Europe
Regional consultation in preparation for EWC-II

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EWC II
Second International Conference on Early Warning

International Strategy for Disaster Reduction

Federal Foreign Office

REGIONAL CONSULTATION
EUROPE

REPORT FOR EWC II

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Regional Consultation Europe
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Erich J. Plate, 4 August 2003

INTRODUCTION

The International Decade for Natural Disaster Reduction, which ended in 1999, has identified "Early warning" as one of the most cost effective methods for reducing loss of lives and property. Among the three initial targets for the decade was the goal of making early warning systems available to every country. Consequently, the topic of early warning has figured prominently in all further activities of the IDNDR. At the midterm conference for the IDNDR in Yokohama in 1994 the need for access to early warning systems was emphasized, and UN Resolution 49/22B of June 1995 underlined the importance of early warning systems. In response the German Foreign Ministry sponsored the Potsdam Early Warning Conference in 1998 (Zschau & Küppers, 2003), which resulted in the Potsdam declaration on early warning. The Potsdam Declaration issued at the end of the Potsdam Conference stressed that early warning cannot be seen only as a technological problem, but also as part of a people oriented effective risk management for natural disasters. We live in a world of risk, and while we cannot prevent natural extreme events from happening, we can mitigate their effects on the population by means of preparedness and early warning – a process that can only be successful if people at risk are involved and participate in the process. The focus of EWC II should therefore be on implementation of early warning in public policy.

The EWC II conference, which is hosted by the German Government under the auspices of the United Nations and supported by the Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UN/ISDR), will take place in Bonn. In preparing for the conference, local experience is to be considered for finding out how people respond to early warnings and what local experiences have been made with existing systems. Therefore, regional consultations were planned for obtaining regional inputs into EWC II. Regional Consultations were scheduled for Asia, Africa, the Americas and Europe. The European Regional Consultation was held in Potsdam, Germany, 28/29 July, hosted by the Geoforschungs Zentrum Potsdam (GFZ).

In European countries awareness of the social component of risk management, and in particular of the early warning process, was strengthened through the experiences of recent large scale natural events which in many parts of Europe caused enormous damage, such as the floods in Poland, the Czech Republic and Germany in 1998 and the extreme floods of August 2002 in the basins of the rivers Elbe and Danube. These revealed some shortcomings of the existing early warning systems, which must be overcome in the future. Although tremendous strides have been made in improving the scientific basis and technologies for forecasting, progress has been slow in the integration of forecasting into effective risk management. The Early Warning Conference EWC II is seen as an opportunity to share European experiences with other parts of the world and to learn from experiences of others.

The purpose of EWC II is to assess the effectiveness of EW systems in different countries and environments and for different types of natural extreme events. The conference is to focus on three major objectives:

1. Integrating Early Warning Systems into Public Policy. Identification of gaps in the transfer of early warning information to policy makers. Translating the many studies done by scientists on Early Warning into easier language, so that politicians can react. Blue prints for actions are required. How does one proceed, and what are the difficulties? What are the messages to be given to the responsible minister of a country? Whom to consult – which other departments are to be contacted – create awareness in the cabinet!

2. Early warning and Sustainable development. Linking early warning to sustainable development. (Objective 2 of the agenda): Land use planning and vulnerability reduction are integral parts of an effective risk management, just as they are integral parts of sustainable development. Environmental degradation is a factor in increasing vulnerability against natural disasters. Long-range warnings against potential disasters from environmental degradation have to be used for planning political actions. If early warning can help to increase the security of endangered populations, it will enable them to better pursue a useful and fulfilling life in harmony with their environment – a necessary condition for sustainable development.

3. Need to Sustain the Dialog on EW. There is a need to keep attention focused on the usefulness of making early warning systems available in times when there are no extreme events. Preparedness actions including early warning should be part of a continuous dialog among different agencies involved in risk management, and in the discussion of self-help action groups of the population. Training of disaster managers and creation of awareness of endangered populations should increase alertness. Networking between all actors being involved in the early warning chain should improve the exchange of information, thus contributing to a maximized utilisation of synergies between different sectors and communities.

For contributing to these issues, the regional consultations are charged with discussing:

a. Disaster patterns in Europe
b. Advances of and constraint for effective Early Warning Systems
c. National planning
d. Needs and recommendation

The results of the regional consultation for Europe, supplemented by additional material provided by participants and the German Committee for Disaster Prevention (DKKV) are summarized in this report.

DISASTER PATTERN: NATURAL DISASTERS IN EUROPE

Due to its fortunate geographical location, Europe has been spared many of the extreme disasters that struck other parts of the world. Nevertheless, although the number of casualties from natural disasters in Europe has been small, the economic damage has been very high, and has been increasing with time. The recent flood disaster in August 2002 on the Elbe and Danube river has caused damage of about € 13.5 billion in Germany, the Czech Republic, Poland and Austria. The economies of these countries have been affected by such disasters; countries with a small economic basis have suffered proportionally heavier losses. Statistics of losses in Europe due to extreme events with losses exceeding half a billion euros are compiled in Table 1, in which the individual cases are listed and sums formed for each type of disaster.

The economic losses of the combined European countries from 1998 to 2003 amounted to more than US$ 60 billion, with more than 600 casualties for these events. The type of extreme events in Europe varies from North to South. It is evident from the statistics of table 1 (made available by the Munich Reinsurance Company, 2000) that floods and storms are the major causes of disaster, in particular in the North of Europe, and in the alpine countries. However, many other types of hazards occur and have caused extensive damage throughout history, although they may not have occurred during the last five years.

The following briefly mentions the most important sources for potential disasters in Europe, with extreme cases that occurred in recent times and ranked according to dominance of occurrence from North to South. Most of the information on the disasters has been supplied by the Earth Hazards Group of the Munich Reinsurance Company.

Storm surges.

The North Sea coasts of Holland in 1956 and Germany in 1962 have seen some of the highest storm surges on record – and in later years the coast has been subjected to many high storm surges, which were prevented from doing damage by means of extensive and well engineered systems of coastal protection works, whose most significant manifestation is the gigantic delta works in the Netherlands, or the Thames barrier in the UK.

Legend	Flood deaths	Flood losses	Storm deaths	Storm losses	Earthq deaths	Earthq losses	Drought deaths	Drought losses	Winter deaths	Winter losses
	37	13,5	110	11,5	143	4,2		3,2	108	0.8
	38*	8.5*	30	4,1			14***	0.7***		
	10	1.5	20	2,9						
	23**	1.2**	33	2,3						
	26	0.7	6	1,0						
	31	0.6		0.7						
Number	6		5		1		2		1	
Deaths	165		199		143		14		108	
Losses		26.0		22,5		4.2		3.9		0.8

*Includes landslides ** includes storm damage ***heat wave and forest fires

Total number: 5
Total losses: US $57.4 bill.
Casualties: 629

Losses due to extreme natural events causing damage in excess of € 500 million in Europe from 1998 - 2003.
(source: Munich Reinsurance, 2003)

Floods:

Major causes of disasters in the North are river floods, such as the major floods on the Rhine (1993, 1995), on the Oder river (1997), on the Elbe river (in August 2002). These large floods have been extensively covered by the international press. Other floods are more widespread rainfall events with local flooding. Intense rainfalls crossed much of England and Wales over a period of seven weeks during October and November 2000, causing the worst flooding since 1947 in the UK, with economic losses exceeding US$ 1.5 billion. Flooding occurred in places that had no previous record of flooding. October floods in 2000 also reached South East France, North West Italy and the Tessin Valley of Switzerland. Much of the cumulative damage resulted from smaller area floods not shown in the Munich Reinsurance statistics of Table 1, such as flash floods in tributaries of the Danube in 1999, which resulted in extensive damage in Bavaria/Germany and Hungary. Floods often are caused by regional rainfall clusters, including flash floods from local thunderstorms. Insurance figures in Germany show that at least half the damage from floods comes from such smaller floods.

Storms:

The highest damage in the North is caused by storms. Extensive storm disasters in Europe used to be avoided by building according to conservative design codes. However, recently extra-tropical cyclones have occurred with winds much higher than usual standards.

For example, in December 1999 storm "Lothar" cut across central France, Switzerland and South Germany, leaving a swath of broken trees and destroyed telephone and power lines, causing damage estimated at more than € 11 billion. It fortunately missed larger cities. Other storm damage is caused by squalls associated with heavy thunderstorms. Recently more localized wind storm events embedded in the large storms have been identified as a distinctive hazard. Called ‘sting jets' in the UK, extreme damage was caused in the 1987 storm over a track some tens of kilometres wide crossing SE England; fallen trees brought two days of standstill and longer disruption of electricity supplies. The frequency and intensity of these events have to be identified. They involve thermally-induced downdrafts, and although generally rare events, they may be becoming more frequent. In fact, it is estimated that sting jet event causes more than € 800 million of damage per year in Europe.

More localized effects are caused by tornadoes. Tornadoes can occur everywhere on earth. About 900 events have been reported for Germany during the last 100 or so years, and a few hundreds of these events occur every year in Europe, causing more or less severe damage.

The earth science group at the Munich Reinsurance Company warns that the paths of extra tropical cyclones that determine the storm weather in Central Europe have shifted towards the South, thus causing more severe storms. Storms "Lothar" in December 1999, which was the storm with highest damage ever observed in Europe, with damage amounting to about US$ 11.5 billion, could have been a result of this trend. This storm was preceded a few weeks earlier by another storm ("Anatol",) which was centred further North, causing extensive damage in the UK, North Germany, Scandinavia, Poland, Russia, and the Baltic states. Since much of the storm damage in Europe is covered by insurance, even small losses, which occur over wide areas, have a large impact on insurers.

Hail storms:

For a long time the hail storm of July 1984 in Munich, with damage of € 0.9 billion, was the most expensive damage to be covered by insurance. Although no comparable hailstorm has occurred recently, every year there is extensive damage due to hail, for example, in Switzerland, a hailstorm causing much damage occurred in July 1999.

Wild land fires:

Fire is the most important natural threat to forests and wooded areas of Europe, particularly in the Mediterranean basin and its adjoining neighbouring nations in South East Europe. Unlike other parts of the world, where a large percentage of fires are of natural origin (lightning), the Mediterranean basin is marked by a prevalence of human-caused fires. Paradoxically, the fundamental cause of forest fires is linked to increase standards of living among the local populations. Far-reaching social and economic changes in Europe have led to a transfer of population from the countryside to the cities, a considerable deceleration of the demographic growth, an abandonment of arable lands and a disinterest in the forest resource as a source of energy. This has resulted in the expansion of wooded areas, erosion of the financial value of the wooded lands, a loss of inhabitants with a sense of responsibility for the forest and, what is important, an increase in the amount of fuel (Goldammer, 2003, Alexandian et al., 2000).

A recent regional situation analysis published in the frame of the FAO Global Forest Fire Assessment 1990-2000 (FAO, 2000) reveals that the average annual number of forest fires throughout the Mediterranean basin is close to 50,000. In those countries where data have been available since the 1950s, a large increase in the number of forest fires can be observed from the beginning of the 1970s: Spain (from 1,900 to 8,000), Italy (from 3,000 to 10,500), Greece (from 700 to 1,100), Morocco (from 150 to 200) and Turkey (from 600 to 1,400).

The average annual accumulated area burned by wildfires for the Mediterranean countries is approximately 600,000 ha. This number is also almost twice as much as during the 1970s. The trend observed is, however, much less uniform than for the number of fires.

Only few data are available on the economic losses causes by wildfires. The fires in Greece in 1998 may serve as an example: A heat wave in 1998 in Greece resulted in widely spread forest fires with damage exceeding US$ 650 million.

The losses of human lives due to forest fires are moderate compared to other natural disasters. During the wildfires of July 2003 in France more than 20,000 people had to be evacuated from camp grounds. Five people were killed by wildfires. During the wildfires in August 2003 more than a dozen of people were filled in Portugal. Inexperienced forest visitors belong to the group of people at risk. At the same time the forest visitors constitute a potential source for ignition.

Table 2 gives an overview on recent fire statistical data of the Mediterranean countries and its neighbours in SE Europe collected by the GFMC from various national and international sources.

Table 2. Fire statistical data of the Mediterranean countries and its neighbours in SE Europe. Data from Bulgaria may serve as an example for recent changes in wildland fire occurrence during the last 25 years and have been provided in detail. Source: GFMC Wildland Fire Database.

Country	**Time period**	**Average number of fires**	**Average area burned, ha**
Albania	1981-2000	667	21,456
Algeria	1979-1997	812	37,037
Bulgaria	1978-1990 1991-1999 2000 2000-2002	95 444 1,710 601	572 6,730 57,406 13,436
Cyprus	1991-1999	20	777
Croatia	1990-1997	259	10,000
France	1991-2000	5,589	17,832
Greece	1990-2000	4,502	55,988
Israel	1990-1997	959	5,984
Italy	1990-1999	111,163	118,576
Lebanon	1996-1999	147	2,129
Morocco	1960-1999	n.a.	2,856
Portugal	1991-2001	6,596	105,112
Romania	1990-1997	102	355
Slovenia	1991-1996	89	643
Spain	1993-2002	10,254	17,719
Turkey	1990-1997	1,973	11,696

The example of Bulgaria shows that an explosive increase of wildland fires affected the country around the turn of the century. Why is this so?

The trend of increasing fire occurrence, fire damage and fire severity is a consequence of the changing rural and urban space due to the economic transition. Unprecedented numbers of catastrophic fires and areas affected by fire have been observed in the South East European countries due to the following reasons:

- Traditional, centrally managed structures for forest fire protection have been replaced by decentralized structures that are not prepared or equipped to manage the fire problem. Lack of advanced knowledge and technology support for fire management (creation of numerous new independent states).

- People are abandoning the agricultural sector (rural exodus) and young people in particular are moving to towns, resulting in an over-aging of rural populations. Consequently there is a sharp decrease in people available for fire fighting in the countryside.
- Economically motivated arson, e.g. for land speculation (construction of buildings) or for obtaining permits to cut and sell fire-damaged timber, and lack of spatial planning of structures, especially in the wildland/urban interface (development of tourism).
- Increasing fire hazard due to a decrease of land-use intensity (less biomass is utilized through agricultural use, pastoralism, and for households, e.g. cooking and heating). As a consequence wildland fires are more intense and more difficult to control.
- Decreasing general interest of the urbanized public in the protection of forest against fire and a lack of coordination between states in SE Europe.

Outside of the Mediterranean region the fire situation is particularly severe in Russia: 12 million ha burned in Russia in 2002 (Goldammer, 2003b). By July of 2003 already 22 million ha of forests and other vegetated land had been burned on the territory of the Russian federation (see daily wildfire situation assessment in the GFMC website). (For comparison: The total forest area in Germany is about 20 million ha!). Damage is not only caused by fires, but also by smoke. Peat fires generate particularly heavy smoke, because smoke from this source stays close to the ground. It is expected that forest fires may further increase due to global warming.

Winter hazards:

Ski tourism is the reason that avalanches in the Alps have become an important cause of disasters. A particularly damaging event occurred in 1999 during the winter months January to March. Extreme snowfalls and variable temperatures led to a large number of accidents with losses of US$ 850 million, with avalanche disasters in Galtür and Valzur in the Patznau valley of Tyrol in Austria. Elsewhere heavy snowfalls and icing of roads have been a cause of major traffic disruption with resulting motor vehicle accidents and traffic slow downs, and power lines broken under the weight of ice.

Landslides:

Landslides occur in all mountainous areas, mostly as result of heavy rainfalls. The flood in Northern Italy of October 2000 was accompanied by many landslides, which destroyed roads and railroad tracks. Of particular concern is a new type of landslide caused by the melting of permafrost in the Alps, due to global warming. In Northern regions, global warming has also resulted in the melting of tundra underground, with releases of huge quantities of methane, a particularly effective green house gas, into the atmosphere.

Earthquakes:

Earthquakes are amongst the most severe natural disasters in the Mediterranean, with increasing frequency from West to East. They are related to the relative motion of the African lithosperic plate towards Europe, and occur as so-called inter-plate earthquakes at the plate boundaries between Africa and the Eurasian continent. Their damage potential is enormous. A strong earthquake of this kind occurred in Greece in 1999 and caused damage exceeding US$ 4 billion, with more than 140 casualties.

The earthquakes of 17 August 1999 (Mw=7.6) and 12 November 1999 (Mw=7.2) in Turkey are considered to be the largest events to have devastated a modern, industrialized area since the 1923 Tokyo earthquake. The two earthquakes caused considerable damage to residential and commercial buildings, public facilities and infrastructures, with substantial casualties in an area of 20km by 200km. The number of condemned buildings after the Kocaeli earthquake amounted to 23,400. About 16,400 of these were buildings that were heavily damaged and collapsed during the earthquakes. These included around 93,000 housing units and 15,000 small business units. Another 220,000 housing units and 21,000 small business units incurred lesser degrees of damage. Average total loss (physical and socio-economic) may range between US$ 16 and 20 billion – about 7-9% of the nation's GNP.

Exposure to Seismic risks exists in all regions of Italy, and some of the largest earthquakes occurred in Northern Italy (and in the Balkan region) in recent times. A geological fault runs lengthwise through the Italian peninsula.

Earthquakes away from the plate boundaries, so-called intra-plate earthquakes, are less frequent. The Rhine Valley of central Europe has been the place of intermediate earthquakes of this category in historical times. Considerably stronger earthquakes could happen in the future. The historical record of earthquakes is too short to rule out this possibility.

Volcanoes.

The Mediterranean is the location of some of the most active volcanoes, in particular in Italy. Mt. Vesuvius near Naples had its last explosive eruption in 1944; Mt. Etna on the island of Sicily erupts more frequently, more in an effusive rather than an explosive manner, at least in recent times. The Campana region, which includes the city of Naples, has three volcanoes that have been active in historical times. The city of Naples itself is located in the caldera of a volcano, and openings of volcanic vents during an eruption are entirely possible. More than 300000 people live in the area directly threatened by eruptions from Mt. Vesuvius. Vertical movements of the ground of Pozzuoli accompanied by small earthquakes may already indicate volcanic activity. Volcano eruptions could also be triggered by earthquakes. For these various reasons preparations are undertaken for evacuations both in Naples and in the region of Mt. Vesuvius.

There are also volcanoes in Central Europe, but these are not active at present. However, they are young on the geological time scale (having had their last eruption about 10,000years ago) and could become active again at any time in the future.

Secondary effects of natural extreme events:

Natural extreme events impacting on the heavily industrialized parts of Western Europe may lead to dramatic consequences, although no major incidents have been reported during recent years. However, tankers and ships stranded in heavy storms have polluted the beaches of Normandy and Northern Spain, destroying the livelihood of fishermen and causing heavy losses for the tourist industry.

Industrial accidents:

Although not directly caused by natural disasters, industrial accidents are a continuous threat in the highly industrialized countries of Europe. Pollution due to accidents has had a significant impact on perception of risk in European countries. Tanker accidents have been mentioned. Other examples of pollution accidents: 31 January 2000 tailing dam below mine failed in the Tisza Basin. (a similar accident occurred in Spain in 1998, leading to a much bigger disaster).

In addition to these known and well-documented causes of potential disasters, some other causes have been discussed and need to be assessed in the future.

Biological dangers:

The original IDNDR programme included biological hazards, such as locust infestations, killer bees, but also of epidemics like HIV and SARS in the programme. Europe has been comparatively free of any of these hazards, and in recent times they never developed into disasters.

Space weather:

A recent concern has been the interaction of solar electromagnetic radiation with magnetic fields in the geo-sphere. Although the effect of space weather has been uncertain, research efforts have been initiated to investigate possible effects on power supply (a power failure in Canada in 1989 was attributed to this effect) and other phenomena involving electro magnetic fields. During a space storm, spacecraft and their crew may suffer from increased radiation; the ionosphere can be disturbed causing interruptions in telecommunication. Monitoring systems for mitigation of disasters are, to a large extent, based on space-borne equipment. Since spacecraft and the telecommunication between satellites and the ground are vulnerable to influences of space weather, it clearly constitutes a subject of concern in connection with risk management and security. ESA has funded and is funding studies related to space weather, and efforts to integrate the issue into the EU Sixth Framework Programme are also being made.

Conclusion:

A review of the losses caused by these events in the period of the last ten to fifteen years indicate that in Europe, due to a high degree of preparedness, the losses in human lives were small, whereas economic losses are dramatically increasing. Although the losses are small compared with the GNP of most European nations, they have large effects on the funds that are available for infrastructure improvement – and also affect the ability of major donor countries to support third world projects.

The Governments of European countries put great efforts into improving security against natural disasters, in response to demands of their citizens, and obliged to act by their constitutions, which assign to them responsibility for the safety of their citizens as a prime duty. However, financial constraints in many countries have set limits to the ability of governments to fully meet this responsibility. In fact, in many European countries existing civil defence organisations were downscaled due to the absence of major disasters during the 1970s and 1980s.

Some encouraging signs of stronger support for civil defence are again observable. For example, the experience of the 2002 flood in Central Europe has started a process of rethinking the structure of civil defence in Germany, and in Eastern European countries the process of converting to a civil society has been accompanied by important changes to a more risk conscious society. For example, in the Czech Republic the whole civil defence was incorporated in the army until 1988. After the floods in 1997 the responsibility for early warning was transferred to the Ministry of Interior, and centres of decisions representing civil society were set up for local actions. This already showed improved response actions to the flood of 2002.

ADVANCES AND CONSTRAINTS FOR EFFECTIVE EARLY WARNING SYSTEMS

Early warning in the context of risk management.

Early warning is among the most cost effective measures for improving human security against natural disasters. It is self evident that early warning has to be an integral part of managing the risk from natural extreme events.

Risk management for natural hazards is the process of ensuring the safety of people and protection of property in areas threatened by extreme natural events. This process for protecting the Elements at Risk (EAR) of an area involves two different groups of actions. The first group comprises the planning and implementation of a new or improved protection system. The second group is the chain of actions that are needed to operate an existing system.

A sequence of actions exists, from planning to operation and from operation to new planning, and the task of risk management is never completed. The planning process is a response to changes in society and environment. Each generation will have to reconsider its options, and to set its own priorities according to the prevailing value system of the society. With changes in the environment or society the risk posed by a natural event changes, and may require new actions. In consequence we have to see risk management as a cycle, as indicated in Fig. 1.

Risk management: the planning process.

Planning is started when it is recognized that a protection system is needed, or that an existing system is no longer adequate to meet the needs of people – for example, because of change in land use, increase in population, or climate change. The planning part of risk management involves not only engineers, but also many groupings of society; from political decision makers to people that are directly exposed to floods. A most important step in planning a protection system is the design of warning systems. Obviously, the basis for a warning system has to be an effective forecasting system, which permits the early identification and quantification of an imminent extreme event to which a population is exposed.

The first step in the planning process is risk assessment; starting with the identification of extreme events, which in combination with their frequency of occurrence defines the hazard. The hazards are to be combined with the vulnerability in the risk, i.e. the vulnerability of the persons or objects (the "elements at risk") in the area that is affected is weighted with the frequency of occurrence of that event. The main problem is the estimation of vulnerability, which may involve damage to buildings of infrastructure systems. Methodology for estimation of flood damage to different buildings in flood prone areas was prepared for Germany and the Czech Republic will use the same basis. (It would be useful to prepare damage estimation with and without early warning and see how the two compare in terms of financial difference and in terms of lives saved.)

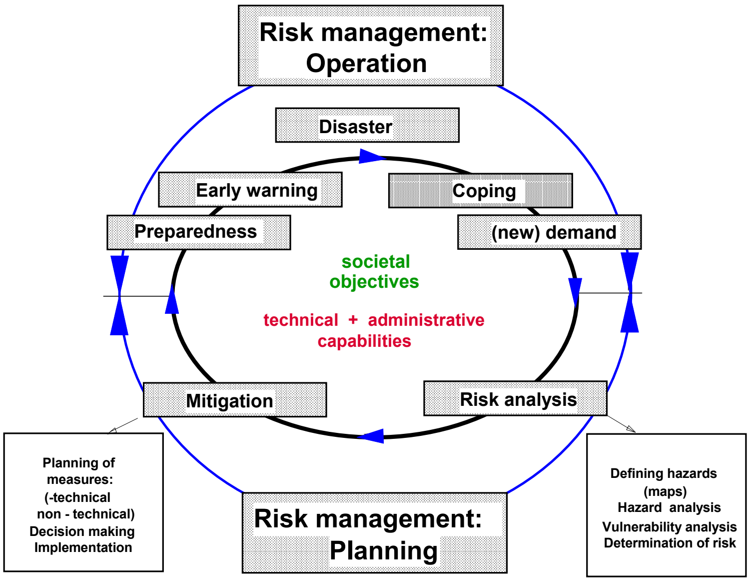

Fig. 1: The risk management cycle and its components.
(adapted from Plate, 2002)

As first step a good risk analysis process produces hazard maps, which today are drawn up using Geographical Information Systems (GIS) combined with topographic maps. For wind and earthquake hazards such maps have been made part of the codes in most European countries. The situation is more complicated for flood risk. Flood hazard maps have their shortcomings – because they cannot be absolutely accurate, and classification of areas as endangered may have significant influence on property values and insurance rates. However, they have been introduced in some countries (i.e. Switzerland). Usually, they do not indicate terms of frequency, but are colour coded; ranging from red, implying high danger from floods, to green, implying no or very small risk of flooding. Recently, the German insurance industry has generated such maps for almost all of Germany, for helping their agents to set appropriate insurance rates. Hazard maps also serve to identify weak points, for example of a flood defence system, or indicate a need for action, thus starting a decision process for improvement of the existing situation.

When considering a protection system we must ask what the lifetime of the system should be. If this has been decided, then we have to ask the question of whether the hazards may be changing with time: due to human influences, or due to other influences, such as climate change. Due consideration has to be given to such changes in deciding on the protection- and early warning system. Such changes may be not foreseen, which is another reason for considering the risk management process as an uninterrupted cycle of actions.

Risk management: Operation.

The operational part of risk management is indicated by the chain of actions indicated in the upper part of the cycle of Fig.1. It consists of three parts. The first is the stage of preparedness, followed by the second stage consisting of the series of actions taken during a disaster. The third is the phase of recovery and reconstruction. The operational part of risk management is conducted by local authorities and the people at risk, in contrast to planning, which usually is done by experts, who are not involved in the operational aspects. The difference in responsible and acting persons is the reason why the distinction is made between operations and planning.

Preparedness implies preparing help during a disaster, by providing the necessary decision support system for the functioning of the system during emergencies – including the case of failure of the existing protection system, because no technical solution is absolutely safe. Even if the system always does what it is supposed to do, it is hardly ever possible to offer protection against any conceivable event. There is always a residual risk, due to failure of technical systems, or due to the rare event that exceeds the design value for the protection system. Stocking of medical supplies, training emergency response and rescue teams, identifying suitable escape routes are important tasks of preparedness. Preparedness should also include the process of risk analysis as the basis for long term management decisions for the protection system (i.e. flood), because continuous improvement of the system requires a continuous reassessment of the existing risks and an evaluation of the hazards, depending on the latest information available: on new data, or on new theoretical or technological developments, or on new boundary conditions, for example for flood protection systems due to change of land use.

As part of preparedness, an early warning system, like every other component of a protection system, requires continuous maintenance, as well as training of its operators, to be always functioning as planned, and new concepts of protection or new technologies for forecasting and warning may require local improvements of the existing system. Also, early warning systems have to be tested and their effectiveness ascertained.

The final part of operational risk management is disaster relief, i.e. the set of actions to be taken when disaster has struck. It is the process of organizing humanitarian aid for the victims, and later reconstruction of damaged buildings and lifelines.

The process of early warning

The process of early warning appears in two places in the risk management cycle: it is part of the planning of a protection system and it is also part of the operation. It is necessary to see the difference between the two. Whereas during the planning process early warning systems are engineered systems whose performance is designed by recourse to natural sciences and technology, the operational aspects are associated with the use of the system in a real situation, as well as with its maintenance, including training and practice in its use.

Design conditions for an Early Warning System.

Basic to the design of an EW system is the identification of the need for a system, i.e. the identification of threatening events on the one hand, and on the other hand the identification of a vulnerable population whose property or health may be endangered, and who could be protected or whose lives and goods could at least be made safer through alleviating actions before the extreme event actually occurs.

Assuming that through the process of a more or less elaborate risk assessment we have determined that the risk, as a combination of hazard and vulnerability, is so high that we are not willing to live with it, then we may decide on actions for reducing the threat. We may decide to develop a permanent protection system, or to apply non-technical solutions, perhaps on the basis of a cost-benefit analysis, or more usually in response to a disaster of similar kind in the neighbourhood of the location considered. In either case a residual risk remains, and if this risk is considered high, and regarded as posing a continuing threat to people and other elements at risk, it is expedient to at least reduce the threat to life and limb and to moveable possessions through the process of early warning. In this early stage the decision first has to be made what kind of an Early Warning system to use. The EW system then has to be designed and installed, and through continuous maintenance and practice the system has to be kept operational for the case of need.

Definition of an Early Warning Process.

There have been many different definitions of what constitutes an early warning system. At one end of the spectrum of definitions for EW is the understanding of it being the process of converting a forecast of some imminent extreme event into a warning in real time. At the other end of the spectrum one sees early warning as encompassing a substantial part of all preparedness actions of the cycle of risk management. A middle position is adopted here, adhering to the declaration of Potsdam, which states: "The successful application of early warning is among the most practical and effective measures for disaster prevention. It is a process that provides timely information so that communities are not only informed, but also sufficiently impressed that they take preparedness actions before and during an anticipated hazardous event. It depends on practical relationships between science and technology, and the understanding of social and economic implications of disaster in the context of sustainable development". Accordingly, an early warning system should have the following components:

a forecasting system and a technical staff able to run and improve the system.

a communication system to bring the forecast to the decision maker – either directly, or in terms of warning levels, such as typical flood warnings consisting of three types of levels of the river: a no flood stage (green), a warning stage (yellow), and a flood stage (red).

a decision system with a clear chain of command, which assures that only one official warning is given to each affected community

a response system guaranteeing that the local population is warned appropriately and timely, and that the population knows what to do.

an iterative dialogue process enabling warning services to both understand the needs and capabilities of warning's beneficiaries and to evaluate or update the warning system.

When we look at the natural hazard management in Europe we realize that these ideal conditions are not always realized.

The forecasting system.

The type of forecasting system depends on the type of extreme event to be anticipated. Forecasting systems for slow onset natural disasters, such as droughts or (in most cases) volcano eruptions, may consist only of indicators, whereas forecasts for rapid onset events may rely on forecasts over short times – which must, however, be early enough to be useful. Forecasts for earthquakes that allow people to be warned are not possible today, but the short time between the earthquake occurrence and the arrival of the seismic waves at the critical point may be long enough to shut down power lines or sensitive computers, close valves of gas and oil flow, or stop electric trains. Forecasts for floods depend on the forecasting system and the size of the area, while forecasts of storms depend on predicting the course of storm tracks over the course of time and on obtaining estimates for the intensity to be expected. On the other hand, droughts or seasons of high temperature may need a long term forecast extending over many months.

The forecasting problem is illustrated in Fig. 2. Consider an event that develops along time as shown by the heavy line in the figure. At some time t_o a forecast is to be made. The forecast extends over a period of time T_F and results in a forecasted value. The forecasting time T_F or lead time, consists of both the time until action is started - that is the time necessary between forecast and issuing a warning and getting warnings to the persons at risk, and the time necessary for taking action. It has to be long enough to allow useful actions to be taken. Because forecasts are subject to uncertainty, the further ahead in time the forecast is made, the less accurate it becomes. The uncertainty of the forecast is indicated in the figure by an error band.

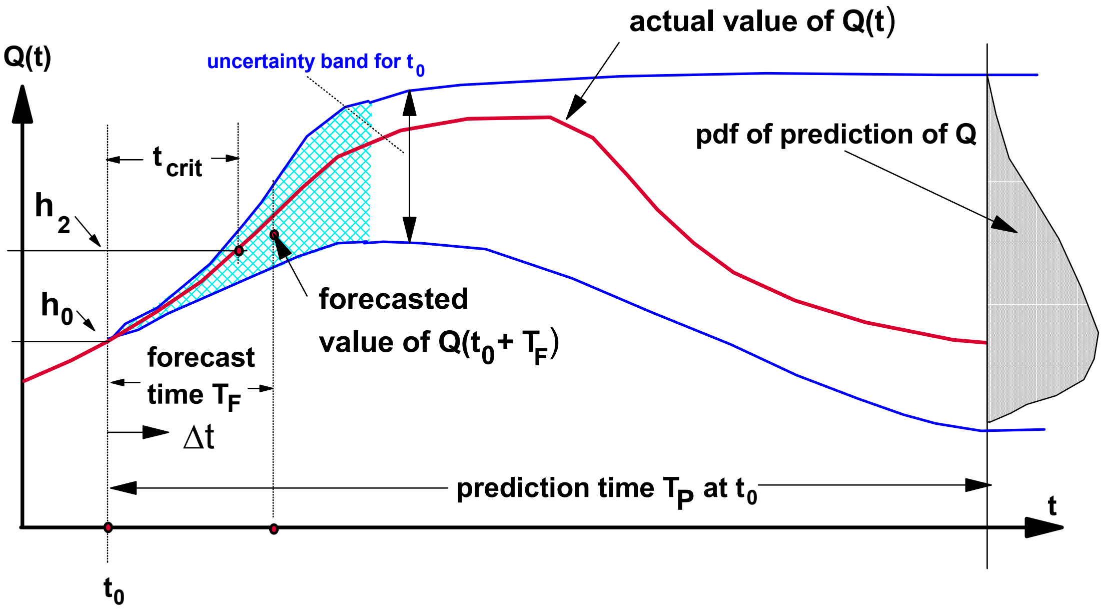

Fig.2: Defining forecasting and prediction in the context of early warning

If we extend the forecast far beyond the useful time, we reach a point where the error band becomes so wide that only a statistical estimate can be made: hydrologists say that the forecast has become a prediction: one can only assert that a certain value of the event will be exceeded with a certain probability within a given time period, such as a year. This is the condition for designing the EW system (as well as any type of protection system): we want to be able to forecast an event over a whole range of event magnitudes. Consequently, we actually need to know the whole range of event magnitudes, as well as to know the probability of having to expect such a value. (The combination of extreme value with probability leads to the concept of a hazard, which assigns a probability to each value of the maximum of the event).

The error band restricts the use of the forecast. What this means is that if we repeat the forecast many times under identical conditions at the beginning indicated by time t_o but taking account of the uncertainty, every forecasted course of the event will be different and lie somewhere within the error band.

Communication of forecasts to the decision maker.

The early warning process starts at time t_o when a signal h (such as the stage of a river indicating a flood, or a critical meteorological situation) reaches a level h_o. A forecast is made to find out if it is possible that within the time T_F h may reach a critical level h_2, i.e. a forecast made at t_o must be compared with the acceptable level h_2. If this level exceeds a critical level, the early warning process is set in motion. The forecast is communicated to the decision maker, either as a forecasted value or already converted into a warning level. Higher levels of h will then lead to higher warning stages h, ranging from alert to attention, pre-alarm, alarm, such as typical flood warnings consisting of three types of levels of the river: an alert stage (green), a warning stage (yellow), and a flood stage (red).

The process of deciding on a warning.

Obviously, the need for taking actions implies to have a long enough forecasting time, which then results in the fact that we have to live with a smaller or wider error band, depending on how much time we need for taking actions. This indicates the most important requirement for an effective early warning system. Its lead time has to be far enough ahead in time. However, if the uncertainty of the forecast for the necessary lead time is large, the forecaster may over-predict the future course of the event. This may lead to a warning when there actually is no danger, or vice versa, which of course reduces the value of the forecast. It may lead to the situation of people being warned many times by an over cautious forecaster without the need for actions – which clearly undermines the confidence in the value of the forecast. The consequence is that the person who has to prepare the warning has to make a decision under uncertainty.

The uncertainty of the forecast should not be transmitted to the people at risk. The stakeholders must know what the official source of warning is - much too often in recent history in Europe we had the case of many different warnings being given. For example, the German Weather Service has the information on which storm warnings must be based, but the data base is subject to interpretation, and different forecasters may interpret it differently. If people hear different warnings from different sources they will not know whom to trust and what to do. Therefore, a clear chain of command is necessary. Many European countries have not yet worked out which command structure of warning is the best for which purpose, to assure that only one official warning is given to each affected community

The EW system has to be operated in a legal and administrative environment that ensures that warnings are authoritative and accepted by stakeholders and agencies.

The process of transmitting the warning to the people :

Of great importance is the process by which the warning is given to the people at risk. Different methods exist, ranging from house to house warning to warning transmission by radio and TV. New methods such as using SMS messages on the cell-phone are being tested. This is an area where much needs be done: for example, one of the most efficient ways of warning people is the siren, which in Germany, for instance, has been dismantled in many cities because of maintenance cost and no discernible need for them. However, a warning is not enough: people must know what to do when warned, and this again is an issue in many parts of Europe. To address this problem, it is recommendable that experts are involved in training workshops with concerned persons in endangered communities. Such workshops were, for example, organized by the European Centre on Risk Prevention (CEPR), located in Niort, France.

Dialogue for improving warning services:

The experiences during the recent Elbe flood have made it very clear that much can be done to improve early warning systems. The dialog with the people concerning what went wrong during a recent disaster is a necessary step for improving the early warning system to become more effective in future. This process has to be conducted as soon as possible after a disaster that has either struck directly or in a nearby region. for two reasons. First, an extreme event may happen again any time in the future. For example, much of the experience gained during the 1998 floods in the Czech Republic has led to an improvement of the system which found the country better prepared during the floods of 2002. But secondly, it is necessary to act while the memory of the disaster is still fresh. Unfortunately, the memory of past disasters usually is short, and the next disaster may come again entirely unexpectedly. For example, the flood of 2002 in Saxony/Germany had many of the same characteristics of a major flood that struck in 1928 - yet nobody remembered and the main railway station was flooded, with some trains caught right in the station.

NATIONAL PLANNING: IMPROVING EARLY WARNING SYSTEMS IN EUROPE

Organisation of Early Warning in European Countries

Early warning responsibilities are vested by laws in European countries. Depending on local legal traditions and constitutional requirements the responsibilities for early warnings are distributed within different agencies and administrative bodies. Usually, the responsibility for the security of the country rests with the Ministry of the Interior (for example in Germany), but the task of early warning for natural hazards is delegated to lower levels (in Germany, the constitution assigns these duties to the states). Some countries have a special Ministry or Department for Civil Protection, for example, in Italy or in Russia. In Italy, technical advisors assist the Department of Civil Protection. There are two advisory boards: on natural risks, and on industrial risks.

In the UK a new "Civil Contingencies Bill" was recently passed, which defines disasters very broadly. It includes a definition of Emergency which can be interpreted to include most conceivable types of disasters, which passes the responsibility for handling disasters down through a chain of command from the national to the local government units down to the district council level and the emergency services. It requires national, local and community level emergency plans, which have to be dove tailed to fit into a common structure of emergency response and disaster prevention.

It is evident from developments in most European countries that the responsibility for disaster mitigation is shifted down from the administrative top to the local level, where the cooperation and involvement of the population is better assured. There is no question that the democratic process of getting people to decide themselves what is good for them has also entered the field of disaster mitigation, and the individual citizen is encouraged to accept part of the responsibility for his own protection, through his own actions or through insurance.

Research efforts in Europe on Early Warning

The emphasis of EWC II will be on the translation of science and technology on early warning into actions in the civil society. However, due to their many research institutes and universities, the European countries are at the cutting edge of research and research applications, which are needed for making progress in improving early warning systems. Progress needs to be made in many areas of disaster mitigation and early warning. A few special research themes have been mentioned in the body of the text. Generally speaking, one of the most notable accomplishments of the IDNDR was the awareness created in the scientific community of the need for cooperation in disaster research, and in particular in early warning research.

Noteworthy is a programme initiated by the European Community after the floods on the Rhine, called RIBAMOD (Casale, et al., 1998) in which the issue of early warning played an important role: it enabled the exchange of information on existing forecasting models, with emphasis on the real time modelling by means of rainfall – runoff models. Another project was concerned with the contribution of communication technology to flood risk management: Project OSIRIS (Operational Solutions for the Management of Inundation Risks in an Information Society), which considered added value of new information and communication technologies for flood related warning and information management. National efforts were also initiated in many European countries. The early approach by the Swiss Government, which set up a special fund for disaster research at the beginning of the IDNDR in the early 1990s, was unfortunately not followed in many other countries. The German IDNDR

Committee, as a typical example, had set up a Scientific Advisory Board for covering scientific issues. This body was composed of members of many different disciplines, ranging from space scientists to medical doctors, and it included engineers as well as social scientists. Because of the differences in specialties, a common project could not be developed, although two books were published of natural disasters and disaster management (Kron et al., 1992, Plate & Merz, 2002).

Recently, however, a number of special research Programmes were initiated at different Universities and research organisations in Germany, among them a special Research Programme on Disaster Resistant Construction, in Braunschweig, and a special research area on Disaster Management in Karlsruhe. Under the leadership of the GFZ, the German Ministry of Education and Science supports a Programme entitled "German Research Network for Disaster Management". This project was intended to overcome the fragmentisation of research interests by concentrating on all disasters of a particular region. For example, all potential hazards for the city of Cologne were investigated - with the surprising result, that the city of Cologne, which had never felt an earthquake in its long history, has probably always been quite vulnerable to earthquakes because of its special location on top of layers of gravel and clay in the Rhine basin.

The German Ministry of Education and Research (BMBF) supports several significant activities. In cooperation with the State of North-Rhine Westphalia it has been instrumental in setting up a Research and Training Institute on "Environment and Human Security" as part of the United Nations University. This centre will start operating in 2003 in the city of Bonn. The ministry also provides most of the funding for the Helmholtz Association of National Research Centres (HGF), which created the initiative "Concerted Action in Case of Disasters", supported by nine Centres of the HGF Research Fields "Earth and Environment", "Transport and Space" and "Health". The GeoForschungsZentrum (GFZ) Potsdam within the Research Field "Earth and Environment" is playing the coordinating role in this.

In addition, disaster management has been established recently as part of the HGF Research Network "Integrated Earth Observing Systems" with sub-programmes on Flood Information Systems, Coastal Disasters, Disaster Mitigation in Megacities, Monitoring of Fire and Volcano events, and Crisis Information Systems. The HGF platform "Task Force Natural Disasters" is currently being initiated for efficiently coordinating the inter-institutional and inter-departmental activities in this field. One of its functions will be to generate data pools on natural disasters, with the purpose of using these data for standard product generation, information technology, marketing and public outreach.

Furthermore, cooperation between HGF centres and universities is supported. One example is the Centre for Disaster Management and Risk Reduction Technologies, which was founded in December 2002 by GFZ Potsdam and the University of Karlsruhe. It includes a user oriented common programme of research and training on risk reduction technologies. As a first step in this cooperation, a set of comprehensive risk maps for Germany is being developed.

Large international efforts on climate change research also are contributing to early warning information. For example, a model for predicting climate change effects on regional climates has been developed at the Danish Met Institute, as part of project PRUDENCE (European Union funded). A regional climate model called HIRHAM has been developed, which is nested within global climate models (GCMs). The GCM used is the ECHAM/OPYC, which has a resolution of 250 x 250 km² per pixel, developed at the Max Planck Institute for Meteorology in Hamburg, Germany, whereas HIRHAM has a resolution of 50 x 50 km². As a calibration, HIRHAM was applied to the period of 1961 to 1990. Then, higher levels of CO_2 emission were introduced. ECHAM, and the more detailed HIRHAM, show a change in mean temperature in Europe: a decrease in mean temperature in Southern Europe, and an increase further North. Investigation also covers duration of precipitation for extreme events > 95%.

Regional climate model simulation forecasts increasing severe summertime flooding events in Europe in future warmer climates, due to heavy precipitation. Although mean precipitation is reduced, in many parts of Europe extreme events are probably increasing by 10 to 30%. (Christensen & Christensen, 2003). Further analysis applies the investigation to sub regions. For example, for the river Elbe the larger the recurrence interval the higher the increase is. In PRUDENCE: in future use longer simulations and more models. The ENSEMBLES project is planned with even higher resolution (like 15 x 15 km²).

Climate change effects on floods have also been studied in other parts of Europe. Whereas statistical analyses of most rivers in Europe are inconclusive as to evidence of climate change, climate studies on the basis of weather pattern frequency, determined from climate models, also indicate higher frequency of extreme events, such as droughts and floods. There are also plans for using climate models for seasonal forecasts, such as forecasting occurrence and results of El Nino / La Nina events.

Forecasting of meteorological extreme events

It is not possible within the space of this report to cover all research and development projects in Europe. Therefore, this report will concentrate on hydro-meteorological events, which are by far the most severe natural extreme events. There is a relatively uniform approach for forecasts of large-scale meteorological events, which is provided by national Meteorological Services, such as the Met Office in the UK, or the German Weather Service DWD. Weather Services issue their reports usually based on a large-scale model, into which the national model is nested. Typical information for the public consists of temperatures and rainfall in a rain or no-rain fashion, for a period of one to three days. These forecasts have generally reached an acceptable level of accuracy. Local phenomena are less well observed. Among the local effects that can be forecasted with reasonable certainty is the "sting jet" phenomenon, which occurs typically at the tip of a cyclone. Research, in particular in the UK, has shown that the location of these jets can be identified quite well, however, it is not yet possible to predict their strength.

Operational forecasts consist of storm warnings. The conditions for occurrence of storm surges on the North Sea, or of heavy winds is part of the product delivered by the weather services. Because the weather forecasts are made on the basis of weather maps and satellite photos available to many different groups of persons, the forecasts of weather are depending on the person who interprets the available information. Therefore, usually no official warning exists for extreme meteorological events, and in Germany for example, the DWD as official source of information is often bypassed by other more or less experienced forecasts and warnings.

Flood forecasting involves not only rainfall information but must include the reaction of the land. The runoff process leading to floods involves hydrological processes, which modify and delay runoff of rainfall. Flood forecasting therefore is the task of hydrological services. In Germany, hydrological services are among the responsibilities of the *Länder* (states), whereas in most other countries there are national hydrological services. For example, the German Weather Service provides 48-hour forecasts for regional rainfall quantities. The accuracy of these forecasts is not sufficient for actual local warnings, and this is even more so regarding forecasts for longer periods. However, concerted efforts are being made in Europe to improve long-term forecasts. A new project in Europe is the creation of EFAS = European flood alert system: flood early warning based on ten day forecast, issued by the European Centre for Medium Range Weather Forecast (Redding, UK). This centre has been set up by the European weather services to improve the operational capacities for forecasts of more than 3 days in advance.

At this time flood warnings on the basis of forecasted rainfall in conjunction with numerical rainfall run-off models are not yet good enough for warning purposes. In most countries Weather Service Data are used as inputs into local warning systems, and they are usually used for indicator purposes only. The Environment Agency of England and Wales only uses rainfall runoff models as indicator information.

Research on improving rainfall - runoff modelling is going on: the European Union has just completed a programme RIBAMOD (Casale, 1998) on flood modelling for early warning. The results of this programme have yet to reach the stage of becoming part of operational forecasting.

Space observations and mapping for disaster mitigation and early warning.

Improvements of early warning capacity for disaster mitigation - not only for meteorological hazards - are expected from progress in satellite borne remote sensing and observation systems. The enormous potential of space observations at different wave length bands has been put to advantage in post disaster observations: spills of mine tailings, forest fire and smoke plume migration, observations of volcanic eruptions are among the easily observed events. An example is the Regional Enterprise Network DDS for Risk and Disaster Management of Volcanic Eruptions. An emerging issue is the potential of space weather: what is the effect of space weather on climate change? This is currently a research topic.

Other opportunities of space technology for disaster mitigation have yet to be explored. It has been recognized by the space research community that remote sensing can be useful only if it cooperates with earth bound authorities. In recognition of this fact, the "International Charter on Space and Major Disasters" has been created, which is a network from different space agencies. This purpose of this project is to provide satellite data free of charge in case of emergency to authorized user. Authorized user in Germany is the Ministry of the Interior in case of disasters within the national boundaries and the Ministry of Foreign Affairs in case data are required for disasters occurring internationally. The DLR Deutsche Gesellschaft für Luft und Raumfahrt), a member of the Helmholtz Association (HGF), Germany's largest research organisation, is a member of the charter and coordinates activities of the charter in ESA. It analyses satellite data and supplies information to the Ministry and later on, also to other authorized users.

This charter is intended to work as follows:

a. For floods: the charter is triggered by flooding events, such as the Elbe flood. Land use maps are generated, which show flooded areas at different times, which is also useful for calibration of models for predicting flood levels and identifying flood risk zones.
b. Earthquakes: rapid damage assessment showing destroyed houses right after an earthquake. This is important for search and rescue teams and thus, for saving lives, and for identifying blocked roads in access routes or the magnitude of damage to individual buildings.
c. Fire detection – reconstruction, refugee camps.

Large numbers of requests for such information have indicated the usefulness of this service – but have also indicated its limitations. Required reaction times between request and delivery range from a few hours to days and even weeks.

An emerging issue is the potential of space weather, which may damage or disturb space-borne and ground-based technological systems and thus cause economic losses and other problems. What effect space weather has on climate change is an open issue that needs continuous research.

Early Warning for Floods in Europe

At present flood forecasting relies on traditional methods. Forecasting for floods generally uses information on rainfall as an indicator, and/or upstream gauges and upstream rainfall measuring stations as input into simple correlation models. The network of communication and the organisation of the warning appear to be more important than the forecast itself. A few examples of different approaches are given.

Flood Early Warning in the UK

In the UK the Environment Agency operates on the basis of information from the Met Office within a National Weather Services Agreement. Because of actions taken after the 1997 flood, the forecasting centres and the associated network of gauges and rainfall stations was well equipped to handle the specific demands from the large flood of 2000. Specific rainfall accumulation forecasts, which provide quantities, areal distribution and timing of rainfall between 2 and 5 days ahead, are provided by daily forecasts. In particular heavy rainfall warnings issued for periods up to 24 hours ahead are relied upon to assist forecasters in deciding when to issue flood warnings. These are used within the regional offices of the Environment Agency for forecasting local conditions and for issuing warnings when considered appropriate. Forecasts are made on this information, but also by using local information from a network of river gauges and outstations. Information is transmitted by telemetry or use of telephones.

The Environment Agency produced a report: Lessons learned (Environment Agency, 2001), to candidly indicate not only the benefits obtained from the system but also the shortcomings, which were in particular related to communication to and response of the people.

Flood Early Warning in Germany

The flood warning system for the Rhine is the most developed regional forecasting and warning system. In response to the large floods of 1993 and 1995 on the Rhine, the International Commission for the Safety of the Rhine (IKSR) has developed a concept of setting up regional centres (HVZ = Flood forecasting Centres), which are internationally connected through the Internet and other communication media. Meteorological information and information from the HVZ is collected at a central office (Gemeinsames Melde- und Lagezentrum = GMLZ), which issues situation reports to the Federal and State Ministries, as well as to the agencies charged with civil protection.

More accurate forecasts for floods are expected on the basis of actually observed local rainfall stations, which permit calculations of better accuracy. The German Weather Service (DWD) is in the process of improving their RADAR network through the project KONRAD = convective radar system. In cooperation with the *Länder* (states) the DWD is planning to improve its rainfall forecasting capability by including real time calibration from continuously broadcasting rainfall gauges (Project RADOLAN). In support of this programme, the German States are in the process of establishing a dense network (one station every 50 km^2) of automatically recording rain gauges to support the RADAR measurements, with the hope of making accurate forecasts over longer lead times.

The problem with the early warning system for floods is mainly associated with people response and communications among the people in charge. During the flood on the Elbe river in August 2002 many of the deficiencies of the Early Warning System for the Elbe became vividly apparent. Different forecasts and warnings were given by different sources, but local administrators, having not been well trained to handle disasters, failed to make the right decisions, such as for example, to inform downstream neighbours of impending floods. The most successful warning systems are those that allow reservoir operation to prevent all or at least reduce most of the floods. Such a system exists in the Ruhr basin (Morgenschweiss et al., 1998)

Flood Early Warning in the Czech Republic

Flood forecasting system was set up to give the following information: water levels, extent of flooded area, depth of flooding and time of flooding. The present system cannot provide answers everywhere. It is based on 20 daily forecasting sites, and delivers 3 levels of warning: alert, emergency, flooding (in Germany there are 4 levels). 200 stations for reporting warning levels have been established. For every important station a web site page is reported. Lead time is travel time in rivers, but new forecasts are also based on rainfall – runoff models, with 48-hour forecasts in some places. The meteorological forecast is based on 4 forecast models: the German Europe and Deutschland Models of and the French Aladin model, which has been calibrated in the Czech Republic. However, the meteorological information (for example, for 11 August 2002) needs to be translated into area of effective rainfall in consultation with meteorologists and hydrologists. The results are distributed through the central and 6 regional centres, and given to the fire rescue service. Also, Internet and radio transmission exist, but have yet to be well organized.

The flood of August 2002 was the highest ever observed in the Czech Republic. The communication and response did not function very well. The media were not prepared to be helpful: Different opinions were voiced and forecasts made by many different sources. This was attributed in part to the change from the communist type of approach (the military were responsible, civil protection services like fire brigades allowed to act only on request) to civil society, with civilian responsibility and public participation not yet well enough established to function in the case of an emergency.

Early Warnings for Storms

Forecasting of storms is the task of the National Weather services, which have access to daily satellite information, and outputs of large-scale models. These models are calibrated daily on temperature and pressure soundings in numerous stations. Because of uncertainties in the data and the models, empirical corrections are usually made based on ground measurements. Yet, the weather services had difficulties forecasting storm "Lothar" in December 1999. Because of the importance of storm damage and the present difficulties in storm forecasting, at a recent German - French - Swiss workshop on severe storms (in Bad Neuenahr, Germany, in March 2003) it was recommended that a European Severe Storm Centre should be created at one location in Europe, with partnership of all European Weather Services. Since October 2001, a storm information sheet has existed in France, the "Procedure de vigilance meteorologique", which recommends four warning stages for storms.

Although they are very costly, there is little that can be done to avoid damage to buildings, except to adhere to building codes (and to have building codes that reflect the actual storm situation). Also, people should be warned to avoid driving when a storm warning has been issued. Fallen trees block highways and interrupt power lines and trucks with high superstructures are blown off the road.

Storm warnings may help to decrease minor damage: windows and doors may be closed safely, and loose objects removed or tied down, because flying objects cause more damage to windows and cladding of houses than the wind. This damage is increasing and amounts to more than 50 % of the total value of financial losses. The main reason for this rise is modern forest management, which does not remove fallen trees and branches.

A general problem in Europe is that locally strong winds are not very frequent, so that people do not listen if asked to be prepared for storms. This is a challenge to the communication managers: to make people understand what should one do when a warning of high winds is announced. In countries with regular records of strong winds, such as Hong Kong, clear instructions are given on what to do.

Early Warning for Wildland fires

A number of national to regional EW systems for wildland fire are in place in Europe and worldwide. The following systems are available on the Internet:

National:

- Finland: The Finnish Forest Fire Index (Finnish Meteorological Institute)
- Germany: Forest Fire Danger Index (by German Weather Service)
- Poland: Forest Fire Danger Index (Forest Research Institute in Warsaw, Department of Forest Fire Research)
- Portugal: Meteorological Support to Forest Fire Prevention (Ministry for Science and Technology, Meteorological Institute)

Regional

- European Forest Fires Information System (EFFIS) (EC, Joint Research Centre)
- Eurasian Experimental Fire Weather Information System (Canadian Forest Service and GFMC)

Global (with regional products)

- Global to regional fire weather forecasts (Experimental Climate Prediction Centre [ECPC], U.S.A.)

Information from these systems is not generally available. The following constraints exist:

- Access to some systems that are available on the Internet require a password that needs to be purchased since the system is maintained commercially (e.g. Finland)
- Some systems are considered "experimental" because of problems of liability (e.g., ECPC)
- The Eurasian regional EW system is incomplete due to restricted or delayed data transmission from hourly-reporting meteorological stations throughout the region, particularly in the CIS countries.
- Some countries have in place national systems that are not made public in order to avoid misuse by arsonists

New developments

For general international developments since 1998 see the Case Study "Early Warning (EW) of Wildland Fires and Related Environmental Hazards: Progress since the completion of the EWC-I (Potsdam 1998)?" in the Appendix.

In addition to the existing numerous national and regional systems in Europe for wildland fire early warning and monitoring (e.g., the system provided by the European Commission, the application of the Canadian Forest Fire Weather Index System in Europe, the development of the Drought code for Coimbra, Portugal, or the systematic improvement of the German Forest Fire Danger Index), a new system has been developed for Russia. The Forest Fire Laboratory of the Russian Academy of Sciences, Krasnoyarsk, has been supported by the German Foreign Office to build a fire web server on which daily fire monitoring and fire danger prediction products are available for display on the website of the GFMC.

Remote sensing from satellites and manned research missions in space have provided new systems and methods of detection and characterisation of smoke from burning of forest and other vegetation.

Future needs

Unlike the majority of the geological and hydrometeorological hazards that are included in the scope of work of the ISDR and a future Early Warning Programme under an Early Warning Platform, wildland fires represent a hazard occurring in natural systems that are shaped by humans and predominantly ignited by humans. Thus, the risk, severity and behaviour wildland fires can be predicted and controlled; most important is that wildland fire occurrence and damage in many cases can be prevented. The very severe situation in the Russian Federation may serve as an example of the need for action. The interaction between human impacts on forests and other lands – e.g. misconceptions in fire management or earlier land-use changes such as drainage of peatlands – and climate change has resulted in an increase of vulnerability of ecosystems to fire. On the other hand, society is increasingly affected by the impacts of fire, both in terms of economic losses and humanitarian problems such as public health impacted by fire-generated smoke pollution.

For short-term prevention and preparedness a combination of systems of fire detection (ground, airborne, spaceborne, lightning localisation), monitoring (ground, airborne, spaceborne) and early warning (remote sensing, meteorological indices, other indices) are required. For medium to long-term assessment of fire hazard, risk and danger it is important to develop prediction tolls based on climate change models (GCMs).

Early Warning for Winter Hazards

Winter hazards are monitored in most countries by the local Weather Services. An important exception are the Austrian Centre for Natural Disasters, in Innsbruck, Austria, and the Eidgenössische Institut für Schnee- und Lawinenforschung (Swiss Research Institute on Snow and Avalanche Research) in Davos, Switzerland, which was created more than 50 years ago. The main activities of the latter are research and development for avalanche protection: active measures include technical and biological measures, artificial avalanche release, passive measures: land use planning, organisational measures: early warning. After the avalanche season of 1999 an Intercantonal Early Warning and Hazard Information System was set up, which includes a warning system of communication with responsible persons in endangered regions, but it also has a well developed programme for educating security services. In winter the institute publishes twice daily a bulletin on snow and ice hazard conditions, in particular on avalanches, which for a country that depends very much on winter tourism and skiing is essential.

The system functions very well among experienced participants in the programme. However, the population (as well as some tourist managers) have very different conceptions of the danger existing from avalanches, either underestimating or overestimating the danger. The goal of early warning predicting avalanches is to cause minimum closure times of ski lift and other tourist facilities while assuring maximum safety, which implies that warnings must be very accurate. This is assured by a dense network of experienced observers, who communicate with one another and the modern communication equipment. In spite of the high quality of the forecasts, warnings are sometimes ignored, because of the impact on tourism.

More than for many other types of disasters the public expectation from an avalanche warning is fraught with preconceived perceptions, the effect either being underestimated or vastly exaggerated. People not experienced with avalanche dangers tend to overreact or to be careless.

Early Warning for Earthquakes:

Earthquake forecasting (i.e. real time prediction of location, magnitude, and time of occurrence) for earthquakes has not yet been achieved. Probabilistic seismic hazard assessments exist for most of the earthquake active regions of the world. For some regions microzoning maps are available. Detailed hazard maps for many regions are yet to be developed, and one has to carry out earthquake micro zoning for all urban areas in earthquake prone regions. Progress has been made in time dependent hazard assessment, by combining statistical approaches with deterministic Coulomb failure stress modelling. The first positive results are available for probabilistic aftershock predictions based on a combination of statistical information on aftershocks with Coulomb failure stress modelling.

Deformation monitoring by means of global positioning systems (GPS) and differential RADAR systems has been realized as important information for seismic hazard assessment, in particular in intra-plate regions where large earthquakes are infrequent, and the historical record of large earthquakes is not long enough for hazard assessment in the classical sense.

A prototype earthquake early warning system has been established for the cities of Bucharest and Istanbul. The test phase of these systems, which make use of the seconds between generation of the earthquake at the earthquake centre and the arrival of the earthquakes in the urban areas has been started. Istanbul in Turkey is one of the cities most endangered cities by earthquakes. As part of the preparations for a future earthquake in Istanbul, Kandilli Observatory and Earthquake Research Institute of Bogazici University, in cooperation with other agencies, have installed a Rapid Response and Early Warning system in the metropolitan area. For the rapid response system (similar to the Tri-Net of Southern California) one hundred (100) 18 bit-resolution "dial-up" strong motion accelerometers were placed in quasi-free field locations (basement of small buildings) in the populated areas of the city, within an area of approximately 50 x 30km, to constitute a network that will enable early damage assessment and rapid response information after a damaging earthquake. Early response information is achieved through very fast acquisition, analysis and elaboration of data obtained from the network. In normal times the stations are interrogated on regular basis by the main data centre located at the Kandilli Observatory and Earthquake Research Institute of Bogazici University (KOERI-BU). However, after being triggered into action by an earthquake, each station will process the streaming strong motion data to yield the spectral accelerations at specific periods, 12Hz filtered PGA and PGV, and will send these parameters in the form of SMS messages every 20 seconds directly to the main data centre through available GSM network services and through a microwave system.

A shake map and damage distribution map (using aggregate building inventories and fragility curves) will be automatically generated using the algorithm developed for this purpose. Loss assessment studies are complemented by a large citywide digital database on the topography, geology, soil conditions, building, infrastructure and lifeline inventory. The shake and damage maps will be available on the Internet and will also be conveyed using spread spectrum radio modem communication to several user nodes, including the governor's and mayor's offices, fire, police and army headquarters within 3 minutes. Full-recorded waveforms will later be retrieved.

An additional forty (40) strong motion recorders will be placed on important structures in several interconnected clusters to monitor the health of these structures after a damaging earthquake. The strong motion-monitoring array on the Fatih Sultan Mehmet Suspension Bridge is already completed. These will be used in an off-line format in the first phase of the project. They will be integrated in the future to the main network for health monitoring and warning purposes. This set of strong motion recorders will have interconnection capability. Currently several instrumented structures exist in Istanbul, including two bridges, Hagia Sophia Museum and Suleymaniye Mosque.

For the Early Warning system ten (10) (24-bit resolution) strong motion stations were installed on the shoreline as close as possible to the fault area (Prince's Islands and specific coastal areas around the Marmara Sea) in "on-line" mode for an earthquake early warning system. An additional two (2) stations are being kept as hot spares. The continuous on-line data from these stations will be used to provide near-real time warning for emerging potentially disastrous earthquakes using several alarm levels on the basis of the algorithm developed. The digital radio modem or telemetry is the communication system between these stations and the main data station with appropriate repeater stations selected in the region.

The users of the early warning signal will be nuclear research facilities and critical chemical factories within the region, the subway system and several high-rise buildings. The central data acquisition and processing centre houses the dedicated GSM and radio telemetry modems and three access servers to provide an interface to an Ethernet LAN.

Basic research on earthquakes is still very much needed. Worldwide no reliable system exists for earthquake forecasting for longer periods than a few seconds - in spite of very high investments into following up all conceivable possibilities and ideas on forecasting methods. High priority is given to the continuation of the promising approach of integrating earthquake statistics with results from deformation monitoring (especially by means of GPS and RADAR) and geophysical process understanding of stress accumulations and - release in the earth crust, as described above. GPS use and RADAR should be integrated into seismological monitoring.

- Further developing the probabilistic method of aftershock prediction. Mobile earthquake early warning systems are to be developed, which should also be used for the investigation of aftershocks.
- Typical additional research topics are:
  - Quantifying uncertainties in hazard analyses
  - Improving hazard analyses in intraplate regions
  - Improving the information on the "maximum possible event" especially for intraplate regions
  - More basic research in the field of deterministic earthquake prediction
  - Developing and testing early warning systems, in particular for large cities
  - Establishing rapid earthquake information systems which provide ground shaking maps and rapid damage simulations
  - Predicting technical, social, economic and ecological vulnerability, as well as potential harm to human beings in various spatial dimensions s
  - Combining seismic hazard maps and vulnerabilities to seismic risks in various spatial dimensions, and for seismically active regions simulating by means of scenarios the interaction of potential earthquakes with existing structures and infrastructures.

In addition to the listed research topics, it is of utmost importance that the civilian population is made to understand and accept earthquake monitoring, and that in earthquake prone regions people are prepared for the potential effects of earthquakes, by information provided during training and other information, so that they properly respond to warnings and are prepared to act. Research on seismic resistance of existing buildings - also of non-engineered buildings - needs to be continued to find optimum ways of protecting these buildings from harming people while collapsing. Administrative procedures are to be improved for enforcing building codes, and for monitoring construction according to required safety standards.

Early warning of volcano hazards

Although changes in the activity of a volcano can be monitored quite well nowadays, the exact onset of a dangerous eruption cannot be predicted accurately within reasonable time. When should evacuation start? Different categories of indicator warnings are required. Basis (no action) attention, pre-alarm, alarm. However, since evacuation is very expensive, the authorities (and the volcanologist - forecaster has the tendency to wait rather than to evacuate). A possible way out: decrease density of population to improve removal of people (spontaneous reduction of the population density by 10% occurred during the last ten years). This requires incentives for people or industry to move.

Early Warning for Pollution hazards

Point pollution in rivers is traced by means of mathematical models. Following the Sandoz accident in 1986, a model was developed for the Rhine, which has been calibrated and put in operation. Numerical models calibrated on actual events (for example, on the concentration development downstream of Basle: after the Sandoz accident concentrations were monitored on many stations along the Rhine river, and the time development of the pollution cloud could be well reproduced by the models. Fortunately, it has not been used for forecasting an accidental spill. Also, the pollutant cloud from the Tisza accident in 2000 was traced accurately. In both these accidents the consequences to the environment proved to be smaller than feared, long term, or even permanent closing of water supply works drawing water from the river, or from the groundwater next to the river, proved to be unnecessary. The works were back into operation after a much shorter time than originally expected, for example, on the Tisza concentrations were reduced below critical after 14 days.

European Joint Efforts of Early Warning: Learning from Past Experience

Perhaps the most important learning effect from natural disasters came with the great floods of the 1990s. In the UK, after the flood of 1998, the UK Environment Agency was charged with improving the flood safety of England and Wales. The UK Environment Agency developed and implemented a two-year action plan to address the lessons learned from the flood. This included the establishment of a National Flood Warning Centre to develop flood forecasting and warning systems. A new four-stage flood warning and dissemination and communication Programme was implemented, high profile public awareness campaigns launched and major defence operational changes made. (Environmental Agency, 2001). The newly installed forecast and warning systems, set up in cooperation with the Meteorological Office under a National Weather Services Agreement, worked well during the flood of Autumn 2000.

The lead event for the Rhine was the 1993 flood, which was followed soon by a second flood in 1995. Although the flood levels of the two floods were almost the same, the damage caused by the second event was only half of that from the first one. People had learned to cope better - and the administrations had also learned. As result of the large floods of 1993 and 1995 on the Rhine, the International Commission for the Safety of the Rhine (IKSR) was charged with setting up an international and interdisciplinary action programme for the protection of the Rhine populations from extreme floods. The IKSR has developed a concept of setting up regional centres (HVZ = Flood forecasting Centres), which are internationally connected through the Internet and other communication media. Meteorological information and information from the HVZ is collected at a central office (Gemeinsames Melde- und Lagezentrum = GMLZ), which issues situation reports to the Federal and State Ministries, as well as to the agencies charged with civil protection. The HVZ are charged with making forecasts and issue warnings in the case of floods, based on four warning levels.

The example of the IKSR is followed for other international rivers, i.e. an international Commission for the Safety of the Danube (IKSD) now exists, as well as the International Commission for the safety of the Elbe (IKSE), the International Commission for the safety of the Oder (IKSO) and the International Commission for the safety of the Moselle (IKSMS).

Typical for East Europe is the Czech experience. The floods of 1997 were evaluated by an expert panel consisting of experts from the fields of science and administration and also involving the people and rescue workers. They determined that the institutional arrangements and technical means aimed at disaster mitigation and reduction of damage from floods and other disasters have been based on prevalent practices from the communist era, assuming non-existence of private property, underestimation of insurance policies and legislative neglect or disregard by state authorities. These practices prevented the participation and intervention of voluntary civil society organs by all possible means, by actions of police and the army. A salient example was the neglect of construction regulations in the frequently flooded areas. Technical capabilities of forecasting and warning by the state and regional institutions were inadequate, mostly as a result of insufficient funding. The whole system of disaster mitigation was incorporated in and operated by the army. Police and fire brigades were assisting on request.

These practices changed after the 1997 flood. The Government proposed, and the parliament accepted to establish "Crisis Action Boards" on a geographic basis, attached to the civil elected authorities. The national technical and operational system was incorporated in the Ministry of the Interior, while the actions of prevention, mitigation and rescue are approved by the "Crisis Boards", which were already successfully operating during the 2002 flood. Since the same type of problems were also observed in the other countries affected by the 1997 flood, the above-named body of experts proposed the establishment of a Central European Disaster Prevention Forum (CEUDIP), which was established at a meeting held in Prague in 1999. It assists in the cooperation among the partners Poland, Germany, Hungary and Slovakia. In part through the results of the meeting of this group, an increased representation of civil society in the actions taken during the flood of 2002 was noted. The success of the new system was mainly attributable to the reorganisation of the disaster warning and mitigation system, although much room for improvement again became apparent, in particular for communication and subsequent coordination among the players in disaster management.

International cooperation also exists in the field of disaster research. The RIBAMOD project funded by the European Union has already been mentioned. In 2001 the German Academic Exchange Service (DAAD) started to fund several International Quality Networks (IQN), one of which is administered by the Faculty of Earth Sciences of the University of Munich in the area of geo-risks related to seismology and volcanology.

NEEDS AND RECOMMENDATIONS

General recommendations:

The different types of problems seen in Europe in the field of early warning were discussed in three working groups during the Regional Consultation. The recommendations developed by these groups are presented here, together with results derived from a previous Forum on Disaster Management in Germany, held in Munich in July 2003. It is recognized that that there are a very broad spectrum of issues that are important for Europe. While the individual hazard may be higher or smaller in different countries, it is recommended that action be taken on the European level to assure that channels of communication across borders and within countries are clear, and a common language is used if warnings are to be given. The introduction of different terminologies in different European countries should be avoided. An effort to standardise terminology would be most desirable.

Although legislative systems may be quite different in different parts of Europe, the governments have to establish common benchmarks for their actions vis-à-vis legislation on early warning in general. Relevant legislation may already exist, but some countries will have to adapt to new ways of managing early warning. In view of the crucial importance of services such as water supply, power (especially electricity distribution) and transport, it is essential that legislation extends to the suppliers of these services. In the context of increasing privatisation in these fields, it is crucial that privatisation arrangements make adequate provision for all the links with risk assessment processes and links with the warning systems in parallel with governmental administrative and emergency services. On the other hand, privatisation may open up new opportunities; the international links of the British electricity supply companies was mentioned in this context. In most European countries disaster prevention legislation is not very specific, and it attempts to cover all kinds of emergencies. EU regulations also tend to be unspecific, but existing Directives point in the right direction: for example, the increasing establishment of risk maps is to be noted, i.e. flood hazard maps or earthquake maps. For this or similar processes the assistance of the reinsurance industry should be encouraged by the civil society and the governments. (It would be advantageous if the maps prepared by the insurers could also be made available to be used for disaster management).

Legislation for disaster management must allow the adaptation of new technologies and new systems, which will be developed for improving Early Warning capability. For example, early warning systems might be developed using opportunities offered by privatisation of services from the public sector to private industry. However, resistance of existing organisations against changes must be overcome, and new results must be accepted and adapted to local conditions. This is not an easy problem, as is exemplified by the attempts to make administrations and people adjust to new knowledge about volcanism in the region of Naples in Italy.

In further refining the legal basis attention should be focused on ensuring that legislative activities provide equal coverage for different regions in a country - no part of the country should be more privileged or deprived.

A special problem in European countries is that research priorities depend on the priorities set by political bodies in different countries. Improving the financing of research and development of early warning in Europe will require the implementation of cost benefit analyses that show the efficacy of early warning systems and prove the relevance of research for reducing costs or increasing benefits, in particular if projects on trans-national issues are contemplated. For this and all other issues concerning early warning systems the dialogue at various levels and sectors among the stakeholders dealing with all aspects of early warning should be a necessary and integral part of disaster reduction.

Special recommendations for improving early warning in Europe

The countries of Europe are highly developed, with generally functioning systems of disaster management, although early warning systems need improvements. Their infrastructure is highly developed, and support from one part of Europe to the next is comparatively easily accomplished. This is indicated by the large amount of help from different parts of Europe for other parts of Europe, which are struck by disasters. Firefighters from France fight the forest fires of Portugal, earthquake rescue teams from Germany operate in Turkey, soldiers from the Netherlands and England help protect the dikes of the Elbe river in Germany, and each disaster releases a large stream of donations from concerned persons who want to help. European Non Governmental Associations (NGOs) not only assist in emergencies in their own countries, but they also offer help with rescue and reconstruction in all parts of the world destroyed networking of infrastructure highly developed. There is also a general willingness and awareness to build capacity and establish links between users and providers, in support of a greater harmonisation and standardisation of EW concepts, terminology and data exchange. The programmes of the EU bring together scientists of different parts of Europe in addressing common goals of early warning and disaster mitigation, such as the RIBAMOD programme on flood disaster management, or the programme for studying landslide problems.

But in spite of generally functioning disaster management systems, there is much room for improving European early warning capacity. In addition to the issues that have been discussed in previous chapters, the improvement of early warning in Europe will depend on a number of issues, to which future attention should be directed. These issues have to do with improving the methods of forecasting, improving the chain of communication, improving preparedness, and obtaining a more appropriate reaction from the people at risk. Important problems, not necessarily in the order of importance, are the following.

Improving data collection and availability:

A good database is a requirement for improving early warning systems. This first of all involves improving the database for local data acquisition systems. For floods, and for calibration of rainfall forecasts models, we need to improve acquisition of rainfall data, which involves making sure that adequate networks of automatically recording rainfall gauges exist. Runoff data profit most from good water level gauges, which have to be suitable for hydrological rainfall - runoff models only if they are accompanied by good rating curves, which convert river flow into river level readings or vice versa. Ground truth rainfall stations are also needed for calibrating RADAR information: RADAR technology will become available in Europe soon, and it can be expected that all of Europe will be covered by a network of RADAR stations. For these to be useful, a network of ground based rainfall stations is needed, which will be useful for real time forecasting of meteorological events only if their data are transmitted by telemetry to flood forecasting centres. Although systems of this type exist in many parts of Europe, they have not yet become useful tools because of the time it takes from data collection to conversion into warnings. This applies even more so to data from satellite imaging: here a particular need arises for improving the density of satellite observations and increasing the speed of analysis. Furthermore, RADAR and other technologies must be used in an integrated way with satellite and lightning observations to obtain maximum benefits from the different technologies.

In addition to the forecasting data requirements it is also necessary that the data base for predictions of future events is also increased. The threat from global climate change is real, and statistics based on data from the second half of the 20th century may need adjustments for this effect. However, other effects, such as man made changes in land area or river courses need also to be considered, and therefore it is important that for studying these effects a central data collection institute exists, which makes climate data available for research purposes to all legitimate research institutes. Many such centres exist in Europe. An example of such a data centre is the GRDC = Global Runoff Data Centre in Koblenz and also the GPCC = Global Precipitation Climatology Center in Offenbach, Germany, on floods, and the Dartmouth Flood Observatory, which provides a research tool for detecting, mapping, measuring and analysing extreme events using satellite images. Every year this institute produces catalogues, as well as maps and images of river floods since 1985. There is also the centre for "European Global Monitoring for Environment and Security", which collects and provides spatial data in Europe (Geographic and other spatial data) through the INSPIRE project. One of the tasks for a centre on geographical information is to develop uniform legends for disaster related maps and to work towards an international harmonisation of symbols and legends. It could also be instrumental in harmonising data (maps, discharge) for trans-boundary problems, such as the management of international rivers across national boundaries. Another recent addition is the charter of the space agencies, mentioned above.

Exchange of information among these centres, and agreement on tasks for the centres to avoid duplications is desirable, as well as an agreement on how to transmit and record data as well as warnings. Use of the Internet and web for transmission for all these data is desirable, so that environmental data can be used in all countries. This is at this time a rather unrealistic concept, since many agreements among different data supplier and user must be arranged before open access of all such data is obtained - lastly but not least because of stringent laws on data protection in many countries and the obligation of some government sources to make data available only to paying customers.

Improve short and medium range forecasting and investigate long term perspectives:

In a number of places it was mentioned that forecasting technology is not as reliable is one would wish, or is not available (i.e. for earthquakes). A major challenge to science is the development of better short time forecasts, either by developing new technology, or by improving existing methods, with the objective of obtaining more accurate forecasts with longer lead times. Although the need for short-range real time forecasts is of paramount importance, advantages may also be that of medium range forecasts, such as forecasting for a season. These forecasts might help to increase preparedness against droughts. However, sufficiently reliable seasonal forecasts are desirable but perhaps not available for Europe in the foreseeable future.

There is a need to further investigate expected changes in frequency and intensity of natural hazards in connection with global warming. Existing EU regional climate change projects (PRUDENCE and ENSEMBLES) are designed to shed some light on possible consequences of global warming on natural hazards related to natural weather and on the reliability of such projections into the future. Early warning experts should pay serious attention to the progress of climate change research, as a potential tool for long range planning. Depending on the estimated reliability, planning of protection systems should take into account climate simulations of possible climate change.

Improve the chain of warning

A general problem exists that the chain of warning is not clearly outlined and regulated everywhere. There is the problem of redundancy: different agencies collecting the same data, warning information going in both directions, horizontal from community to community, agency to agency, from top to bottom. An indistinct chain of warning not only causes confusion for the people at risk and for local administrations, but it also diffuses responsibility and accountability. It has been established that the best solution is to have a local grouping as target for a warning, which then takes responsibility for ensuing and necessary actions. This group must get a clear warning: warnings should be succinct and, if possible, use clear wording that has been agreed on beforehand to convey what type of extreme event is to be expected and what strength is to be expected, as well as what actions are to be taken. This group should then act locally to warn the persons at risk. For this, local cooperation is necessary and the establishment of local warning systems (alert systems).

An ideal system of the described kind would have a number of problems that need to be resolved. There is the accountability of persons who do voluntary service: what if they do not function in case of emergency? Also, the cost effectiveness of warning systems for rare events has to be considered. If a technical protection system exists, such as providing dikes along rivers to prevent flooding, it will increase the confidence of the people living in the protected area, but it does not protect them against higher flood levels which exceed the level stipulated with a probability chosen during the design of the protection system. In such a case, people expect an efficient risk management, although staff and funds are likely to decrease. If danger exists only for a "once in a 100 years event", would we be willing to be prepared for it? This option means that an extreme event can occur anytime, but on the average it will occur only once every hundred years, so that our forecaster will be idle for 99 years on average, and then act, i.e. issue a warning, only for the duration of the extreme event! Clearly, such an option cannot be sustained. This problem occurs, of course, only in areas where a high degree of technical protection exists, whereas in countries or areas with no or little protection floods of lower magnitude may be very frequent and early warning may be useful even for smaller floods occurring in an area of many thousand square kilometres.

The solution for the problem of protection against rare events found by the flood warning centres in European countries is for them to be responsible for large areas. The probability of having a once-in-a-hundred-years flood in a small area, for example, can be increased manifold if many such areas are combined and served by the same flood forecasting and warning system. Elsewhere, it might be advantageous and cost effective to concentrate on one agency warning system for all extreme event types threatening a certain area. In any case, such agencies should be required to ascertain the efficiency of the warning, for example by setting targets for number of people reached within a specified time frame (in the UK the Environment Agency recommends among "lessons learned from the flood of 2000" to set targets: for example 77% of property at risk should have at least two hours of warning – obviously, whether the target has been reached can only be determined after an extreme event).

The most important aspect of early warning improvement is to obtain the confidence of the people at risk: to convince them by different means available, such as training children or provision of easily understandable guiding material, that they should, as far as possible, take reduction of the risk into their own hands. This requires much effort, because experience has shown that even the best-prepared preparedness campaign has only limited success if the people are not feeling threatened. A rare event that is not in sight does not motivate. People file away preparedness material and do not read the guidelines of the agency! The best motivation comes from a disaster that has just occurred, as was experienced in the Rhine after the flood of 1993, with positive results for the flood of 1995, or in Prague, where experience of the Odra flood in 1997 resulted in better preparedness for the flood in 2002.

Improve the training of people involved in early warning and risk management.

In some European countries a number of courses for training disaster managers already exist. A long list of institutes is involved in offering training courses in most European countries. These not only offer courses on local laws, regulations, and practices, but also on the fundamentals of better understanding background and behaviour of extreme events. Many core issues of disaster management are the same for all kinds of disasters, and activities involved in preparedness of a community against different disasters can be treated in more or less the same way. Emergency plans have a common structure for all disasters, and the special considerations for special types of disasters can be taught, without requiring a graduate course in, for instance hydraulic flood modelling, to know how to use mathematical models for flood forecasting.

The centres can also get involved in training local persons to become disaster advisors, who can transfer basic knowledge of how to respond to a disaster to their fellow citizens. Creation of a common core curriculum may also include clarification of terms, so that a common language develops which is understood by risk managers everywhere, at least within each country. The creation of a unified core of education and training of risk managers might be an issue to be considered within the EU.

Other issues in Early Warning

Although main goals for future planning in early warning systems have been outlined in the previous section, there are a number of other issues that have been considered in the context of early warning during the Regional Consultation for Europe. These are issues that have a bearing more on the vulnerability of people living in an area that is threatened by an extreme natural event, rather than being connected directly to the early warning process.

The strategy followed, in part under the influence of ecologists, is to reduce vulnerability of the population by removing them permanently as much as possible out of endangered areas. This solution is an option only if it does not interfere with property rights. It is therefore more effective to discourage people from moving into hazardous areas: buildings in a flood plain are both endangered, but they also cause backup of the river, as the example quoted from the city of Prague shows. The benefits of warning must be made clear to the people – and for those that live in the flood plain it must be made clear to them that they should not impede the flow of the river. Although the benefits of appropriate land use – use the land threatened by extreme events only temporarily and do not settle permanently – are recognized, it will be difficult to convince people, for example by means of a general cost benefit analysis, to abandon their property. Indirect motivations, for example through insurance rates that reflect the hazards of the area, may be more successful.

It is known that in many parts of the developing world people migrating into urban areas are more likely to be endangered by natural events, for a number of well known reasons. Problem of people migration: conceived as problem? People moving into flood plains. Emerging issues: people migration – language problems and lack of experience of new citizens. Expanding on our understanding of social vulnerability: increasing societal complexity brings new problems for an early warning system. Reaction of people is different in different countries. The disaster handling structure in different countries is different, as it is integrated into the general disaster management.

RESULTS TO BE OBTAINED FOR THE FUTURE:

The European countries hope to obtain from EWC II Directives for further international actions and guidance in the task of finding targets for EW for the next ten to 15 years. It is realized that EWC II is only a milestone on the path toward obtaining the best early warning systems for every type of hazard everywhere in the world. To continue on this road, we need a platform for recording and supporting progress towards reaching the targets. The platform should bring together early warning information from different countries, and disseminate early warning knowledge on data collection, assist in the development of standards for early warning and in the dialog between institutions of all continents. This platform should assist the work of Working Group 2 of ISDR.

In recognition of the need to further develop networks, both regional and national, to strengthen coordination and cooperation, to build capacity, and to establish links between users and providers, and to support a greater harmonisation and standardisation of EW concepts, terminology and data exchange:

The creation of an international platform within ISDR is recommended to facilitate the implementation of these tasks.

Case study: The Central European Flood of August 2002

The large flood of August 2002 on Elbe and Danube caused one of the largest disasters that ever hit Germany and Czech Republic, with economic losses of more than US$ 13 billion. Here is a brief description of what happened, by referring to the map of Fig.1, which shows Elbe basin, Elbe river and its main tributaries.

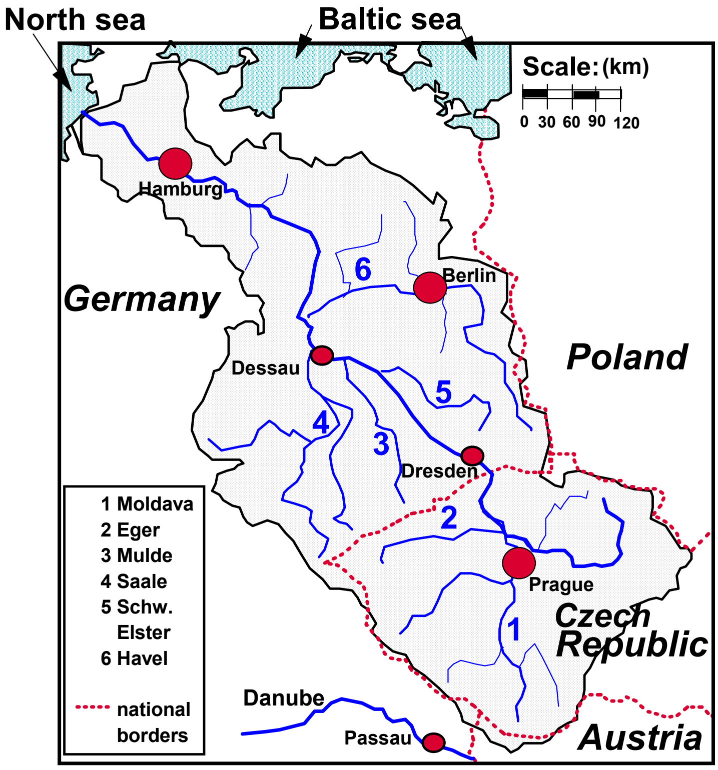

Fig.: The Elbe catchment in Central Europe

<u>The meteorological situation:</u> A very cold and rainy July and early August set the conditions of the basin. The cold air slowly moved to the East, being pushed from the South by a low pressure area originating over the western part of the Mediterranean. Winds from this depression were channelled by the Alps and carried moist and warm air from the Mediterranean, which was forced upwards when it met the cold air over East Germany and further East, cooling it and causing it to precipitate its moisture in the form of torrential rains. This meteorological situation corresponded almost exactly to the one which led to the 1997 disaster on the Odra river - the next larger river further to the East – a disaster that caused enormous damage exceeding US$ 4 billion in Poland, but which spared Germany: only a small region on the northern border to Poland was affected, and losses were less than US$ 300 million.

This time, the areas most affected by the rains were located in the basin of the Elbe river comprising the Western part of Czech Republic, and in the mountain ranges surrounding Czech Republic –the Ore mountains in the North – separating that country from Saxony (East Germany), and the mountains of the Bohemian and Bavarian forest between Czech Republic, Bavaria and Austria to the South. Starting on 8 August a first extreme rainfall fell on the Moldova basin – the largest tributary of the Elbe river in the Czech Republic. The basin of the Danube regions South of the Czech Republic was also strongly affected. A second extreme rainfall event occurred four days later, with two extreme rainfall cells: one causing floods in the Czech Republic. A further maximum was concentrated on the Ore mountains and the adjacent regions further North. The observed rainfall in parts of the country was more than 350 mm/24 hours – an amount of rainfall higher than the total in many summers in that area, and as high as the largest daily rainfall ever recorded in Eastern Germany.

The flood: The Elbe basin was already soaked from the long rainfalls in July - and base flow runoff was very high. With the strong rainfall of 8 August in the Czech Republic extreme floods occurred – low-lying parts of the city of Prague were partly under water. The flood wave from the first event in the Czech Republic reached its peak on 9 August, then moved down the Elbe river into Germany towards Dresden. The second flood wave occurred when the floods from the 12/13 August rainfall arrived, leading to a maximum flood level in Prague 2.94 metres higher than the highest flood level in 1890 (but flooding about the same area), which was up to then the best documented extreme flood in Prague – it was reported that at least 1 metre of this was due to buildings obstructing the flood which had been built into the flood plain. The superposition of the two events caused enormous damage in the Czech Republic: more than 1.5 million people were affected, about 220,000 persons had to be moved out of the flood area, and very high property damage resulted, for example, the subway in Prague was flooded in many parts and many other Czech cities were partially flooded. Losses were estimated to exceed the damage from the 1997 flood. In the South the floods in the Danube caused extensive damage, making the flood one of the highest in comparison with previous floods. In the city of Passau, on the confluence of the Danube and the Inn river, the floods affecting the lower parts of the city were the highest observed since 48 years, and further downstream along the Danube in Austria large damage occurred in cities almost up to Vienna.

The largest damage occurred in the German states of Saxony and Saxony-Anhalt, where the flood waves from the two rainfall events almost coincided. Small cities on the Elbe river (Pirna) and Mulde (Grimma) were caught ill prepared and suffered enormous damage. Among the worst hit was Grimma, which just had been rejuvenated after having been in a very poor state before the 1989 reunification of Germany. The hardest hit, however, was the city of Dresden, which suffered from an unusual accumulation of contributing causes. On 13 August the second wave of extreme rain, centred on the Ore mountains, producing flash floods of unheard magnitude. Small reservoirs, which gave a certain sense of safety to the people downstream, filled up rapidly and overflowed into usually harmless little creeks, which became rapid torrents. Among them was the Weisseritz. It had been diverted many years ago from its original bed, and the main railway station was now located where it had once flowed into the city. The creek broke its diverting dike and smashed into the train station, where the trains were submerged in the flash flood. The lower part of the city went under water. Floods from Czech Republic and from the Ore mountains reached the city of Dresden on 13 October and peaked about a week later: the water level was more than two meters higher than the largest flood ever measured – and the problem was aggravated by a very poor forecast: some time between 15 and 16 August the water administrator of the city had warned that the level of the flood may reach 8.30 metres gauge level – and on 17 August it actually peaked at more than 9.30 metres! The Elbe overflowing its banks continued the flooding of the city. The severe impediment to transportation had a great impact. In Dresden, the bridges over the Elbe river were closed for days, (as were the bridges over the Moldova in Prague) and the floods over the land destroyed hundreds of kilometres of roads and railroads.

From Dresden, the flood moved towards the North: cities like Meissen in Saxony, Dessau at the confluence of Mulde and Elbe, the small city of Mühlberg and a large part of the city of Magdeburg were swamped by the floodwave. Dikes broke in many places, and diversions had to be opened, for example in the area of the confluence of the rivers Elbe and Havel. The flood diminished so that the cities further to the North were not as badly affected as the ones further South.

The damage everywhere would have been much higher, and many more dikes would have failed if the dikes had not been strengthened through large numbers of sand bags, which were filled by everybody, from army soldiers to citizens of the affected villages, towns and cities. In the face of this disaster wonderful solidarity developed, and thousands of people helped – neighbours and helpers of all kinds flocked to the affected area from all parts of Germany, bringing supplies, equipment, and their own commitment. Together with about 35,000 German soldiers there were groups from other nations – probably more than 1,000 soldiers from England, France and the Netherlands volunteered. Nevertheless, in terms of cost the damage of this flood disaster will be the highest ever incurred in Germany, estimated at about US $ 7-9 billion The number of fatalities is very small: probably less than 30 persons in Germany, and 16 in the Czech Republic as a direct effect of the flood.

The German Government reacted by postponing a planned tax cut for 1 year, so that next year something like € 8 billion will be available. The European Community also is helping, and many millions of euros are coming in from donations by private citizens, companies, clubs, and other organisations. Politicians and financial experts are at work to make plans how to best distribute this large amount of money intelligently and most effectively. The issue is not only that large numbers of households are affected, but also that thousands of small businesses are ruined – businesses which very often just had started, whose stocks are destroyed, and whose debts are not covered. They were already at the upper limit of what could be financed, because they had to start from zero after German reunification in 1989. There is also a psychological issue: how to let people feel that it is worth starting again after they may have lost everything for which they had worked and toiled during the last ten years. It is hard to assess the damage to the spirit of the people: the first reaction was tremendous solidarity, but there is a let down after the flood is gone, and the realisation sets in on what has to be done to reach the point again that one had reached before the flood. Appropriate encouragement is perhaps the most important support for the people of this part of East Germany.

The flood not only provided wonderful examples of solidarity and self-help, but also provided some insight into what could be done better. The warning system left much to be desired: the rainfall field was too local to be accurately forecasted by the German Weather Service, the warning did not reach people early enough, and much confusion was caused by not having a clear chain of command for the actions that needed to be taken, and the logistics of where to put which group of helpers did not function in many instances. In the Czech Republic and Bavaria, the authorities had learned from 1997 and later disasters, but in the Elbe basin in Germany the authorities were not prepared for such a disaster. Although a number of studies were available, which indicated the weakness of the flood defences on the Elbe, and although scientists had warned after the flood of 1997 that the events on the Odra river could be repeated on the Elbe, the authorities had largely failed to act. By learning from the experience preparedness will be improved in the future.

Case study: Early Warning (EW) of Wildland Fires and Related Environmental Hazards: progress since EWC-I (Potsdam 1998)
(summary assessment by the Global Fire Monitoring Centre (GFMC) and the UN-ISDR Working Group of Wildland Fire)

The Global Fire Monitoring Centre (GFMC) was founded in 1998 and became operational one month after the EWC-I, at a time when it became obvious that there was a need for the application and improvement of existing methods and technologies and the development of new, innovative technologies to generate, disseminate and apply information on early warning for wildland fire. Among other tasks, the GFMC facilitates the access and application of early warning systems at global, regional and national / local levels. The following statements are given from the GFMC perspective.

1. Technologies in place

Early warning of wildland fire and related hazards include a variety of methodological approaches and systems to identify precursor developments and assess / predict the escalation of the wildland fire theatre.

(a) Assessment of Fire Hazard. Ground measurements and to a certain extent also satellite-generated information allows determination of the amount of fuels (= combustible materials) available for wildland fire. This is important because dryness and fire risk alone do not determine the extent and severity (= severity of impact) of fire.

(b) Prediction of Fire Risk. Methods exist for observing / tracking lightning activities as source of natural ignition (ground-based lightning detection systems; spaceborne monitoring of lightning activities). Modelling / predicting human-caused fire starts is possible by application of logistic models.

(c) Prediction of Fire Danger. This term is used for the readiness and ease of vegetation to burn. EW systems include meteorological danger indices and spaceborne information on vegetation dryness (intensity and duration of vegetation stress) and soil dryness. Prediction of inter-annual climate variability / drought, particularly related to ENSO, is important for preparedness planning in many countries.

(d) Assessment of Smoke Pollution. *In situ* air quality monitoring systems allow tracking of fire smoke pollution and issue alerts (warnings to populations). Surface wind prediction allows prediction of smoke transport from fire-affected regions to populated areas. Satellite imageries can depict smoke transport.

(e) Prediction of Wildfire Spread: Airborne and spaceborne monitoring of active fires allows the prediction of movements of fire fronts to areas with values at risk. The technologies used include airborne instruments to monitor fire spread in situations of reduced visibility (smoke obscured) or to cover large areas. A large number of orbiting and geostationary satellites are available to identify active fires.

2. Application

Most industrial countries have systems in place to address the above-mentioned issues. In countries where fire occurrence and fire smoke pollution is of minor importance such systems are not in use or are restricted to the prediction of fire danger (item 1.c).

The majority of developing countries and countries in transition do not have in place most of the systems.

3. Policies, Gaps and Trends

At national level many countries in the developing world are seeking technical and scientific cooperation with donor countries to develop locally applicable EW systems. There is a new trend to support decentralized approaches such as the use of "simple" EW indices to be used at local (community) level.

At international level it has been recognized that the EW component in fire research and development has received less attention than fire monitoring.

Consequently, it has been decided to push R&D in early warning of wildland fires. The World Weather Research Programme (WWRP) is currently preparing a new international collaborative activity. A kick-off workshop "International Collaboration in Fire Weather Research" will be held in Australia, 9-10 October 2003.

A focussed scientific workshop has been convened in June 2003 to address the contribution of remote sensing to EW of wildland fire. The results will be brought to the 3rd International Wildland Fire Conference and Summit (October 2003). The recommendations from these two international workshops will be transmitted to the Early Warning Conference-II.

The UN-ISDR Working Group on Wildland Fire through the GFMC and in collaboration with the UN-ISDR Working Group on Early Warning is monitoring and facilitating international collaborative efforts in EW of wildland fire. On request the GFMC also supports countries in the development, adaptation and application of EW systems.

4. Information Sources and References

Global Fire Monitoring Centre (GFMC) website:
http://www.fire.uni-freiburg.de/

Global, Regional and National Fire Weather and Climate Forecasts:
http://www.fire.uni-freiburg.de/fwf/fwf.htm

Regional and Global Vegetation Fire Emissions:
http://www.fire.uni-freiburg.de/vfe/vfe.htm

Wildland Fire Monitoring:
http://www.fire.uni-freiburg.de/current/globalfire.htm

IDNDR Report on Early Warning for Fire and Other Environmental Hazards
http://www.fire.uni-freiburg.de/Programmes/un/idndr/idndr_co.htm

Global Observation of Forest Cover/Global Observation of Landcover Dynamics (GOFC/GOLD) - Fire Mapping and Monitoring:
http://gofc-fire.umd.edu/

World Health Organization (WHO), Health Guidelines for Vegetation Fire Events
http://www.fire.uni-freiburg.de/Programmes/un/who/who.html

UN-ISDR Working Group on Wildland Fire:
http://www.unisdr.org/unisdr/WGroup4.htm

Wildland Fire Meetings in 2003, including EW of Wildland Fires:
http://www.fire.uni-freiburg.de/course/meeting.htm

Innovative Concepts and Methods in Fire Danger Estimation by Remote Sensing
http://www.fire.uni-freiburg.de/iffn/iffn_28/research2.pdf

State-of-the-art synthesis volume on spaceborne wildland fire monitoring, published as a contribution to the ISDR:

Ahern, F., J.G. Goldammer, and C. Justice (eds.). 2001. Global and regional vegetation fire monitoring from space: Planning a coordinated international effort. SPB Academic Publishing by, The Hague, The Netherlands, 302 p.

References:

Alexandrian, D., F. Esnault, and G. Calabri. 2000. Forest fires in the Mediterranean area. UNASYLVA 59 (No. 197), and on the FAO Web Site: http://www.fao.org/docrep/x1880e/x1880e07.htm

BfG 1994: The 1993/94 flood in the Rhine basin. Federal Institute of Hydrology (BfG), Koblenz, Germany

Casale, R. et al. (eds): 1997 Proceedings of the First European Expert Meeting on River Basin Modelling (RIBAMOD) published by the European Commission

Christensen, J.H. & O.B.Christensen, 2003: Severe summertime flooding in Europe. Nature Vol. 421, p.805

Environment Agency UK: 2001: Lessons learned: Autumn 2000 floods. Environment Agency, Rio House, Waterside Drive, Aztec West Almondsbury. Bristol BS 32 4 DU

Göppert, H., J.Ihringer, E. J. Plate 1998: Flood forecasting model for improved reservoir management in the Lenne Catchment, Germany. Hydrological Science Journal, Vol.43, pp.215-242

Goldammer, J.G. 2003a. Towards international cooperation in managing forest fire disasters in the Mediterranean region. In: Security and the environment in the Mediterranean. Conceptualising security and environmental conflicts, Chapter 50 (H.G. Brauch, P.H. Liotta, A. Marquina, P.F. Rogers, and M. El-Sayed Selim, eds.), 907-915.Springer Verlag, Heidelberg, 1134 p. (ISBN 3-540-40107-5).

Goldammer, J.G. 2003b. The wildland fire season 2002 in the Russian Federation. An assessment by the Global Fire Monitoring Centre (GFMC). International Forest Fire News No. 28, 2-14.

FAO 2000: Global Forest Fire Assessment 1990-2000 http://www.fao.org:80/forestry/fo/fra/docs/Wp55_eng.pdf

ISDR 2003 (?): Draft Report on "Living with Risks", Chapter 5.6, United Nations

Plate, E.J. 2002: Flood risk and flood management. Journal of Hydrology, 267, pp2-11

Plate, E.J. & B.Merz (eds.) 2001: Naturkatastrophen: Ursachen, Auswirkungen, Vorsorge. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, Germany

Plate, E.J., W.Kron & U. de Haar (eds.) 1993: Naturkatastrophen und Katastrophenvorbeugung. Bericht des Wissenschaftlichen Beirats des Deutschen IDNDR Komitees. Published by the German Research Association (DFG), Weinheim.

Wilke, K.1997: Forecast systems for large rivers – the Rhine River Catchment, in R.Casale et al. (eds) Proceedings of the First European Expert Meeting on River Basin Modelling (RIBAMOD) published by the European Commission, pp.105-126

Zschau, J. & A.N.Küppers (eds.): 2003: Early Warning Systems for Natural Disaster Reduction. EWC 98. Springer, Berlin