



GIFT – Geosciences Information For Teachers Workshop
Merida, Yucatan, Mexico, October 5-7, 2016

Discover floods

Background science and suggestions
to teach young about flood
protection

Giorgio Boni

Introducing myself....



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EGU Natural Hazard Division President



CIMA Research Foundation, remote sensing applications to hydrology



In cooperation with World Meteorological Organization, APFM-WET Project

WMO Associated Programme for Flood Management

Mission

To support countries in the implementation of Integrated Flood Management (IFM) within the overall framework of Integrated Water Resources Management (IWRM) to maximize net benefits from the use of their floodplains and minimize loss of life and impacts.



<http://www.apfm.info>



APFM's **Key Strategic Areas** can be seen in the image on the left while the goals stemmed from those areas are:

- Assisting countries, regions and communities in the implementation of IFM
- Collecting and disseminate knowledge on IFM**
- Advocating for IFM
- Growing and reinforcing a network of partners for cooperation on IFM
- Strengthening partnerships to increase technical, institutional, and financial contributions to IFM
- Efficiently and effectively manage APFM

Course format

- The target of the course is to provide the science background on relevant physical and social processes that produces floods and damages
- For each topic first the science background is provided, then some examples on how to teach the topics involving actively students
- Teaching material provided by APFM Helpdesk, WET project will be used

Course target

The target of the course is to learn how to know our own "water address"

- The natural features of a specific location, such as topography/landscape, geology, hydrology (atmospheric, surface and ground water), soils and vegetation; weather and climate;
- the human environment, including structures and utilities (e.g., roads, buildings, power lines, dams, dikes, levees).

The features of a specific site may change over time.

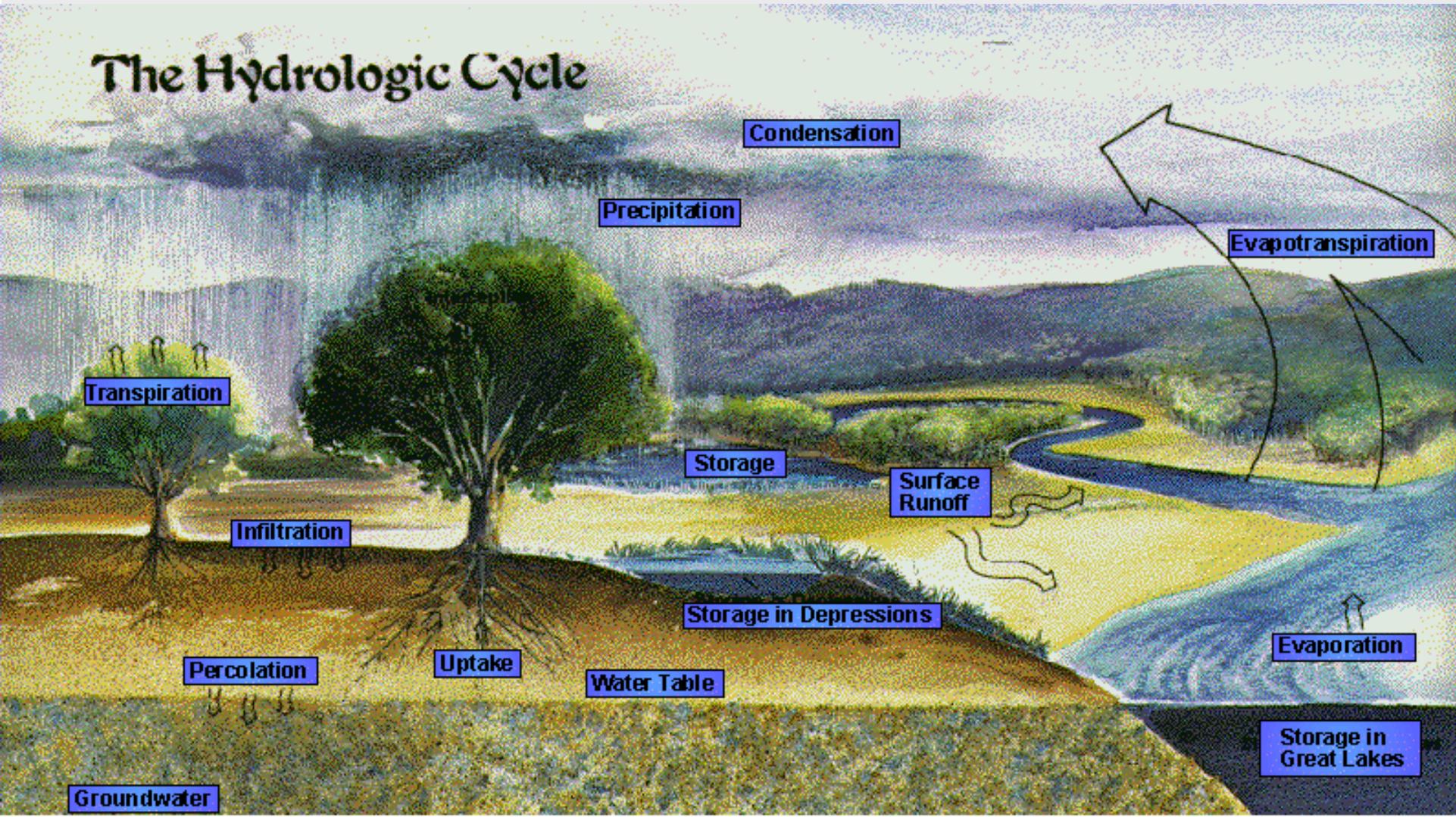
Individuals should determine their water address to assess the likelihood of their location becoming inundated during a flood.

A person's water address changes if she or he is on vacation, at school/work, in a car, camping or on a hike. If flood waters approach an individual's water address, it is important to be prepared.

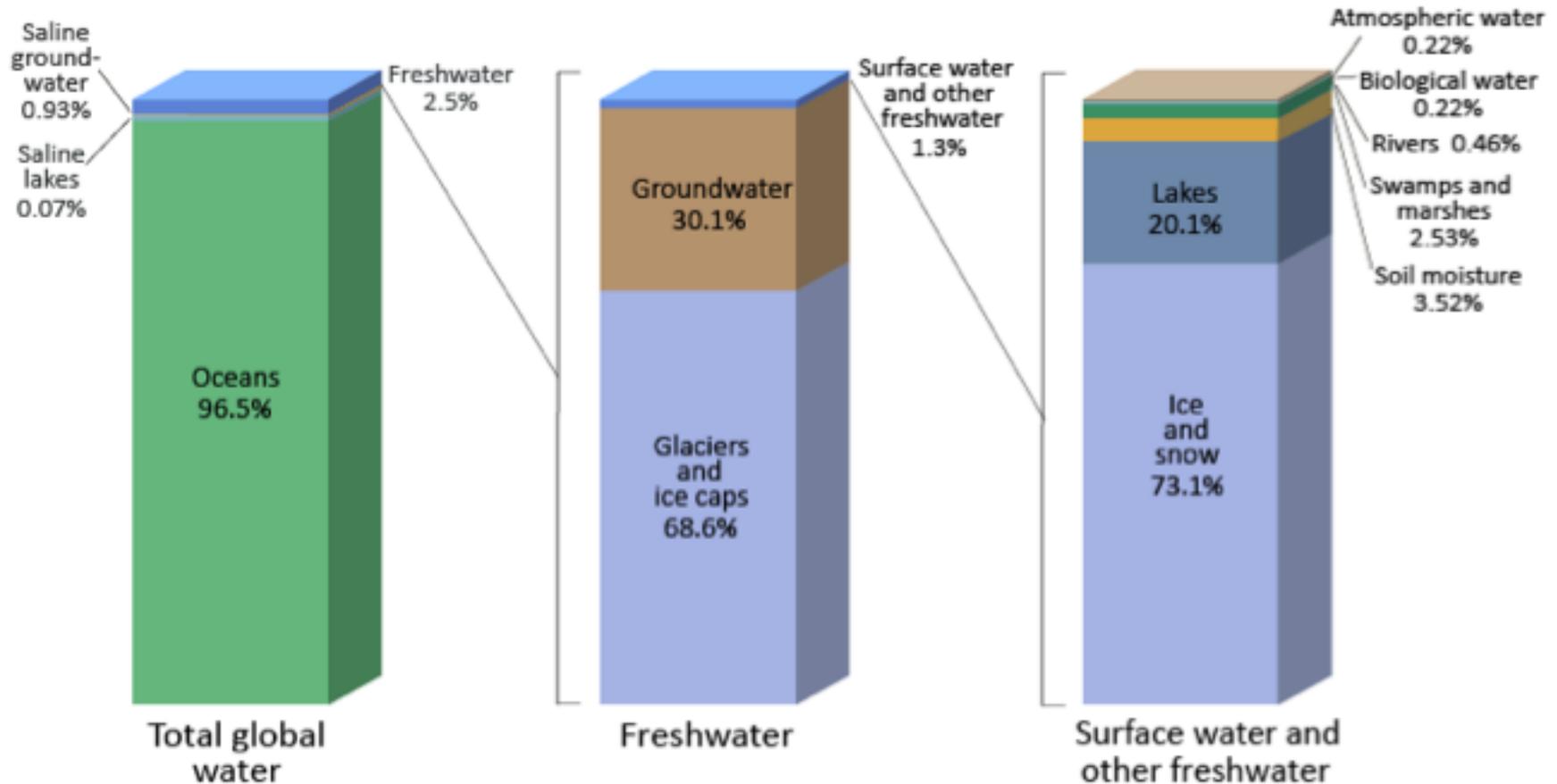
Course outline

- What is a flood:
 - The incredible journey: the hydrological cycle
 - Thunderstorm!
- Color me a watershed
 - what is a watershed
 - some principles of hydrology of the extremes
 - role of land use in flood formation
- Where we can expect a flood
 - my hazard map: how to identify risk prone areas?
- During and after a flood
 - flood forecast
 - Take action! What to do to reduce the impact of a flood

The hydrologic cycle: the way our planet circulates water and energy and then defines its climate

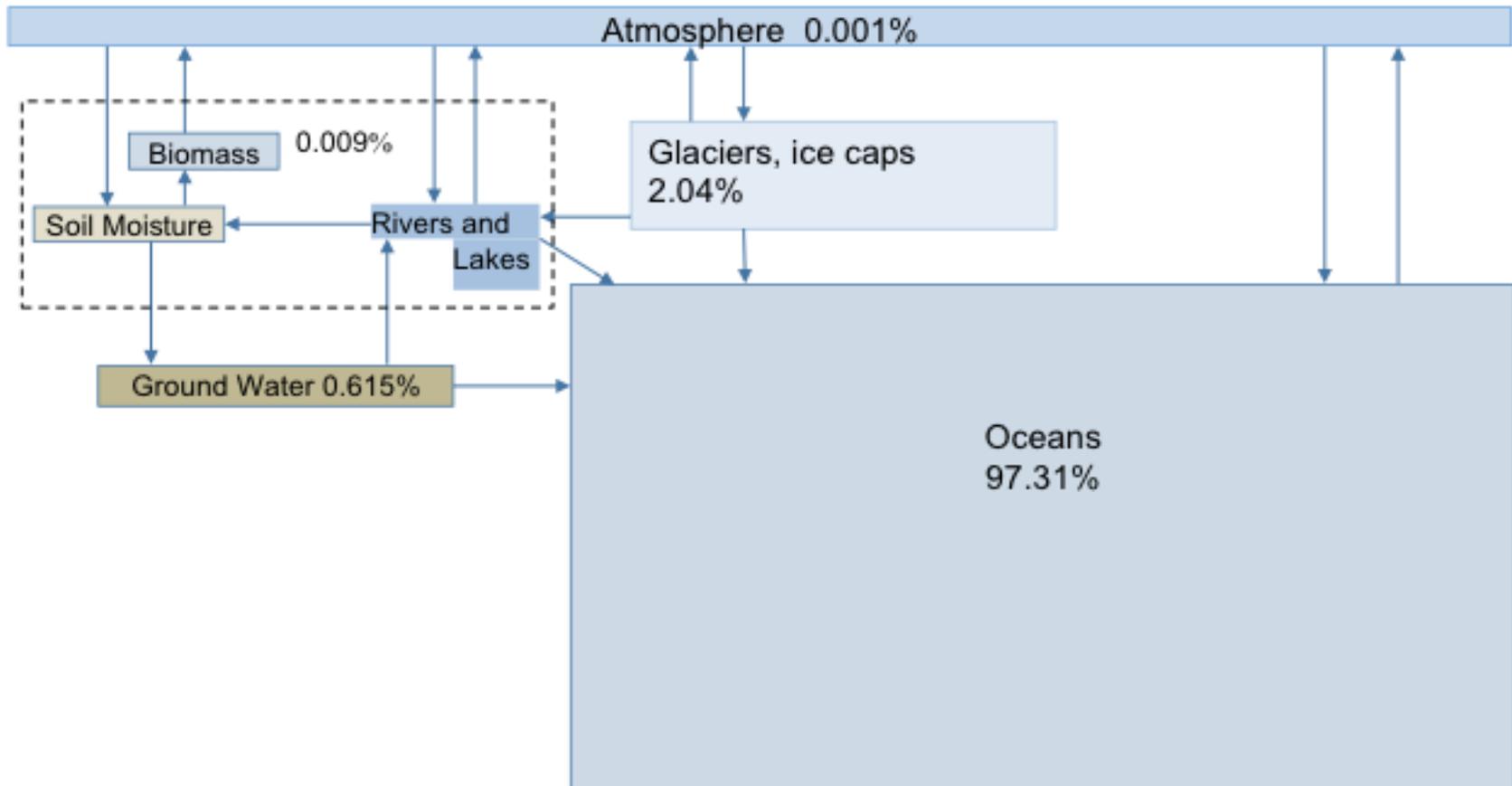


Water distribution on Earth

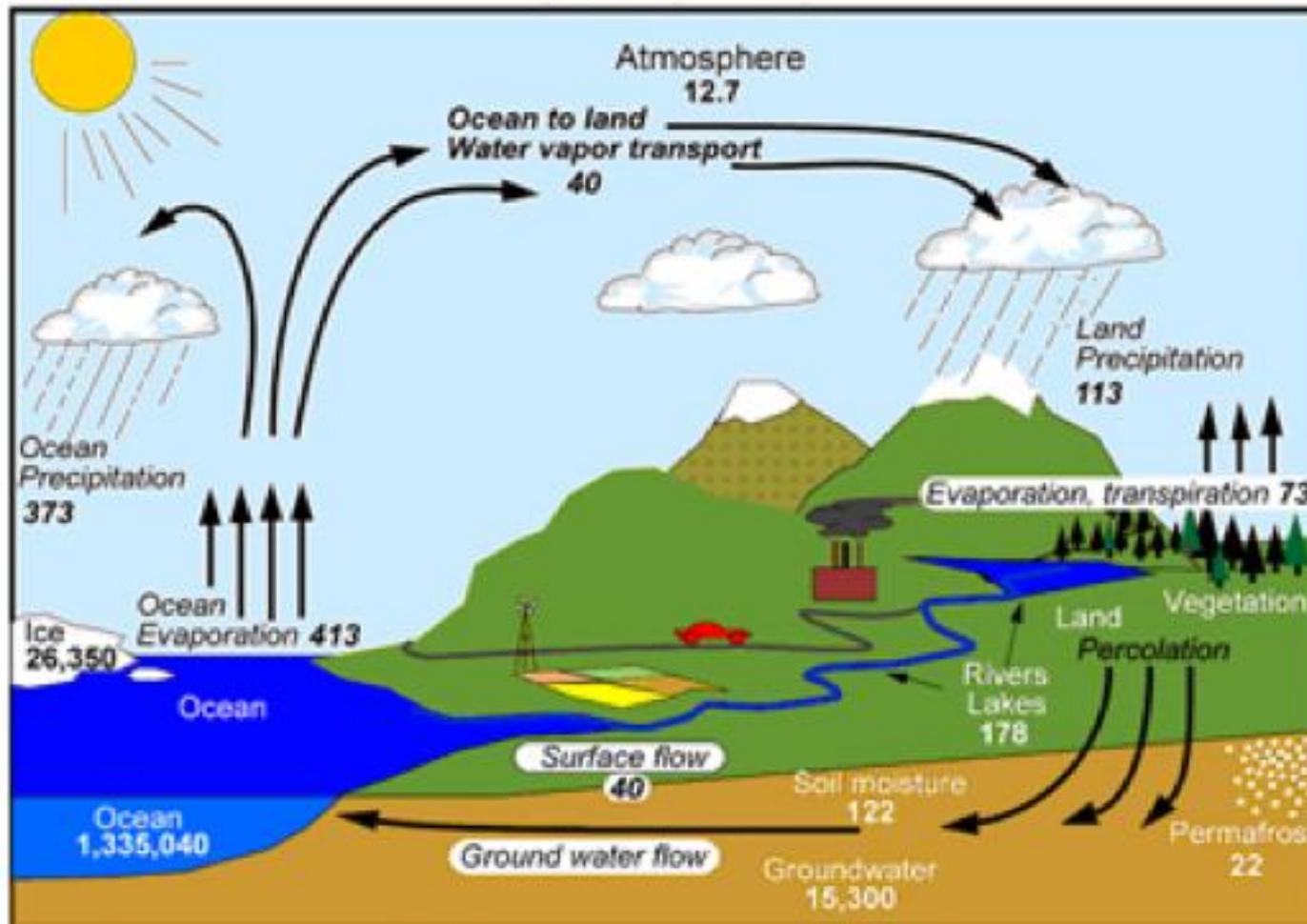


Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, *Water in Crisis: A Guide to the World's Fresh Water Resources*.

Water distribution on Earth



Water cycle time scale



Units: Thousand cubic km for storage, and thousand cubic km/yr for exchanges

Water cycle time scale

Component	Volume (10^6 km^3)	%	Turn-over time (year)
Oceans	1320	97.22	3000
Groundwater	8.25	0.61	5000
Ice caps and glaciers	29.2	2.15	8000
Saline lakes and inland seas	0.105	0.008	7
Fresh water lakes	0.125	0.009	7
Soil moisture	0.06	0.005	1
Atmosphere	0.013	0.001	10 days
Rivers	0.001	0.0001	11 days

The engine is powered by..

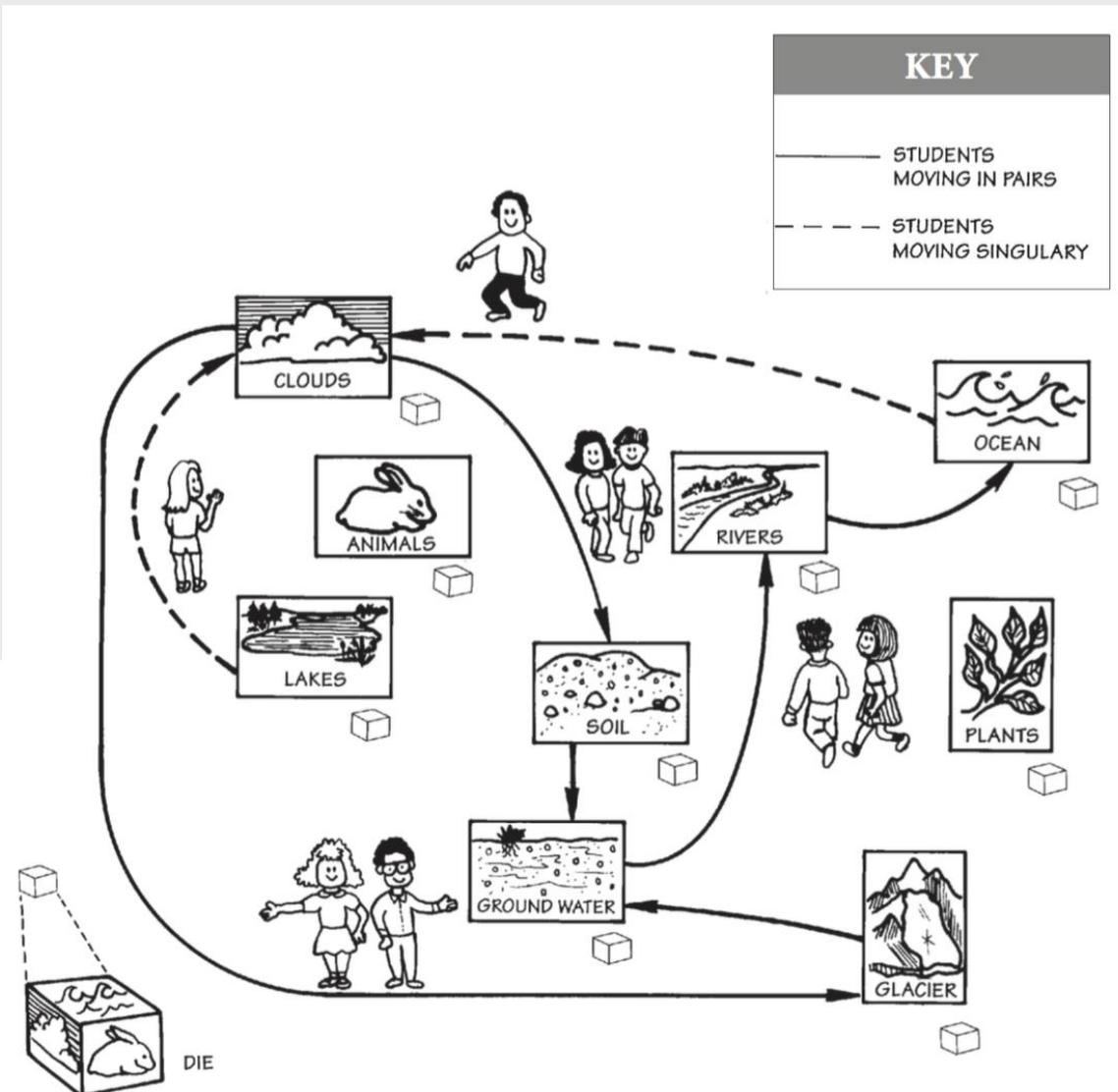


Solar Energy

Play the hydrological cycle

- Target:
 - describe the movement of water within the water cycle.
 - identify the states of water as it moves through the water cycle.
- Students play the role of “water molecules”
- they often think the hydrological cycle as a linear path. This game is specifically designed to understand the complexity underlying the hydrological cycle

Play the hydrological cycle



Thunderstorm!

Thunderstorms are one of nature's most spectacular phenomena. They occur throughout the world. What distinguishes a thunderstorm from other types of storms? Thunder and lightning.



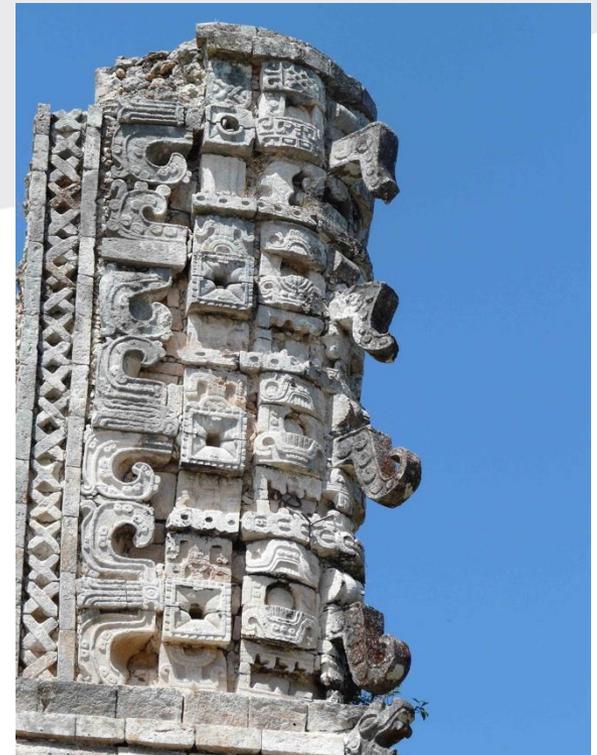
They also can generate **Flash Floods**, which are very dangerous to humans, wildlife and human-made structures. Flash Floods form when too much precipitation falls in a relatively short time.

Background: air mass uplift

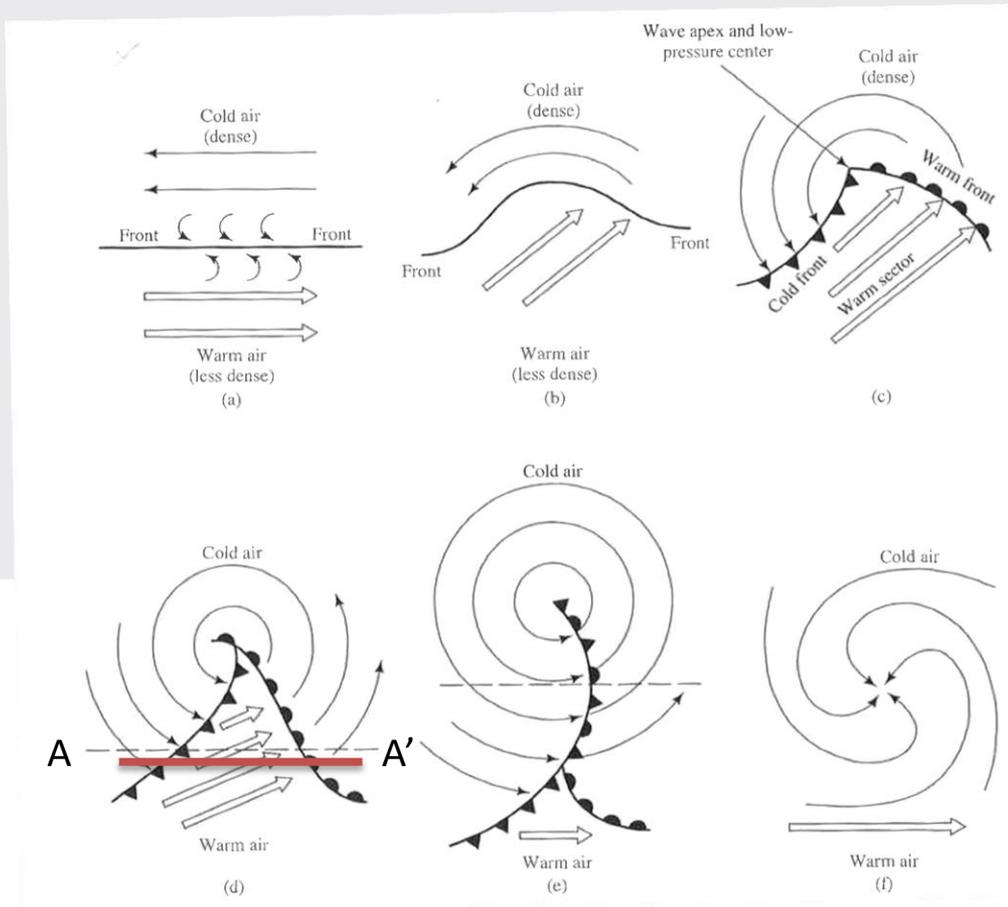
To have rainfall moist air masses must be uplifted

Three kinds of uplift mechanisms are usually observed:

1. Air masses convergence
2. Convection
3. Orographic uplift



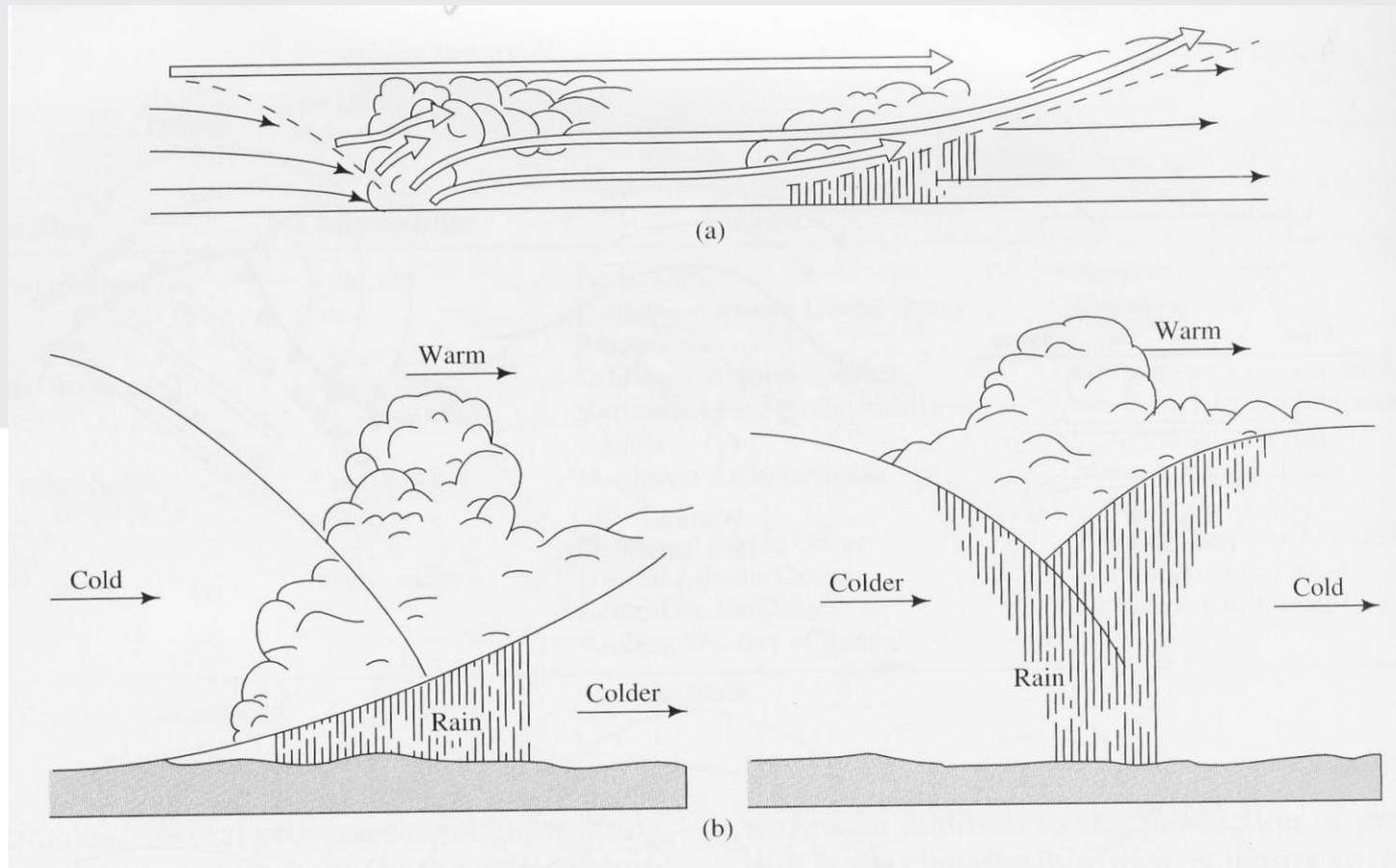
Convergence uplift



- **Extra tropical cyclones- frontal convergence:** vertical uplift, cooling and condensation generated by convergence of cold and warm and moist air masses

Convergence uplift

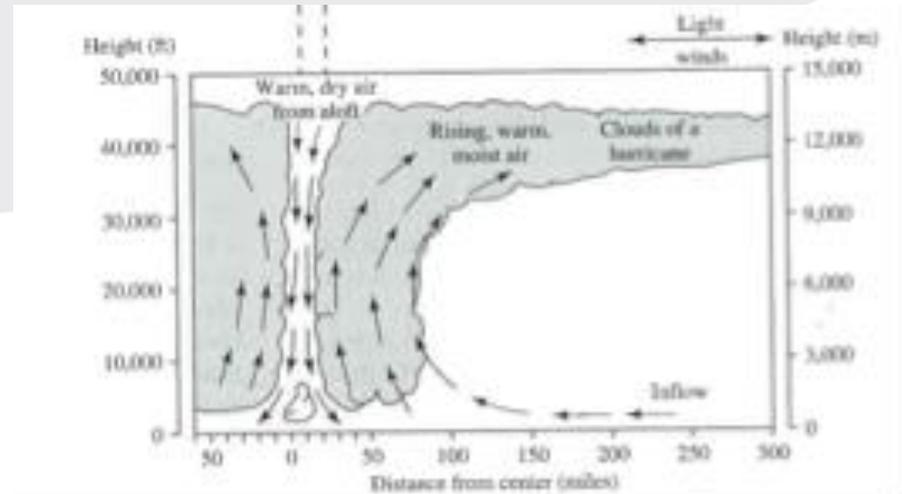
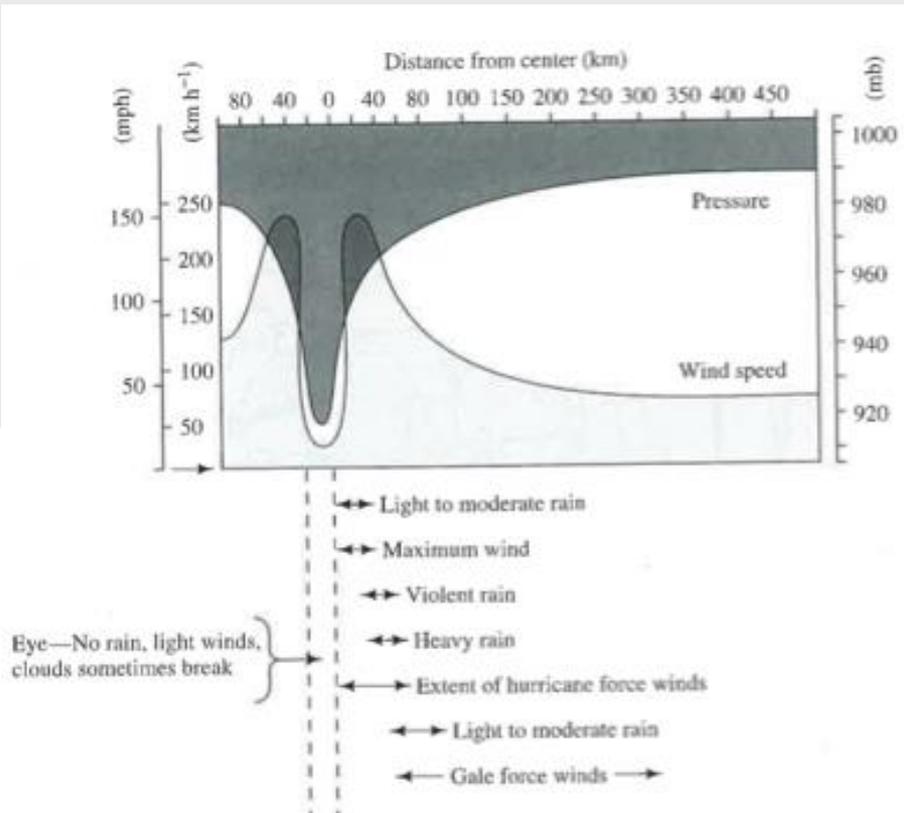
Sezione A-A'



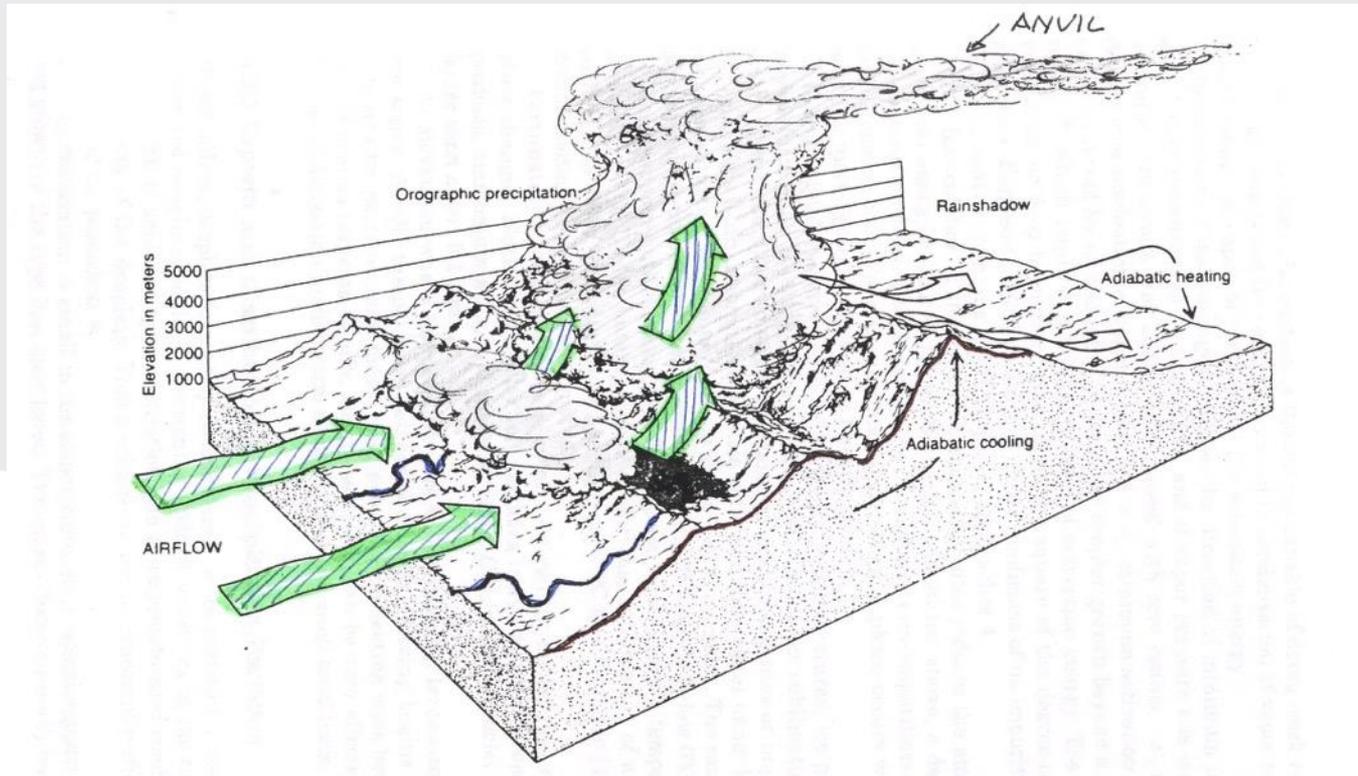
Fronti occlusi

Convergence uplift

Non frontal convergence: tropical storms, hurricanes



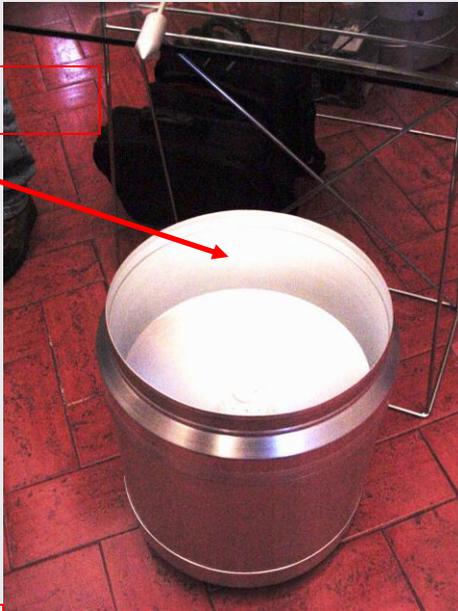
Orographic uplift



- Un secondo meccanismo, molto più efficiente e in grado di produrre precipitazioni molto intense, è il sollevamento orografico: un flusso di aria umida e calda, incontrando una catena montuosa, è costretto a sollevarsi per superarla.

Rainfall observation

Area 0.1 m²



spatial resolution: 0.1 m² (point observation)
Temporal resolution:
variable (traditional sensors)
few minutes (last generation sensors)

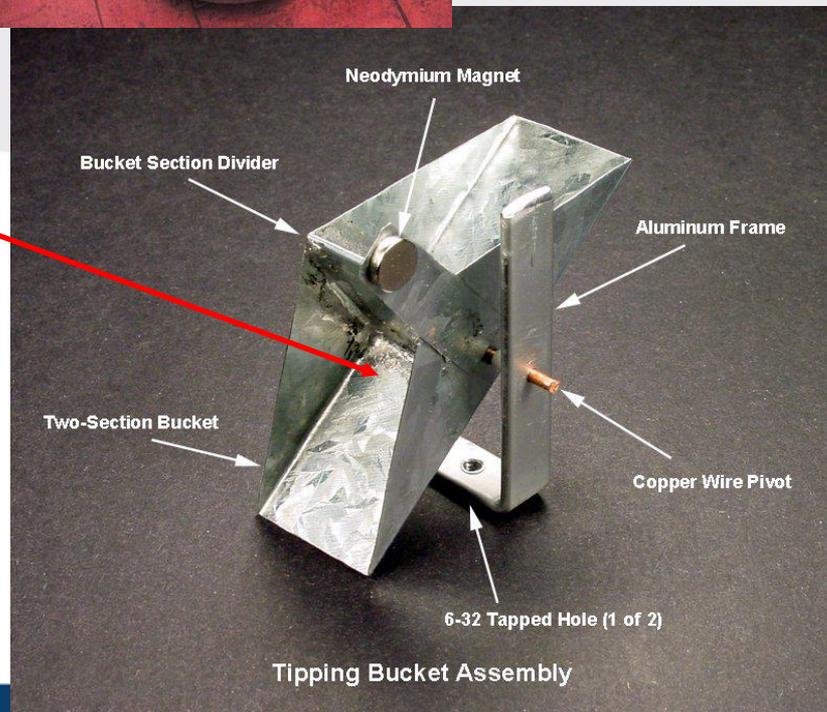
Tipping bucket

Capacity

0,020 kg

Rainfall depth

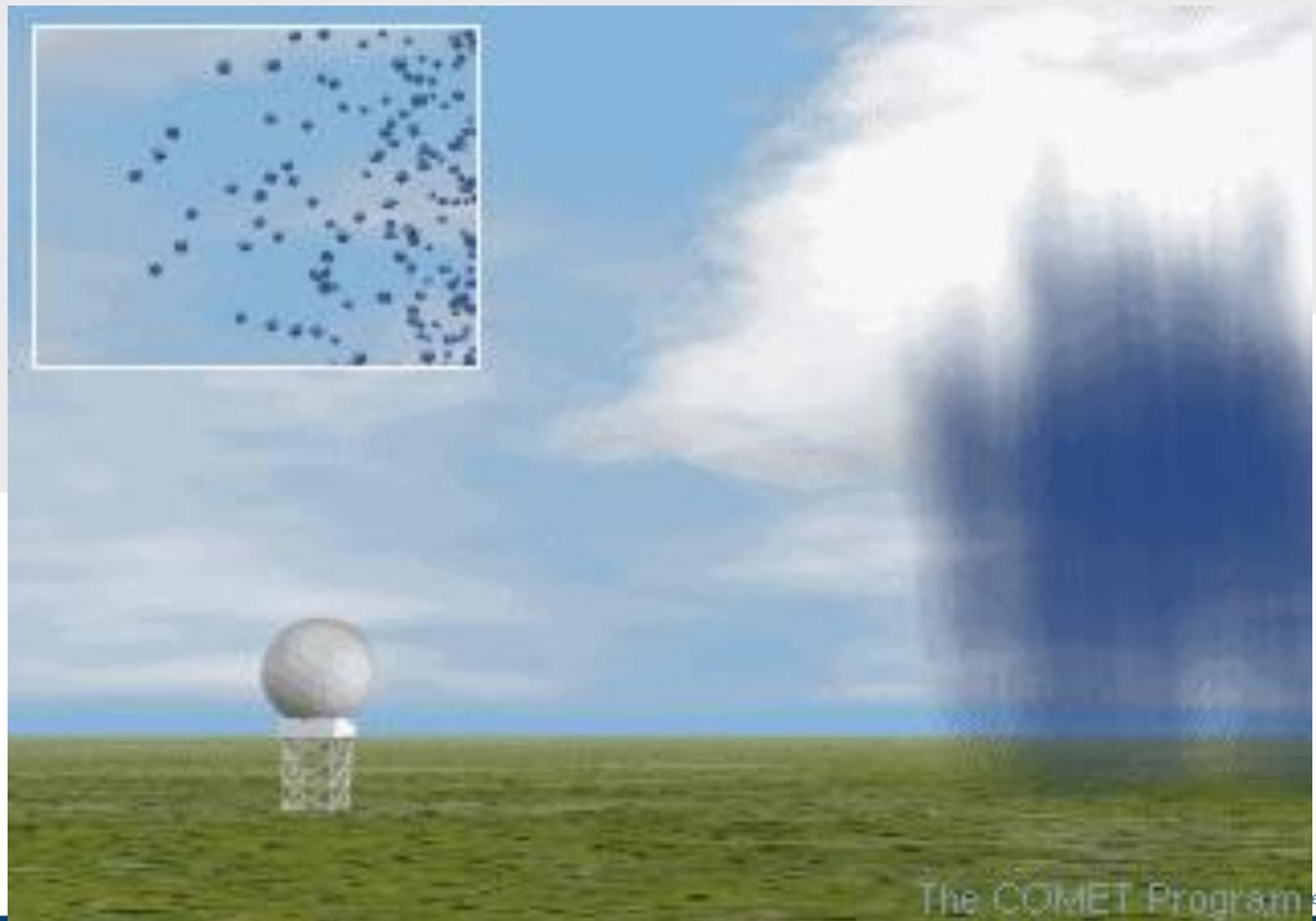
0.2 mm



Problems: underestimation

- **Obstacles close to the gauge**
- **defective support of the bucket**
- **bucket filling decreasing with rainfall intensity**

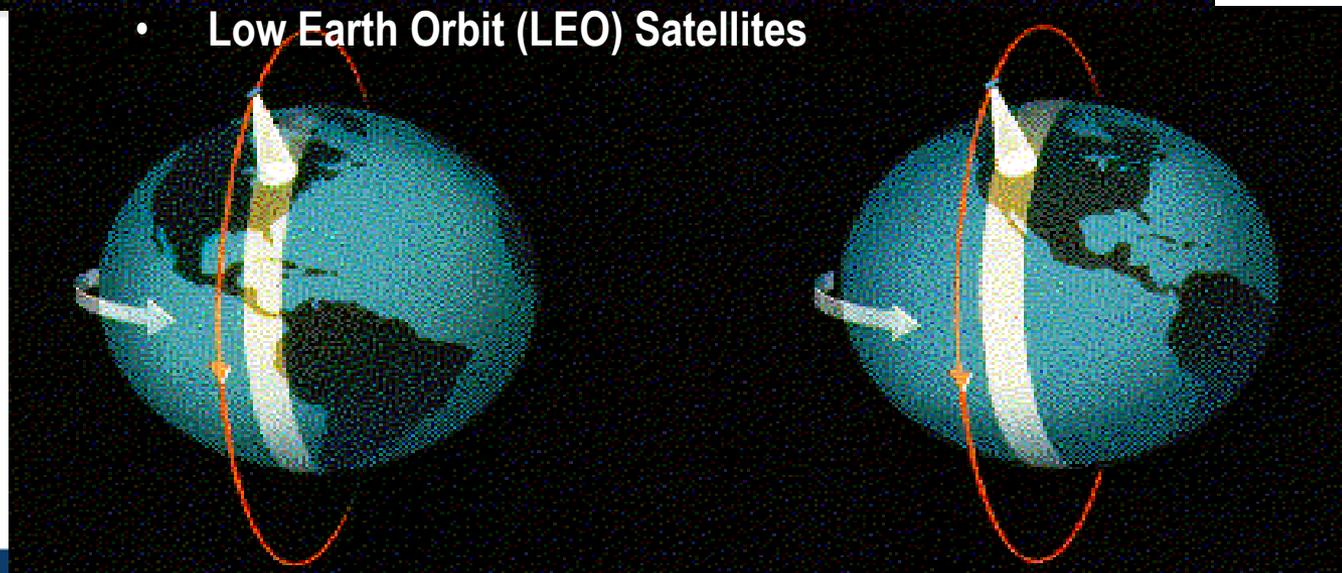
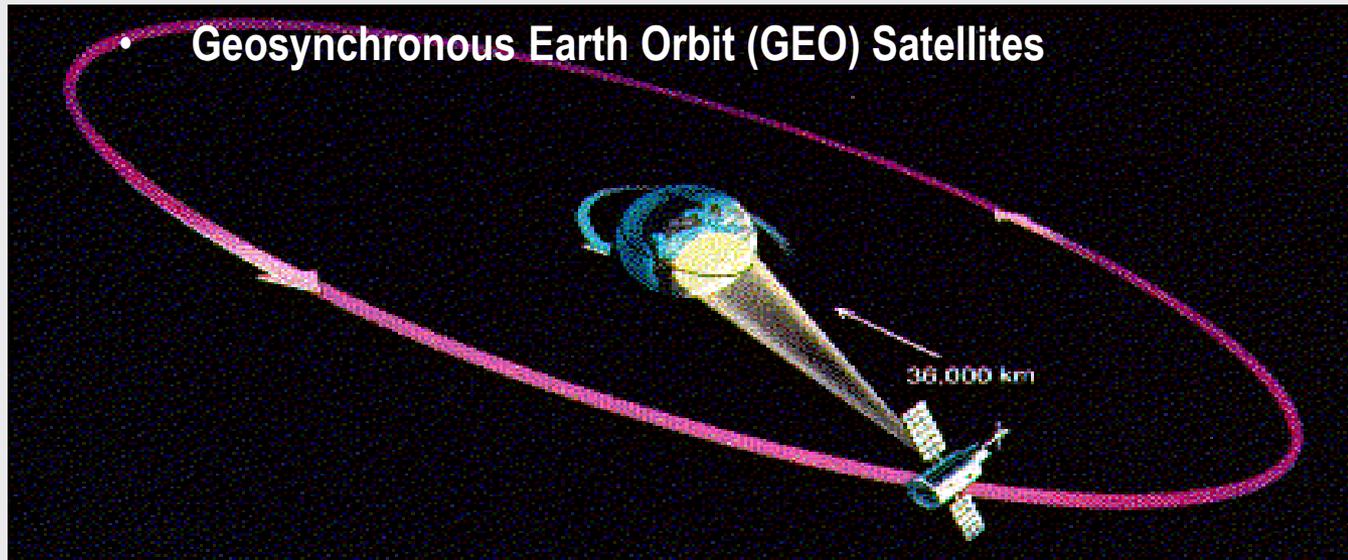
Remote sensors: the meteorological radar



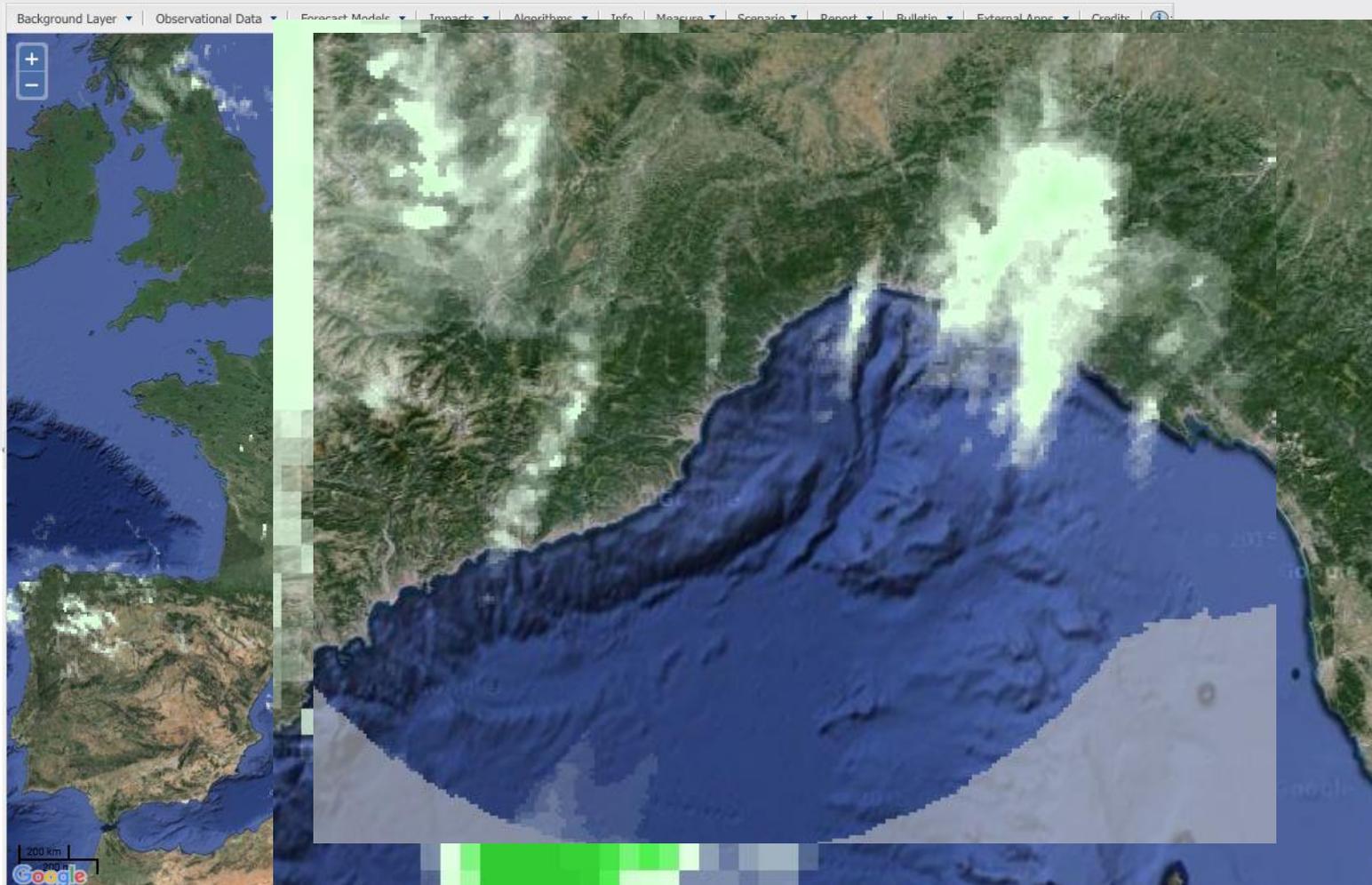
Example of radar rainfall map



Remote sensors: satellites



Comparison satellite-radar



Tuesday, 27 October 2015 15:47 UTC

Wednesday, 28 October 2015 15:47 UTC

User:
cima

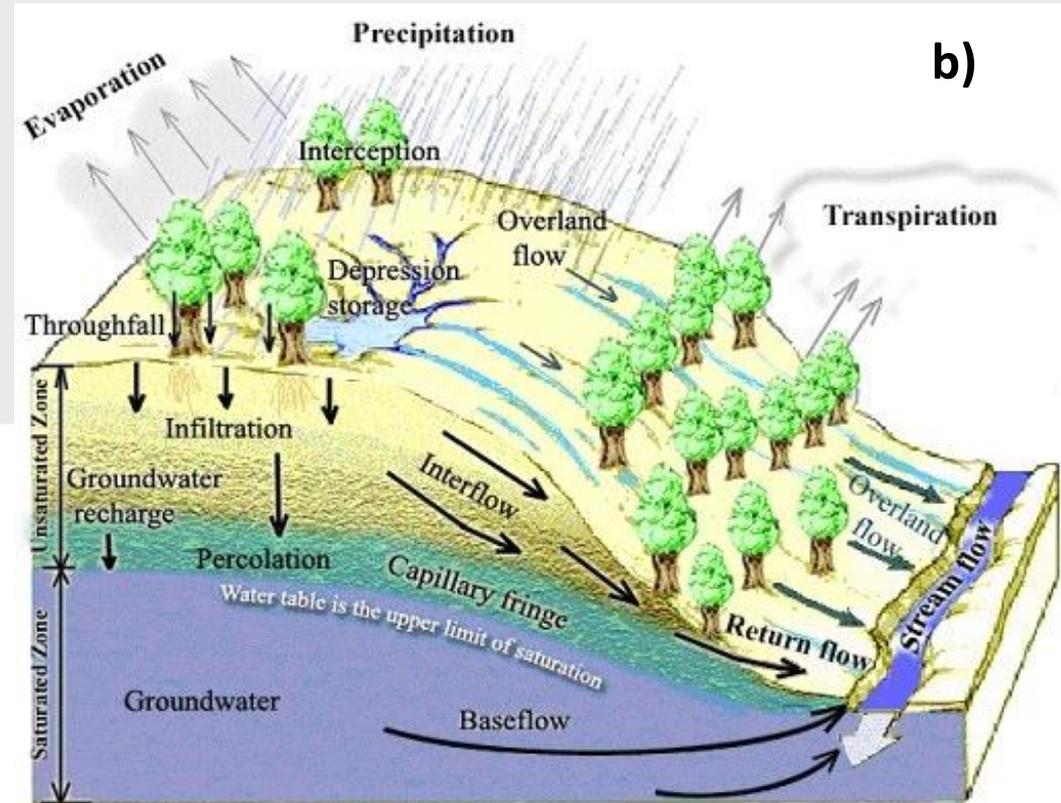
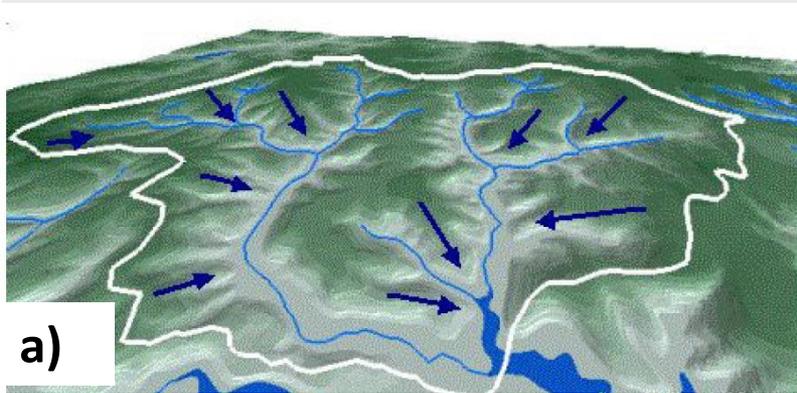
cima

Osservare per prevedere, prevedere per prevenire

Color me a watershed

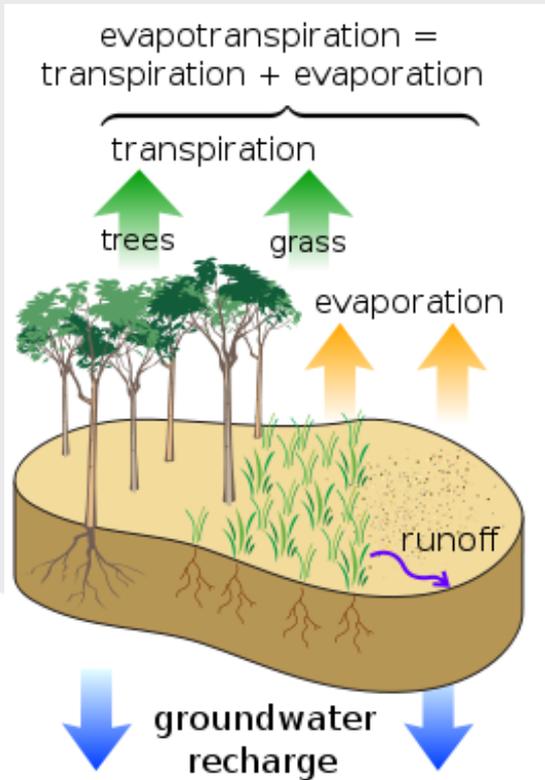
- understanding how floods form needs to know what a watershed is and how it works when rain comes
- size matters: floods in small and large basins have complete different characteristics
- population growth and settlement cause land-use changes.
- land-use variations in a watershed can affect surface-water runoff and flood frequency

Water cycle at catchment scale



Interception
Evapotranspiration
Infiltration
Surface runoff

Evapotranspiration



Sum of evaporation and plant transpiration from the earth's land surface to atmosphere.

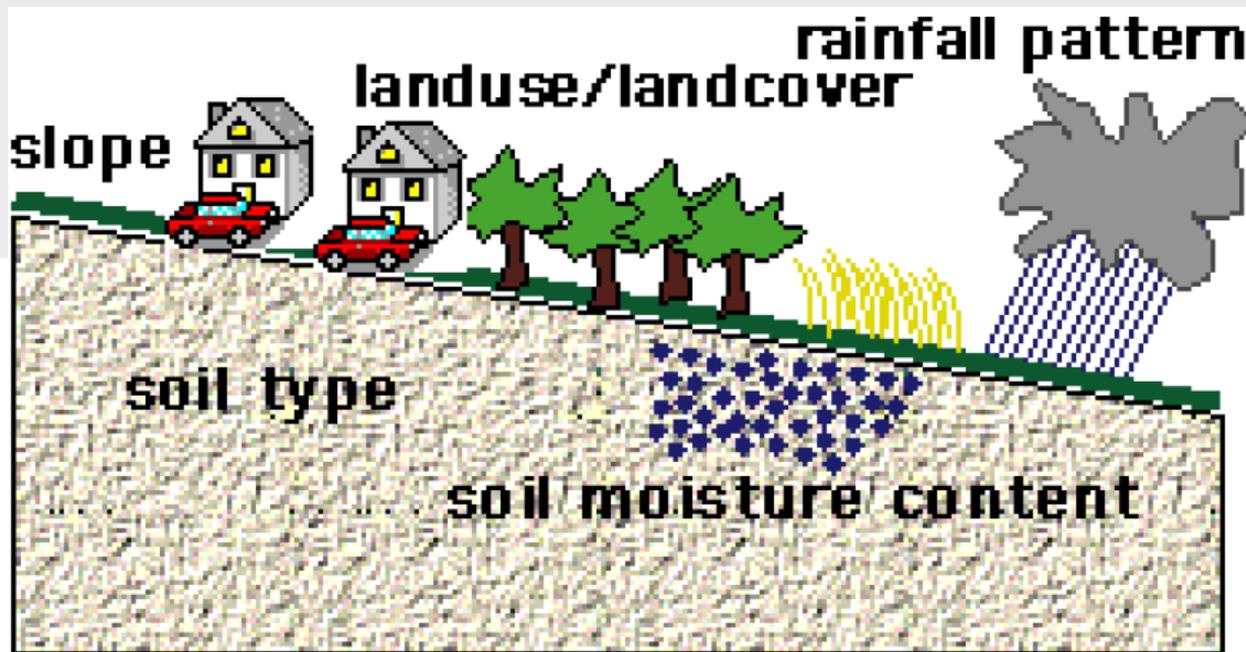
Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and water bodies.

Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves.

Is a function of the availability of energy and water in soil

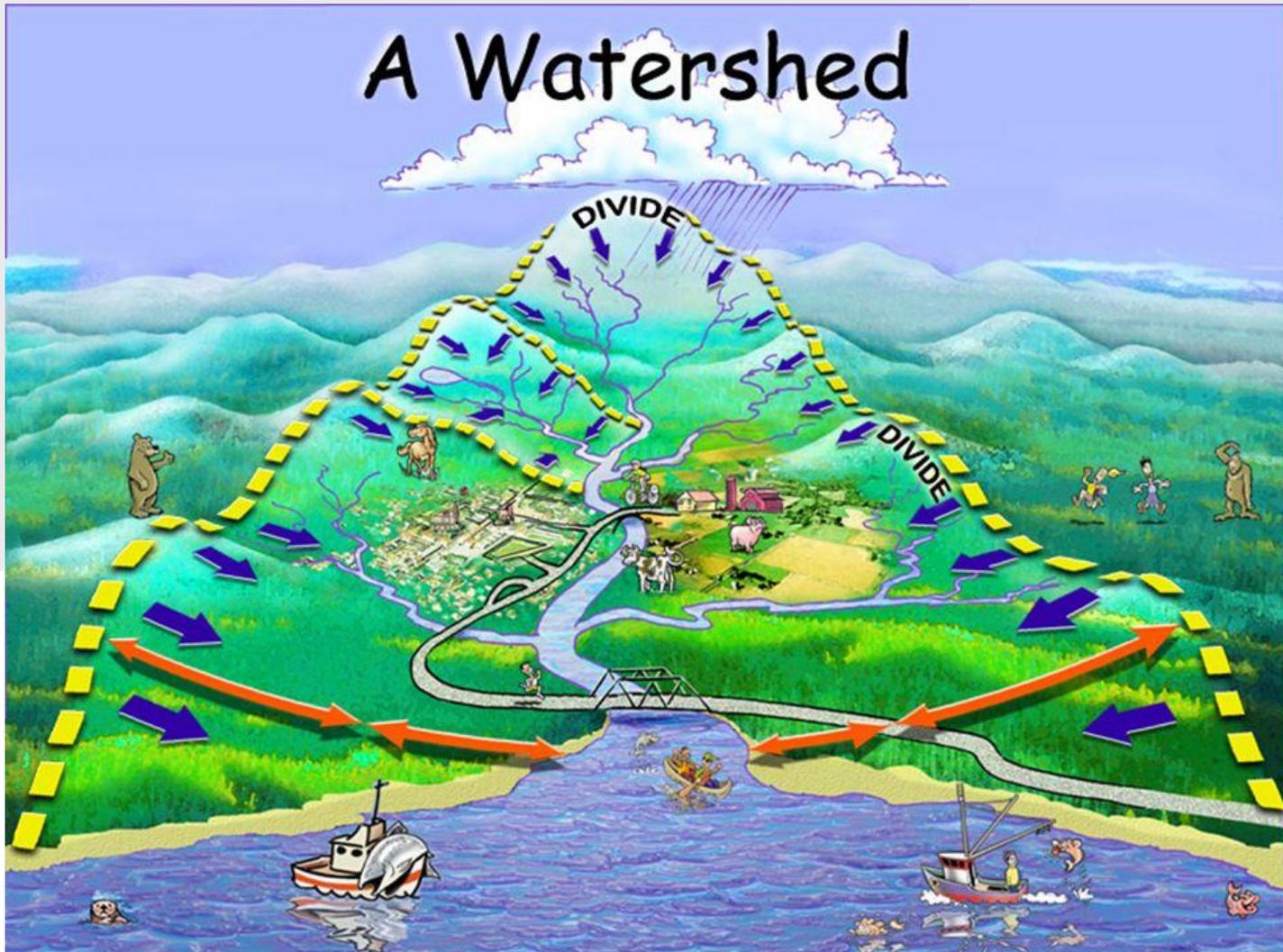
Infiltration

Is the process by which water on the ground surface enters the soil. Infiltration rate in soil science is a measure of the rate at which soil is able to absorb rainfall or irrigation. The rate decreases as the soil becomes “**saturated**”. If the precipitation rate exceeds the infiltration rate, runoff will usually occur unless there is some physical barrier.



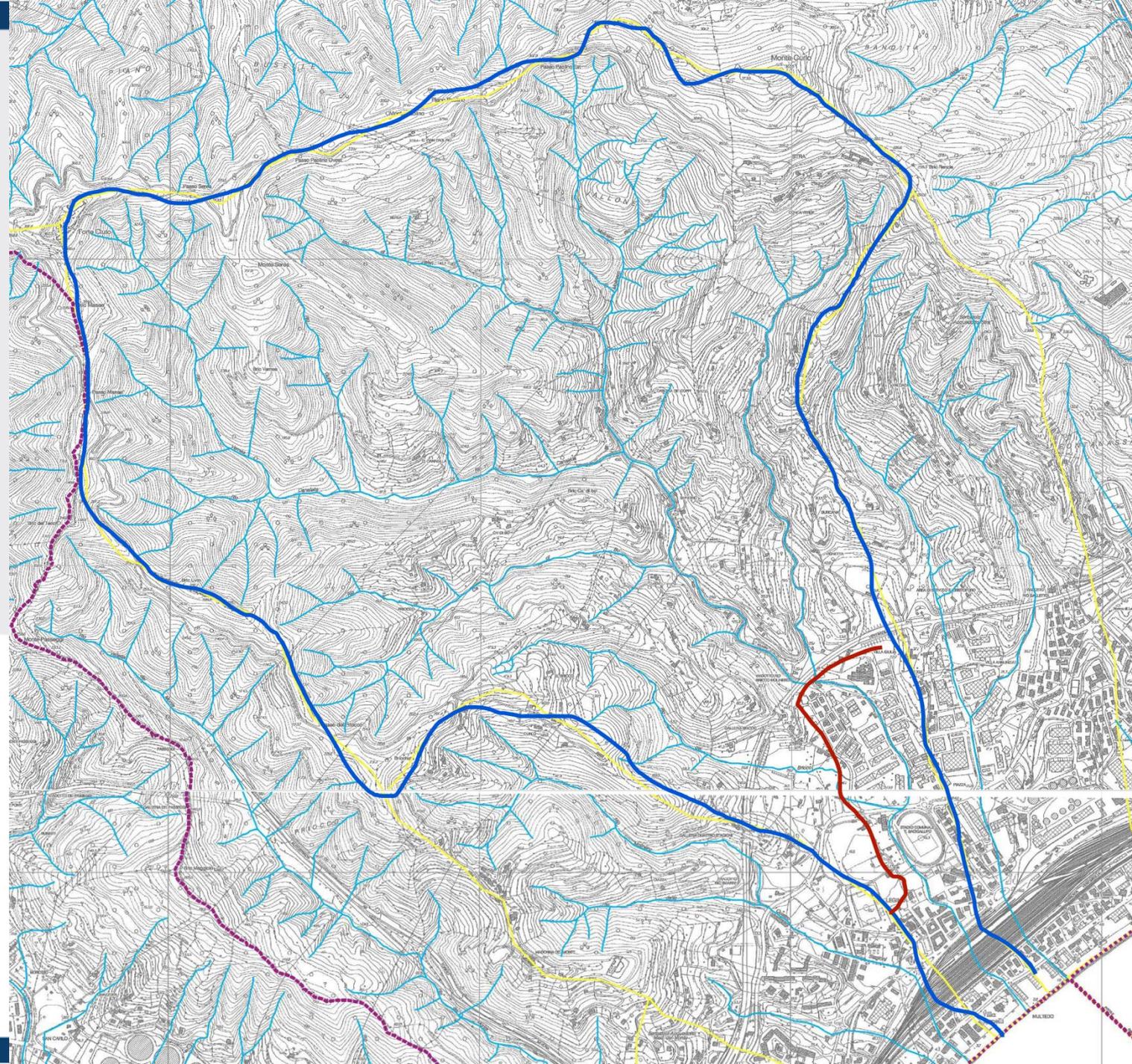
Major factors affecting infiltration

Where are the boundaries of a watershed?



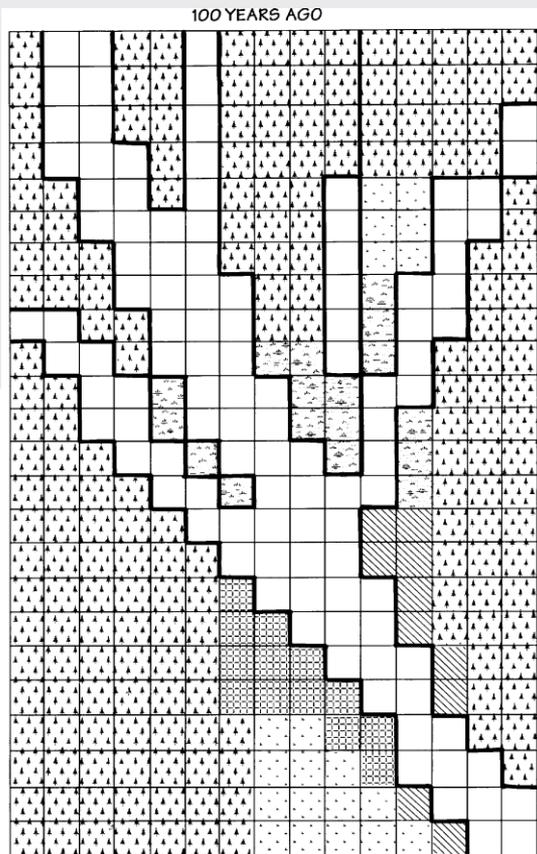
Credits: WATER Resources Mr. Manskopf , <http://slideplayer.com/slide/6458761/>

Observare per prevedere, prevedere per prevenire

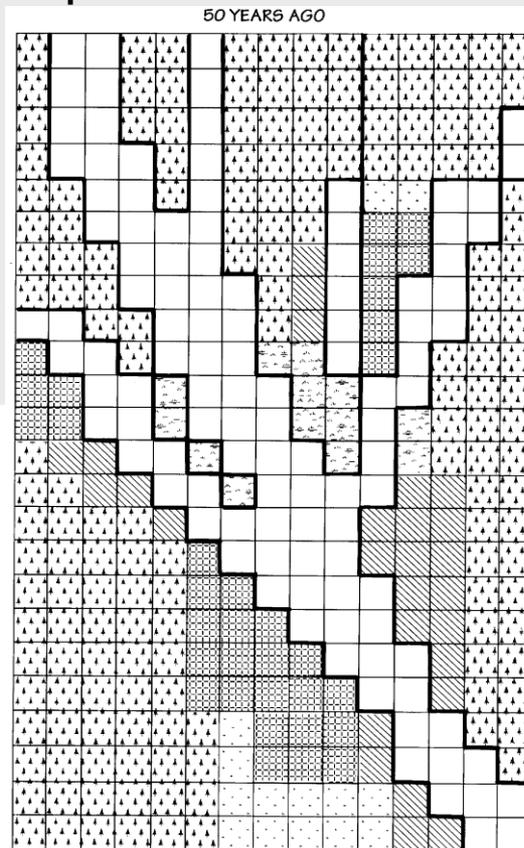


Evaluate runoff and land use changes effects

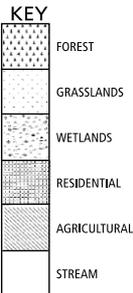
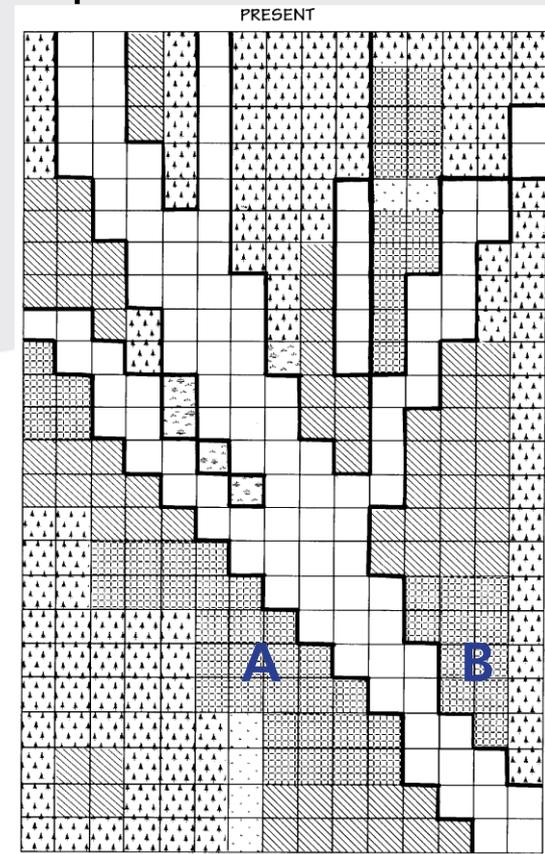
Map A



Map B



Map C



Name: _____ Date: _____

Chart for Option 2 AREA OF LAND COVERAGE

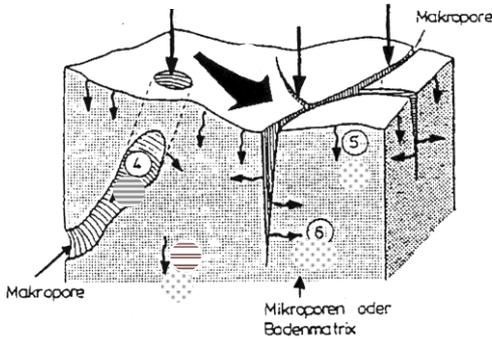
Land coverage	MAP A 100 yrs. ago		MAP B 50 yrs. ago		MAP C Present	
	km ²	%	km ²	%	km ²	%
Forest						
Grasslands						
Wetlands						
Residential						
Agricultural						
Stream						

Chart for Option 3 VOLUME OF RAIN AND VOLUME OF RUNOFF

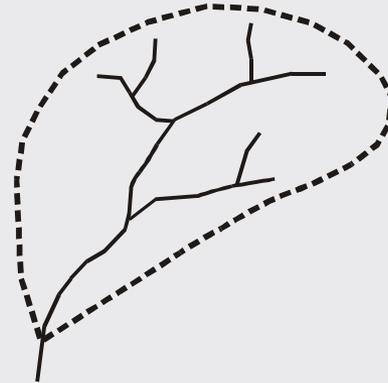
Land coverage and % runoff	MAP A 100 years ago		MAP B 50 years ago		MAP C Present	
	volume m ³	runoff m ³	volume m ³	runoff m ³	volume m ³	runoff m ³
Forest 20% runoff						
Grasslands 10% runoff						
Wetlands 5% runoff						
Residential 90% runoff						
Agricultural 30% runoff						
Total runoff						
Total runoff plus stream discharge (5,550,000 m ³)						

From runoff to floods

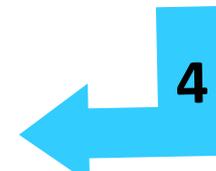
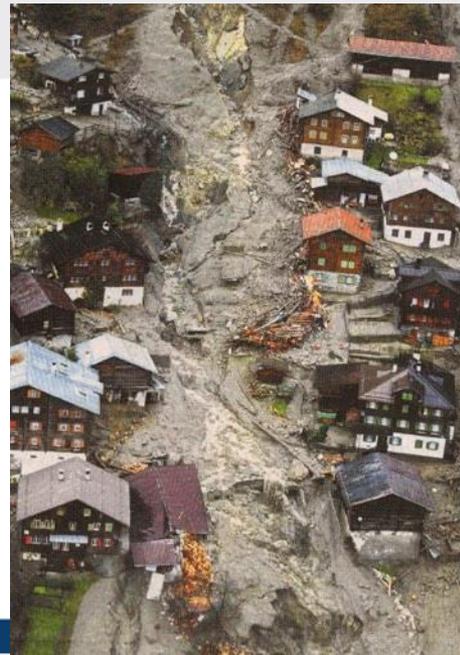
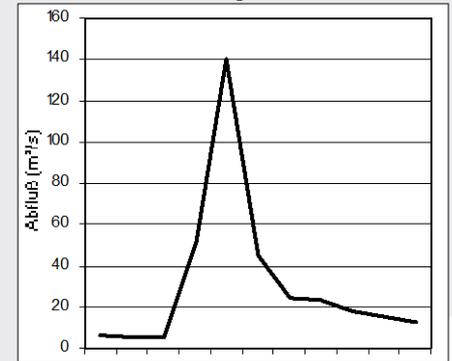
Precipitation



Catchment Runoff



Flood peak



Osservare per prevedere, prevedere per prevenire

Flash floods

22/09/1992 - 10.45



22/09/1992 - 15.30



22/09/1992 - 15.40



22/09/1992 - 15.45



Where we can expect a flood

- A floodplain offers enormous advantages for communities, although living in a floodplain exposes its occupants to flooding.
- History shows that absolute protection from flooding is neither technically feasible nor economically (or environmentally) viable.
- Any risk-reduction strategy—aimed at reducing flood damages through structural measures (such as flood embankments)—provides only partial protection for people inhabiting floodplains.
- Such measures, too often, offer a false sense of security
- Everyone living in a floodplain must be aware of the risks and be prepared for flood.
- **Flood-hazard and risk maps** are one tool to help achieve this.

Effects of land use: not only runoff



1840



1890



1940

Flood risk

Flood risk depends on

- ❑ Magnitude (flow speed, depth, extension, duration): HAZARD (H)
- ❑ Location, numerosity and value for different economic categories of exposed (E)
- ❑ Vulnerability (V) of the exposed elements (people, shops, roads, schools...)

... All these variables defines the risk in the most classical way....

$$R = H \times E \times V$$

Ask students which environment is more exposed to risk

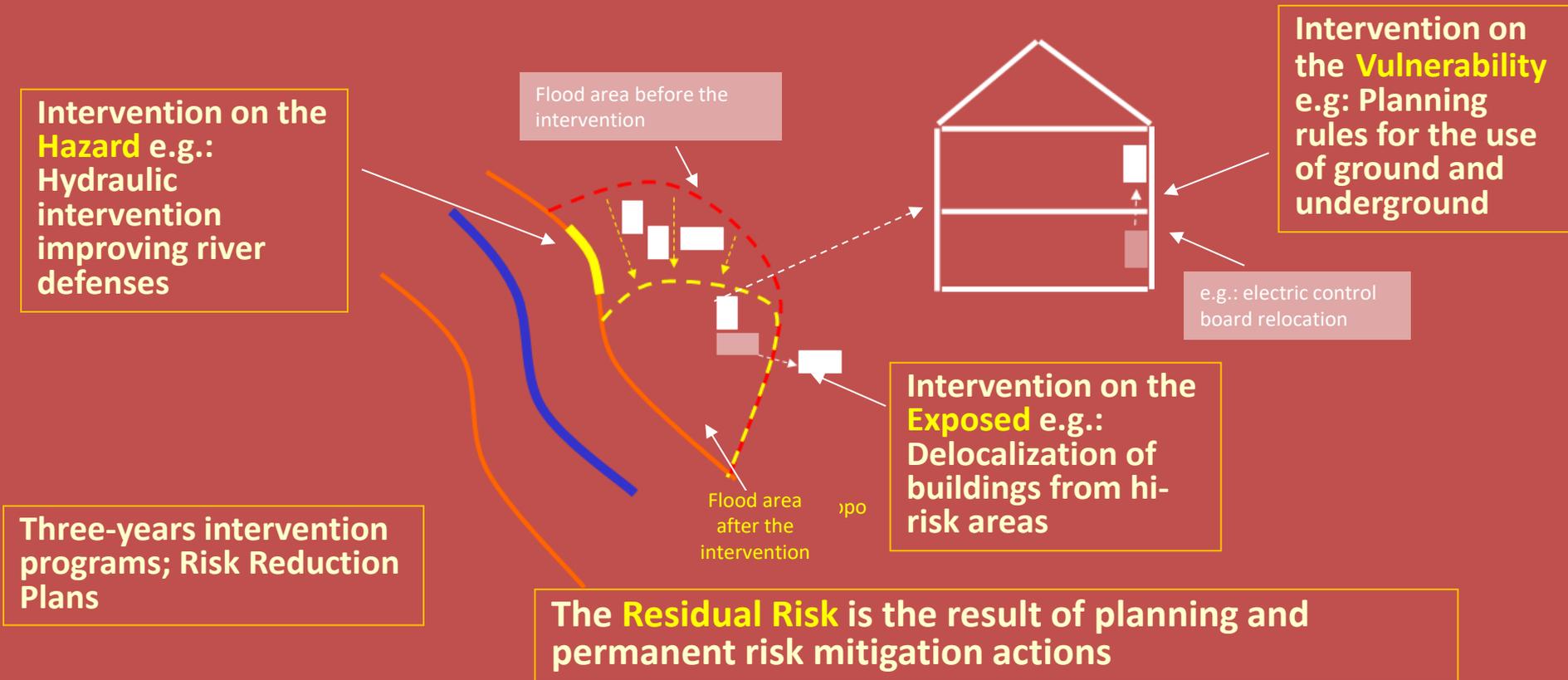
Right: Yellow River, China

*Below: River in northern
Canada*



©iStockphoto.com/wonganan

Risk assessment



Residual Risk (R_R) must be faced, if it realizes, with real time intervention by **Civil Protection**

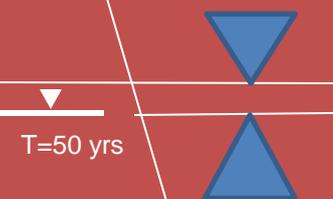
A simple example of Residual Risk



High vulnerability to Very frequent inundation (T=5-10 years)



Very low probabilities of rare events remain – Civil Protection warnings, insurance



Residual Risk

Local defense measure against flooding to reduce the inundation frequency

Drawing a risk map

- interview people about past floods
- look for past floodmarks
- go to the field with a map and try to draw areas where flood can occur
- identify other risks (landslides on hillslopes)
- identify infrastructures (hospital, schools, shops, ...)
- identify possible escape roads and safe places



During and after a flood

- we have seen as floods are “produced” and where they can hit
- it is important that everyone knows her/his “water address”
 - The likelihood their location (home but also school, workplace...) can be flooded. A person water address can change during the day!
 - timing: floods may come quickly on small creeks (flash floods) or take days (riverine floods)
- flash floods are hard to predict while riverine floods can be predicted days in advance
- once the water address is known, emergency plans must be drawn
 - for cities and neighbourhoods usually this is made by authorities -> be informed!
 - for your family is good to prepare a family emergency plan

Flood forecast

Precipitation



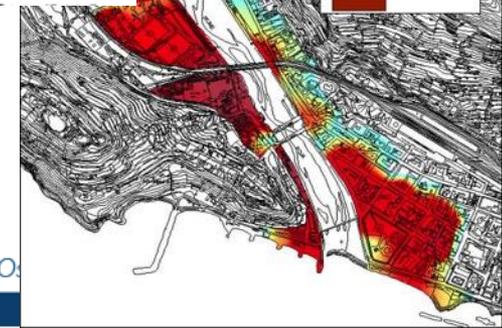
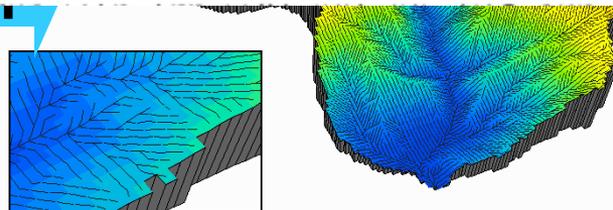
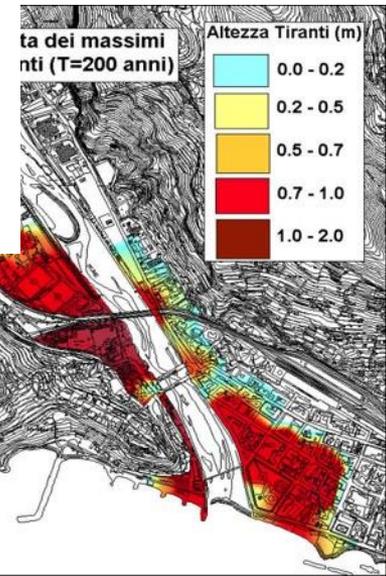
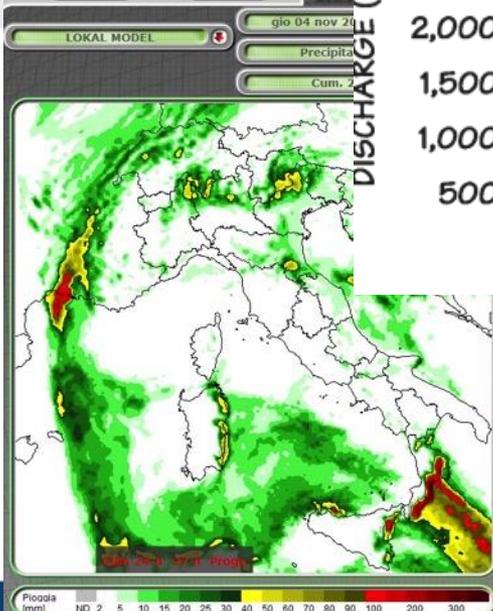
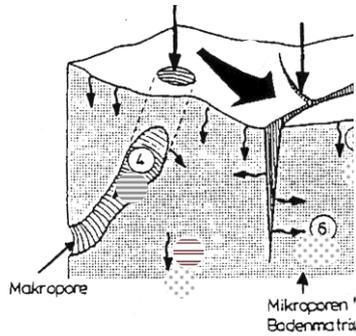
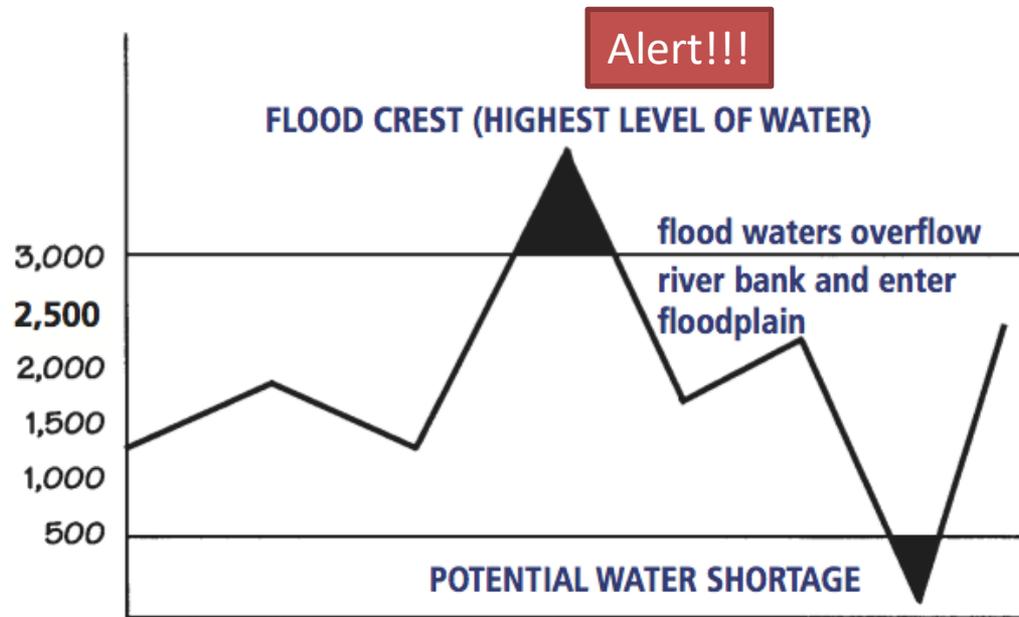
Catchment runoff



Flood



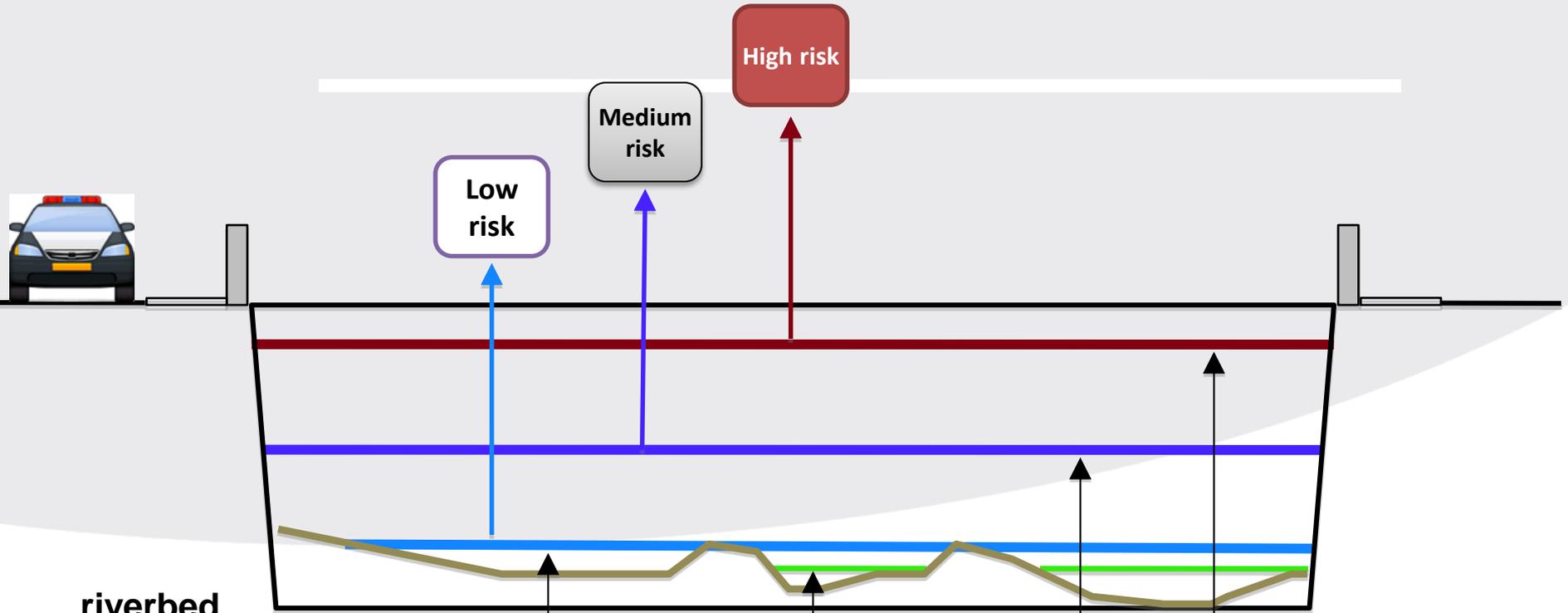
STREAM HYDROGRAPH FOR A HYPOTHETICAL RIVER



How to protect yourself if a flash flood comes

- know your “water address”
- monitor water level in rivers
- monitor water level and water speed on the roads
- have ready or know the action plan depending on where you are

Rivers

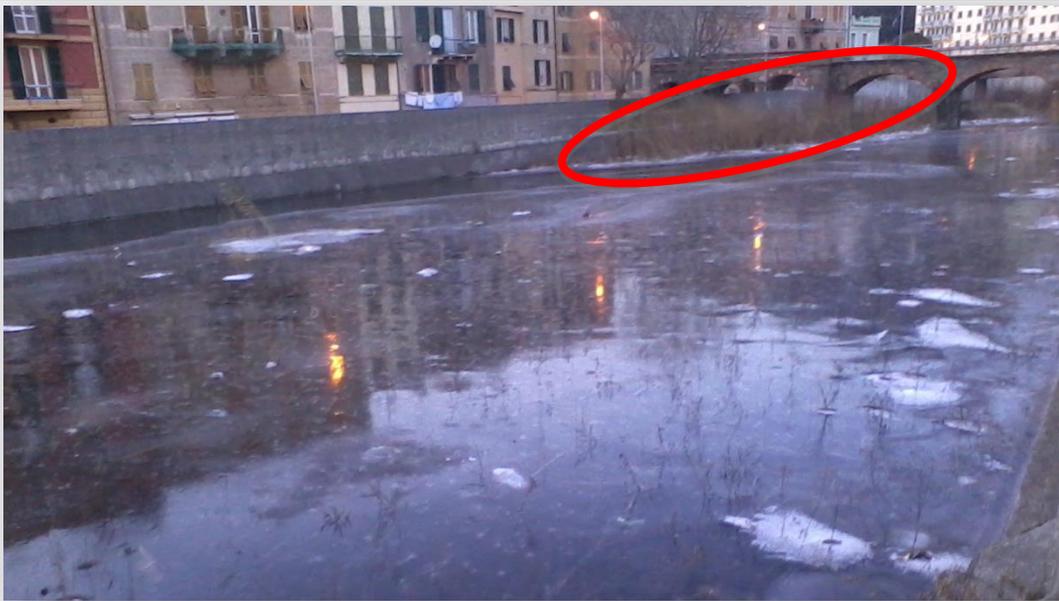


riverbed

f

-  Not critical
-  about 1/3 of the riverbed
-  about 1/2 of the riverbed
-  about 2/3 of the riverbed

Examples



**Low
risk**

Low flow



Examples

Medium
risk



**High
risk**

2/3 of the riverbed and
bridges



DANGER!!!



**A nearby river is
flowing out the
sewer system**



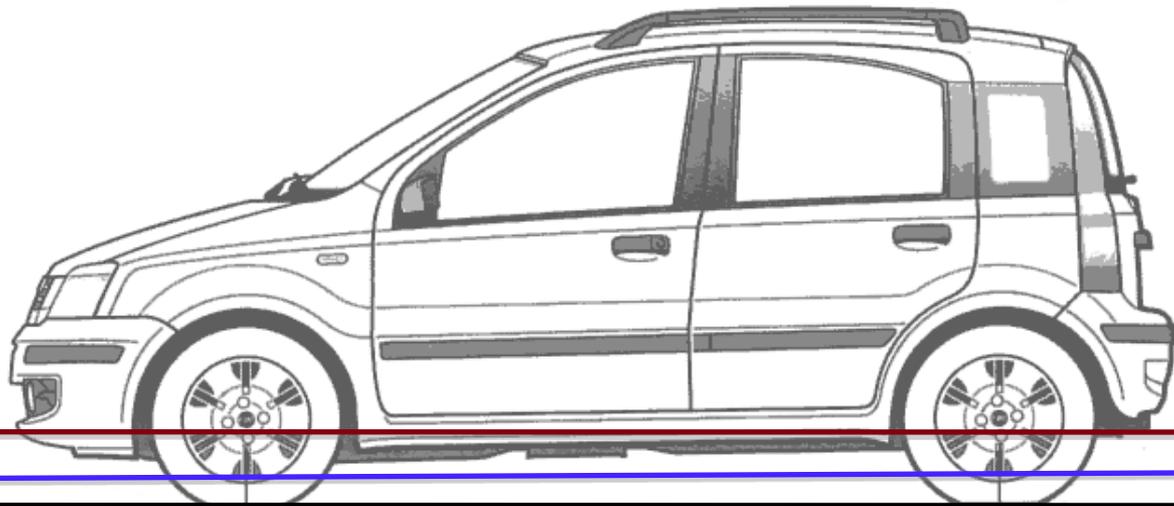
Osservare per prevedere, prevedere per prevenire

Water on the road

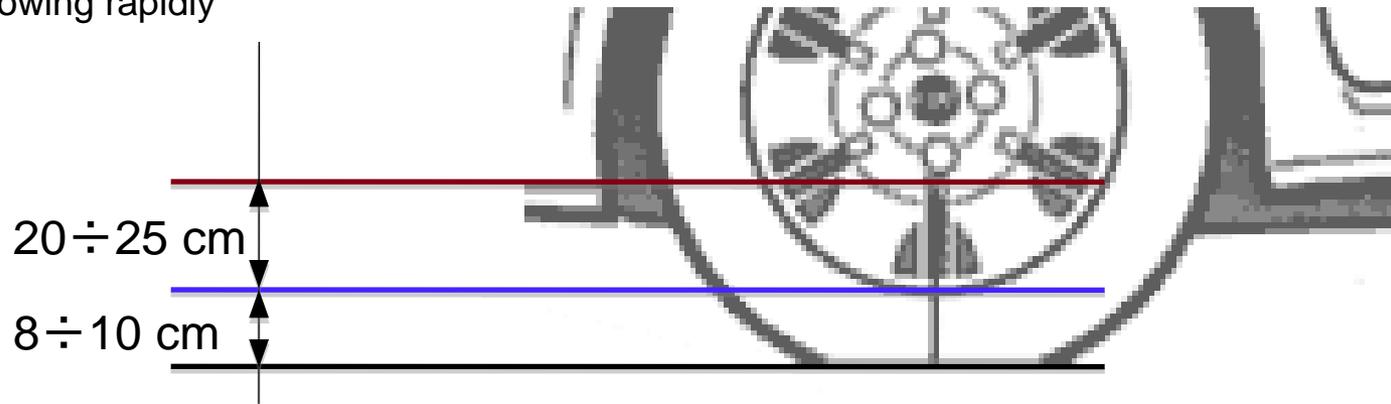
RISCHIO
ALTO

cars start to float!

MEDIUM
risk



water covering tires, flowing rapidly



Examples



Mediun
risk

Some ponding

water level cov





HIGH risk conditions



MONITORAGGIO CORPO FRANA



**RISCHIO
MEDIO**

Modesta presenza di
acque di ruscellamento

Copiosa presenza di
acque di ruscellamento
e segni di erosione e
movimento

Movimento di terreno,
distacchi o
interessamento della
sede stradale



**RISCHIO
ALTO**



PERICOLO

Osservare per prevedere, prevedere per prevenire

Family action plan

An Action Pack could include:

- Containers of water—drinking water may be polluted.
- Flashlight with batteries—electrical power may be out.
- Battery-powered or hand-crank radio to hear flood warnings and updates.
- Batteries—to power the radio and flashlight.
- First Aid kit—for minor scratches/injuries.
- Rain gear—protection in a storm.
- Canned food—fresh food may be contaminated by flood waters.
- Can opener—to open canned food.
- Emergency cooking supplies—power to cook may be unavailable.
- Pet food, water—pets need basic essentials, too.
- Medicine/prescriptions—anything you need to stay healthy.
- Emergency phone numbers—to call for help if you become separated from your family.

A Family Action Plan could include the following points:

- Prepare an Action Pack (or emergency supply kit).
- Put special treasures and memorabilia in a waterproof container.
- Plan how you will secure your home; moving furniture and appliances to the second floor, also any chemical agents, paints, etc. You must shut off electricity, gas and water, and if possible hermetically seal sewage installations.
- Know where to go and where your family will meet.
- Know evacuation routes to safety, either to higher, stable ground or away from the flood area.
- Know how to stay in contact with family if separated.
- Have pets and personal items ready, so you can evacuate immediately.
- Know where you will store farm machinery, cars, etc. and where you will keep livestock.

- Listen to flood watches and warnings on the radio, television and Internet. Follow instructions.
- Make those around you aware of a possible flood.
- When you are away on vacation, be aware of your surroundings.
- Pay attention to the weather and think about how a flood could affect you and your activities.
- Stay away from rushing water, storm drains and rising rivers.
- Stay out of flood water.
- Never drive through flood water in a vehicle.
- Understand weather patterns in your area.



Course material and references

Discover FLOODS – Kids in Discover Series - Joint development of WMO and “Project WET: Water Education for Teachers”. In English

http://www.apfm.info/education/kids/WET_Discover_Floods_KIDs.pdf

Discover FLOODS – Educators Guide - Joint development of WMO and “Project WET: Water Education for Teachers”

http://www.apfm.info/education/kids/WET_Discover_Floods_Ed_Guide.pdf

READY FLOODS – Kids in Discover Series - Developed by U.S. FEMA – In Spanish

<http://www.ready.gov/kids/know-the-facts/floods>