URBAS: Prediction and Management of Flash Floods in Urban Areas

Thomas Einfalt[1], Klaus Friedeheim[2], Andreas Wagner[3]

[1] einfalt&hydrotec GbR, Breite Str. 6-8, D-23552 Lübeck (Germany)

[2] Hydrotec GmbH, Bachstr. 62-64, D-52066 Aachen (Germany)

[3] Deutscher Wetterdienst, Albin-Schwaiger-Weg 10, D-82383 Hohenpeissenberg (Germany)

1 Introduction

Recent studies about climate change indicate growing frequency and intensity of flash flood events in Western Europe. Flash floods are caused by extreme local precipitation and are often accompanied by thunderstorms. Precipitation of such events partly corresponds to return periods of more than 100 years and triggers flooding in urban areas.

The URBAS project is being supported by the German Ministry of Research in the framework of the RIMAX project cluster. RIMAX is grouping together more than 30 projects which are all investigating aspects of extreme floods in Germany.

URBAS has as a main objective to increase the preparedness and the range of possible actions of urban actors (e.g. communities, public enterprises) before and during rare small scale flash flood events.

2 URBAS project overview

URBAS is organised in an interdisciplanery manner. Aspects from city planning, hydrology, hydraulics, meteorology, damage assessment, emergency planning, and insurance issues are playing important roles. In order to get an overview over occurrence of urban flash flood events as well as their management, a data base with recent events has been set up. The above mentioned aspects are contained in this data base, providing a basis for drawing statistical conclusions e.g. on preferred regions of damage producing urban flash floods or on topographical preferences (Fig. 1).

Correspondence to: Thomas Einfalt.

thomas@einfalt.de

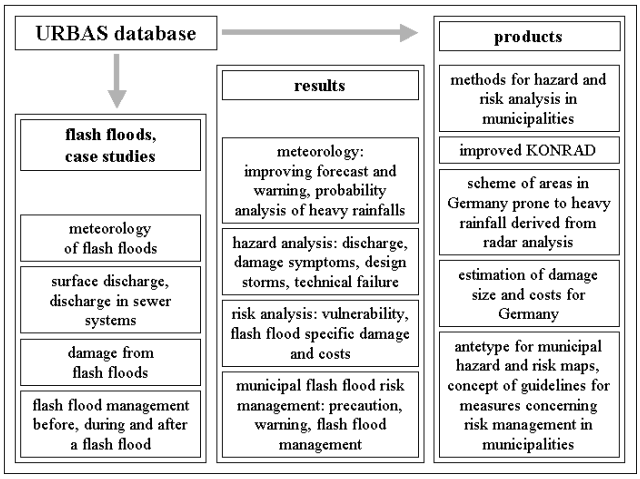

Fig. 1. Project overview: methods, results and products

The following results are expected at the end of the project:

- A database with flash floods and heavy rainfall events in Germany
- Improving quality of flash flood forecasts
- A detailed analysis of 15 case studies
- Hazard maps and risk maps for chosen case studies
- An approach to a flash flood hazard map for Germany]
- Development of measures and recommendations for a preventive flood control of flash floods in urban areas

2.1 Urban flash floods: small scale disasters in large numbers

Little is known about distribution, frequency and typical damage of flash floods in urban areas in Germany. There are no adequate forecast or warning systems, poor knowledge about effective precautionary measures and disaster control.

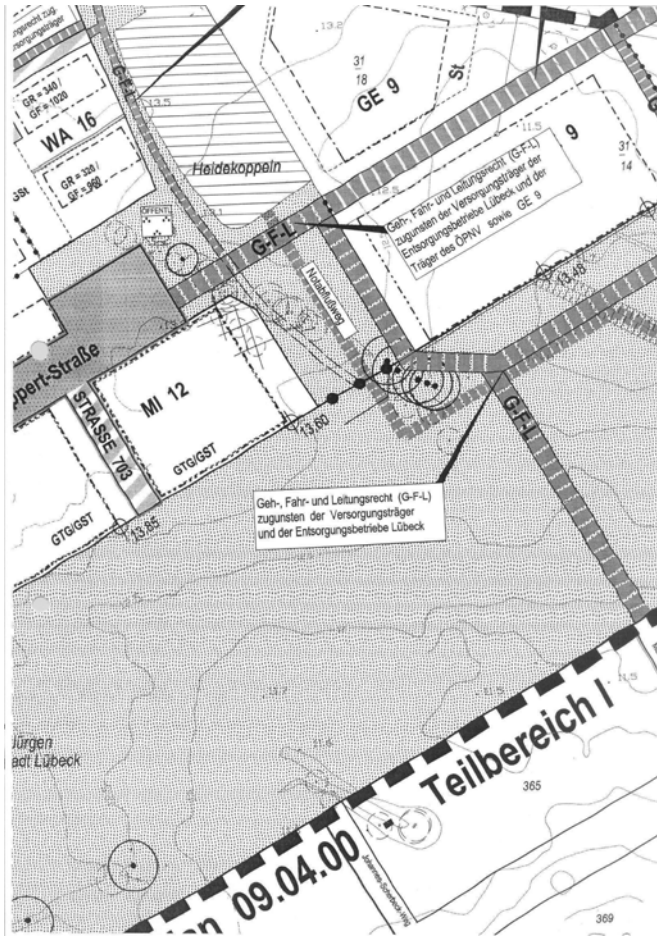

Fig. 2. Emergency floodway in a city planning document of Luebeck

Urban flash floods are flood events which cause damages in small catchment areas of less than 100 km² (and sometimes even less than 10 km²) and are caused by small scale rain events with volumes far above design rainfall for the concerned hydrological structures.

Since the impact of extreme events on a small area remains limited to a small part of an urban area, these events frequently are not widely published in the media although they are – locally – causing considerable damage. The large number of such small events sums up to several million € of damage volume per year only for Germany. In regions with more predominant convective activity, the impact may even be larger.

URBAS is producing a data base for Germany of urban flash floods and rainfall events beyond a return period of 100 years, spanning over the period since 1990.

2.2 Improvement of precaution, warning and management

Within URBAS meteorological parameters, runoff and damage of flash floods are investigated. Innovative and feasible actions and precautionary measures of a reasonable cost-value-ratio are developed.

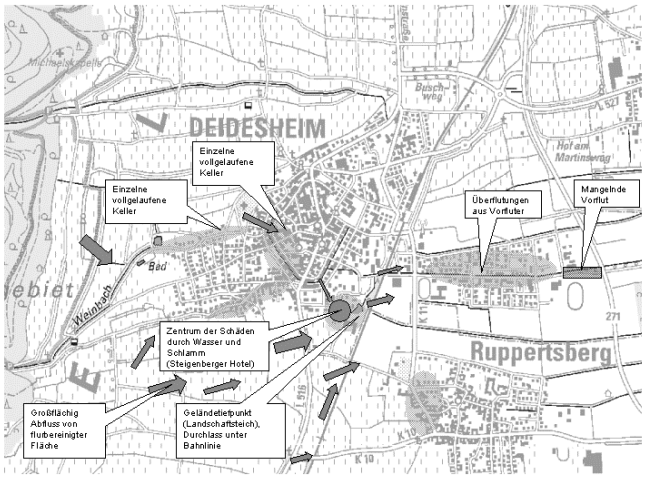

Fig. 3. Flow paths of the flash flood in Deidesheim (7 August 2004)

2.3 Learning from case studies

For 15 municipalities, “interesting” / “representative” case studies are analysed. Modern technologies such as the German Radar Network for hydro-meteorological investigation of precipitation and runoff are exploited. Assessment of damage at micro scale as well as ex-post-analysis of typical courses of action are carried out. Based on these studies, forecast tools will be improved and recommendations will be given concerning information management, early warning, precautionary measures and disaster control (e.g. Ackermann et al, 2006).

Each case study has a particular focus which is being analysed in depth. These special investigations range from rainfall representativeness analyses via 2D hydraulic simulation to the improvement for operational warning systems and further on to recommendations for city planning (e.g. emergency floodways, fig. 2).

A detailed documentation of past events is collected, based on interviews of the different actors during the event. This documentation also shows past flow paths of the water in the urban area (fig. 3).

Common element for each case study is a radar based overview of the rainfall distribution (event sum, fig. 4) in order to provide guidance to the investigation of rainfall and flow related aspects. These initial analyses comprise the application of radar data correction schemes (Einfalt/Fennig, 2006) as well as adjustment of radar data to raingauges (Einfalt et al., 2004).

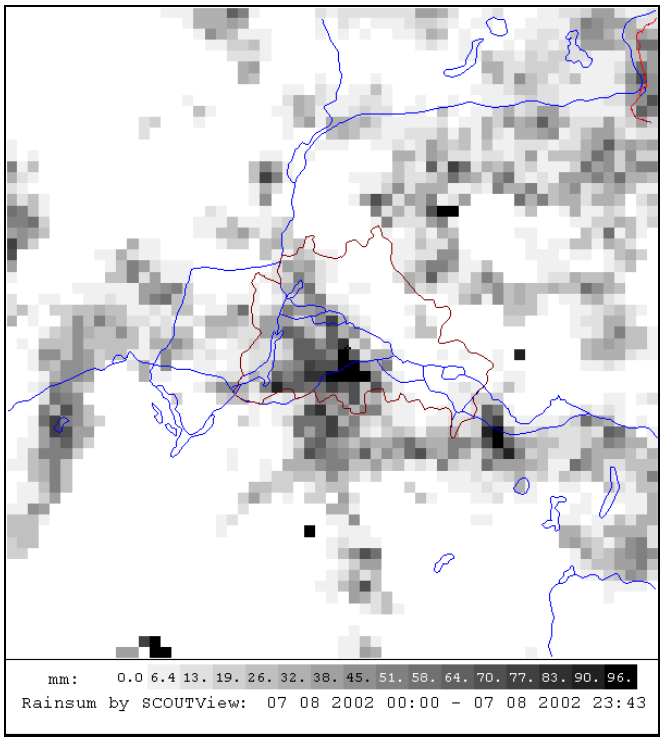

Fig. 4. Event sum as support to the case study analysis

3 Hydrometeorological studies

An important part of the project tasks is a close cooperation of the three organisations presenting the current paper. It comprises the analysis of the following hydometeorological items:

- Measurement aspects

  Here, the representativeness of point rainfall for extreme events will be discussed. This includes the rainfall statistics which – in Germany – are available through the KOSTRA regionalisation approach provided by the German Weather Service (Bartels et al. 2005).

  The KONRAD radar based cell tracking tool of the German Weather service (Lang 2001) will be statistically analysed. The present severe convection warning will be complemented by a second warning level.

- Temporal development analysis

  Small scale extreme rainfall will be analysed in time and brought into context with the location of urban structures. The probability of antecedent moisture conditions is also subject of analysis for these events.

- Causes of selected flash floods

  Flash floods may be triggered or enhanced by urban effects, orography or other influences on the development of strong convection.

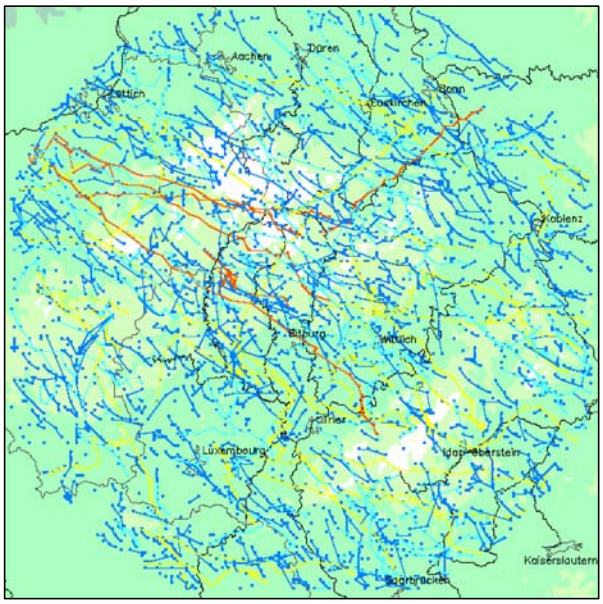

Fig. 5. Cell track paths of the Essen radar for 2005

- Statistics for a flash flood hazard

  Extreme value analysis based on traditional rainfall measurements (point rainfall) will be used in a first step to derive a spatial map of flash flood hazard for urban areas in Germany. Based on several years of radar data which are being analysed for convective cells, a complement to the first statement will be produced. This will start with an analysis of cell track paths over Germany (fig. 5).

- Warning methods

  An overview of the currently available nowcasting approaches will be produced. One focus will be on the KONRAD system mentioned above. The use of this tool for the fire brigade information system (the fire brigade in Germany is also in charge of fighting flood events) will be further developed and improved.

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4 Discussion

Remote sensing methods such as radar or satellites are capable of locating small-scale precipitation fields. Several aspects are here of importance for urban areas:

- the location of small scale precipitation fields,
- the analysis of the temporal development of small scale precipitation fields,
- the (tentative) quantitative estimation (QPE) of small scale intensive precipitation fields, in particular for locations without raingauges,
- the tracking of these fields for a nowcast in order to provide a quantitative precipitation forecast (QPF). An overview over QPF can be found in Mecklenburg et al. (2002).

The German Weather Service (DWD) has developed a procedure for localisation of thunderstorm cells with extreme precipitation. This cell tracking method called KONRAD is operationally in use.

KONRAD is expected to localize typical thunderstorm tracks and regions frequently struck by extreme precipitation. This knowledge shall be used for generating flash flood hazard maps

Precipitation measured by radar needs to be adjusted to ground measurements from rain gauges. Only then precipitation will be reliable in quality and quantity. Small scale extreme rainfall is particularly difficult to quantify. Studies are being carried out that identify the range of plausible adjustment results, based on the variation of the parameters location, time, rainfall volume and adjustment method.

The statistical analysis of small scale precipitation fields and areas with flood damage is expected to locate urban areas prone to flash floods. Ideally, the map overlay of extreme rainfall with topographical features, with pipe diameters or with housing structure will yield additional results.

Good overlay results have already been made with rainfall amounts and emergency service interventions, and with flow bottlenecks (e.g. street underpasses).

Interviews with representatives of municipalities, fire brigades and other emergency service units reveal a strong desire for improving quality of weather forecasts and for extending flash flood forecast periods beyond a period of one hour. Forecast improvements requested by rescue units will be taken into account when adjusting KONRAD to the needs of rescue services.

The reliability of forecasts under these conditions is crucial and needs to be transported in an adequate manner, e.g. through a dedicated information and warning system.

Finally, URBAS is one element of preparation for the consequences of climatic change. If the urban communities can improve their local flood management by means of innovative planning tools and through modern information technologies, the project will be able to contribute to the quality of life of every citizen.

5 Outlook

The project will be finished in May 2008. More detailed results from the case studies can be expected to be finalised on the way.

The website of the RIMAX project cluster on extreme floods can be found under http://www.rimax-hochwasser.de/ and the URBAS website is http://urbanesturzfluten.de .

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