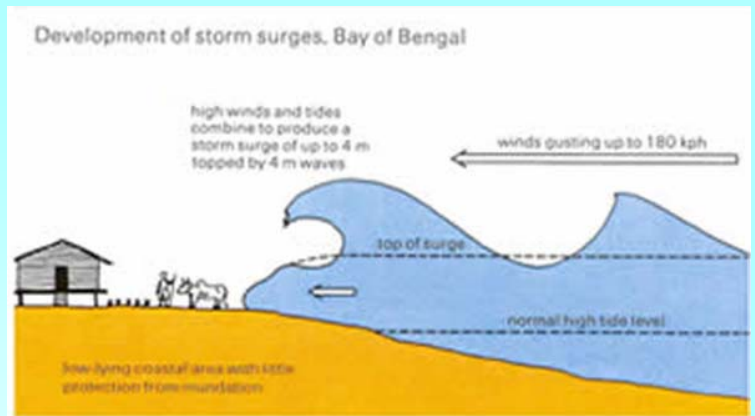


Flooding hazards

Flooding may result from a large amount of rain or from rapid thawing of snow and in coastal regions may also be caused by a storm surge or a combination of high tide and high river level. The consequences of flooding are often disastrous but there can also be beneficial effects of flooding.

Storm surges

Storm surges are mainly caused by the effect of the wind on the sea, not changes in atmospheric pressure. The effect of wind on the sea surface is known as wind stress. The wind stress on the surface of the sea causes the water level on a coast to rise if the net transport of water is towards land and to fall if it is away from land.



Many coasts are at risk from storm surges and these include the Atlantic side of the United States, the Bay of Bengal area around India, Thailand and Indonesia, the coastal areas of the Netherlands and eastern England coastline. At the head of the Bay of Bengal large storm surges (up to 4m in height) are initiated by hurricane force winds coupled with low pressure tropical cyclone systems. Fortunately for the UK surges large enough to bring about catastrophic flooding of these North Sea coasts are experienced only a few times each century, and improved sea defences should stop all but the most extreme surges. On the Indian sub-continent, especially near the mouths of the River Ganges, death tolls from storm surges caused by tropical cyclones have been huge. In 1970, for example, more than 200,000 died when such a surge struck the area. Here, as in other places where storm surges occur, the same strong winds that create the surges also create large waves. These waves increase the storm surge problem by damaging coastal defences.

Examples of storm surges in the UK and their effects

Flooding of the Thames on 6th -7th January 1928 highlighted the need to find ways of forecasting storm surges. However, the real push to investigate storm-surges was on 31st January and 1st February 1953, when, a surge exceeding 2.7 metres at Southend in Essex and 3.5 metres in parts of Holland killed 307 people died in eastern England and 1,800 in the Netherlands. The storm that caused the 1953 surge was among the worst to hit the UK in the 20th century. Before the storm's low pressure and storm-force northerly winds



raised water levels in the southern North Sea, hurricane-force winds blew down more trees in Scotland than were normally felled in a year; and a car ferry, the Princess Victoria, on passage from Stranraer in Scotland to Larne in

Northern Ireland, sank with the loss of 133 lives. Only 41 of the passengers and crew survived. Nowadays, surges are forecast with considerable accuracy and storm-surge barriers are in place in the most vulnerable places in the Low Countries and eastern England, one of them on the Thames a (south of Greenwich).



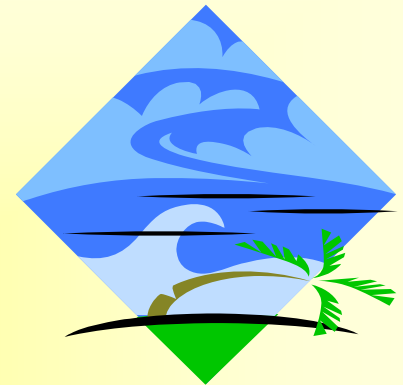
The effects of pressure on sea level

When pressure falls by one millibar, sea level rises by one centimetre. Thus, a deep depression can cause sea level to rise 60 or 70cm above the level predicted purely on the basis of tidal theory. The pressure-induced rise in sea level caused by a tropical cyclone can be much greater, maybe a metre or more.



Flash flooding

One of the most energetic and destructive of all weather systems are tropical cyclones. The hurricane-force winds can reach 50m/s and torrential rain falls from their towering cumulonimbus clouds. The winds can cause disastrous surges on coasts and the downpours of rain can cause serious flooding. Power and water supplies are disrupted, buildings are damaged, crops are destroyed, people and livestock are drowned, bridges collapse, roads and railways are undermined or blocked by debris, and beaches are scoured. Tropical cyclones nearly always leave behind a trail of destruction and misery.



Flash floods are exceedingly dangerous. When water cannot percolate into the ground, it runs off the surface as it would from impermeable concrete. This is particularly so when the ground is very wet or when baked hard after a hot dry spell. Potholers can be especially at risk, such as on 24 June 1967, when five drowned in Yorkshire. The water which fell in a heavy thunderstorm after a spell of dry weather ran off rapidly into underground streams and caverns at Mossdale. The rise in water levels below ground was too rapid for the potholers to scramble to safety.



Flash flooding examples in the UK

The storm that occurred over Exmoor on 15 August 1952 left behind it a trail of destruction and misery. Torrents of water and debris in the East and West Lyn rivers destroyed bridges. Boulders and trees created temporary dams that suddenly gave way, with catastrophic consequences. Approximately 200,000 tonnes of huge boulders were swept into the holiday resort of Lynmouth. The human death toll was 34 and almost 400 people were left homeless. Twenty-eight bridges were destroyed and 93 houses ruined or damaged so badly that they had to be demolished later; 28 cars were wrecked and another 38 disappeared out to sea. A gauge on Exmoor recorded 228mm of rain in 12 hours, and this fell on ground already sodden after weeks of wet weather. The culprit was an almost-stationary cumulonimbus system.



The hills of Somerset and Devon do appear to be storm-prone. Even greater falls of rain than that recorded in the Lynmouth storm have been measured in Somerset. Cannington recorded 238 mm in 24 hours on 18 August 1924 and Bruton recorded 243 mm in the same period on 28 June 1917. More recently, on 10 July 1968, a storm deposited 125mm of rain on parts of Somerset and Devon in 90 minutes, and several people in Sidmouth drowned.

Flash flooding has occurred in other parts of the United Kingdom, too. At Louth, Lincolnshire, on 29 May 1920, for example, an estimated 8 million tonnes of water poured through the town after a cumulonimbus system deposited 120mm of rain on the nearby Lincolnshire Wolds. Again, temporary dams formed and suddenly gave way, turning the River Lud into a raging torrent. All six bridges in the town were destroyed, the fire station was demolished, fifty houses collapsed, another 700 houses were damaged, nearly 1,000 people were made homeless, and twenty people died.

At Hampstead, London, on 14 August 1975, 170 mm of rain fell in approximately 2½ hours. This is believed to have been the highest point rainfall in the last 100 years. Drains were unable to cope with the volume of water, basements and subways filled with water, cars floated along streets and dozens of families had to be rescued from their badly-damaged homes. Mercifully, there were few fatalities. One man drowned and two people were struck by lightning.

Even more mercifully, no-one died when the Cornish village of Boscastle was devastated by flash flooding on 16 August 2004. On this occasion, thunderstorms deposited more than 200 mm of rain on the rocky catchment east of Boscastle in four hours.

Floods resulting from persistently wet weather and thawing of snow

case studies

In terms of water flow, the Mississippi is the sixth largest river in the world. Its annual average flow rate is 14,000 cubic metres per second and it discharges into the Gulf of Mexico 580 cubic kilometres of fresh water per year. The greatest flows occur in the period March to May and the least in the period August to October. A large proportion of the United States is drained by this river.



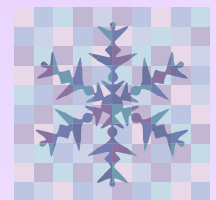
To protect against flooding, which would otherwise occur frequently, the Mississippi River is constrained by levees (embankments) all the way from the State of Missouri to the sea. This barrier, much of it concrete, has isolated the river from a lot of the surrounding countryside, but without it and other means of dealing with excess water in the river, low-lying cities such as New Orleans could not exist.

Tragically, some of the levees around New Orleans were breached on 29 August 2005 when they failed to withstand the battering imposed by the waves and a storm surge generated by Hurricane Katrina. Flood depths reached six metres in places and more than 1,000 people died.

Despite levees, spillways, reservoirs, pumping stations and other constructions, flooding does still occur. The flood-control system proved incapable of containing the flood of 1973, for example, and again proved inadequate in the summer of 1993, when abnormally high rainfall over central parts of the United States caused extensive flooding of the upper and middle Mississippi and lower Missouri rivers. The city of St Louis was particularly badly affected. Discharges of water from the Mississippi into the Gulf of Mexico in the late summer of 1993 were abnormally high. A study using satellite imagery showed that water from the Mississippi spread out far and wide off the States of Louisiana, Texas and Alabama. Indeed, some of the Mississippi water passed through the Florida Strait into the Atlantic.

There was rain, more rain and even more rain in northern California soon after Christmas 1996. From 29 December 1996 to 4 January 1997, depression after depression from the central Pacific brought rain to northern California. As the air was unusually warm, a consequence of the precipitation was that large amounts of snow melted. During the week of the storms, 61 cm of rain was recorded. Significant flooding occurred in northern California and southern Oregon and 43 counties were declared disaster areas. Flooding occurred rapidly because soils became saturated and amounts of snowmelt were large. Flood-control reservoirs could not cope, as their storage capacity was no more than moderate because of near-normal rainfall and run-off prior to the onset of the severe weather. Levee failure occurred on several rivers.

After the United Kingdom's snowy winter of 1947 came the thaw. In many parts of the British Isles in February and early March 1947, deep drifts of snow, some five metres or more deep, caused villages and hamlets to be cut off for days on end. Then, on 10 March, warm air and rain edged into south-west England and advanced across the British Isles. By



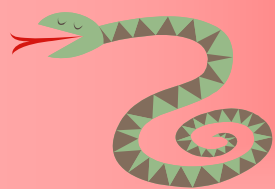
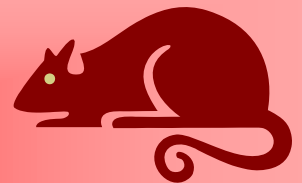
13 March, floods were widespread. Vast areas of Fenland, the Severn Valley and other parts of Britain were submerged. At Selby, Yorkshire, three-quarters of all the houses were under water. A severe south-westerly gale on 16 March drove water ahead and caused dykes in the Fens of eastern England to burst. Warm air and rain are much more effective at thawing large quantities of snow than sunshine. The albedo of old snow (proportion of light reflected) is about 55%. The albedo of fresh snow is about 80%.

On 9 and 10 April 1998, just before Easter, prolonged heavy rain fell over a wide area of Wales and central England. In the Midlands of England, there was serious flooding, with Northampton and Leamington Spa badly affected. In these Easter Floods, as they have come to be known, 4,500 homes were inundated, five people died and the estimated cost of the damage exceeded £350 million. The culprit was a slow-moving depression centred over Brittany. North of it, lying east-west across the Midlands, there were two parallel fronts which were almost stationary, producing prolonged heavy rain that fell on a catchment that was already saturated.

In coastal regions, flooding may be caused not only by a storm surge but also by a combination of high tide and high river level. An example of the latter occurred in South Wales in 1979. On 26 and 27 December of that year, falls of rain exceeded 100mm in many places, especially over the hills. Extensive flooding occurred on the 28th. Cardiff was badly hit when the River Taff in spate met a high tide from the Bristol Channel. Hundreds of homes and offices near the city centre were inundated. Flooding with sea water is bad enough, not least because the salt in the water is left behind when the water evaporates, but the flooding in Cardiff on this occasion was particularly unpleasant, as the water welled up into streets and houses through the sewers.

Health risks after flooding

In many parts of the world, there are serious health risks after disastrous flooding. Mosquitoes, flies and other insects may become more abundant than usual, as the filth, debris and stagnant water left by the floods provide suitable breeding conditions. Consequences may include out-breaks of typhoid, dysentery and encephalitis.



Rats and mice displaced from their natural habitats may find conditions to their liking in houses, sheds, barns and other buildings. In some parts of the world, snakes also become a problem after flooding, as they, too, are displaced from their natural homes by the water. Quite often, they appear inside houses. However, snakes can be beneficial, as they help to reduce populations of rodents.

Beneficial Effects of Flooding

Some of the most fertile land in the world lies beside rivers, the Nile valley being the classic example. For thousands of years, the people of Egypt have relied upon the waters of the Nile to overflow their banks every year, carrying with them fertile silt that makes agriculture possible. The flow of this river is nowadays controlled by means of the Aswan High Dam, an operation that can have its advantages and disadvantages. Salinity levels in the Nile Delta have increased, for example, because the outflow of fresh water from the river is much less now than before the High Dam existed. On the other hand, availability of water from the lake behind the dam, Lake Nasser, has allowed water levels downstream to be maintained in drought years, thus benefiting agriculture when in olden times crop failure and famine might have occurred.



The Ganges Delta is another place where flooding brings benefits for agriculture. Here, every June to October, the waters of the Ganges, Brahmaputra and other rivers overflow and inundate the countryside. There is, however, no equivalent of the Aswan High Dam to control the waters of the Ganges Delta. Sometimes, crops are destroyed, hamlets ruined and humans and animals drowned.



In some arid regions (e.g. Namibia and central Australia), floods occur very occasionally. When they do, glorious displays of flowers follow. In these areas, seeds can lie dormant for many years and germinate (grow) very rapidly when the rains come.



The heavy rains brought by tropical cyclones can help revive crops and replenish water supplies. Sometimes, fruit trees have flowered and borne fruit a second time after the passage of a cyclone. Sometimes, floods have flushed away mosquito breeding areas. There is a danger, however, that residual pools of water will, in turn, become mosquito breeding areas.