Topic 8: Water and Climate

Topic 8 Section 1

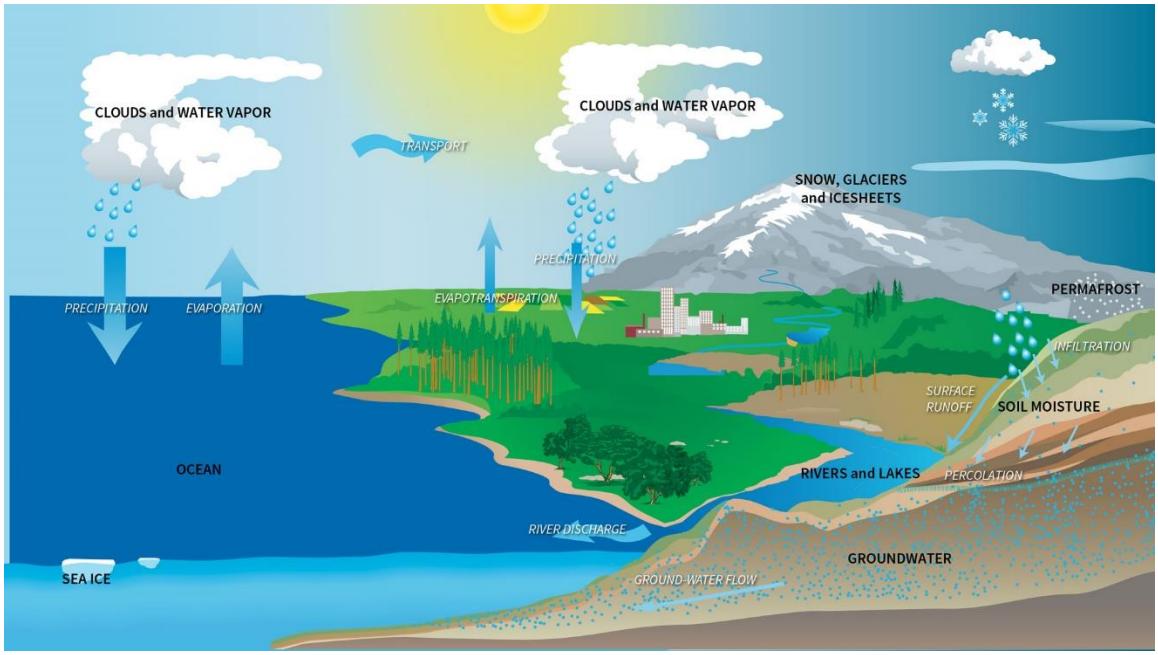
Overview: remember that weather studies short-term events. Climate studies long-term events over decades, centuries, or even millennia. Climate affects landscapes, plants, animals, and erosion. Availability of water is one of the biggest factors affecting climate.

The water (or *hydrologic*) cycle – model that shows movement of water near Earth's surface

The hydrologic cycle is fueled by insolation

Energy changes liquid or solid water into vapor, condensation results in precipitation, gravity causes precipitation and water at or near the surface to move to oceans

Earth recycles its water supply



Earth's water supply:

97% – ocean or salt water

2.8% – fresh water

2.2% – icecaps and glaciers

0.6% – subsurface (mostly ground water)

0.02% – surface water (lakes, streams, inland seas)

0.0001% – atmospheric

Four things can happen to precipitation that falls on land:

- retention – stored as ice, snow, or in leaves of plants and trees
- infiltration – seeps into upper parts of Earth's lithosphere, becomes *subsurface* water
- runoff – flows over Earth's surface, runoff accounts for ⅓ of precipitation
- evapotranspiration – evaporation and transpiration account for about ⅔ of precipitation

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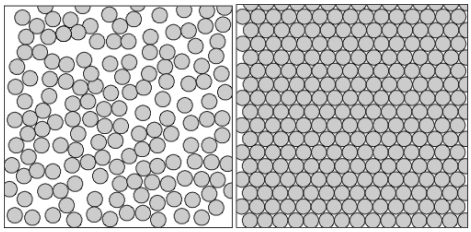
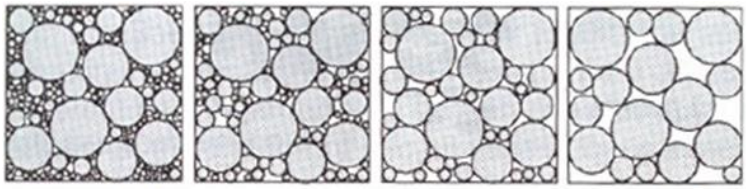
Factors affecting infiltration:

- slope (*gradient* of Earth's surface) – steeper slopes allow less seepage or infiltration
- saturation – surface water will infiltrate the zone of aeration to the zone of saturation
  water table the boundary between the zone of aeration and the zone of saturation
  ground water – water below the water table
  higher rates of infiltration raise the water table
  wells and springs tend to lower the water table
- porosity – percentage of open space in loose material compared to the total volume
  shape – well rounded particles have more porosity than angular particles

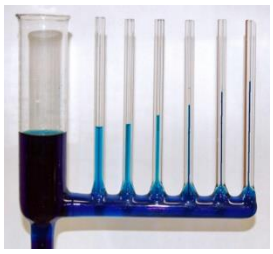
  packing – closer packing reduces porosity – packing results from constant travel over land



  sorting – sorted material has higher porosity than unsorted material



- permeability – ability of a material to allow water to flow through, large particle size increases permeability
- Capillarity – cohesive and adhesive forces (IMFs) can stop the downward movement of water in the zone of aeration, small pore size increases capillarity



- vegetation – plants slow precipitation and store some water above the surface allowing more time for infiltration
- land use – roads, parking lots, and buildings are impermeable and often shunt runoff into drainage pipes or streams reducing seepage – farming cuts trees, reduces plant life, and grazing and tractors increase compaction decreasing permeability

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Factors affecting runoff and stream discharge

Stream discharge – the volume of water passing a specific point in a stream in a specific amount of time – usually cubic meters / second or liters / second

Since most runoff enters streams, runoff is directly related to stream discharge

Surface runoff occurs when:

- rate of precipitation exceeds permeability (or infiltration) rate
- the pore space of a material is already saturated with water
- the slope or gradient is too steep for infiltration to occur
- water on the surface has not yet evaporated or sublimated

Flooding

Occurs when a stream overflows its normal channel, when water is not able to infiltrate fast enough, or when water is unable to move to a stream quickly enough

The first rule of safety in dealing with flooding is to move to higher ground

Many communities have planned escape routes based on topographic maps or other elevation models

Topic 8 Section 2

Climate – overall view of a region's weather conditions over a long period of time (tens to thousands of years)

Climate includes extremes like number of hurricanes and number of days with hail damage

Two major aspects of climate are temperature and moisture

In terms of climate, the two important aspects of temperature are:

- average yearly temperature
- range of average monthly temperatures or the *annual temperature range*

Annual temperature range is the difference between the month with the highest average temperature and the month with the lowest average temperature

In terms of climate and moisture:

- dry or arid climates have an average yearly potential evapotranspiration greater than the average yearly precipitation
- wet climates have an average yearly potential evapotranspiration lower than the average yearly precipitation

Temperature is determined by insolation

Potential evapotranspiration is determined largely by available energy or temperature

Temperature is determined by insolation

Insolation has two main factors:

- insolation increases as latitude decreases (nears the equator)
- insolation increases as elevation increases

Why? There is less air to filter insolation at high elevation

Whether a climate is arid or wet does not depend on the amount of precipitation, but rather on the difference between the amount of precipitation and the amount of water lost by evaporation and the rate of evaporation depends on temperature

Factors affecting climate:

- latitude
- planetary wind and pressure belts
- oceans and other large bodies of water
- ocean currents
- elevation
- mountains
- amount of cloud cover
- vegetation

Usually many factors interact to determine the type of climate for a given region

Latitude is a major factor for determining climate because latitude affects both temperature and moisture

Latitude and temperature

What is the relationship between latitude and temperature?

Angle of insolation increases as latitude increases and so temperatures decrease

Duration of insolation near the equator is always 12 hours per day but as latitude increases, duration of insolation varies widely with the season (0 to 24 hours per day above the Arctic Circle)

Duration is compounded by angle at high latitudes because the highest angles occur at the time of longest duration resulting in a large annual temperature range

Latitude divides the Earth into climate zones:

- tropical climate (0° to 30°) no winter
- mid-latitude climate (30° to 60°) 4 seasons
- polar climate (60° to 90°) no summer

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Latitude and moisture
Moisture varies with latitude due to the planetary wind and pressure belts
Rising air (0° and 60°) cools resulting in high precipitation and wet climates
Falling air (30° and 90°) warms reducing relative humidity causing dry climates

Large bodies of water
Large bodies of water modify climate by reducing the annual temperature range
Why? Water has a very high specific heat
This effect is increased if winds blow off the water toward the land most of the time
Areas near large bodies of water have *marine climates* (m)
Land masses far from water have *continental climates* (c)

Prevailing winds
Prevailing winds are the result of air pressure differences caused by uneven heating of Earth by the Sun and the Coriolis effect
Most of the year, the US experiences a SW prevailing wind
The west coast has maritime climate
The rest of the nation has continental climate
New York State
Most of the state has continental climate
NYC, Buffalo, and Watertown have maritime climates
Why? NYC is on the ocean, Buffalo and Watertown are downwind of a Great Lake
Tug Hill region gets higher rainfall and more snow because of the maritime effects of Lake Ontario
Prevailing SW winds cause weather to 'track' in a NE direction except in winter when axial tilt allows polar winds
Monsoons – weather changes caused by the seasonal shifts in the direction of prevailing winds
Axial tilt and revolution about the Sun cause variation in the angle of incidence which results in a latitudinal shift in the planetary wind belts

Surface ocean currents
Planetary winds cause surface ocean currents which form a *gyre* or circular movement of surface water in the oceans that are bounded by continents
Currents that bring cooler water from polar regions will have a cooling effect
Examples: the California coast is cooled by the California Current from Alaska while NYC is warmed by the Gulf Stream Current
The Gulf Stream Current is responsible for the moderate, warmer, and moist conditions of most of the British Isles

Elevation
Rising air cools making higher elevations experience cooler temperatures
The cooling of rising air also results in increased precipitation
There are less greenhouse gases at higher elevations which also has a cooling effect

Mountains
Orographic lifting causes:
- windward sides of mountains to experience cooler, moister climate
- leeward sides of mountains to experience warmer, arid climate

Mountains also act as barriers to air masses

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Vegetation
- Most of us understand that climate will affect the amount and types of vegetation but vegetation also affects climate
  - If tropical rain forests are cut down, *deforestation occurs*, then the climate will become less humid and hotter
    - The humidity is less because there is less transpiration
      - The decrease in transpiration reduces humidity which reduces precipitation
      - Deforestation increases runoff (which decreases available water)
    - Temperatures increase because transpiration requires energy
      - Less vegetation allows the land to heat faster which increases air temperature
  - Urbanization (building cities) reduces vegetation which has the same effect as deforestation

Cloud cover
- Clouds block insolation and reflect it back into space
  - Most people think the hottest regions on Earth are near the equator, but the high moisture content there creates a lot of cloud cover which reduces the temperature
  - Desert regions at or around 30° are dry with few clouds and are often hotter than regions nearer to the equator

Climatic change
- Ice ages in the past are clear indicators that the climate changes periodically
- Factors that can affect climate change
  - global warming
  - El Niño
  - the greenhouse effect
  - the ozone hole problem
  - volcanic ash