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1.11 Water disasters: A historical review

MICHAEL BÖRNGEN

SUMMARY: *Water disasters can vary greatly. Those occurring inland are usually caused be heavy rainfall or rapidly melting snow, whereas coasts are prey to tropical and nontropical hurricanes and tsunamis. However, but both regions can be vulnerable to hailstorms, avalanches, and glacial deterioration. Each form can bring enormous loss to human life and livestock, damage to property, and substantial topographical change, bringing dire economic destruction in its wake. This paper aims to set forth examples of each type of natural catastrophe from the recent and not-so-recent past.*

It is a fact that water is essential to life on our planet. However, this indispensable element is not always available to us in the proportions or at the times desired. The lack of water, which for the purposes of this presentation will not be discussed, and its overabundance can have calamitous consequences on human civilisation and the natural world. This report will examine floods from today's headlines as well as those from earlier times.

Flooding inland

In this presentation, the use of the term »high water« will be restricted to mean the difference between the mean high-water measurement at a given site and any level over that. The term »flooding« will be used in those cases where a surfeit of water overflows banks and natural conduits to inundate low-lying land-masses and the settlements thereon. The two most frequent causes of both high water and flooding are abnormally heavy rainfalls in summer and rapidly melting snow in winter or early spring.

Even taking into account the margin for error in past record-keeping practices, the high-water marks and a vast number of historical accounts of flooding provide a rich mine of information. An outstanding example is »The Flood of Thuringia« account, which tabulated the actual results from the flood disaster of 29 May 1613. Official record-keeping, however, did not take place on a regular basis until the mid 19th century (*Table 1.11-1*)

One of the greatest European environmental disasters during the last millennium occurred in 1342. The following excerpt from an eye-witness offers testimony to the destruction when certain weather conditions interact:

»In the same year there were great floods, both in the winter and again in summer, causing damage in the areas around the Rhine, Danube and Inn Rivers, and in these affected regions whole villages and cities, livestock and citizens – no one knows how many – were wiped out. Bridges also were annihilated. In the mountains the Etsch [or Adige in Italian] River destroyed 6 miles of fertile land« (cited in WEIKINN 1958, p. 197).

The 1342 flood, which occurred in July, brought with it an added dimension of tragedy. As never before, this flood wreaked permanent changes to the terrain. Starvation threatened owing to the complete annihilation of the harvest. As note in the text quoted above, the inundation in summer was compounded by a flood from early in the year. Chiefly affected by this flood were Bohemia with the Vltava (Moldau) River and Saxony with the Elbe River.

A further memorable flood year took place in the year 1784. A very cold winter having an extraordinarily high snowfall had occurred in 1783. The coincidence of a quick thaw brought on by torrential rains and the premature break-up of ice from 28 February to 1 March resulted in one of the largest inundations ever experienced in Central Europe at that time. Many of the high-water marks from that flood still exist and still set the record. The years 1799 (February) and 1845 (March/April) also saw significant flooding, most particularly in Central Germany (GLASER 2001).

Many of these historical high-water marks were exceeded only by the recent flood of August 2002 (*Fig. 1.11-1*). Although there had been past instances of the Rhine's bursting its banks in 1993 (December) and 1995 (January), the Oder's flooding in 1997 (July), and the Danube's in 1999, what the 2002 disaster brought above all was a new awareness of the degree of destruction because of daily detailed coverage in the media, which subsequently brought on a fear of further and even more intense flood damage in the future. An analysis of the Elbe and Oder floods (*Fig. 1.11-2*) shows, however, that no such fear is warranted, even since the beginning of industrialisation. Remarkable is rather the large variability in flood events, particularly in the winter.

Egyptian records thousands of years old annotating the annual flooding of the Nile notwithstanding, there have been few reports available regarding inland flooding from countries outside of Europe. A large number of reports now come out of China, home to the world's greatest population, which has begun to address the problem in official speeches. In recent times, the Yangtze has flooded its banks four times: in 1991, 1994, 1996 and 1998 (July). In 1995 there was a significant inundation in neighbouring North Korea. In the USA, the largest river flood disaster occurred in 1927, when the Mississippi burst its banks. Numerous levees burst, putting about 7 million acres of pastureland and open field under water and drowning approximately 300 people. The extent of property damage was estimated to be $300 million at the time. The most recent occurrence of the Mississippi's flooding was in 1993.

m_boerngen@ifl-leipzig.de

In areas lying near the Equator precipitation and its high-water levels will be steered by the ENSO mechanism (LATIF & ENDLICHER 2001). The strong El Niño event from 1997/98 was followed by La Niña event at the end of 1999/ beginning of 2000. In the Equatorial region of *northern* East Africa there was hardly any precipitation registered, while in *southern* East Africa exactly the opposite conditions prevailed. In February 2000, this anomaly was particularly strong. In tandem with a tropical hurricane came huge inundations with devastating consequences to both life and property, affecting the entire region of southern East Africa.

High mountainous regions are especially vulnerable, as often a heavy rainfall precipitates a premature thawing of ice and snow, which in turn mix rapidly with Earth and rock particles to form sludge (in the alpine countries: »Mure«), which then causes an even deadlier from of destruction. This was recently the case in the Alps in August 2005.

Coastal flooding

Coastal flooding is more often the result of storm tides and tsunamis. These are both calamitous events that arise at very short notice but from very different sources, each depending on its geographical location. Their destructive effect can be strengthened by long-term processes such as coastal sinking or a gradual rising of sea level.

Let us take, for example, the North Sea and Baltic coasts. In these regions, when strong onshore winds blow with great ferocity against the coast, an abnormally high sea level threatens as a result. In tidal seas, the danger is even higher when storm conditions coincide with a spring tide.

From what we know, the earliest record regarding the approach of a storm tide in the North Sea dates from the Second Century B.C. It is said to have caused such total destruction on the Jutland Peninsula that the native tribes of Kimbries (latter-day Cumbrians) and Teutons emigrated.

Table 1.11-1: Largest meteorologic floods from river basins lager than 500,000 square kilometres since 1840 (I Ice Jam; R Rainfall, S Snowsmelt).

River basin	*Country*	*Basin area (10^3 km²)*	*Station*	*Station area (10^3 km²)*	*Peak discharge (m³/s)*	*Date*	*Flood type*
Amazon	Brazil	5,854	Obidos	4,640	370,000	June 1953	R
Nile	Egypt	3,826	Aswan	1,500	13,200	Sept. 25, 1878	R
Congo	Zaire	3,699	Brazzaville B.	3,475	76,900	Dec. 27, 1961	R
Mississippi	USA	3,203	Arkansas City	2,928	70,000	May 1927	R
Amur	Russia	2,903	Komsomolsk	1,730	38,900	Sept. 20, 1959	R
Parana	Argentina	2,661	Corrientes	1,950	43,070	June 5, 1905	R
Yenisey	Russia	2,582	Yeniseysk	1,400	57,400	May 18, 1937	S
Ob-Irtysh	Russia	2,570	Salekhard	2,430	44,800	Aug. 10, 1979	S
Lena	Russia	2,478	Kasur	2,430	189,000	June 8, 1967	S/I
Niger	Niger	2,240	Lokoja	1,080	27,140	Feb. 1, 1970	R
Zambezi	Mozambique	1,989	Tete	940	17,000	May 11, 1905	R
Yangtze	China	1,794	Yichang	1,010	110,000	July 20, 1870	R
Mackenzie	Canada	1,713	Norman Wells	1,570	30,300	May 25, 1975	S
Chari	Chad	1,572	N'Djamena	600	5,160	Nov. 9, 1961	R
Volga	Russia	1,463	Volgograd	1,350	51,900	May 27, 1926	S
St. Lawrence	Canada	1,267	La Salle	960	14,870	May 13, 1943	S
Indus	Pakistan	1,143	Kotri	945	33,280	1976	R/S
Syr Darya	Kazakhstan	1,070	Tyumen'-Aryk	219	2,730	June 30, 1934	R/S
Orinoco	Venezuela	1,039	Puente Angostura	836	98,120	Mar. 6, 1905	R
Murray	Australia	1,032	Morgan	1,000	3,940	Sept. 5, 1956	R
Ganges	Bangladesh	976	Hardings Bridge	950	74,060	Aug. 21, 1973	R/S
Shatt al Arab	Iraq	967	Hit (Euphrates)	264	7,366	May 13, 1969	R/S
Orange	South Africa	944	Buchuberg	343	16,230	1843	R
Huanghe	China	894	Shanxian	688	36,000	Jan. 17, 1905	R
Yukon	USA	852	Pilot Station	831	30,300	May 27, 1991	S
Senegal	Senegal	847	Bakel	218	9,340	Sept. 15, 1906	R
Colorado	USA	808	Yuma	629	7,080	Jan. 22, 1916	R
Rio Grande	USA	805	Roma	431	17,850	1865	R/S
Danube	Romania	788	Orsova	575	15,900	April 17, 1895	S
Mekong	Vietnam	774	Kratie	646	66,700	Sept. 3, 1939	R
Tocantins	Brazil	769	Itupiranga	728	38,780	April 2, 1974	R
Columbia	USA	724	The Dalles	614	35,100	June 6, 1894	S
Darling	Australia	650	Menindee	570	2,840	June 1890	R
Brahmaputra	Bangladesh	650	Bahadurabad	636	81,000	Aug. 6, 1974	R/S
Sao Francisco	Brazil	641	Traipu	623	15,890	April 1, 1960	R
Amu Darya	Kazakhstan	612	Chatly	450	6,900	July 27, 1958	R/S
Dnieper	Ukraine	509	Kiev	328	23,100	May 2, 1931	S

Source: O'CONNOR; COSTA (2004), modified

Historically, the worst storm conditions to have occurred took place on the German coast of the North Sea on 16 January 1362 (the »Second Marcellan Flood«). Altogether, a total 100,000 people lost their lives. The storm tide led to the complete eradication of Rungholt, formerly an important port city and commercial centre situated at the southwestern edge of the North Frisian island of Strand. The great storm tide of 19 October 1634 continued to add to the already catastrophic obliteration. Today, only Pellworm and Nordstrand remain of the original island of Strand.

Other storm tides in history have been the Julian Flood (17 February 1164), the First Marcellan Flood (16 January 1219), the Lucia Flood (14 December 1287), the three All Saints Floods (First of November in the years 1436, 1532 and 1570), the Christmas Flood (24 December 1717), the Heavy Ice Flood (25 February 1718), the Very Heavy Flood (7 October 1756), the February Flood (3/4 February 1825), and more recently the Holland Flood (1 February 1953) and the Storm Flood of Hamburg (16/17 February 1962). Taken altogether, they cost thousands of lives and changed the coastal landscape significantly (see also *Fig. 1.11-3*).

Fig. 1.11-1: A house in Prague near the Charles Bridge shows high-water marks from two past floods. The high-water marks from August 2002 exceeded that from March 1845 by 75 centimetres and the one from February 1784 about 55 centimetres (photo J. Kubát) (Source of picture: ONDRÁCEK et al. 2003, S. 59).

In the 20th century, on 3 January 1976, the hurricane »Capella« – named for a ship sunk during the storm – released one of the heaviest storm tides in Europe. Capella had been raging for two hours when it combined with an incoming tide at the vertex. The water on the west coast of Schleswig-Holstein as far as the Elbe accumulated levels never before attained (e.g. in Hamburg 6.45 m over NN). This calamity was further compounded by the presence of the new moon, ergo, a spring tide.

An example of so-called »low-water flood tides«, when a storm and high tide do not coincide at the same time, is the severe storm tide of 23 February 1967. During the hurricane, gusts of approximately 160 km/h were measured, at that time the highest wind speeds for the North Sea coast (EUSEMANN 1999, SAGER 1972).

We speak also of storm tides even in seas like the Baltic Sea, one with a singularly weak tidal current, where violent winds are capable of driving water levels up on coasts and in bays. The first storm flood on the coast of the Baltic Sea was recorded in the year 1044. Another major one occurred on 10 February 1625 with a high-water mark approximately 2.8 m over mean water in Rostock and Lübeck. Occurring at the same time as a severe cold snap, it killed several people. In 1824, 10,000 people died in St. Petersburg and neighbouring Kronstadt as a result of a storm tide in the Baltic Sea. Again in the following year, 1825, the same region suffered a storm tide similar to the February Flood

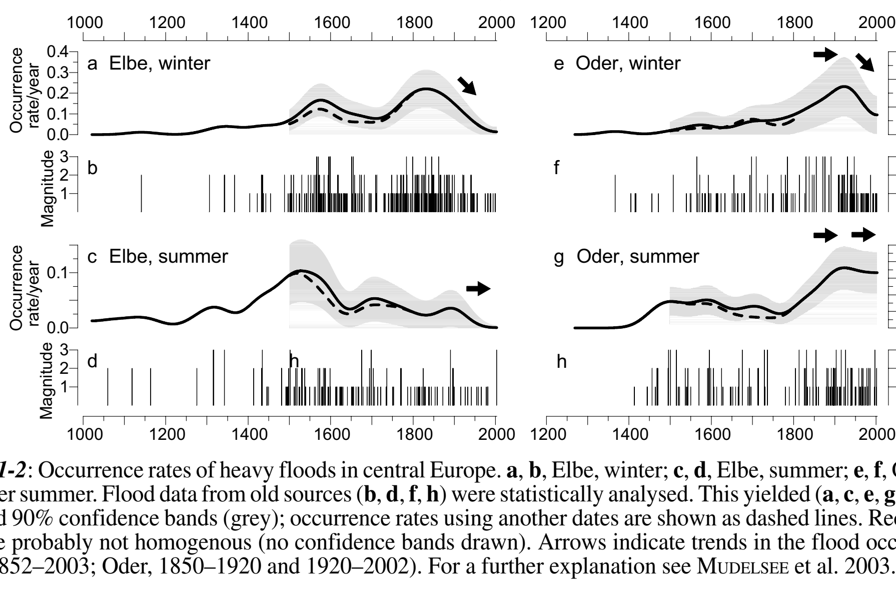

Fig. 1.11-2: Occurrence rates of heavy floods in central Europe. **a**, **b**, Elbe, winter; **c**, **d**, Elbe, summer; **e**, **f**, Oder winter; **g**, **h**, Oder summer. Flood data from old sources (**b**, **d**, **f**, **h**) were statistically analysed. This yielded (**a**, **c**, **e**, **g**) occurrence rates and 90% confidence bands (grey); occurrence rates using another dates are shown as dashed lines. Records before 1500 are probably not homogenous (no confidence bands drawn). Arrows indicate trends in the flood occurrence rate (Elbe, 1852–2003; Oder, 1850–1920 and 1920–2002). For a further explanation see MUDELSEE et al. 2003.

on the North Sea coast. A century later, in 1924 (23 September), a storm tide inundated Leningrad, putting 75% of the city-surface under water. St. Petersburg is particularly vulnerable, as in this area a storm tide forces the Neva River to back up, thereby causing further damage upstream. More recently, storm floods at the German Baltic Sea coast have occurred in the years 1872 (13 November), 1904 (31 December) 1913 (30/31 December), 1954 (4 January) and 1995 (3/4 November) (Neef 1970, Sager 1972).

Tropical hurricanes, which are also called cyclones, typhoons, cordonazos, willie-willies, etc. according to the local region, are low-pressure areas, in a ±2° latitude-belt around the equator, where the water temperature is at least 27 °C. Because of the small Coriolis force, however, they do not form on the Equator itself. The course of a hurricane runs westward, before careening towards the Poles. The range of a tropical hurricane can amount to hundreds of kilometres. The eye of the hurricane is characterised by few clouds, weak wind, and a dry zone of approximately 10 to 50 km diameter. This eye, however, is surrounded by powerful cumulo-nimbus clouds, which within a short period can let forth rainfalls of between 500 and 1,000 mm, roughly the yearly precipitation of Central Europe. Wind velocities of more than 200 km/h increase the potential for further danger. Lastly, waves ranging from as high as a metre or more, backed by fierce winds, ensure total destruction when hitting coastal regions or islands (see New Orleans in September 2005).

Fig 1.11-3: Dorum Neufeld (near Cuxhaven, Germany): Monument to the builders of the dykes erected to protect the North Sea coast against storm tides (photo: Karin Börngen)

To protect extremely vulnerable areas (the American Gulf Coast; Japan) hurricane-warning systems have now been put into place. For early recognition and continuous tracking of tropical hurricanes, observations from weather satellites are also able to furnish crucial information. In 1961 it was thanks to TIROS 1 that the inhabitants on the Gulf Coast could be evacuated before the onslaught of hurricane »Carla« (Anon 1987).

The »Great Hurricane«, which reached the Lesser Antilles in October 1780, marks one of the most significant in history. This storm, which first laid waste to Barbados, sinking some ships, then followed the curve of the island chain, churning up a wall of seawater 7 metres high, which then hit and flooded both Martinique and St. Lucia. Nearly 15,000 inhabitants met their deaths. In September 1938 in the USA, the Northeast experienced a hurricane having a storm tide of 12 metres. Five-hundred people died as a result, and property damage was assessed at $ 400 million. In 1992 (August) hurricane »Andrew«, which caused extensive damage in Florida and Louisiana, and »Mitch«, which raged during autumn of 1998 in broad swaths of Central America and claimed over 25,000 lives, received frequent mention. »Mitch« ruined the infrastructure to a great extent, destroying harvests and rendering agriculture temporarily useless. In Honduras and Nicaragua, material damage exceeded the billion-dollar threshold (Eusemann 1999 Newson 2001, Sager 1972).

The Indian coast on the Bay of Bengal has been hit several times by tropical hurricanes. Devastating cyclones occurred in October 1737, December 1789 and 1864, October 1876, November 1970 and in April 1991. High waves flooded the low-lying area, most specifically the Ganges delta, which resulted in enormous human casualties in the hundreds of thousands and untold devastation to the terrain. Making matters even worse, following the hurricane countless numbers died as a result of epidemics brought on by the total breakdown in the infrastructure and the large numbers of rotting corpses (Newson 2001, Sager 1972).

As mentioned above, tsunamis, or seismic waves, are also responsible for coastal inundations (*Table 1.11-2*). Ever since the disaster in the Indian Ocean on 26 December 2004, which caused 220,000 to 300,000 deaths, this form of natural catastrophe is on everyone's lips. Tsunamis originate from under-water earthquakes that arise from a vertical charge under the ocean floor, generating surface waves in a series of 3 to 7, which then spread concentrically from the epicentre, traversing large bodies of water. The speed of the tsunamis depends on the water's depth: in the Pacific, the speed averages 700 km/h. The height of the wave is small only on the open seas. It increases gradually, however, as the water's depth decreases (tsunami translates as »harbour wave«!), finally bringing a wall of water several metres high as it hits dry land, wreaking unimaginable devastations. What begins as a relatively low wave often increases by drawing the coastal sea in a backwards direction, which causes a huge under-tow. This process in turn not only lays bare the ocean floor in places but also adds to the size and strength of the original wave.

Most tsunami centres lie in the Pacific region. Off the coast of Japan one registered about 250 tsunamis over a period of hundreds of years, costing 100,000 lives. At intervals of about 15 years tsunamis have been recorded having a height of 7.5 metres. Waves of over 30 metres have been recorded four times over the last 1,300 years. One of the worst tsunami disasters occurred in June 1896 on the northern Japanese island of Honshu. An underwater earthquake 300 kilometres off the coast produced seismic waves measuring up to 38 m high, claiming 27,000 lives and injuring 9,000 (EUSEMANN 1999, SAGER 1972).

The Mediterranean Sea has also produced its share of tsunamis and is thought to be responsible for the disappearance of Knossos (ca. 1650 B.C.) and other ancient cities. A tsunami might also have been behind the disaster which took place on 21 July 365 on the Mediterranean coast: »Briefly after daybreak... suddenly... from deep in the Earth's crust, the ground began to tremble and shake, and the sea receded sharply, forming waves which returned and pounded the shore, after which various sea creatures were exposed in the cracks of the ocean floor ... Numerous ships were beached, standing, one next to another. A group of people ran around eagerly in the newly created shallows in order to pick up the sea's bounty with their hands. Suddenly the sea waves rose in reverse, hurtled over the boiling hot sands surrounding the islands, and spread vast distances over the fallow mainland, surrounding the buildings in cities and flattening anything that stood in their way. In an instant …, the incoming flood drowned many thousands of people ... Ships of enormous size were ripped out of the sea by the storm and now sat perched atop houses, as had happened at Alexandria. Some were carried as far as 200 paces inland« (cited in WEIKINN 1958, S. 4).

On the First of November (again on All Saints Day) 1755, Lisbon was devastated by a strong earthquake. It had the strength of 8.5; its epicentre lay just off the south-west coast of Portugal. At 9:30 a.m. three powerful tremors were felt. In addition to the usual destruction in these cases, major fires broke out and seismic waves were released. By 11:00 a.m. the first tsunami reached the city, followed by more waves as high as 12 metres. Approximately 60,000 people met their deaths, perhaps more from drowning than from the earthquake itself.

More than a century later, in 1883 the eruption of Krakatoa caused two-thirds of what formerly had been a large volcanic island measuring 33 square kilometres, lying between Sumatra and Java, to explode into the air, causing the largest tsunami to date. It measured about 30–40 metres high and brought with it indescribable devastation, claiming the lives of more than 36,000 people.

In earlier times, there were certainly more powerful tsunamis. There is evidence that, ca. 65 million years ago, the seismic wave caused by the impact of the »Chixculub meteorite« on the Yucatan Peninsula (Gulf of Mexico), may have had a height of several hundred metres.

A form of seismic waves can also be caused by the break-up of glaciers or large rock outcroppings crashing into the sea. This occurred in 1934 in Norway over the Tja Fjord. An outcropping of rock measuring 1 million cubic metres broke off and fell from a height of 700 metres into the Fjord. The ensuing wave, even at a distance of several kilometres, was 10 metres high and claimed 41 lives (EUSEMANN 1999, NEWSON 2001, SAGER 1972).

Table 1.11-2: Historic Tsunamis (According to different sources).

Date	*Source, Location (Magnitude)*	*Affected area*	*Wave height (metres) (Location)*	*Deaths*
circa 1650 B.C.	Volcano, Santorini Island, Greece	Aegean Islands, Crete, Turkey	6–11 (Crete)	
November 1, 1755	Earthquake, Atlantic Ocean (8.5)	Portugal, Caribbean, Spain, Morocco	5–10 (Lisbon)	60,000
August 27, 1883	Volcano, Krakatao Island	Java, Sumatra, Hawaii, Australia, New Zealand, Sri Lanka, India	30–35 (Java)	36,000
June 15, 1896	Earthquake, Pacific Ocean (8.5)	Sanriku, Japan	23–38 (Sanriku)	27,000
March 2, 1933	Earthquake, Pacific Ocean (8.4)	Sanriku, Japan	20–29 (Sanriku)	3,000
April 1, 1946	Earthquake, Aleutian Islands, Alaska (7.3–7.8)	Alaska, Hawaii, USA, Chile, Polynesia, Japan	35 (Alaska), 10 (Hawaii)	5 (Alaska), 159 (Hawaii)
May 22, 1960	Earthquake, Pacific Ocean (9.5)	Chile, Hawaii, Japan, USA, New Zealand	25 (Chile), 11 (Hawaii)	1,000 (Chile), 61 (Hawaii)
December 12, 1992	Earthquake (7.5)	Indonesia	25 (Flores Island)	1,000
July 12, 1993	Earthquake (7.6)	Japan	30 (Hokkaido)	230
July 17, 1998	Earthquake (7.1)	Papua New Guinea	10	3,000
December 26, 2004	Earthquake, Indian Ocean (9.0)	All continents, particularly in Sumatra, Indonesia	35 (Aceh, Sumatra)	220,000–300,000

Water in solid form (ice, hail, avalanches, glaciers)

Water can also be dangerous to man in its solid form of snow or ice. It can at least cause serious interruption in daily life. This was very much the case during the winter of 1978/79, when also all see-going traffic was halted after the Danish Belts, the Oeresund and other waterways froze over. In North America it is a blizzard which is feared, a violent gale from the north, which develops when Hudson Bay freezes over and there are no orographic obstacles in its path on its way south. This weather condition is manifested by extremely low temperatures accompanied by heavy and frequent snowfalls. In January 1977, a storm of this kind raged for five days in Buffalo, claiming 29 lives; in January 1996 a blizzard hit the Northeast corridor of the USA, claiming 23 lives (EUSEMANN 1999, NEWSON 2001).

Heavy damages to harvests, damages to property, and every now and then personal injuries can be caused by hail. Hail derives from ice crystals formed in thunder-clouds drifting at high altitudes, which then go through a process of alternately thawing slightly when in contact with warmer rain droplets, then refreezing when met by strong up- or down-drafts, gaining in size all the while until they drop of their own weight. Hail can reach considerable size. In the hailstorm of 3 September 1970 in Kansas, USA, one stone measured nearly 15 centimetres in diameter and weighed ca. 750 gram. On 14 April 1986, if one can believe the Guinness Book of Records and similar sources, the heaviest hailstone to date – weighing ca. 1 kg – fell on Bangladesh's Gopalgan district, taking over 90 lives. In 1888, the Indian city of Moradabah was the victim of a hailstorm having stones as big as fists, which killed 346 people.

On 27 August 1860, a freak hailstorm struck Leipzig, Germany. Big hailstones damaged most roofs of the city and broke all the windows on the windward side. Contemporary reports emphasise the devastating consequences the hailstones had on songbirds. A well-known example from recent times is Munich's hailstorm on 12 July 1984. The storm caused tremendous damage to vegetation and property within the space of a few minutes. Hailstones often reached diameters of 5–6 centimetres. Nearly 400 persons were injured. At the time, the insurance payout was the largest in the history of the German Federal Republic, amounting to DM1.5 billion (MÜNCHENER RÜCKVERSICHERUNG 1984).

On 23 February 1999, in the Tyrolean quarter of Galtür (Austria), after avalanches rained down killing 31 people and destroying a few houses, attention is finally being paid to the danger avalanches pose in mountainous regions. Avalanches, which on mountain slopes erupt suddenly and with little warning, are not necessarily an event of modern times: Hannibal, in the year 218 B.C., is said to have lost numerous soldiers, horses and elephants to avalanches while attempting to cross the Alps. An average of 80 people die from them every year. In January 1954, 125 people in the Austrian Vorarlberg area died; in 1970, 143 people lost their lives in the alpine French and Swiss regions. The heaviest avalanche toll in Germany was when 10 died in 1965 on the Zugspitze. One can assume that heavy tree-clearing on the slopes to make way for ski runs, not to mention the increasing popularity in the sport in general are two factors that are exacerbating an already precarious natural condition (EUSEMANN 1999).

Various disasters noted already in the discussion of tsunamis can be attributed to the break-up or melting of glaciers. In a direct sense, these disasters can take the form of a large chunk of a glacier breaking off, as happened in the Bernese region of Switzerland with the Altels Glacier on 11 September 1895, when 4 million cubic metres of ice and debris were set in motion. However, there are other ways in which glacial breakdown can be more insidious, as when advancing glaciers can blockade rivers to form glacial lakes, which then sooner or later burst their banks. The Bernese Aletsch Glacier dammed up the Maerjelen Lake in this manner, which held 8 millions cubic metres, until the lake suddenly emptied in 1878. A melting glacier also caused a lake in Peru to burst its banks, causing 5,000 deaths. In volcanic areas long frozen over, the eruption of the volcano can cause a sudden melting of glaciers, known as a »glacier run«. This happened, for example, in 1934 at the Skeidarar Joekull on the island of Iceland (ANON. 1987, EUSEMANN 1999, NEEF 1970).

In Colombia (South America) the Nevado volcano erupted on 13 November 1985. The melted ice mixed with ash and rock particles to form a river of sludge (»Lahar«), which buried the city of Armero and killed 20,000 inhabitants.

Concluding remarks

The examples listed above cover some of the more spectacular water disasters of the past. The increasing amount of information added to the increasing degree of destruction leads one to believe too easily that the number of the disasters is multiplying with increasing frequency, all as a result of human activity. However, thorough scientific analyses do not reinforce this supposition. Nevertheless, one can try to preserve certain climatic conditions. The emission of greenhouse gases must be dealt with, a there is little doubt that they contribute finally to sea levels' rising. As 15% of the Earth's population live in coastal areas, a further water catastrophe is foreordained, especially if the rise of sea levels is a rapid one.

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