Catastrophe portrait I Flooding and landslides in the Alps

06

The flood disaster in Italy and Switzerland of October 2000

Meteorological background

In the southern Alps, the approach of autumn is always accompanied by worries about rain. Since the Mediterranean is at its warmest in late summer, the low-pressure systems that frequently form over the Gulf of Genoa (eddies in the lee of the Alpine arc) are able to absorb a great deal of water vapour Atmospheric circulation pushes the humid air masses northward, where they come into contact with the significantly cooler air masses over the land and the orographic barrier of the Alps. Both effects cause the humid air from the Mediterranean to rise and cool, resulting in plentiful and intense precipitation on the southern slopes of the Alps. The torrential rains resulting from the so-called Genoa low typically occur between September and November and are the principal cause of the flood disasters in northern Italy and the areas of Austria, Switzerland, and France south of the main Alpine ridge. Sometimes these torrential rains also reach areas to the north and west of the main Alpine ridge.

A glance at the statistics suffices to see that this region is very frequently the scene of major loss events. The records for recent years in the MRNatCat*SERVICE* database show billion-dollar losses in 1987, 1993, and 1994, and million-dollar losses nearly every year.

Especially hard hit in October 2000 were the following areas:

- Switzerland. Wallis and Ticino
- Italy· the Aosta Valley and the provinces of Piedmont, Lombardy, Emilia Romagna, and Liguria

October 2000: new records for rainfall almost everywhere

The "great rain" began on 13th October. Between two stable high-pressure systems, one over the Atlantic and the other over Russia, a low-pressure system had formed over the Mediterranean and was pushed against the Alps by high-altitude winds from the south. Right from the start, the rainfall was extremely intense; Bognanco, a Piedmont village in the catchment area of the Ticino, recorded 402 mm on the first day alone. That was equivalent to twice the 50-year rainfall for a period of 24 hours (205 mm) and was thus an event with a return period of several thousand years. Over the next three days, another 338 mm of rain fell, bringing the four-day total to 740 mm By way of comparison, the area's October precipitation averages approx. 300 mm. Yet a new record for rainfall was set not only in Bognanco, but all along the western part of the southern Alps. The chart on page 30 shows the distribution of precipitation in the province of Piedmont

The consequences: landslides, mudflows, flooding

The soil was not in the least able to absorb these immense amounts of rain. In many places, the water shot down the slopes, washing away the surface and creating numerous debris flows At other places, water seeping through the soil reduced the friction with underlying slip planes, triggering landslides and rock falls.

Mountain streams and rivers have steep courses, with correspondingly fast rates of flow. Floods of this sort tear away everything in their path, eroding even the beds and banks of streams and rivers and washing away the soil supporting bridge piers and abutments. Boulders carried along by the water, some of them more than a metre in diameter, develop tremendous destructive force when they hit structures or other obstacles.

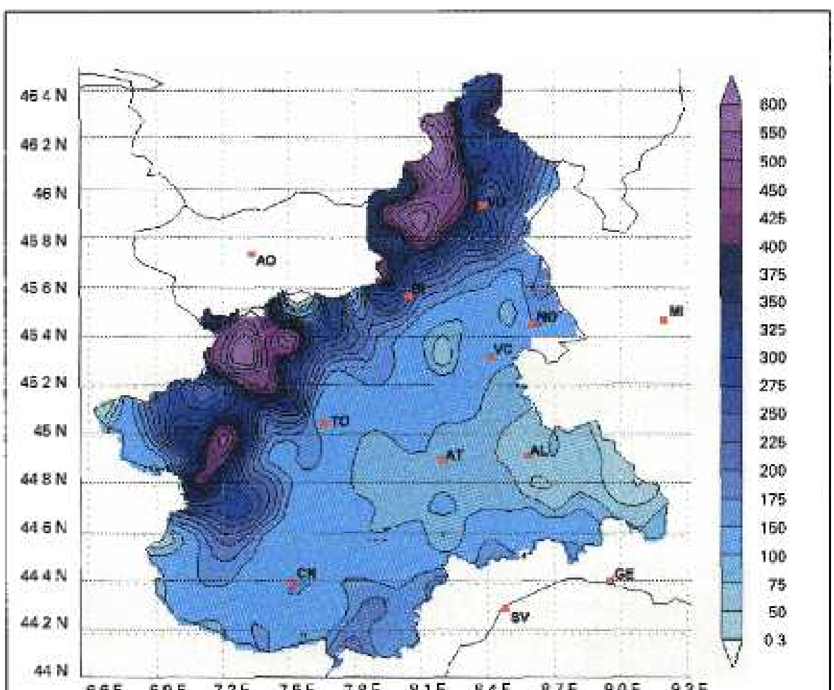
The flood wave along the Po: a battle against inundation

While the situation in the mountains gradually improved starting 17th October, the threat of large-scale, catastrophic flooding along the entire length of the Po River loomed ever larger The torrential downpour had immediately caused flooding in the river's upper reaches, and high water rendered many of the towns in the region inaccessible. Even certain parts of Turin, a city of more than one million inhabitants, were temporarily cut off, and the people there stranded. The flooding affected numerous industrial and commercial companies, which were compelled to cease operations, first, because their employees were unable to get to work and, second, because the supply of components was interrupted. Even a major car maker in Turin was unable to produce for several days. Normally, companies in Italy are not automatically insured against business interruption (BI). Also, losses are compensated only when an insured

30 Landslide in Gondo, Switzerland, on 14th October 2000 plant is unable to operate because the plant itself is directly affected, that is to say is itself at least partially submerged.

The situation in the middle reaches of the Po grew worse from one day to the next, particularly since it continued to rain – even if with diminished intensity. Each day, as the flood wave progressed further down river, it confronted new sections of the valley with a critical situation. In the lower reaches as well, the inhabitants were girding themselves for the worst. To reduce the volume of water being carried by the river, authorities diverted floodwater into agricultural areas. Everywhere in the region, dykes were strengthened and emergency measures prepared Aided by disaster relief workers, the entire populace feverishly fought the flood.

They won the battle. but their success was certainly due in part to their good fortune that the water did not rise several centimetres higher. Ultimately, the dams held almost everywhere, but especially at particularly threatened towns such as Brescello, near Parma, which even under normal circumstances are lower than the water level of the Po A break in a dyke at any of these places would have had disastrous consequences. All in all, the plain of the Po may be said to have got off lightly, considering the circumstances. If there had been just a little more rain, most of the plain would have been flooded again – as it was most recently in 1951. Nevertheless, the losses in the region amounted to more than €1bn.



The distribution of rainfall in the province of Piedmont from 13th to 16th October 2000. Many areas registered historic highs of several hundred millimetres In the northwest, rainfall over the four-day period reached even 600 mm, a value equalling the average annual precipitation of some places on the northern Italian plain Source Direzione Regionale Servici Tecnici di Prevenzione, Regione Piemonte.

AO	Aosta
VD	Verdania
NO	Novra
BI	Biella
VD	Vercelli
TO	Turin
MI	Milan
GE	Genoa
CN	Cuneo
AT	Asti
AL	Alessandria
SV	Savona

The overall loss picture

The floods, landslides, and mudflows claimed at least 38 lives in Italy and Switzerland and made it necessary to evacuate 40,000 people in Italy alone. In view of the enormous extent of the natural events in the mountain valleys, the toll of 38 fatalities was surprisingly small, particularly since one-third of the victims met their deaths in what was presumably the most spectacular event of all, a debris flow in the Swiss village of Gondo at the southern foot of the Simplon Pass between Brig and Lake Maggiore. In financial terms, the losses resulting from the events are approximately equivalent to those of the catastrophe of 1994, which occurred in more or less the same area. Although the meteorological event was even more extreme this time, its additional severity was more or less compensated by improvements in the safeguards (dams, civil defence measures, etc.) that were effected following the event of 1994. The economic losses in Italy are estimated at €8bn, and those in Switzerland at more than €385m. The insurance industry has to pay about €450m, of which about 150m is destined for Switzerland and 300m for Italy

The flood swept away everything that was not firmly cemented in place. Trees and branches frequently clogged bridge passages, causing flooding in the surroundings. Branches, stones, and other objects carried along by the water became projectiles with high penetrating power that caused massive damage again and again. This photograph shows the Cisone River near Turin (Piedmont)

Background: the development of settlements in Alpine valleys

Even well into the last century, the Alps were a thinly populated, relatively unattractive area that offered only a meagre livelihood to its inhabitants. Most of the people living in the mountains were poor. It was not until the advent of tourism that the mountains began to offer opportunities with sufficient income to support a family throughout the year. As tourism continued to develop, the number of people living in the Alps increased very rapidly. In the past 130 years, for example, the population of Tyrol has increased from 237,000 to more than 600,000, and the number of buildings there has quadrupled just since 1960. In addition to the year-round residents, there are now millions of tourists who spend some time in the Alps every year

The growth in the population was accompanied by a virtual explosion of construction activity: houses, hotels, streets, railway lines, mountain railways shot up everywhere and, by increasing the attractiveness of their locations, again intensified the settlement – one could almost say the invasion – of mountainous regions that are often highly sensitive, yet virtually always entail a high degree of risk. Areas thought to be secure from natural hazards were few and far between, and it seemed self-evident that the best place to settle was in the river valleys, which the locals had always kept clear of – for good reason. The building activity was not always well-planned and only seldom took the existing perils properly into account. This is particularly true of many areas in Italy, where it was and still is more a rule than an exception that buildings are constructed without a formal building permit.

The construction of buildings in hazardous areas is only one side of the coin, however. At the same time, many localities invested substantial resources in safety structures and measures in an attempt to tame the forces of nature, anchoring unstable slopes, building avalanche-retaining walls, setting up rockfall nets, constructing shingle traps in torrents and constricting rivers into channel-like watercourses. Most of these measures are helpful and expedient in controlling relatively small and relatively frequent natural events, but very often they have a counter-productive effect when an extremely hazardous event occurs.

Many Alpine river valleys are now virtually lined with houses, car parks, and streets, and consequently have extensive paved surfaces from which the water rapidly runs off into the nearest stream or river. The best example of this is the Aosta Valley, one of the regions hardest hit in the autumn of 2000. Channelling the course of a river also has the effect of increasing the water's speed of flow. Both of these factors often lead to shorter discharge times, i.e. heighten the peak of discharge waves. Water flowing at higher speeds also transports greater amounts and, even more importantly, larger pieces of sediment, which can develop enormously destructive mechanical force when they hit an obstacle such as a house, bridge pier, etc. Boulders as large as cars are by no means unusual. Material (especially wood) carried along by the water poses the threat of clogging bridge passages and other bottlenecks and can cause the water level above such places to rise several metres within an extremely short time.

Another important negative consequence of safeguards is that they impart a sense of absolute security that is nearly always false. People lose sight of the peril and thus also of the necessity of adequately countering it. A dramatic demonstration of the consequences was once again provided by the autumn of 2000.

Yet there are also very positive examples of well-conceived and well-executed disaster preparedness. In September 1993, the Swiss city of Brig was devastated by the flood waters of the Saltina, a tributary of the Rhône. Following the flood, the streets were covered by a metre-thick layer of mud and rubble. This happened because the bridge passage was too narrow, initially, it was clogged by rubble, which was then carried away suddenly by the force of the water. After the 1993 flood, the bridge was completely redesigned as a lift bridge which can be raised when the Saltina is in flood to allow the water-sediment mixture to flow downstream unhindered. In mid-October, the Saltina's discharge wave was higher than in 1993, and the river came close to flooding, but more extensive damage was prevented by raising the bridge

The influence of climate change

In addition to record levels of rain, many places also recorded new highs in discharge and water levels. The upper reaches of the Rhône carried more water than had ever been recorded before, and Lake Maggiore also reached a historic high. It would be mistaken to see this single extreme event as proof of climatic change, but it can be classified as a further link in the chain of evidence because it closely concurs with the forecasts of experts

The most important aspects:

- As the atmosphere becomes warmer, it can absorb more water vapour, allowing greater differences in pressure and temperature and leading to more frequent and more severe weather extremes. This expectation was fulfilled by the heavy rainfalls locally, but also throughout the Alps, in October 2000.
- The Mediterranean Sea is now an average of 2°C warmer than it was 20 years ago. As a result, it imparts even more water vapour to the air masses moving towards the Alps. The temperature gradient to the air masses over the mountain range tends to be greater, thus intensifying precipitation
- Climate models suggest that the paths of Atlantic low-pressure systems are shifting in a more westerly/southwesterly direction, and that weather conditions such as those of last October (and, incidentally, of the avalanche winter of 1999) are consequently becoming more frequent in the Alpine region.
- As the Alpine glaciers rapidly continue to melt away, the Alps are losing a natural buffer for the water of precipitation This melting is also accompanied by the increased run-off of melt water, which especially in late autumn raises the basic level of Alpine rivers, producing higher and faster-moving flood waves. The record-high discharge waves in the upper reaches of the Rhône, just a few kilometres after they leave the glacier, are an example of this.
- The Alpine snowline is rising. In October, the snowline normally

lies at about 1,600 m, but was more than 1,000 m higher at some places in October last year. This meant that considerable amounts of precipitation were no longer being bound in the form of snow or ice, but immediately ran off into the valleys.

- The permafrost area, that is to say the area in which the soil is frozen throughout the year, is shrinking. Since the thawed-out slopes are very loose in structure and consequently unstable, precipitation can trigger sliding. This is also true of the areas uncovered through the melting of the glaciers, and is probably closely related with the heightened frequency of rockfalls, landslides, and especially debris flows which has been observed in the Alps for years. Debris flows (also frequently referred to as mudflows) are mixtures of water and solid components (each varying in proportion from 30 to 70%) that flow downhill at speeds of up to 60 km/h. The disaster of Gondo was an event of this type.

In northern Italy, the flood submerged highways and streets along rivers, cutting many towns off from the outside world

In the aftermath of the floods and mudflows, many mountain villages were scenes of devastation Large numbers of old houses were total losses

Since restaurants, hotels, and other infrastructure of the tourist trade are generally located on the lakefronts, loss potentials there are especially high

Conclusions and outlook

– The conclusion to be drawn from the above must be that mountainous regions are now, and will continue to be, more dangerous than ever before. This is true not only of the Alps, but also of every other mountainous region around the globe. One need merely recall a very similar event in South America, namely the mudslides in Venezuela of December 1999, which cost tens of thousands of human lives

– It is necessary to recognize that while safeguards are necessary and expedient, extreme meteorohydrological events such as that of October 2000 cannot be controlled.

– Sustained minimization of losses arising from extreme events can be achieved only through the consistent application of land-use restrictions, and in many places, unfortunately, there is just cause for pessimism as to whether this will happen.

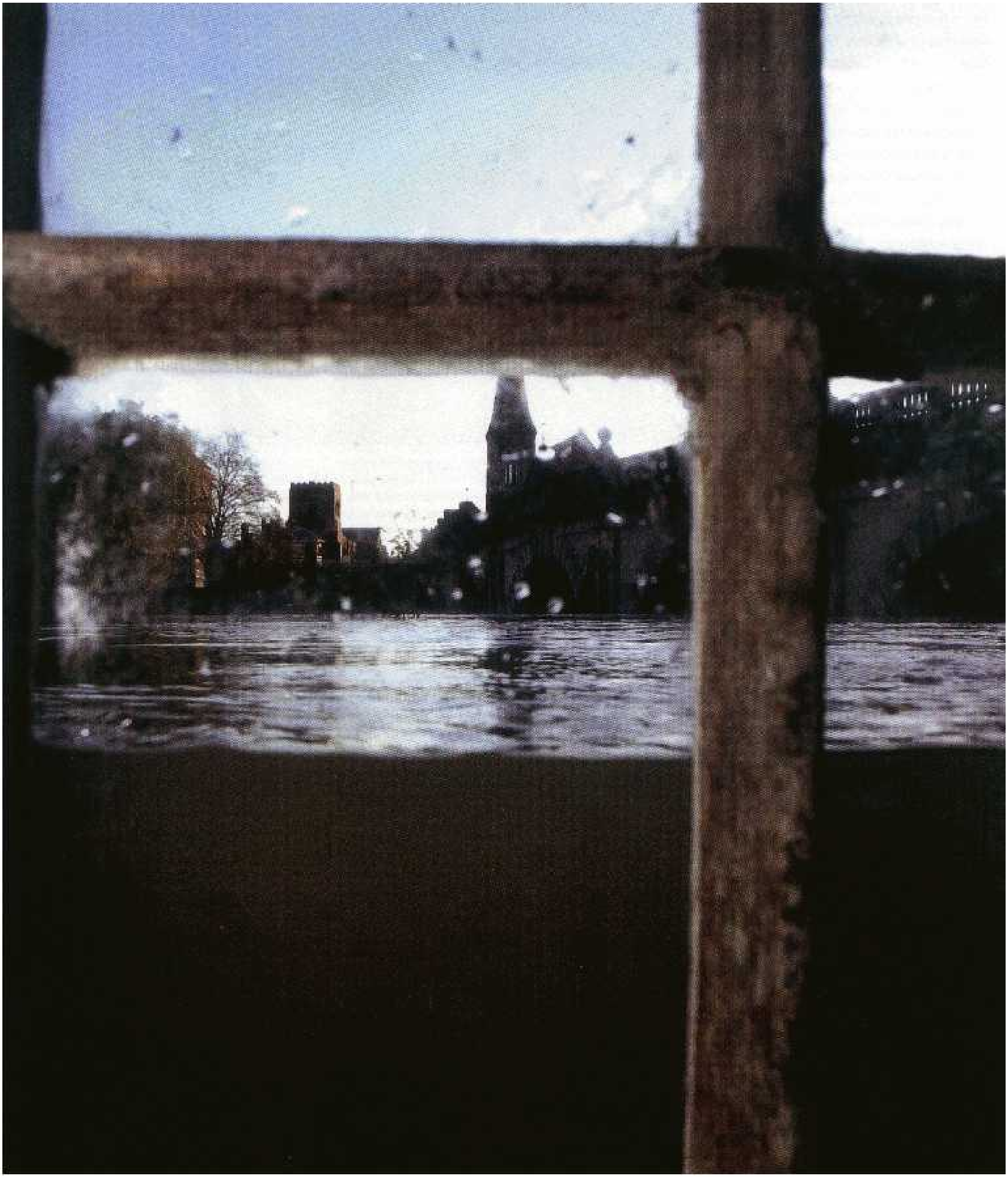
– The latest floods can by no means be considered a one-hundred-year event, as that would fail to reflect reality It is far more probable that it was merely a ten-year event. One need not be a prophet, therefore, to predict that we will experience something similar again in the not too distant future, even if perhaps not in the same region

– The next few years could give rise to a new underwriting situation in Italy, where the introduction of obligatory natural hazards insurance is now under discussion. In view of the existing extremely pronounced hazards – in terms of not only meteorological but also geological perils (earthquakes, volcanoes) – this confronts the insurance and reinsurance industry with a great challenge.

35 A view through a window over – or rather into – the Severn (Shrewsbury, October 2000)

Catastrophe portrait II
Autumn floods in Great Britain

07



The catastrophic events in Great Britain were another outstanding episode in a year of major floods. The months of October and November presented the country with its worst river floods since 1947. Both the extremely profuse rainfall in the autumn and the country's current policy towards land development are to be seen as the fundamental reasons behind the loss events that were ultimately triggered by a series of low-pressure systems. Burning questions again need to be asked. Are we confronted here with discernible signs of climate change? And if so, how will these conditions develop in the future?

Starting point – record precipitation in the autumn

In September, October, and November England and parts of Wales recorded up to 470 mm of rain. This was the largest amount of rainfall for these months since recordings were first made in the year 1766. The last comparable amount (456 mm) was recorded in 1852.

Usually a large proportion of rain water seeps into the ground or is returned to the atmosphere in the evaporation process. Surface runoff or the groundwater takes the rest into streams and rivers. Last autumn, however, there was so much rain that the ground was soon unable to absorb any more water. An extremely large proportion of the rain ran straight into the rivers. As a result the levels in many rivers rose considerably.

This is a satellite image of the intense low-pressure system Oratia, which travelled across the North Atlantic at the end of October. On the day the picture was taken, 30th October 2000, the centre of the low-pressure vortex was already to the east of the British Isles. The southwest of England including Cornwall and Devon may be seen at the bottom of the picture, at top left is Scotland under an almost cloudless sky. Source: NASA-supported Dartmouth Flood Observatory, 2000

The responsible low-pressure systems

In the middle of October two low-pressure systems, Imke and Heidrun (in the shape of a double vortex for a time), produced heavy rainfall in the southeast and parts of the southwest of England. On Thorney Island, for instance, about 80 mm of rain fell within three days. The ground was already so saturated that it could not absorb these volumes. The first severe floods occurred particularly in East and West Sussex, Kent, Devon, and Hampshire. The two mentioned low-pressure systems developed into a secondary low, which travelled south of the Alps and triggered the fateful rainfall in the southern Alps (see report on page 28).

The first floods had begun to recede when on 28th October a tornado swept through the town of Bognor Regis on the south coast of England. This was the vanguard of further extreme weather events, because the very next day the intense low-pressure system Oratia was forming over the Atlantic south of Greenland. It crossed Great Britain at great speed and attained a very low central pressure of 940–945 hPa over the North Sea. Oratia (see photo) carried winds up to 160 km/h into South Wales (Mumbles Head) and some parts recorded up to 50 mm of rain in 12 hours. In parts of northern England there were also intensive falls of snow. The town of Newton was deluged by 9 cm of snow in a single hour.

As a result there were numerous heavy floods in the west, southwest, south, and southeast of England, which in terms of their geographical dimensions and intensity were comparable to the historical events of 1947.

On 5th November, after the intense low-pressure system had attenuated over the North Sea, the low-pressure system Rebekka developed over the sea west of Ireland and then moved along the north coast of Brittany. On 6th November, Gloucester recorded wind speeds of up to 100 km/h. Rebekka also brought more than 20 mm of rain in 24 hours, in Dublin no less than 56 mm. As a result Ireland and the northeast and again the southwest and southeast of England were hit by floods.

The effects

The gales and floods caused major damage, particularly to infrastructure. The gales tore down power lines, hence affecting the public transport system. In Greater London rail traffic came to a partial standstill. Road traffic was also severely disrupted. Some sections of the A40 and the M25 in Greater London were no longer passable because of the floods. Some towns, like Shrewsbury, were cut off entirely for a time.

In York the Ouse reached its highest water levels for 375 years and it took considerable effort and a good portion of luck to avert an even greater catastrophe. If the dams had failed, several thousand households may have fallen victim to the waters. Many towns in the southeast of England were hit several times by floods

Early warning and overall balance

The last major flood events in England were the Easter Floods in April 1998. Important lessons had been learnt from the experience of an early-warning system that did not operate efficiently. So this time the Met Office and the Department of the Environment managed to issue warnings to the population in advance. How much positive impact these early warnings had on the number and severity of the material damage cannot be quantified at the present point in time. In individual cases, however, it was observed that the amount of damage depended to a large extent on the precautions that had been taken. Many houseowners whose property had been inundated almost every year and had taken appropriate precautions had less damage to report than those who were caught completely unawares.

The following overall loss picture may be drawn:

- Ten people lost their lives in the floods.

- The economic loss generated by the windstorm and floods events is likely to be some US$ 1.5bn.

- The overall insured loss is currently estimated to be about US$ 700m. This mainly involves, besides private households, small commercial firms and in some cases industrial installations.

General factors impacting the extent of loss

The loss amounts of the objects affected are influenced by many factors, the specific impact of which varies from case to case. A few of the main aspects are presented in the following:

- **The level of flooding in buildings**
  The height of the floodwater in buildings is one of the most important factors The higher the water rises, the more it affects furnishings and fittings, e.g. electric cables. Each time the water reaches a new storey, the loss amount must be expected to rise abruptly because the exposed values (particularly furnishings and fittings) are concentrated near the ground. The degree of flooding may be identified by floodmarks on the inside and outside of buildings.

- **The length of time water stays in the flooded object**
  The longer masonry, plaster, floors, and furnishings are in contact with water, the greater the damage to be expected. Standing water may also affect objects such as pictures or wall and ceiling coverings that do not even come into direct contact with the water but are damaged by the elevated humidity and the rising moisture.

- **The flow speed of the water**
  The faster the water flows, the greater the damage that is to be expected above all to the structure of buildings. The pressure exerted on walls by the water rises, the erosion of the foundations is promoted, and the amount and size of the debris transported by the water increases. The mechanical impact of debris may be very destructive. High flow speeds occur on steep terrain or when dams or dykes fail.

- **The nature and volume of transported sediment and pollutants (e.g. oil)**
  The nature and volume of the transported sediments and possibly pollutants, e.g. oil or chemicals, have a bearing on the degree of damage inflicted on buildings and their contents. In the course of a flood the water loses speed outside the river channel and deposits the transported sediment, which may lead to mud deposits on walls, floors, and the furnishings of a building. If the water is polluted, the degree of damage may increase many times, as the 1999 Whitsun floods in Bavaria demonstrated.

The degree to which individual objects are damaged depends to great extent not only on the cited parameters but also on the material the objects are made of. Electronic appliances, for instance, or foodstuffs must be classed as very susceptible and will normally be unusable after a flood. In the majority of cases the damage to the contents is much more costly, in both absolute and relative terms, than the damage to the buildings themselves This is due, on the one hand, to the stark increase in the value of the contents of households, in which purchases like highly sensitive stereos or computers play a major role On the other hand, a large proportion of the values, at least as far as detached houses are concerned, are to be found on the ground floor.

What impact does climate change have?

Are these flood events signs of or even the results of a change in the climate? This is a question that was repeatedly posed in connection with the extreme floods. Generally speaking, there is always a possibility of several low-pressure systems hitting the British Isles in close succession (the last major series of gales dates back to the year 1990). The comparatively slow forward speed is nothing particular either. How much impact global warming may have is not quantifiable in practical terms; it is relatively certain, however, that in the future – in a changed climate – the United Kingdom is likely to experience more frequent and more severe floods. This is borne out by the findings of British climatologists, who are regarded among the world's leading experts. One of the climate scenarios of the UK Climate Impacts Programme (UKCIP) even assumes a below-average (medium-low) increase in carbon dioxide emissions in each of the years 2020, 2050, and 2080. Even on the basis of this relatively optimistic scenario, winter precipitation will increase percentage-wise more steeply than the respective annual figure. This means that in the UK, as in many countries in the moderate latitudes, the summers will tend to be drier and the winters wetter. If air temperatures are low in the autumn and winter months and there is a reduction in direct evaporation and in water consumption by vegetation, the storage capacity of the ground will be exhausted that much quicker so that more rainwater will flow off on the surface.

Town planning and the development of high-risk areas

Particularly in connection with floods, however, the question as to the possible effects of a changing climate is eclipsed by the even more urgent question of acceptable town planning. If the values continually increase in what are often known to be high-risk areas, the frequency and intensity of natural catastrophes will inevitably increase too even if the number of natural events remains constant. Very unfavourable developments may already be observed today in this respect, as in the case of the increasingly common practice of designating flood-prone areas as residential or industrial zones. Land that can be used for housing and commerce is at a premium in the UK. Consequently, more and more people are tending to settle immediately next to bodies of water. According to a recent study, it must now be assumed that almost 10% of the population and about 1.7 million homes and 130,000 commercial properties, accounting for about 7% of the total stock of buildings, are located in potentially flood-prone areas. The aggregated values in the flood-prone areas of the UK are estimated to be about £215bn (in 2000), half of this figure being accounted for by the Thames catchment area including Greater London. The tendency to develop these regions is likely to continue, especially since the government has announced that it intends to create more than four million new homes by the year 2015. Added to this comes the fact that the department responsible for questions relating to flood (Environment Agency) only acts in an advisory capacity in the designation of areas for development. If future flood losses are to be averted, however, it is essential to involve water authorities or the Department of the Environment in local planning processes. Only if the evil can be attacked at the roots, i.e. in the flood plains themselves, is there any chance of the situation gradually improving.

In addition to industry, trade and commerce – restaurants, pubs, and in this case a supermarket in Longden Coleham – were affected. If warnings are given well in advance, there will be enough time to move goods onto higher shelves