STORM IN THE STREAM

Educational Guide about FLOODS and THUNDERSTORMS

Floods and **storms** are phenomena related with meteorology that cause material losses and human injury or death each year, so it is best to know about them and how to be forewarned about them. We hope that the information you find in this booklet will be very useful to you, particularly in dangerous situations.

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THE ATMOSPHERE AND HOW TO OBSERVE IT

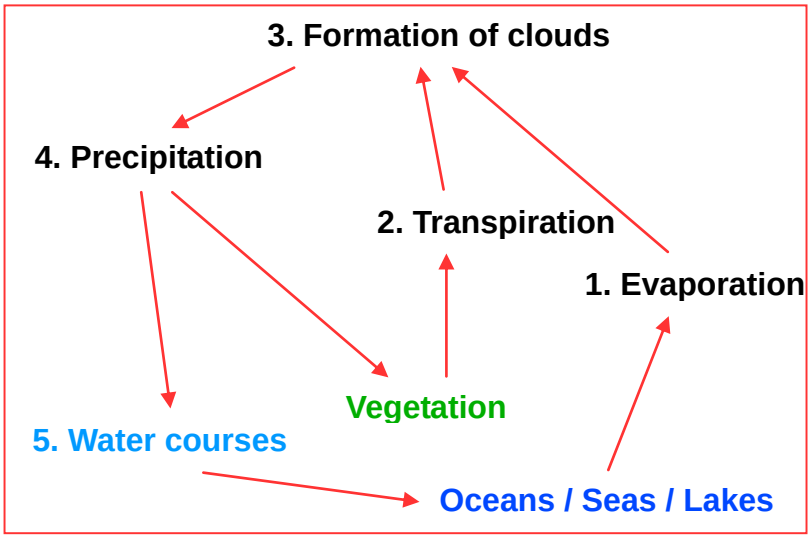
THE ATMOSPHERE AND HOW TO OBSERVE IT

1. THE GIFT OF CLOUDS

The atmosphere is host to meteorological phenomena such as wind, rain, hail or snow, rainbow, halos, thunder, fog, etc.

Although its edges are considered to lie at an altitude of 10,000 km, it is the very first of the layers of the atmosphere where the main meteorological phenomena are produced. This layer, called the troposphere, is some 10-13 kilometres thick, and is where the clouds form that can cause rain, storms, lightning, floods and so forth. The cloud formation is part of the water cycle. So, how does the process work?

THE WATER CYCLE



1. Evaporation: process by which water passes from liquid to gaseous state thanks to the heat of the sun. Water in gaseous form (water vapour) forms part of the atmosphere and comes mainly from seas, lakes, rivers, etc.

2. Transpiration: The vegetation absorbs water from the soil through its roots. The water then goes up to the leaves, where photosynthesis takes place. This process involves a loss of water through the leaves in the form of vapour. This vapour becomes part of the atmosphere in amounts proportional to the vegetation cover. Evapotranspiration is the sum total of transpiration and evaporation combined.

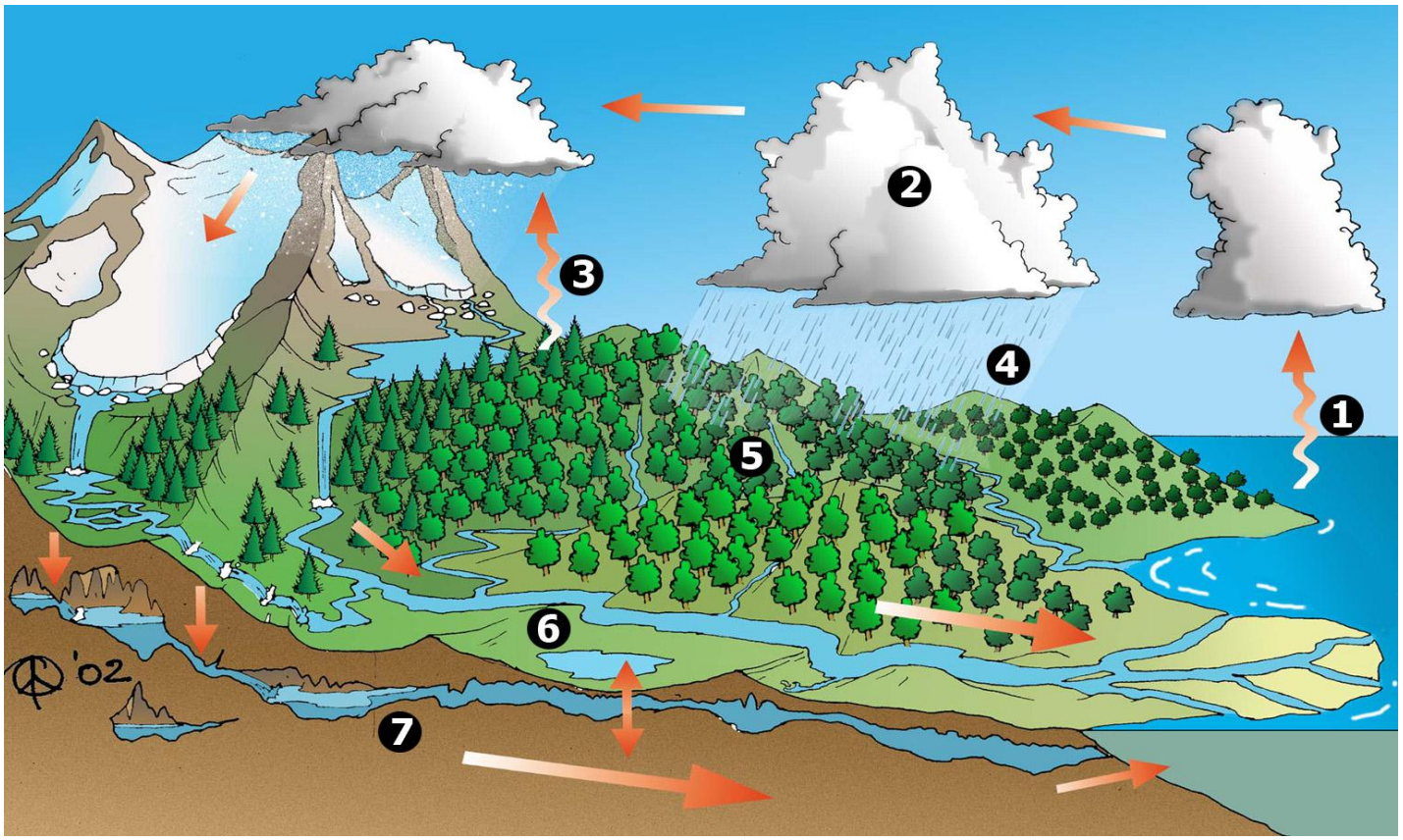
3. Formation of clouds: Clouds are groups of tiny drops of water or crystals of ice which, because they are so small (0.01 mm), are held up by and float in the air. When the water vapour in the atmosphere cools as it ascends it passes from the gaseous to the liquid state. This process, called **condensation**, is what forms the clouds. Sometimes the air can rise at high speed within the cloud (over 10 m/s), carrying the little drops and crystals with it and forming very thick clouds.

4. Precipitation: The tiny water drops or ice crystals suspended in the cloud (measuring up to 1000 drops/ cm^3) may combine and become heavy enough to fall. Then, depending on the temperature inside the cloud and at ground level, the precipitation will be as water or snow. Cumulonimbus (thick clouds that extends from the lower troposphere until 8000 meters or more) can also produce hail.

5. Water courses: Water precipitated onto the ground travels under the force of gravity towards lower levels. This process can take place directly on the ground (**runoff**), in water courses (rivers) or underground (subterranean courses and **aquifers**). The entire land surface that drains water towards a river is known as a **river basin**. Most of this water emerges into seas and oceans, though some evaporates, some is absorbed by living beings and some remains trapped underground.

Based on the text, label the numbers on the diagram as follows:

EVAPORATION	TRANSPIRATION	CLOUDS
RAIN	RUNOFF	RIVER COURSE
AQUIFER		



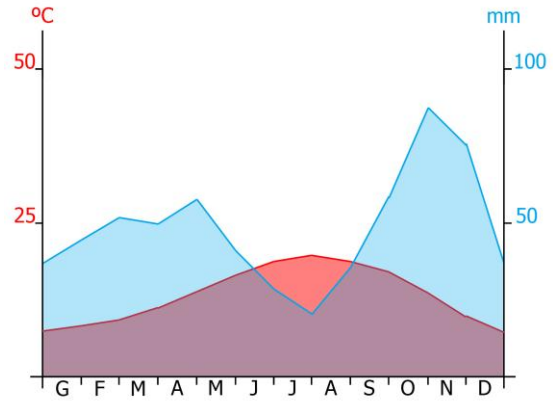
THE MEDITERRANEAN CLIMATE

Climate is the overall set of atmospheric conditions that characterize a region. It is important to distinguish between the climate of a region and the weather on a specific day (a wet climate does have warm and dry days, too).

The Mediterranean climate is characterized by a hot and dry season in summer and winters with mild temperatures. This is the climate typical of the lands close to the Mediterranean Sea, although it is not exclusive to this zone, for Mediterranean climates can be found in Africa, North and South America and Australia.

FEATURES OF THE MEDITERRANEAN CLIMATE:

- Warm, dry summers
- Mild, moist winters
- Irregular rainfall, with dry periods
- Short but intense periods of rainfall
- Mean annual temperatures between 15-20 ºC
- Mean annual rainfall between 300 and 800 mm

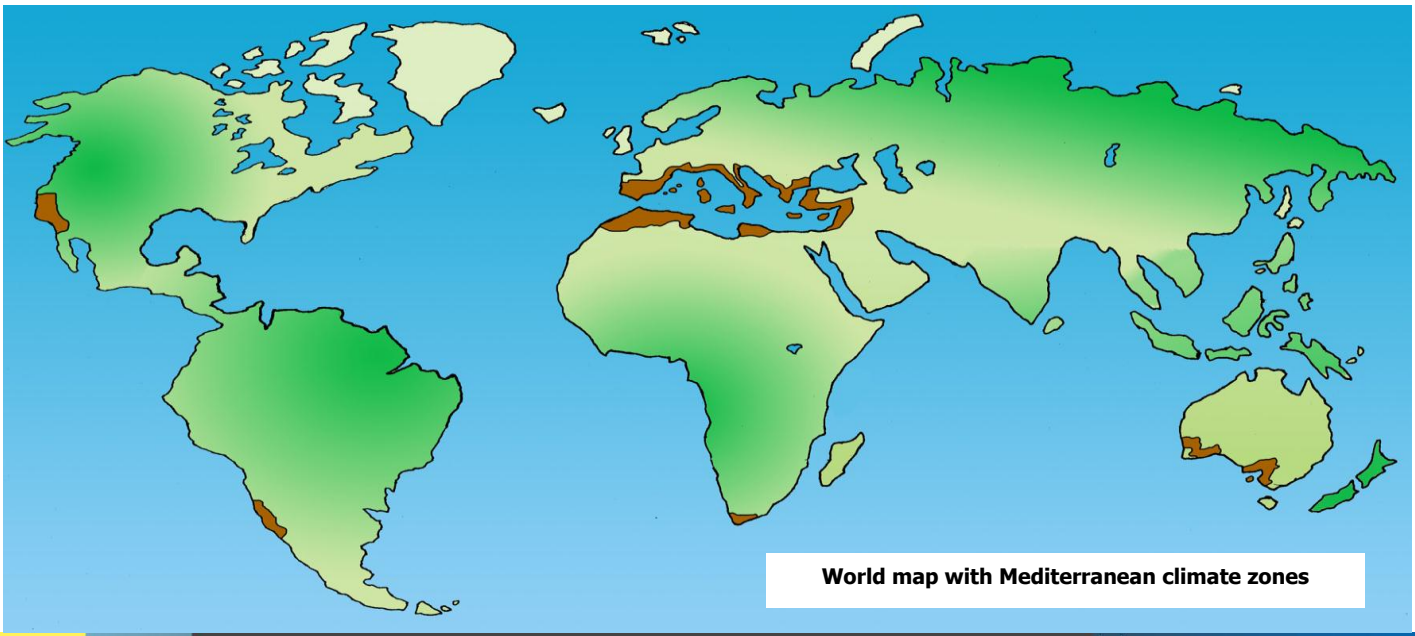


Climograph of Barcelona

We should note the **pluviometric irregularity** of the Mediterranean climate. For example, the mean annual precipitation of Paris (moist Atlantic climate) and Barcelona (Mediterranean climate) is around 600 mm in both cases. In Barcelona, however, this annual precipitation is distributed irregularly throughout the year and even from one year to the next, while in Paris it is uniformly distributed.

These cities are in Mediterranean climate zones. Can you place them on the map?

1. Adelaide (Australia)
2. Barcelona (Spain)
3. Cape Town (South Africa)
4. Jerusalem (Israel)
5. Marrakesh (Morocco)
6. Perth (Australia)
7. San Diego (USA)
8. Santiago (Xile)



World map with Mediterranean climate zones

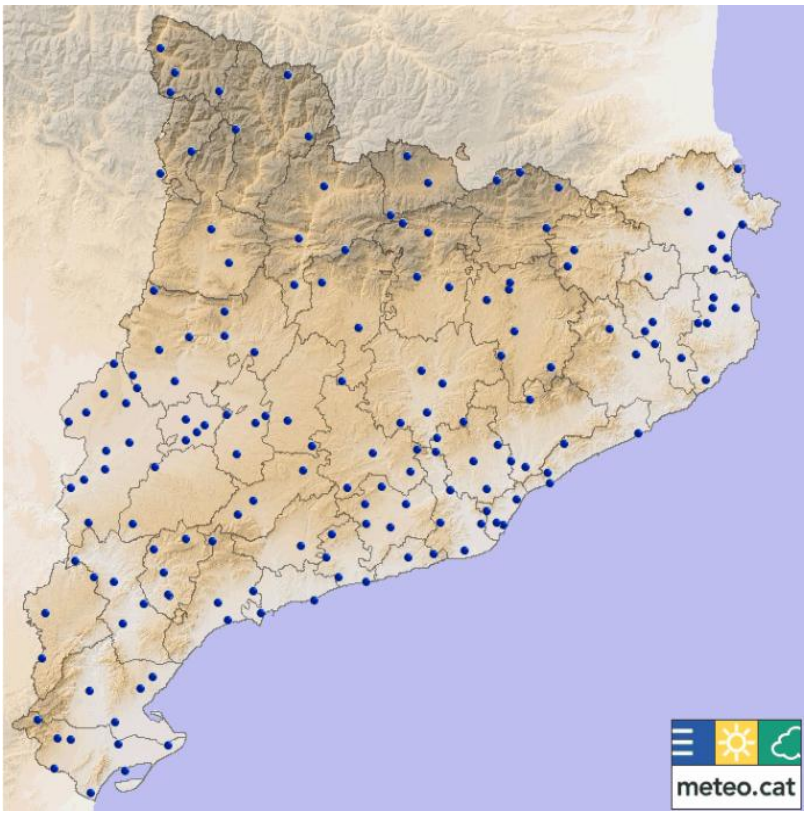
2. OBSERVING THE ATMOSPHERE

Knowledge of climate has been of fundamental importance for the historical development of human societies. Even nowadays, its connection with many outdoor activities leads today's society to find it a matter of great interest, and one that can prevent significant human and material losses.

Various instruments are now used to gather metrological data to find out about climate and to forecast weather. The data gathered by such instruments is interpreted and processed as a whole.

The automatic weather stations have sophisticated sensors that can record meteorological variables that will be automatically archived and sent to the computers where they will be reviewed and processed.

Weather station. Note the two anenometers set at different heights, the shelter housing the thermometer. (Sant Pau de Segúries, Spain). Photo: CEA Alt Ter – www.alt-ter.org



Map of automatic weather stations of the Meteorological Service of Catalonia (SMC). Source: SMC.

WEATHER STATION

Weather stations collect the various meteorological variables using different appliances for each. Many of them are automatic and gather data without human intervention, while others are manual. The instruments usually to be found at a station are:

Thermometer: Measures the temperature of the air. In order to make a correct measurement, the thermometer is placed in a raised shelter that allows air to pass through it but not sunlight.

Barometer: Records changes of atmospheric pressure, i.e. the weight of air on the ground.

Rain Gauge: A receptacle in which the rain from water or snow accumulates. In places with temperatures lower than 0ºC these appliances have heating elements to melt the snow. It allows the precipitation that has fallen to be measured.

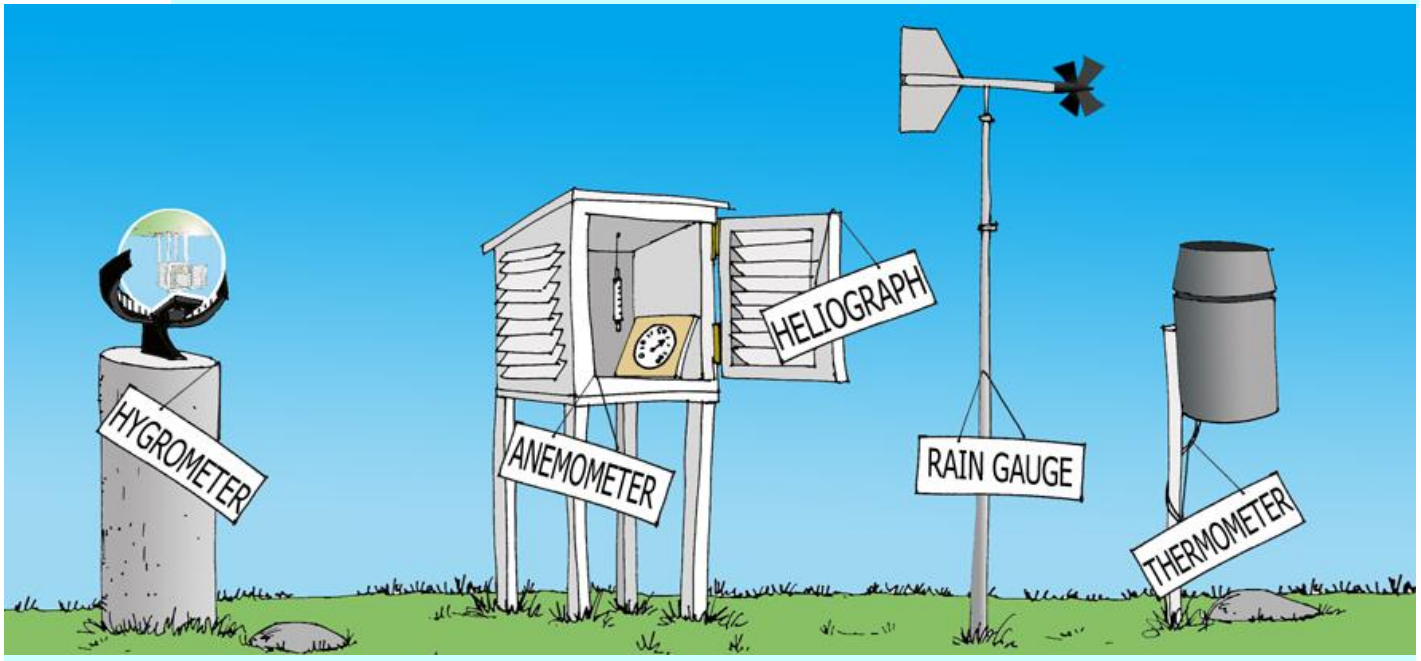
Hygrometer: Measures the relative humidity of the air (amount of water vapour in the air).

Heliograph: Glass sphere that concentrates the sun's rays burnig a piece of graph-paper. It measures the sunlight, i.e. the number of hours of sunlight and its intensity as shown by the burnt line.

Anemometer: Small *propeller* that rotates with the force of the wind. Allows wind speed to be measured.

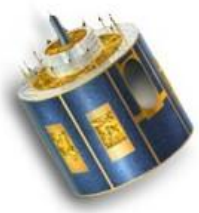
After a spell of strong winds, the signs at the station have become jumbled up.

Can you rearrange them correctly?



METEOROLOGICAL SATELLITE

Orbiting around the planet are artificial satellites that allow different kinds of atmospheric data to be gathered, such as cloud temperature, distribution and thickness. They also permit observation of snow-covered surfaces, sandstorms, contamination, forest fires, volcanic ash clouds, etc.



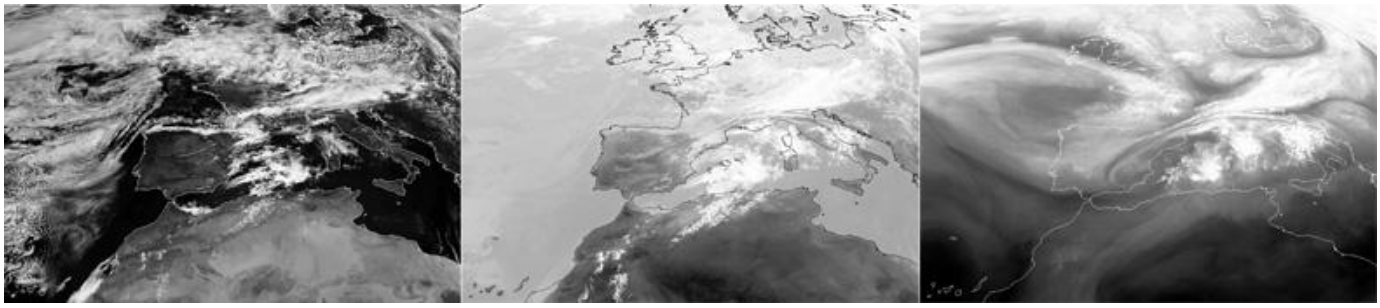
Meteosat satellite
(Source: ESA)

The meteorological satellites can be classified according to their orbit and movements. The **polar-orbiting**, such as the NOAA or LANDSAT, are at 1,000 km altitude and periodically go past the same point at the same hour.

The **geostationary** satellites (or geosynchronous satellites) such as METEOSAT or communications (i.e. TV), always stay above the same area on theearth's surface and move at the same speed as the earth at 36,000 km altitude. The main objective is the observation of meteorological events such as snow coverage, water steam contents in the atmosphere, etc.

Meteosat orbits over the Mediterranean zone, collecting images in different channels (different wavelengths) such as visible, infrared and water vapour. The latter allows the amount of water vapour in a mass of air to be determined. The infrared channel can distinguish between snow, ice and clouds.

IMAGES FROM SATELLITES



From left to right, images from the visible channels, infrared and water vapor (© EUMETSAT, 12:00h of 17/07/2008)

The **visible channel** shows the same we would be seeing if we were looking down from above because they capture reflected solar radiation. The images will be brighter if there's more water content than ice and of its thickness

The infrared channel can detect temperature. A cold body will be very bright while a warm body will be darker. It allows to differentiate between temperatures and cloud altitudes among others.

The **water vapor channel** estimates the content of water vapor. The more water vapor the brighter it will appear.

THE RADIOSONDE

The troposphere, which contains most meteorological phenomena, is 10-13 kilometres high. The atmospheric conditions of the upper part of the troposphere influence those in the lower part.

The meteorological conditions high in the troposphere are studied by releasing balloons that rise to heights of some 10 kilometres; hanging from them are instruments able to measure and transmit meteorological variables. Tracking is done through GPS, and from its trajectory, velocity and wind direction can be obtained.

From the data provided by the weather balloon, we can analyse the vertical profile of the temperature, humidity and wind around the area it was released. Its data is important for the meteorological models.

WEATHER BALLOON
Weather balloon with radiosonde of SMC released from Faculty of Physics, in Barcelona. (Source: M.C. Llasat)

METEOROLOGICAL RADAR

Radar is an appliance that emits and receives electromagnetic wave impulses. These waves bounce off the objects in their path. These echoes are proportional to the density and size of the objects they bounce off, and are measured by the radar itself. These waves also bounce off raindrops, and can be therefore be used to measure the intensity of precipitation within the zone encompassed by the radar.

LIGHTNING MAP

Atmospheric electrical discharges (lightning) emit various forms of radiation: light, sound and radio. A kind of radio-wave receiver allows detection of the lightning formed in storms, whether it be within the clouds themselves or lightning that discharges down to the ground. This allows thunderstorms to be tracked from the instant they form.

METEOROLOGICAL RADAR
Map of the Iberian Peninsula and surrounding area with bands of precipitation detected by the meteorological radar network (16 July 2008) (AEMET)

3. PREDICTING THE FUTURE

Weather forecasts give some idea of what the weather will be like in the near future. The methods used nowadays are based on mathematical equations calculated using powerful computers: **meteorological models.** Until such models came into existence, however, it was necessary to use methods based on observation of the changes in nature as against atmospheric changes (useful locally and in the short term): the **traditional methods**.

TRADITIONAL METEOROLOGICAL METHODS

The **clouds**: the shape, location and appearance of the clouds. Large, billowing dark clouds often produce rain, thunderstorms and even hail.
The **wind**: according to where it is blowing from and the way it veers. In some coastal zones, the onshore wind (from sea to land) is loaded with moisture and creates the conditions for clouds to form and release rain.
Swallows: low-level flying by these birds is usually associated with imminent rainfall.
Migrations: an early migration of birds towards the south is associated with a short summer, while an early arrival is associated with mild weather. Moreover, during cold winters the birds typical of northerly zones reach the Mediterranean in larger numbers than usual, fleeing from the cold. This behaviour pattern has sometimes even lent its name to certain species, such as the lapwing (*Vanelus vanellus*), known in some languages as the "cold-bird".
The dried flowers of the **carlina** (*Carlina acanthifolia*) react to moisture by closing (associated with rain). This and other mythological reasons led to them being placed in house doorways.
Aches and pains: When the weather changes some people feel aches from old bone fractures and other injuries of the musculo-skeletal system. Such aches and pains are associated with changes of atmospheric pressure.
Sayings: the popular memory is a storehouse of information regarding meteorological phenomena, with sayings such as "*One swallow does not make a summer*".

To judge by the signs shown in the picture ...
What do you think the weather will be like?

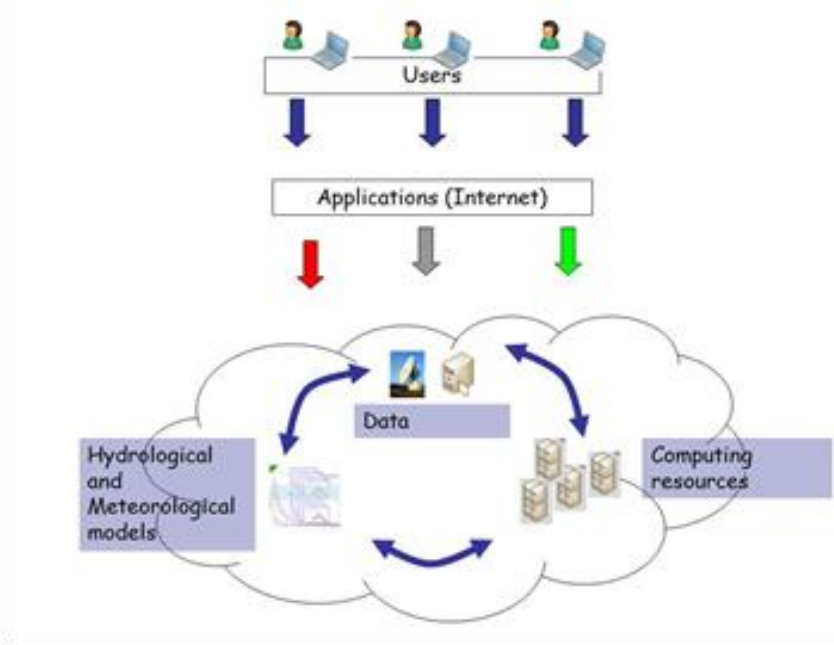
CURRENT METEOROLOGICAL AND HYDROLOGICAL MODELS

In order to predict the atmospheric weather of the following days, the actual data provided by the systems that collect meteorological data (stations, satellites, weather balloons, etc.) is used. This data is entered into a software that simulates the atmospheric behaviour. They are numerical forecast models and they work with huge amounts of variables. Therefore the use of a high-power computers is required.

An hydrological model describes, through mathematical models consisting of a lot of mathematical equations, the fundamental processes that could take place at a catchment area. These models are mainly used to convert rainfall into flow data, and they can be executed at real time (so, for example, to give an early warning).

Researchers from different countries are continuously working together so as to improve these models. One of the biggest challenges is have easy access to hydrometeorological data and models, and facilitate the collaboration between meteorologists, hydrologists, and Earth science experts. So, with the aim to develop a prototype e-Science environment to facilitate this collaboration, a few research projects like the European DRIHM, are currently trying to develop ICT environments (Information Communication Technology) and networks (Grid) that simplify the transmission of knowledge and research.

DRIHM is a project from the EU (FP7) that consists on the creation of an interactive technological platform with the objective of improving hydro-meteorological knowledge and forecast. Mainly targeted at students, scientist, and professionals, it allows the combination of different meteorological and hydrological models. In the figure a simplified diagram of this e-environment can be seen.



From one computer, the user can access to applications that are already connected to the network. These applications will allow the user to execute hydrological and meteorological models so they can obtain data on the rainfall and its flow.

Source: Own production from DRIHM (www.drihm.eu)

EXTREME PHENOMENA AND HAZARDS

EXTREME PHENOMENA AND HAZARDS

4. THE RIVER OVERFLOWS: Floods

FLUVIAL DYNAMICS

The nature of the precipitations involves irregular dynamics in the Mediterranean rivers. Some of these rivers have no water (or very little water) in their **beds** (terrain through which the river waters run. Riverbed) for much of the year, particularly during the summer dry periods. An intense period of rainfall, however, can lead to such water courses filling with a great deal of water in very little time. This leads to very sharp variations in **flow** (the amount of water that flows or emerges over a certain period).

The main **danger** of this irregularity lies in forgetting that the beds will sooner or later fill up again with raging water that can carry before it all in its path (people, cars or buildings).

FLOODS

Floods occur when water occupies zones or regions where there is normally no water. This is due to an unusual and more or less sudden surge of an amount of water greater than the basin is able to drain away.

Floods happen in terrain where this is a recurrent phenomenon. Despite this recurrence, floods cause losses that can be **prevented** by weather forecasting and good town planning. In order to understand where flooding occurs, we must distinguish between certain concepts:

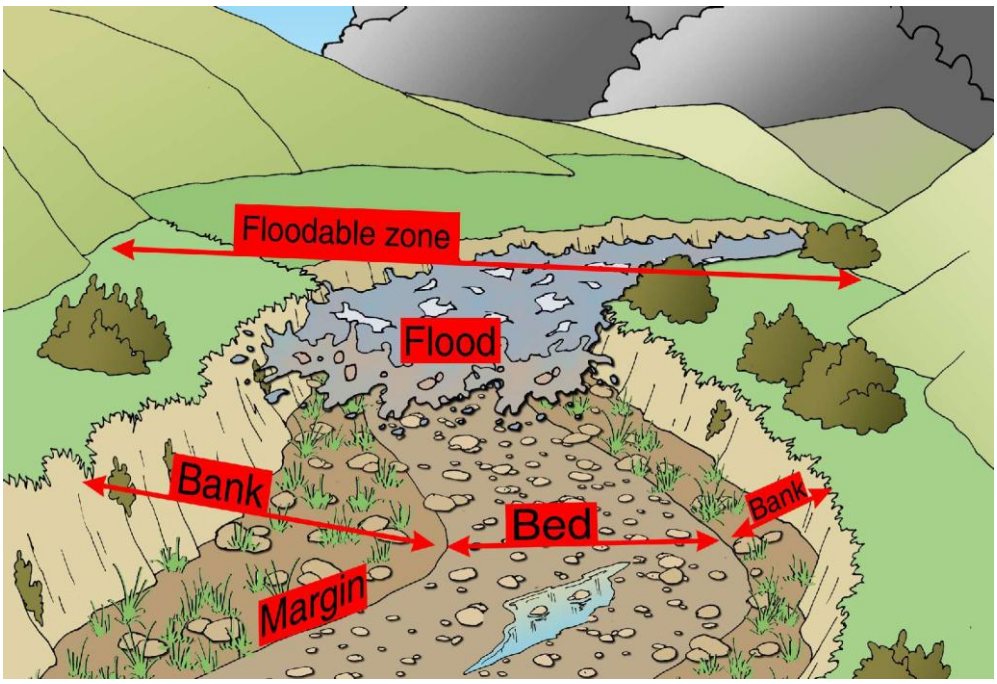
Dry gully or stream: Natural bed of rainwaters, usually dry but filling with water when it rains heavily.

Flood/spate: Floodwater from rain, swelling of rivers.

Bed: the bottom of rivers.

Margin or confine: Strip of land immediately beside the water.

Banks: Land near rivers even if not right beside the water's edge.



Floodable zone: The strip of land on both sides of the river than can flood when there are large floods/spates.

In floods account must be taken of the **natural factors** and **human influence**.

Natural factors are related with **HAZARD**, or the likelihood of a particular natural phenomenon of a certain intensity, a certain extensiveness and duration occurring, with negative consequences.

- Example: persistent rainfall and large volume of precipitation in a particular zone.

The human influence is related with **VULNERABILITY**, the impact a phenomenon has on society.

- Example: building in flood-prone areas.

RISK is the product of vulnerability and hazard. The increase in vulnerability increases the risk of natural phenomena.

Do you want to know more about floods? Through this QR code you can watch a video about these topic

The brook can hardly be made out in the photo, but in a recent swelling due to spring rains it carried along remains of vegetation

Can you identify the concepts explained earlier?
Can you mark the line of the floodable zone?

CAUSES OF FLOODS

NATURAL FACTORS: Floods are recurring natural phenomena. Land near rivers has historically flooded, thus helping to increase the supply of sediments and organic matter that made that land fertile. A classic example is the overflowing of the River Nile until the period when the Aswan Dam was built in order to control the periodic rises of the river. Natural causes:

- **Meteorological**: Caused by the development of thunderstorms and situations that give rise to torrential rains (e.g. due to build-up of heat and moisture during the summer, the arrival of cold air over a warm sea in autumn, etc.). Also due to persistent rains and snow melt and sea storms.

- **Geological and geographical**: These include causes related with geological phenomena (e.g. landslides on slopes). It is nevertheless advisable to consider the geographical aspects of the basin, as in the case of temporary rivers or low-lying land close to rivers, which flood more often. Flooding also more often affects low-lying land close to mountain ranges that favours the formation of thunderstorms, forcing them to discharge intensely in that particular zone.

- **Biological**: River basins that are devoid of vegetation (whether naturally or due to forestry) have lower **filtration*** capacity, so that during heavy rainfall episodes the volume of water borne by surface runoff and flowing into river basins is larger.

Photography of a river in the Maresme area with *motes* on each side, the *motes* (word in Catalan) are terrain elevations made by the farmer so as to prevent the water from flooding its crop. The knowledge of the local river behavior allows the population to live in harmony with the surroundings. (Source: M. Carme Llasat)

THE HUMAN INFLUENCE: Human activities have had an effect on the natural environment, whether by altering it (e.g. by channelling river beds) or occupying it (e.g. by building in floodable zones)

- **Channelled stretches**: River beds are often channelled with the intention of guiding the waters and preventing them reaching certain zones. But these vary channels often cause an increase in water speed and lower **filtration** (the capacity of land to absorb water. This is greater on land with plant cover) down into the ground, setting up a movement of greater water volume and speed that has destructive capacity downriver.

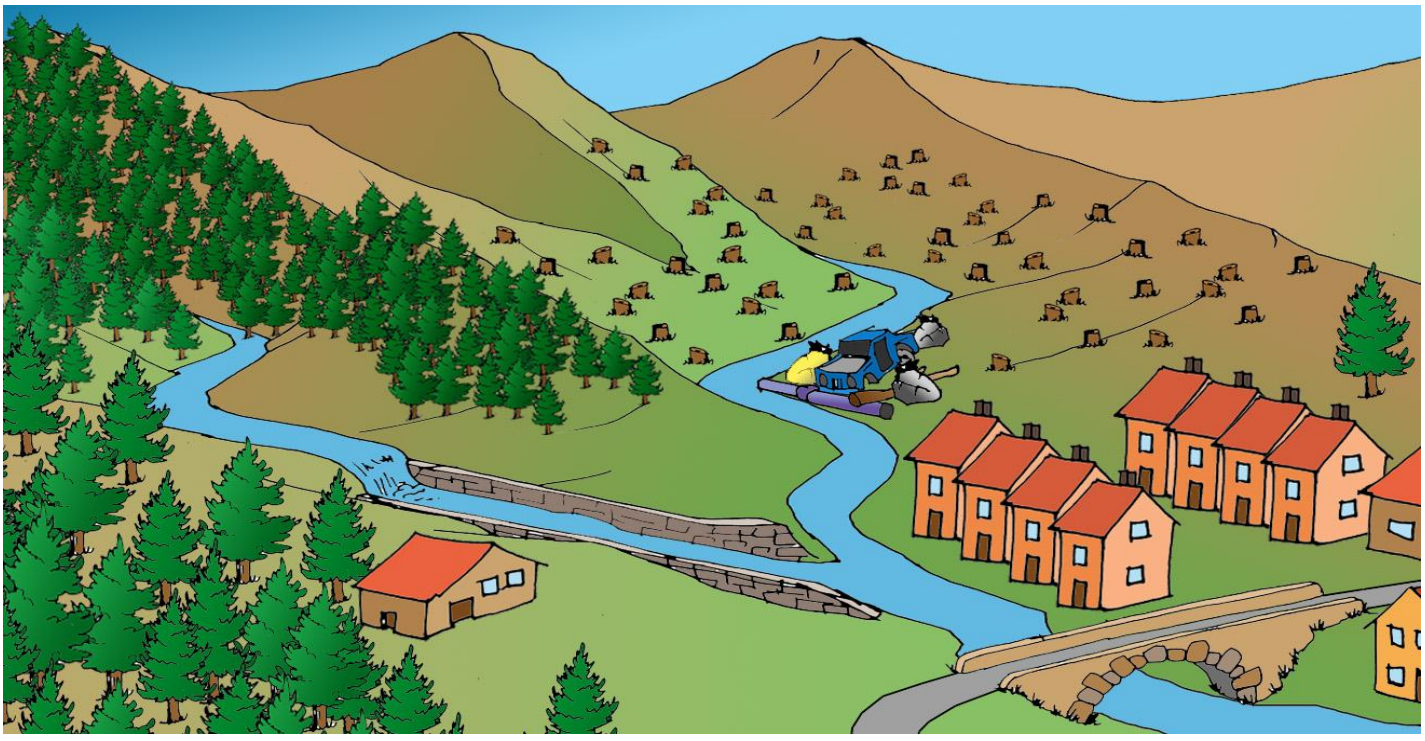
- **Developed areas**: Urban and industrial zones very often grow up close to floodable land. Although for much of the year (and for many years in a row) the land that has been gained remains free from water, at times of heavy downpours the fluvial dynamics will prevail over human interests.

- **Bridges**: The sections of river between the pillars of a bridge can form dam-like structures in the event of a flood that carries along solid materials (items of rubbish, remains of vegetation). This "dam" can prevent the water passing, leading to a rise in water level which then floods the nearby land (or streets).

- **Waste**: The use of dry river beds as tips, particularly low-flow ones, ends up creating a dam effect if there is a flood (as happens with bridges). This is particularly likely to happen in places where the water passes through underground pipes (under roads, buildings, etc.)

This landscape contains various works that increase the risk of floods

Can you find the 6 risks illustrated?



TYPES OF FLOODS

Depending on their SOURCE:

- Due to **"in situ" precipitation**: abundant precipitation in the same place the flood occurs. The rain that has fallen exceeds the land's capacity to absorb and channel it.
    - E.g. floods in urban areas, such as the Plaza Cerdà in Barcelona or in Athens in October 1994 (in the case of Athens 68 millimetres of rain fell in only one hour, producing damages estimated at €14 million).

- Due to **floods or overflowing of banks**: due to water overflowing the beds of rivers, lakes and marshes due to rising water (whether due to precipitations, snow/ice melt or blocking of beds).
    - E.g. The rise of the River Arno in Tuscany (Italy) in November 1966 due to intense rainfall. The water level in the city of Tuscany exceeded five metres.

- Due to **breakage of or incorrect operations with** hydraulic infrastructures.
    - E.g. The bursting of the Tous dam in Valencia (Spain) in October 1982 due to its retaining walls being too weak to support very abundant rain. The accident caused thirty deaths, and some towns were left under eight metres of water.

Floods in Tortosa. 20 November 2011. Source: meteotortosa

Depending on DURATION:

- **Very rapid floods** (*flash-floods*): very heavy rainfall (over 3 mm/min) within a very short period of time (less than one day) The actual amount of rain fallen may not be so very great, but the speed of the precipitation causes drainage problems and local floods. Typical of summer and the beginning of autumn.

  - E.g. Floods in Arenys de Mar (Spain) in August 2004 due to precipitation of 50 mm in only 25 minutes. The channels provided to carry away water could not drain away the amount of rain that had fallen. Vehicles had to be rescued, as well as the odd person trapped inside them.

Severe flash floods in Genoa, Italy, on 4th November 2011 (about 450 mm of rain fell in six hours). Six people were killed. (Source: DRIHM Project)

- **Floods due to moderate rains lasting a few hours over several days**: these are caused by rains of moderate intensity (more than 1 mm/min) but long duration (1 to 4 days), leading to a great accumulation of water (usually more than 200 mm). At the heads of rivers, with a steep gradient, floods arise more suddenly, while in the middle and lower reaches of the rivers the high water can arrive up to a day later. Typical of autumn, although historically they have also happened in spring.

  - E.g. Floods in the Pyrenean Region that affected Spain, France and Andorra in November 1982 due to heavy rains that lasted three days. A total rainfall of 610 mm was recorded in Py (France). Some villages were partially destroyed and more than 20 people death.

- **Floods due to light rain spread over several days:** these are caused by rains of low intensity but long duration (more than five days), leading to accumulations of water usually exceeding 200 mm.

- E.g. A dynamic typical of the rains of central Europe. In Catalonia (Spain) such an episode arose between 20 and 30 January 1996 with accumulated rainfall of 300 mm in one week.

According to its IMPACT:

This kind of classification is the most used when research on historical floods are made, such as the one made for the evolution of floods in Catalonia since the XV century.

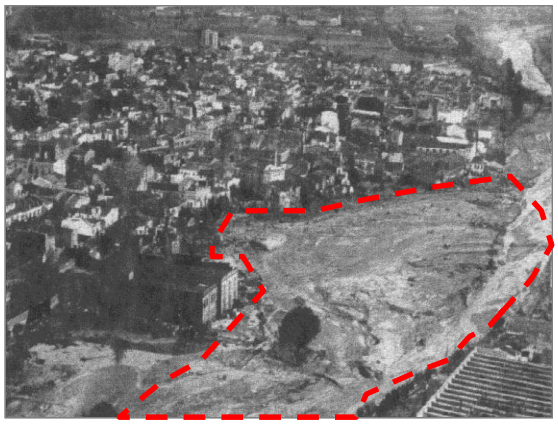
- **Ordinary flood:** It takes place when the river flow increases in such a way that it can affect the day-to-day of local population, temporary infrastructures around the river (e.g. walkways) or flood river crossings. However there's no major damage.

An **ordinary flood** in the Arenys stream . (Photo: M.C. Llasat)

- **Extraordinary flood**: It takes place when the river overflows and even though it does affect the day-to-day of local population and it does cause some damage it does not completely destroy infrastructure. These floods can be local or extensive

Floods during the 9th and 10th of October 2012 in the area of Baix Llobregat had a huge socioeconomic and media impact. However, according to the historic-climatic classification, it was in fact an **extraordinary flood**. (Source: La Vanguardia)

- **Catastrophic flood**: It takes place when serious material losses happen such as total or partial destruction of bridges, mills or any other infrastructure, as well as cattle and crop loss.



Floods in the area of the Valles during 1962 are a clear example of a **catastrophic flood**. The red line shows the area completely destroyed by the water. (Source: La Vanguardia)

PREVENTIVE MEASURES IN THE FACE OF FLOODS

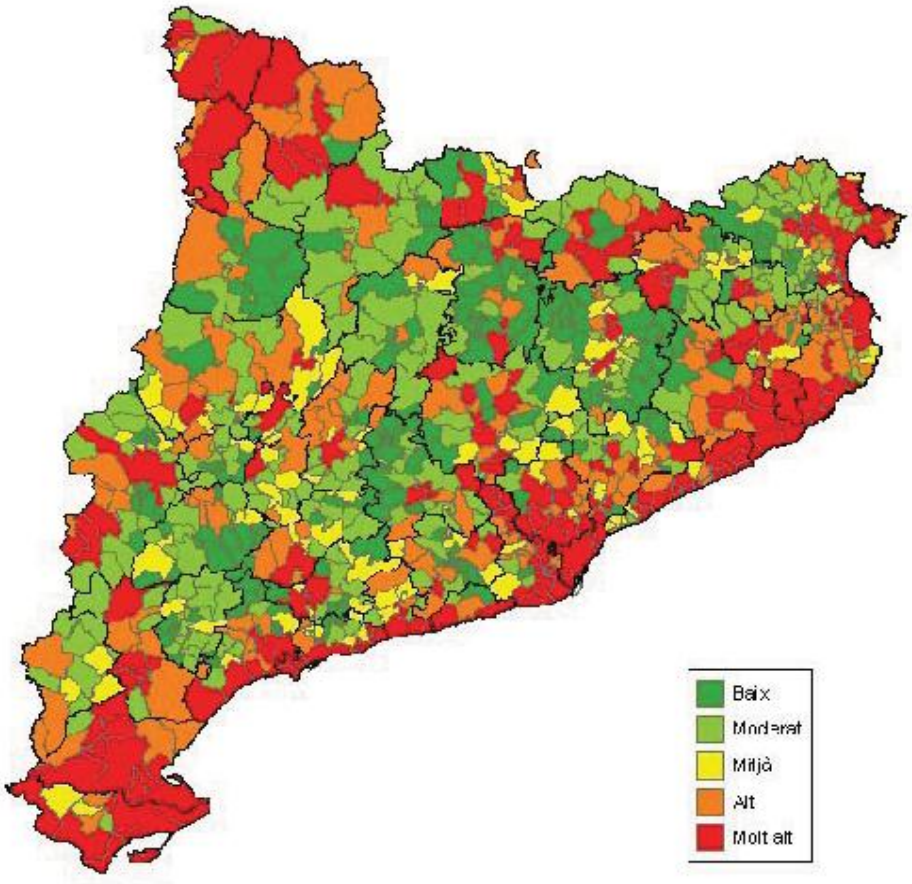
CARTOGRAPHY:

The availability of detailed cartography (maps) with information on potentially floodable zones, as well as their magnitude, provides knowledge of the **HAZARD** (likelihood of suffering some type of flooding) and **VULNERABILITY** (potential material and personal damage). In short, knowledge of the **RISK**, i.e. an analysis of the population, buildings, essential services and potentially affected infrastructures, natural features in the danger zone and the effects of potentially associated geological phenomena such as landslides.

With this map we can identify the level of flood risk of all municipalities of Catalonia.

Could you find your municipality?

What level of risk have it?



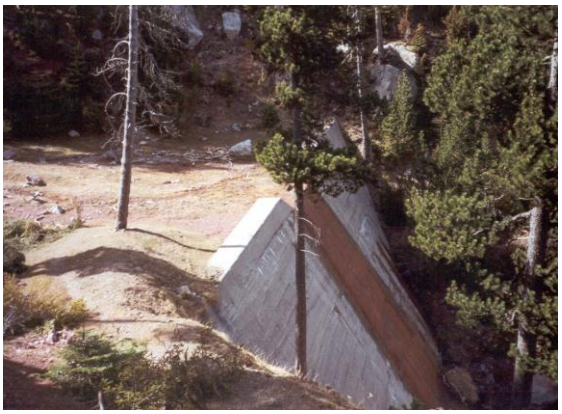
Map of RISK of flooding by municipalities in Catalonia (Spain) Drawn up in 2012, this map is based on criteria of affected population, economic losses and damaged infrastructure. (High risk: red; low risk: green) (www.gencat.cat – INUNCAT)

ALERT:

Alerts are put in place according to the amount of rain precipitated, which depends very much on the zone/country in question. Two reference intervals of time are generally used: precipitation fallen in 1 hour (for short, intense rains) and precipitation fallen in 12 or 24 hours (for continuous precipitation). A flood-risk alarm will be activated if certain critical values are exceeded.

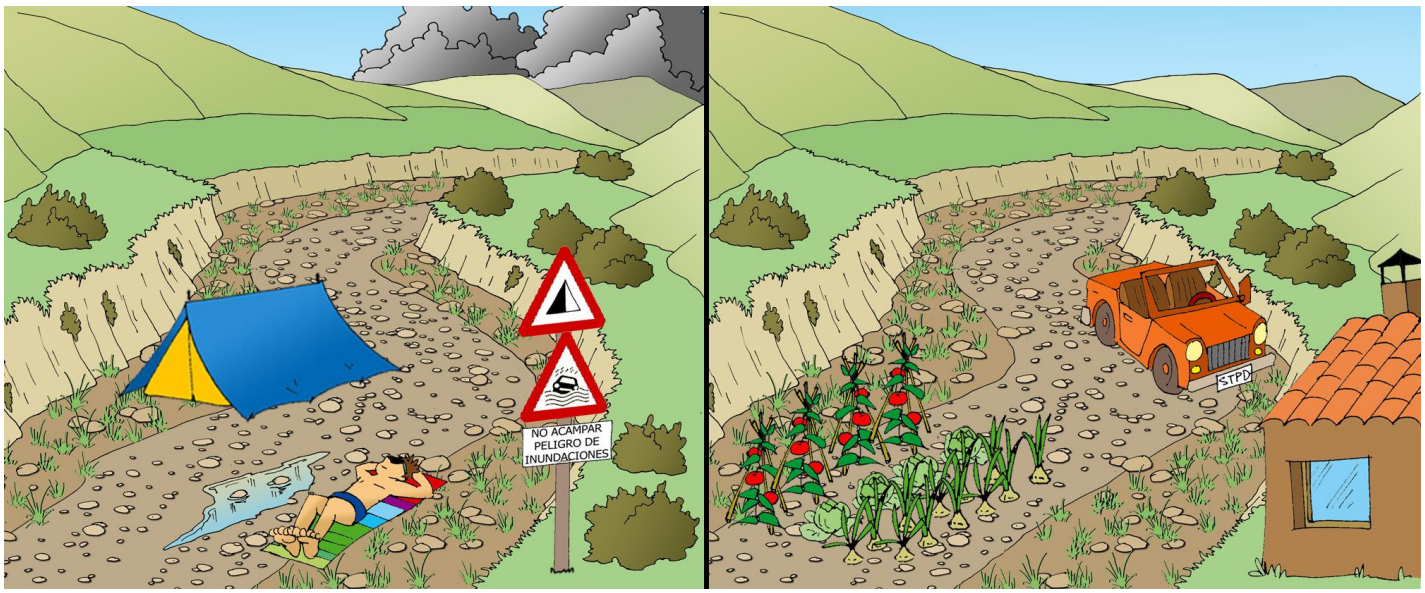
PROTECTIVE MEASURES:

- **Hydraulic infrastructures**: canals, dams, river diversions, etc. While useful, it is best to be aware that these do not provide complete protection. They do give the population a feeling of safety, it is true, but in the event of flooding this can even make the situation more catastrophic. They have considerable environmental impact.
- **Hydrological-forestry correction:** reforestation and other work such as fluvial dams to enhance filtration and reduce run-off.
- **Regulating land use:** preventing or reducing activities and goods in potentially floodable areas. Depends on the territorial and planning approach taken and the political and social will to implement it.



Hydrological modification in Font Roja stream in the municipality of Campello (Ripollès) (Photo: CEA Alt Ter / Pablo Ortiz)

Flood warning signal (Photo: M.C. Llasat)

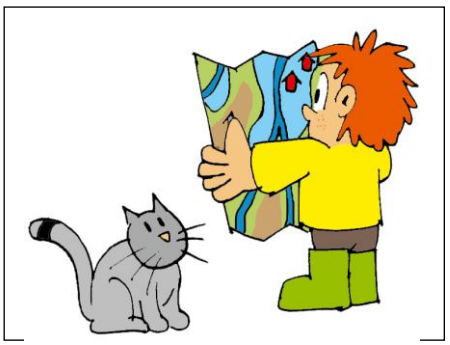


Look for the 7 differences:

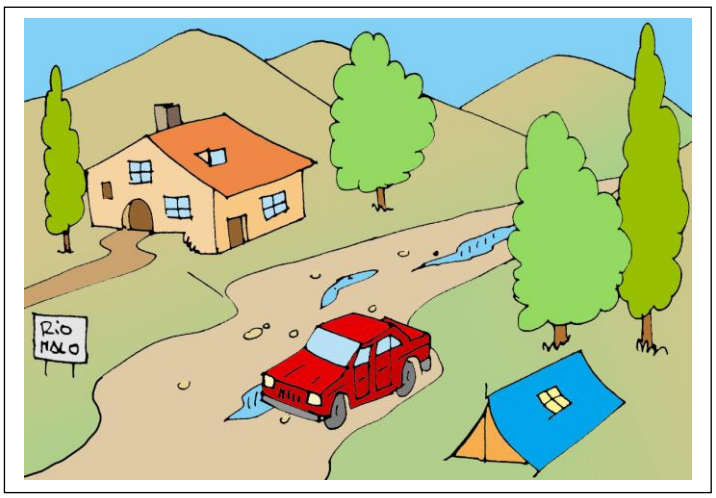
PREVENTIVE MEASURES IN THE FACE OF FLOODS

WHAT CAN YOU DO?

TO PREVENT:



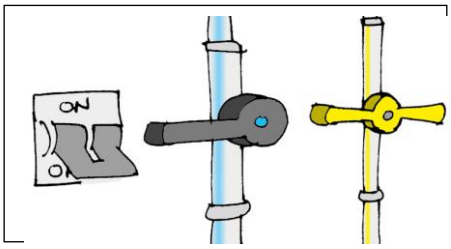
- Know the zone's flood risk
- Keep the area around your house free from materials that could be carried along by the water.
- Check the state of the house at intervals, and particularly the drains.
- Don't park your car in dry river beds.
- Don't camp beside the river or in dry river/stream beds.
- Do not build in areas where there is a risk of floods.



DURING A FLOOD:

AT HOME:

- Go to the upstairs part of the house.
- Close doors and windows. Switch off the electricity and gas, and turn off the water supply.
- Keep your documents and mobile phone dry. Make an area to shelter in, with warm clothes, water, food, and torch.
- Keep yourself informed by radio.

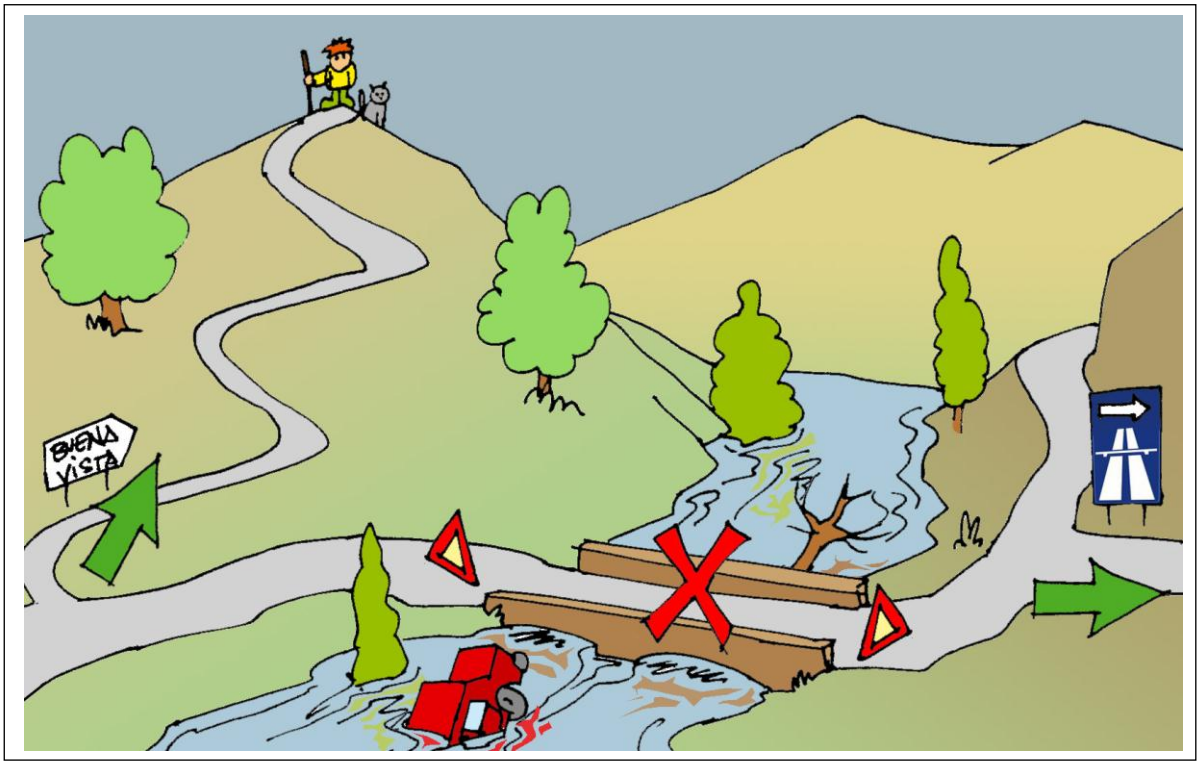


WHAT CAN YOU DO?

DURING A FLOOD:

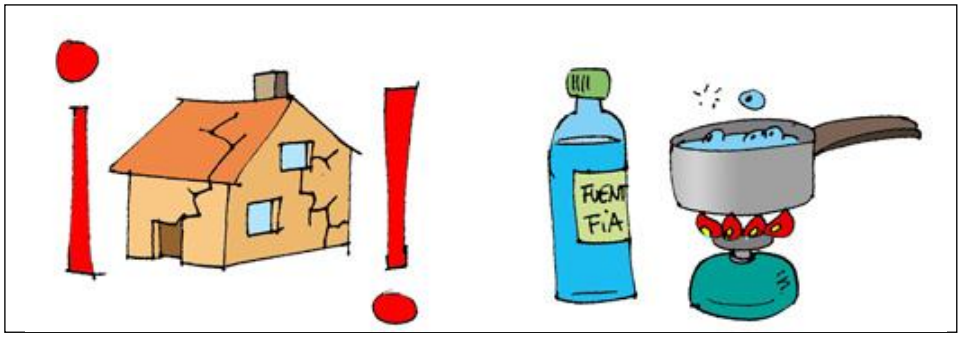
AWAY FROM HOME:

- Keep away from river beds; go to the highest point in the area.
- Avoid crossing bridges, even if they appear to be in good condition.
- Do not cross rivers or streams, whether on foot OR IN A CAR: although vehicles can float, their occupants often do not survive. In such cases get out of the vehicle as quickly as possible.
- Use main roads for travelling by car; rule out secondary and minor roads.



WHEN RETURNING HOME:

- Check the building for risk of collapse.
- If the water is not definitely suitable for drinking, drink bottled water or boil the water first.
- Remove any dead animals as soon as possible.



5. THE SKIES OPEN: THUNDERSTORMS

Thunderstorms are local meteorological phenomena with strong winds, heavy rain or hail, and lightning associated with **cumulonimbus**. Cumulonimbus are large, thick clouds forming a high vertical stack that is narrower at the top, billows out in the middle part and is flat at the bottom. This type of cloud usually forms in summer, lasts from 20 minutes to a few hours and can travel 15 to 30 kilometres, depending on the direction of the prevailing winds.
Lightning are massive electrical discharges unleashed within storm clouds, between one cloud and another or between the cloud and the ground.

But how do storms start? Let's look at how a summer storm develops:

1. The warm summer Sun efficiently heats the surface of the land or water (sea, lake), and that surface in turn heats the air in contact with it. The heat also causes water to evaporate from the surface and pass into the air in the form of vapour.

2. Warm air tends to rise (it is lighter): there thus forms a current of warm, ascending air which in its ascent carries the water vapour that the air contains (moisture) to higher and colder levels.

3. As the air ascends it cools, until it reaches a level (from 1000 to 3000 metres) at which the water vapour condenses and forms little droplets. Crystals of ice can form if the temperature is low enough. **The cumulus forms**.

Cumulus. Ripoll (Ripollès) (Photo: CEA Alt Ter / Pau Ortiz)

4. The temperature differences between the air that ascends and the surrounding air allow convection (ascent of warmer air) to continue, causing the **cumulus to grow until a cumulonimbus** is formed. The drops and crystals increase in size inside it and hail is formed. When the hailstones fall under their own weight and emerge from the base of the cloud, then **precipitation** (rain or hail) occurs. The storm is said to have reached its **phase of maturity**.

5. A cumulonimbus normally reaches up to the top of the troposphere, the **tropopause**. From there upwards, however, temperature increases with height and hinders any further vertical growth of the cloud. That explains why the cumulonimbus then extends in a flatter shape at its upper part and forms the **anvil**. Downward currents form, carrying the cold (denser) air from the top of the cloud. Rainfall is very intense.

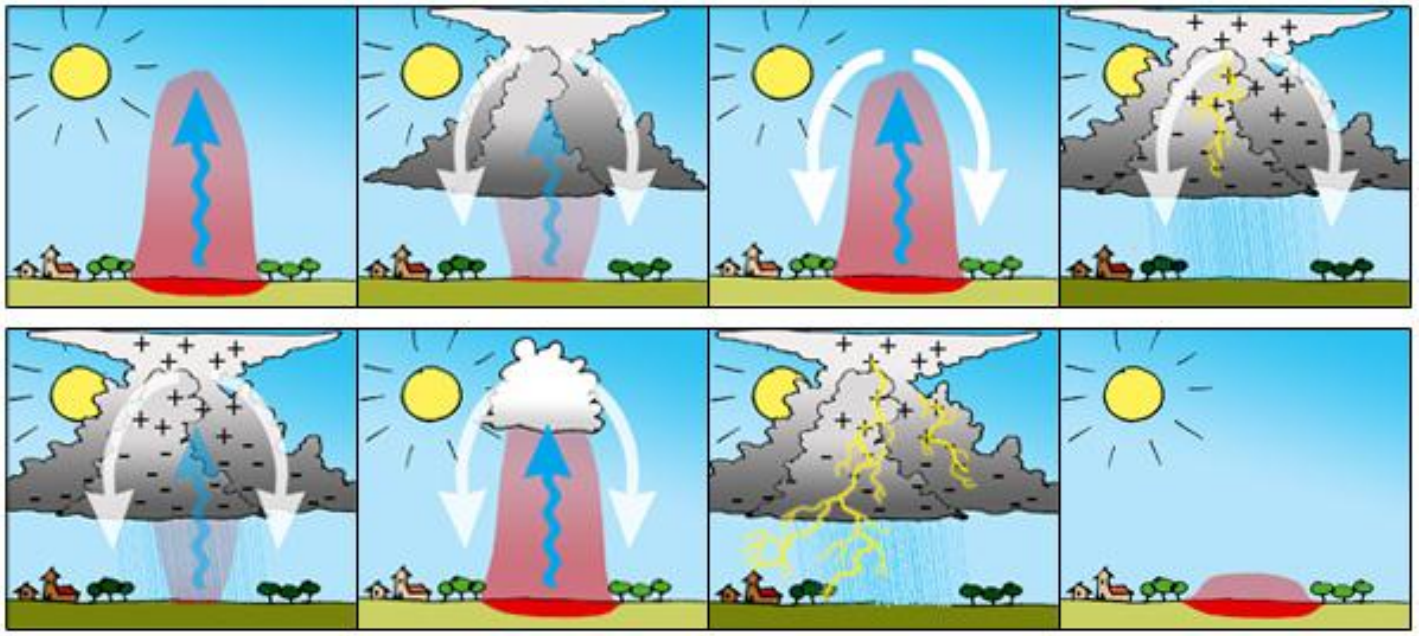
Do you want to know more about thunderstorms? Through this QR code you can watch a video about this topic.

6. The ascending and descending currents of air carry **water drops, hail and ice crystals** within the cloud, which **hit and rub against one another and set up transfers of electrical charges**. The charges are divided within the clouds: positive in the upper part and negative in the lower (a dipole, as in a battery).

7. The difference of polarity (difference of positive and negative charges) **permits the electricity flow** between the two zones, **producing lightning flashes** within the clouds, between different clouds and from cloud to ground.

8. When the descending currents dominate the entire cloud the cloud ceases to grow and begins to disperse. It has reached its **dissipation phase**. The intensity of the rainfall and lightning diminishes.

Can you put the pictures in the right order according to the above text?



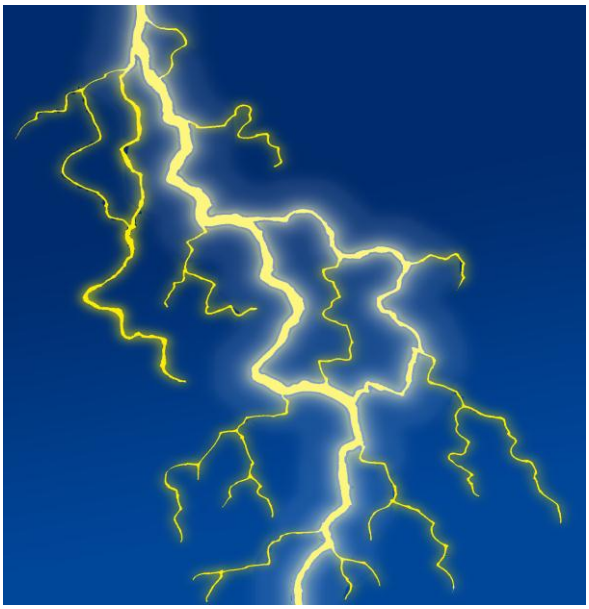
CHARACTERISTICS OF LIGHTNING

Speed: 300,000 km/second

Temperature: 8,000 to 30,000 ºC (up to five times hotter than the Sun's surface)

Intensity: 10,000 to 200,000 amperes (a portable computer consumes only 3.4 A)

Potential: 1 to 1000 million volts (if the electrical current were compared with a waterfall, then the volts would be the meters of height of the water column, and the intensity the force with which it strikes the ground)



Lightning: High-intensity electrical discharge

Flash: Extremely bright and instantaneous light from the lightning bolt

Thunder: Noise from the sudden expanding of the heated air as the lightning goes through it.

Lightnings cloud-to-ground start with small discharges from the cloud that form a set of branches (called **stepped leader**) which go down towards the ground (though only one or two actually reach it). When these discharges get close to the ground an ascending flow of positive charges is set up, and these rise to meet the downward one (**positive streamer**). When the descending negative charges connect with the ascending positive charges the circuit is closed and the return stroke occurs. The following discharge goes directly down (**dart leader**), following the ionised path formed when the stepped leader meets the ascending positive streamer. The process is repeated on average between five and ten times, following the same path, although to the human eye the entire sequence looks like a single bolt or flash.

The lightning follows the fastest route to objects/features with a positive charge that allow the voltage difference (potential) to be discharged between the ground and the cloud. If such features are made of metal and/or project from the ground they have a tendency to attract lightning bolts. That is why **lightning conductors** are installed at high points where they can attract the bolts.

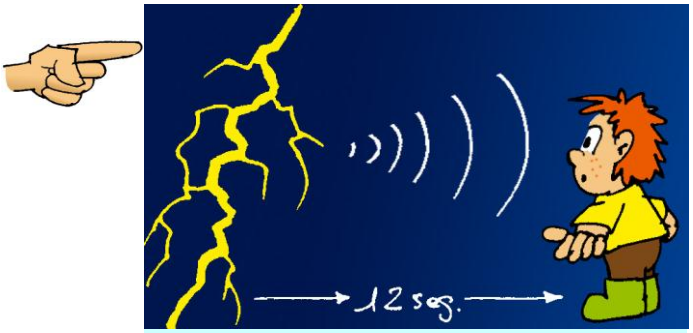
THE DANGER OF LIGHTNING

There are over 40,000 electrical storms each day. Of the lightning bolts unleashed in those storms, some 20% reach the ground. In Catalonia the day between 2003 and 2007 on which there was most lightning was 15 August 2006, with 27,800 cloud-earth lightning bolts. **In mountains, lightning strikes are one of the most common fatal accidents.**

The lightning bolt causes damage to the human body due to the direct or indirect electrical discharge, burns from the superheated air and the shockwave.

effects of electricity on the health are evaluated in milliamperes (0.001 amperes):

Intensity	Effects on the health	
1 to 3 mA	Sensitivity threshold. The passing of current is noticed, but there is no danger.	
3 to 10 mA	Tingling. Can trigger reflex movements.	
10 mA	Muscular contractions. If the electricity source is in the hand, it can cause it to clamp the object and make it difficult to drop.	
25-30 mA	Asphyxiates due to contraction of the respiratory muscles	If the current affects the thorax
60-80 mA	Alteration of the heartbeat with arrhythmia that can cause death	If the current passes through the heart



The light is immediate, while the sound travels at 1 km per 3 seconds.

How far away did the lightning fall ...
if the sound of thunder reaches us 12 seconds after we see the lightning?

The lightning rods are an important measure of protection against the possible impact of lightning. (Source: Torrente Tecnoindustrial)

PREVENTIVE MEASURES IN THE FACE OF STORMS

WHAT CAN YOU DO?

AWAY FROM HOME:

- Height (and humidity) attract electrical charges and lightning. **Never seek refuge beneath a tree nor remain near a lamp-post or electricity mast** (not even in the city). The risk is smaller in a large wood, but move away from or come down from peaks or hills.

- If you are on bare open ground, then you are the feature that stands out (you act like a lightning conductor). **Never start running** to escape from the storm. Try to seek refuge, but if that is not possible you should in the last resort **crouch down on the ground**: that way you minimise the chance of being struck by lightning.

- If you are in **a group: split up into smaller groups or individuals**. If you are close to each other and lightning strikes one of the group, you will all be affected. For the same reason, move away from flocks of sheep or herds of cows.

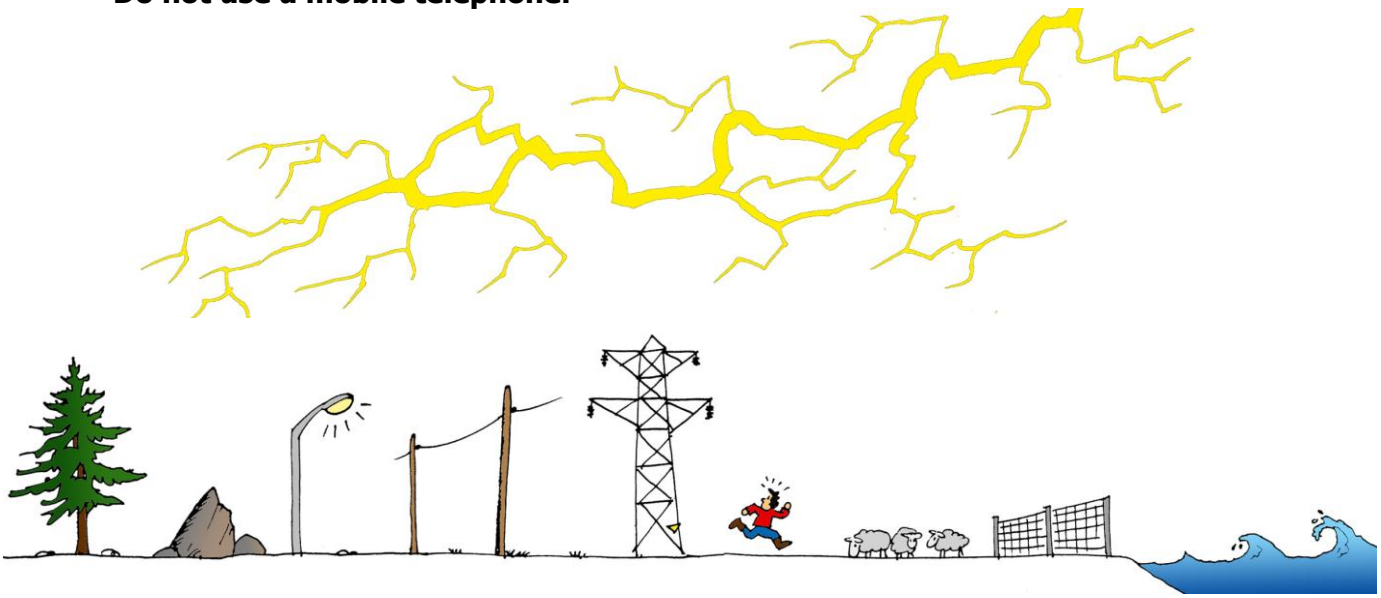
Do you want to know more about the thunderstorms and lightning formation? Look at, through this QR code, the short vídeo.

- **Don't go near water** such as rivers, lake, the sea (the salinity or saltiness of the sea makes it an excellent conductor).

- **Don't use tools or metallic objects** during the storm. Hikers/climbers should move away (30 metres or so) from any metal tools and equipment they have (ice axes, karabiners, etc.).

- **Move away from metal railings**: they are efficient transmitters of the lightning's energy, and can cause death even without the affected person being in contact with them.

- **Do not use a mobile telephone.**



AT HOME:

- **Close windows and doors. Do not walk on wet floors or wear wet shoes. Do not go near a lit fire**: the smoke and the chimney itself set up currents of air that attract electrical discharges. It is best to put out the fire and move away from the chimney.
- **Unplug electrical appliances from the mains**: lightning often comes in via the mains electricity network or through the TV aerial and burns out all the appliances.
- The safest place is lying on a bed, especially if it is made of wood.
- **Don't use a phone** (whether fixed or cordless)
- **Don't take a shower or a bath**: water is a good conductor

IN A VEHICLE:

- **Close all windows and air entry points. Switch off the heating. Fold in the aerials.** If the vehicle is hit by lightning the energy will be transmitted by the metal body and will then pass out through the tyres into the ground without affecting the occupants. Open windows allow the lightning access to the interior metallic structures (seat-belt buckles, clocks/watches, decorative items, etc.)

IF SOMEBODY IS STRUCK:

- If the person survives, he/she will be left unconscious and with breathing and heart problems: **give immediate help with breathing assistance (mouth-to-mouth) and heart massage**. Any burns can be treated later. Move the person to the nearest medical centre. The affected person is NOT left charged with electricity, and so can be touched without any danger.

The pictures on this page show features that attract lightning. All except one … which one?

FLOODS AND THEIR ENVIRONMENT

FLOODS AND THEIR ENVIRONMENT

6. NATURAL HABITATS

Floods and storms are normal, natural phenomena that have always occurred historically. Knowing something about the dynamics of nature allows us to predict events involving a risk for us, though some aspects of these phenomena actually are beneficial for people.

FLUVIAL DYNAMICS

Rivers have carved out the valleys through which their waters run. These valleys were the sites of extraordinary floods that have, for example, permitted the formation of **alluvial plains**.

And erosion and transport of sediment by rivers lie at the origin of **deltas.** They are both examples of flat fertile lands that have been used actively since antiquity for agriculture and for building cities.

It should nevertheless be borne in mind that the events and situations that allowed them to form can occur again. So the best way of being prepared for risk phenomena such as floods is to be aware of their dynamics and of what is **floodable terrain**, and then reducing in so far as possible the activities carried out in them.

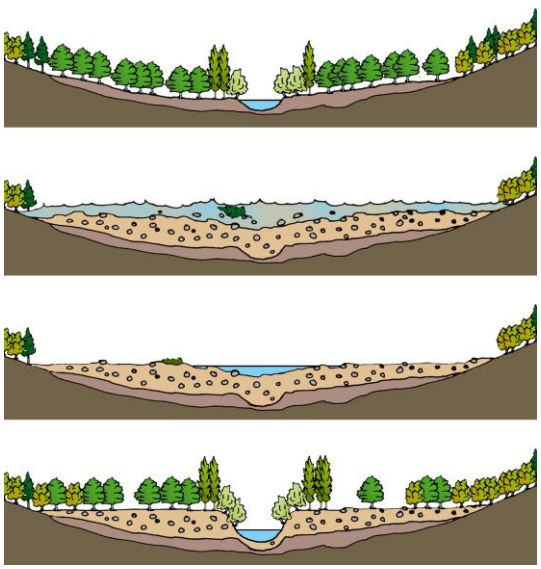


Diagram of formation of an alluvial plain

Around zones with an abundance of water (rivers, lakes, lagoons, etc.) there grows a wood adapted to this kind of environment. It is known as **riverbank woodland** and has various useful characteristics:

- With its roots, the riverside vegetation fixes the soil **and prevents riverbank erosion.**
- Where waters run high, the woods on either side help **to channel the waters** inside the bed, at the same time **slowing the speed of any floods**.
- It is capable of **filtering waters** and carrying out a purification function.
- It assists animal life by offering refuge, paths of travel (biological corridors), food, etc.

Riverbank woods along the River Ter (Ripollès, Spain)

A river whose floodable hinterland and woods are respected is an environment that will provide very many more benefits than obstacles.

So, what advantages?

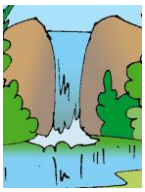
We have just seen some of the advantages to be gained from conserving riverside floodable terrain and woods. But rivers and storms do bring us other benefits.

- Rivers and precipitation **provide us with water** (for drinking, washing, cooking, etc.). In Europe the average water consumption per inhabitant of a flat is about 160 litres a day, while for houses with gardens the figure rises to over 200 litres a day.

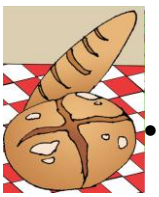
- They are also a source of water **for agricultural and industrial consumption**. Consumption for agriculture varies greatly depending on watering/irrigation systems, transport efficiency and so forth. In Spain, agriculture consumes around 77% of the total, urban uses 13% and industrial 6%. Quite a large amount of water is also lost without being consumed at all — some 4 %, or 802 hm^3 , in other words 8,2000 million litres of water (8,200,000,000 litres of water). (Data of National Institute of Statistics)

- Hydraulic installations (dams, reservoirs) on rivers form the main water reserves in Mediterranean areas. Such installations also provide clean and renewable **electrical energy** (a resource that does not run out and can be generated without pollution).

- Fluvial dynamics, with carrying along of organic matter (plant and animal remains), which is then deposited regularly in the floodable areas, produces **fertile land for agriculture**.



- Rivers also transport sediments: materials in suspension in the waters and mostly made up of remains of rocks of various sizes and kind of soil. The sediments we find at the sources of rivers are of large size, while the erosion caused when the waters drag these larger sediments along reduces them to sands in the lower reaches of the rivers. These sands accumulate at the mouths of the rivers (**deltas**), but are also carried along by marine currents and deposited on the shoreline, forming **beaches**.



- Rivers with their waterfalls, pools, meanders, etc. provide landscapes of unique beauty — **leisure areas** that are like inland beaches.

- Lightning acts as a natural fertiliser, for the electrical discharge produces ozone, ammonia and nitrous oxide that react with rainwater to form soluble nutrients for plants.

Design, implementation and adaptation:
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