flood risk reduction by space borne recognition of indicators of excess runoff generating areas	ENV4960368
Debris flow management and risk assessment in the Alpine Region	ENV4960253
Forecasting floods in urban areas downstream of steep catchments	ENV4960257
Satellite and Combined satellite-radar techniques in meteorological forecasting for flood events	ENV4960281
River Basin Modelling, management and flood mitigation	ENV4960263
European river flood occurrence and total risk assessment system	ENV4970535
Heavy precipitation in the alpine region	ENV4960332
Runoff and atmospheric processes for flood hazard	ENV4970552
The European multi-hazard risk assessment project	ENV4970589
Concerted action on Dam-break modelling	ENV4970555
The Development of active on-line hydrological and meteorological models to minimise impact of flooding	ENV4960290
Dynamics of sediments and water in alpine catchments - processes and prediction	IC20960064
Distributed Environmental Disaster Information and Control System	EN1003
Telematics-assisted handling of flood emergencies in Urban Areas	EN4003
Risk of inundation - planning and response interactive user system	EN4302
Rapid Damage Assessment Telematic Tool	EN1011
Scaling behaviour in models of river networks and landscape evolution	FMBI972746
Dynamics of sediments and water in alpine catchments - processes and prediction	ENV4960247
Tsunami hazard assessment for the Mediterranean Region	INTAS-RFBR95-1000
Torrent hazard control in the European Alps. Practical tools and methodologies for hazard assessment and risk mitigation	EVG1-1999-00012
Realistic evaluation of temporal interactions of natural hazards	EVG1-2001-00046
Advanced Study Course in River Basin Modelling	EVG1-2001-65001
Mitigation of climate-induced natural hazards	EVG1-CT-2000-20001
A European flood forecasting system	EVG1-CT-1999-00011
Critical assessment of available radar precipitation estimation techniques and development of innovative approaches for Environmental Management	EVG1-CT-2001-00045
European satellite rainfall analysis and monitoring at the geo-stationary scale	EVG1-CT-2000-00030
Microwave Attenuation as a New Tool for Improving Stormwater Supervision Administration	EVK1-CT-2000-00060
Multi-sensor precipitation measurements integration, calibration and flood forecasting	EVK1-CT-2000-00058
Near real-time flood forecasting, warning and management system based upon satellite radar images, hydrological and hydraulic models and in-situ data	EVG1-CT-2002-00085
Real Time Flood Decision Support System Integrating Hydrological, Meteorological and Radar Technologies	EVK1-CT-2002-00117
Systematic, palaeoflood and historical data for the improvement of flood risk evaluation	EVG1-1999-00010
Achieving Technological Innovation in Flood Forecasting	EVK1-CT-2002-80014

Friendly Operational Risk Management through Interoperable Decision Aid Based on Local Environment	IST-1999-11679
Cluster Initiative for Flood and Fire Emergencies	IST-1999-14104
Operational Solutions for the management of inundation risks in the information society	IST-1999-11598
European Generic Emergency Response Information System	IST-2000-28345
Production of precipitation scenarios for impact assessments of climate change in Europe	EV5V0510
Water Resources: influence of climate change in Europe	ENV4970452
Sustainable water uncertainty, risk and vulnerability in Europe	EVK1-CT-2000-00075
Networking European Research on Natural Hazards	EVG1-CT-2002-60003
Climatic scenarios for European climate change impacts assessments: network for dissemination of climate data, climate change scenarios and scientific advice.	ENV4950128
A concerted action towards the improved understanding and application of Results from Climate Model Experiments	-
Automated fire and flood hazard protection system	EVG1-CT-2001-00057
Climate change, sea level rise and associated impacts in Europe	EPOC0015
Climate change and Extreme events: Altered Risk, Socio-Economic Impacts and Policy Responses	EV5V0391
Debris fall assessment in mountain catchment for local end-users	EVG1-CT-1999-00007
Data assimilation within a unifying modelling framework for improved river basin water resources.	EVK1-CT-1999-00022
Development of a European Land Assimilation System to predict floods and droughts	EVG1-CT-2001-00050
Applications of weather radar for the alleviation of climatic hazards	EV4C0022
Earth Observation Linking SMEs to face real time natural disaster management	IST-1999-57450
Survey and prevention of extreme glaciological hazards in European mountainous regions	EVG1-CT-2000-00018
European Flood Study	EV3C0035
Development of Nowcasting Techniques	COST4-78
Modelling the impact of climate extremes	EVK2-CT-2001-00118
Investigation of extreme flood processes and uncertainty	EVG1-CT-2001-00037
International workshop on palaeoflood and historical evidence in flood risk assessment	EVG1-CT-2002-60001
The management of the consequences of climatic change: extreme sea surge and runoff events	-
Development of polarisation diversity and Doppler radar data analysis for qualitative and quantitative precipitation monitoring in severe weather	EV5V0181
Development of advanced radar technology for application to hydrometeorology	ENV4960261
New Opportunities for altimetry in hydrology	ENV4960371
Earth Observation based flood risk information Management Service	ENV4980742
Flood Hazard Assessment	EPOC0044
European-Asian workshop on protection and upgrading of ecosystem for preventing flood disasters in the Asian tropical and subtropical region	ICA4-CT-2000-50011

Ecosystem Service and Sustainable Watershed Management towards Flood Prevention, Pollution Control and Socio-economic Development in North China	ICA4-CT-2000-50019
Decision support system for ecosystem upgrading and flood control of a sustainable development in the red river system (China, Vietnam) pilot phase	ICA4-CT-2001-10035
Innovative Application of Satellite and Radar Technology to real time flood forecasting systems	INNOVATION4-600
Data Fusion for Flood Analysis and Decision Support	IST-1999-11676
Decision support system for risk assessment and management of floods	IST-2001-37581
Weather Radar Networking	COST1-73
Environmental design of low crested coastal defence structures	EVK3-CT-2000-00041
International Conference on Environmental Security in the Danube River Basin	ICA1-CT-2002-60031
Statistical Analysis of some climatic Extremes (Hail, Thunderstorms, heavy rainfalls, risk of forest fires) and their characterisation and measurement with automatic systems for improving their climatological understanding	EV3C0055
Temporal and spatial variability of major floods around North Sea coasts	EV4C0046
Atlantic Sea Level Rise: Adaptation to imaginable worst case climate change	EVK2-CT-2002-00138
Towards natural flood reduction strategies	EVK1-CT-2002-80017
European River Margins as Indicators of global change	EV5V0100
Contribution to the reduction of debris flow damage, with the analysis of triggering factors, initiation, propagation and deposition phenomena, in the Alpine Region	EV5V0453
Impact of hydrometeorologic changes on slope instability	EV5V0295
Big Sources of Earthquake and Tsunami in SW Iberia	ENV4970547
Development of integrated catchment models for supporting water management decisions	ENV4950187
Real time forecasting of water levels and discharges on the lower part of the Danube River	CIPD925074
Studies and modelling of severe hydrometeorological conditions along the polish coast/hydrological protection of the coast/forecasts of storm surges, low sea level, ice conditions, etc.	CIPD925076
Sediment Transport and flow at high river stage	CIPD940760
Environmental Monitoring Warning and Emergency System	EN1009

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Today, HR Wallingford has a 50 year track record of achievement in applied research and consultancy, and a unique mix of know-how, assets and facilities, including state of the art physical modelling laboratories, a full range of computational modelling tools, and above all, expert staff with world-renowned skills and experience.

The Company has a pedigree of excellence and a tradition of innovation, which it sustains by re-investing profits from operations into programmes of strategic research and development designed to keep it – and its clients and partners – at the leading edge.

Headquartered in the UK, HR Wallingford reaches clients and partners globally through a network of offices, agents and alliances around the world.

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