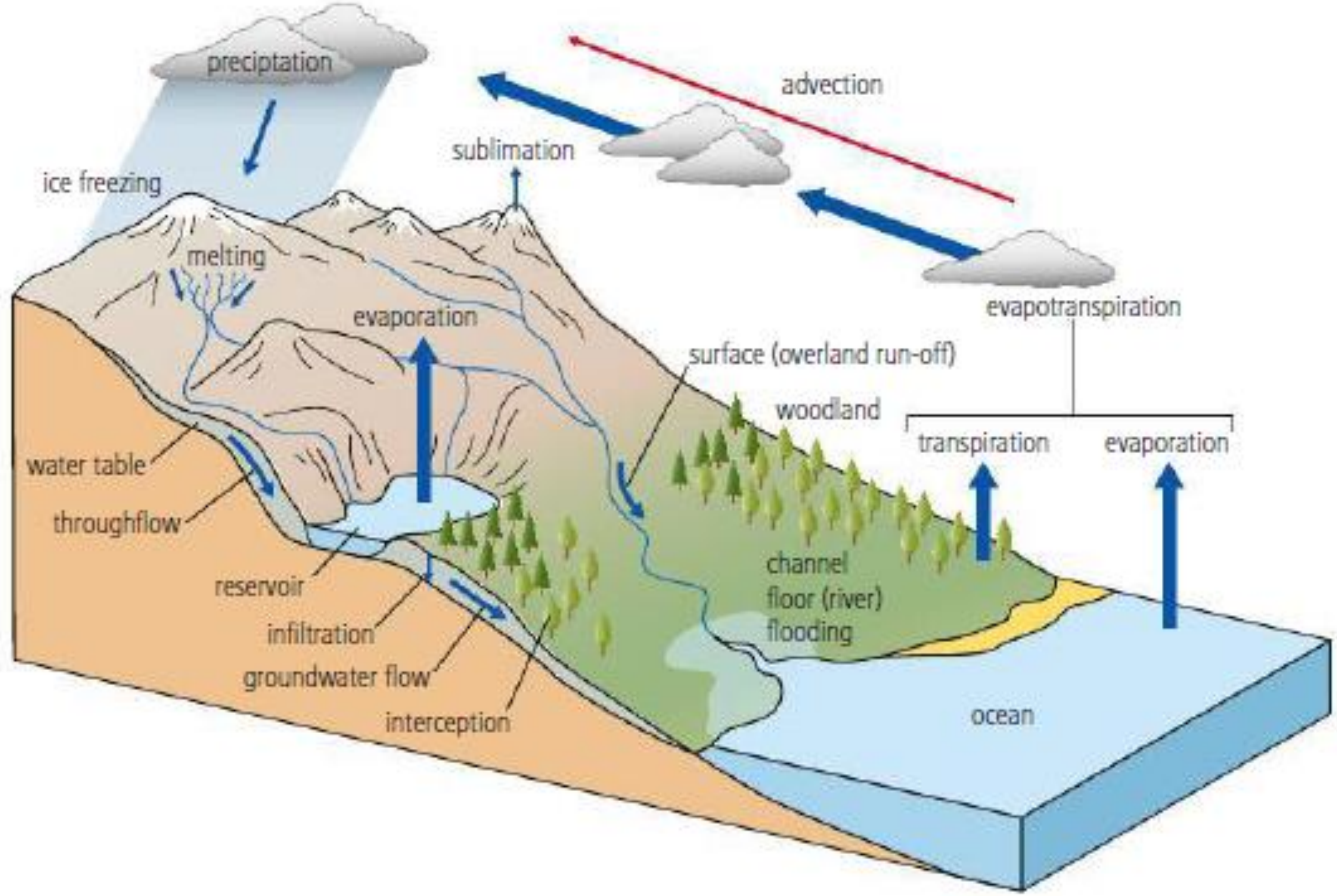
Introduction to water systems

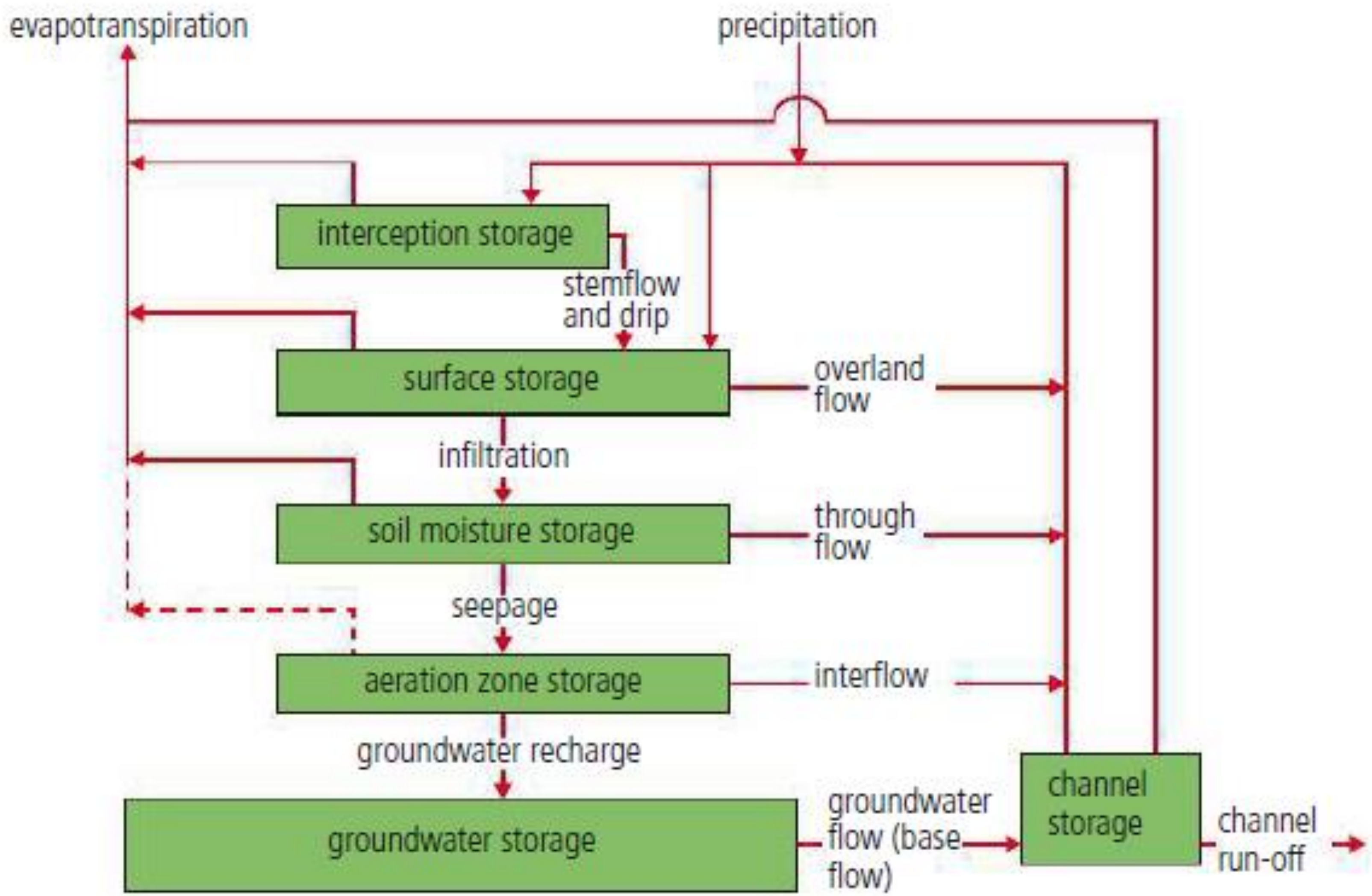
Significant ideas

The hydrological cycle is a system of **stores** and **flows** that can be easily disrupted by human activities.

The ocean circulatory system influences global climates by transporting water and energy around the Earth.


preciptation
advection
sublimation
ice freezing
melting
evaporation
evapotranspiration
surface (overland run-off)
woodland
transpiration
evaporation
water table
throughflow
reservoir
infiltration
groundwater flow
interception
channel
floor (river)
flooding
ocean

Solar radiation drives the hydrological cycle.

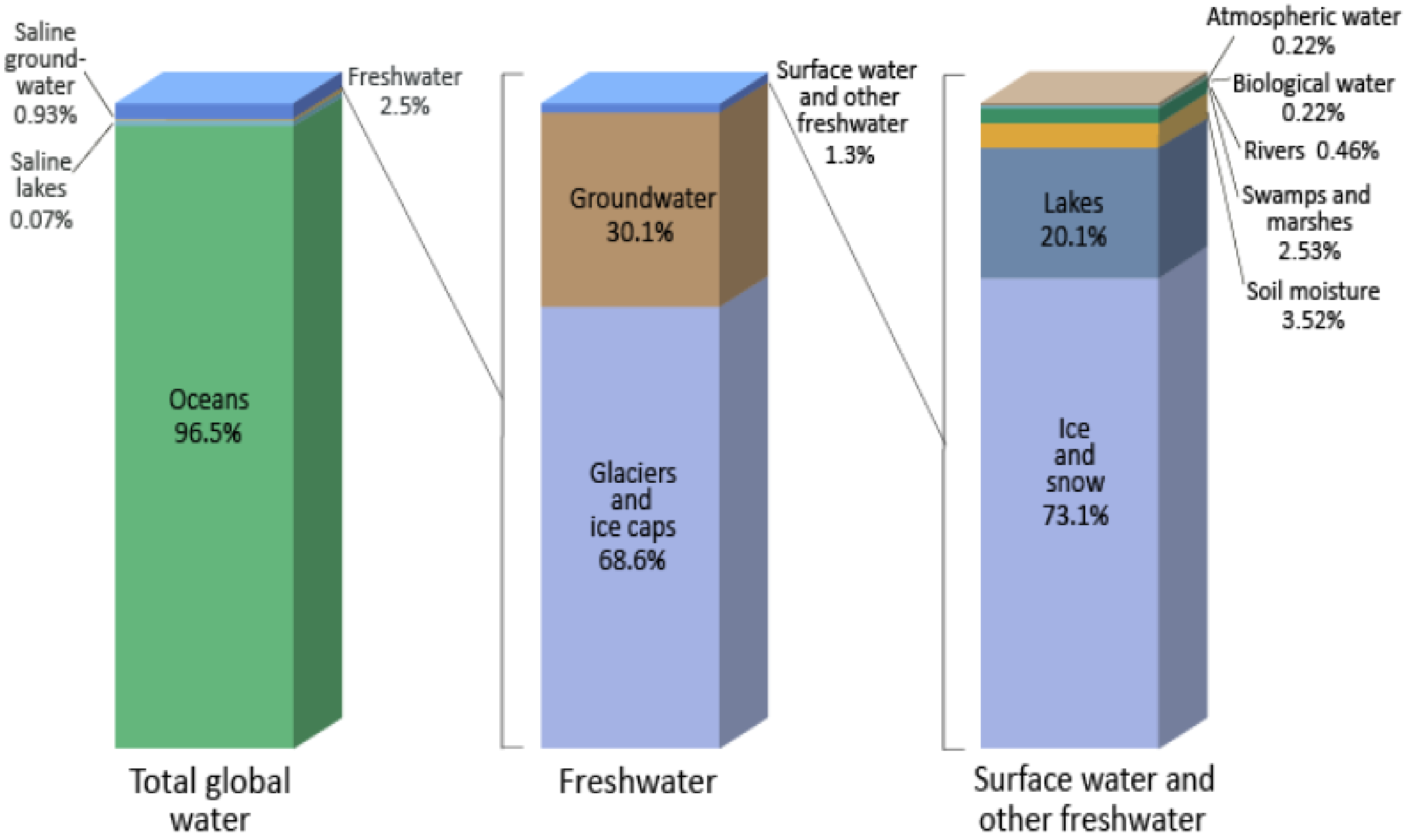


Of the fresh water, around 70 per cent is in the form of ice caps and glaciers, around 30 per cent is groundwater.

Only a small fraction (approximately 2.5 per cent by volume) of the Earth's water storages is fresh water.

Reservoir		Thousands of cubic kilometres	% of total
ocean		1 350 000	97.403
atmosphere		13.0	0.000 94
land		35 977.8	2.596
of which	in rivers	1.7	0.000 12
	in freshwater lakes	100.0	0.007 2
	in inland seas	105.0	0.007 6
	in soil water	70.0	0.005 1
	in groundwater	8 200.0	0.592
	in ice caps/glaciers	27 500.0	1.984
	in biota	1.1	0.000 88

Distribution of Earth's Water



The time for a water molecule enter and leave a part of the system is called **turnover time**.

Is water renewable?

The degree to which water can be seen as a renewable or non-renewable resource depends on where it is found in the hydrological cycle.

Renewable water resources are waters that are recycled yearly or more frequently in the Earth’s water turnover processes.

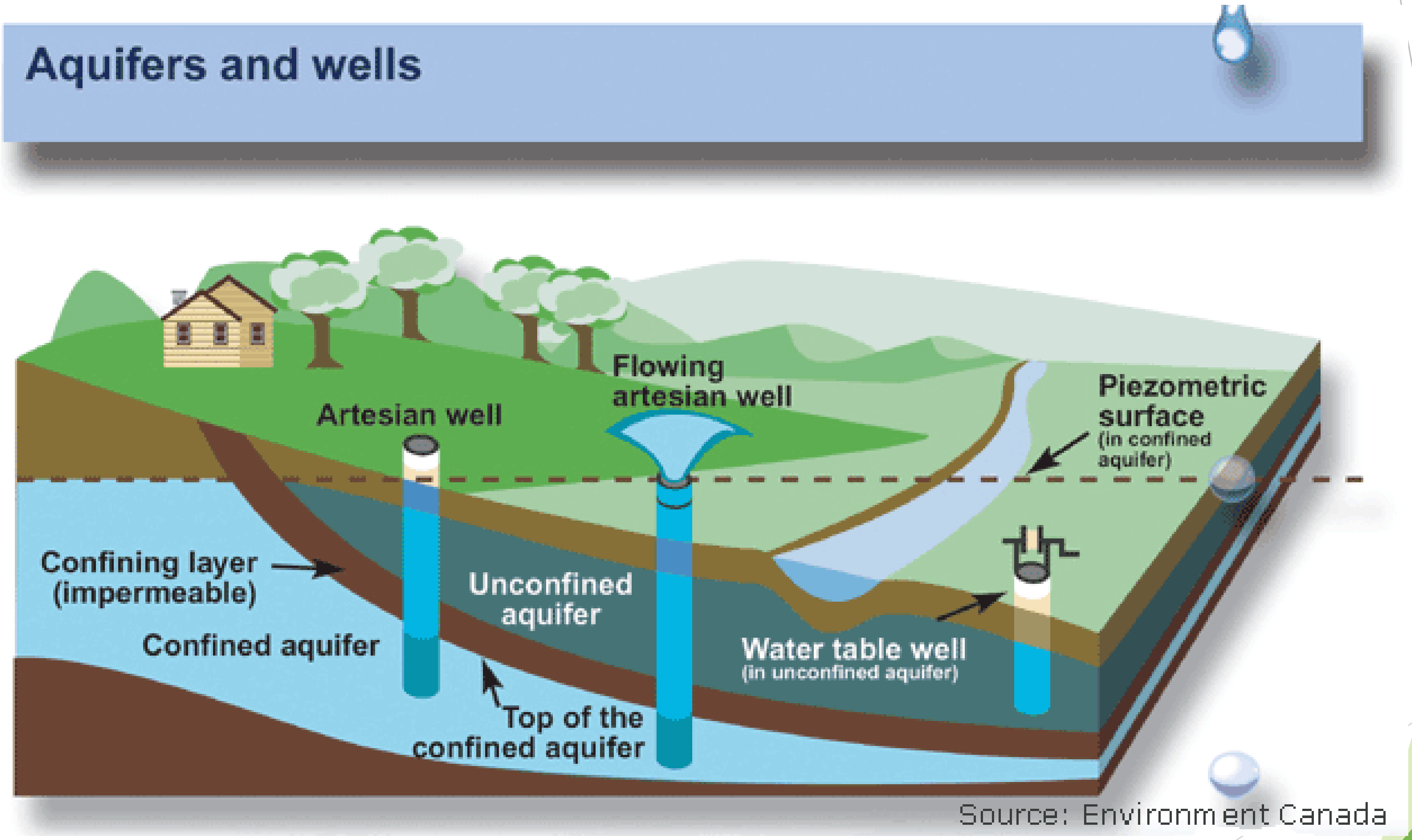
Groundwater is a non-renewable source of water as turnover time is very long.

Turnover time

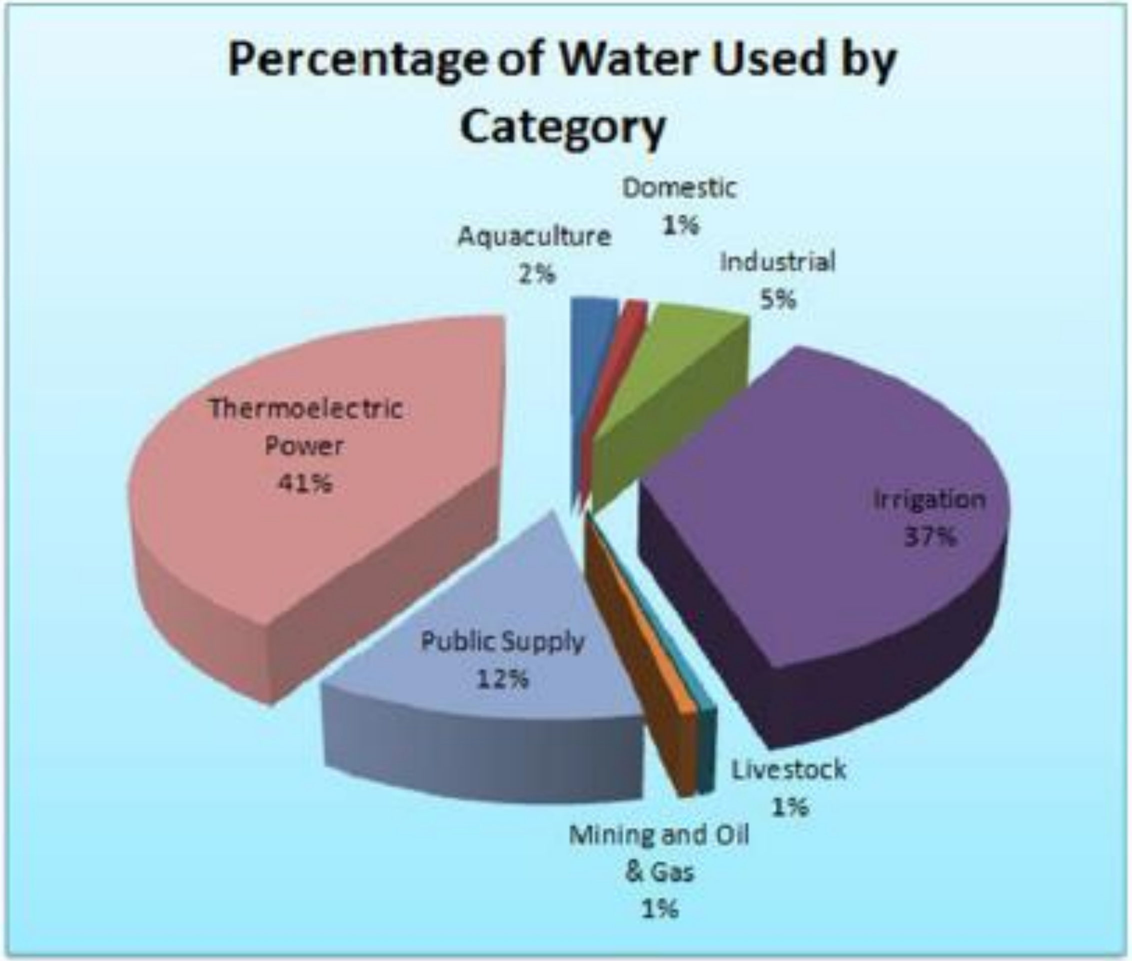
Water location	Turnover time
polar ice caps	10 000 years
ice in the permafrost	10 000 years
oceans	2 500 years
groundwater	1 500 years
mountain glaciers	1 500 years
large lakes	17 years
bogs	5 years
upper soil moisture	1 year
atmospheric moisture	12 days
rivers	16 days
biological water	a few hours

Aquifer

An underground formation of permeable rock or loose material which stores groundwater. They can produce useful quantities of water when tapped by wells and come in all sizes. Aquifers may be only a few metres thick, or they may measure hundreds of metres from top to bottom. Unsustainable use of aquifers results in depleting the storage and has unfavourable consequences. Restoration requires tens to hundreds of years.


Aquifers and wells
Flowing artesian well
Artesian well
Piezometric surface
(in confined aquifer)
Confining layer (impermeable)
Unconfined aquifer
Confined aquifer
Water table well
(in unconfined aquifer)
Top of the confined aquifer
Source: Environment Canada

Too Little Freshwater



Discuss human impact on the hydrological cycle.

1. Withdrawals
   - Domestic use, irrigation and industry
2. Discharges
   - Adding pollutants – sewage/fertilisers
3. Changing flow speed
   - Rivers are channelled underground
   - Canalising (straightening large sections)
   - Dams/barrages/dykes
4. Diverting rivers
   - Away from important areas to avoid flood damage
   - Towards dams to improve storage

The effect of urbanization on water systems

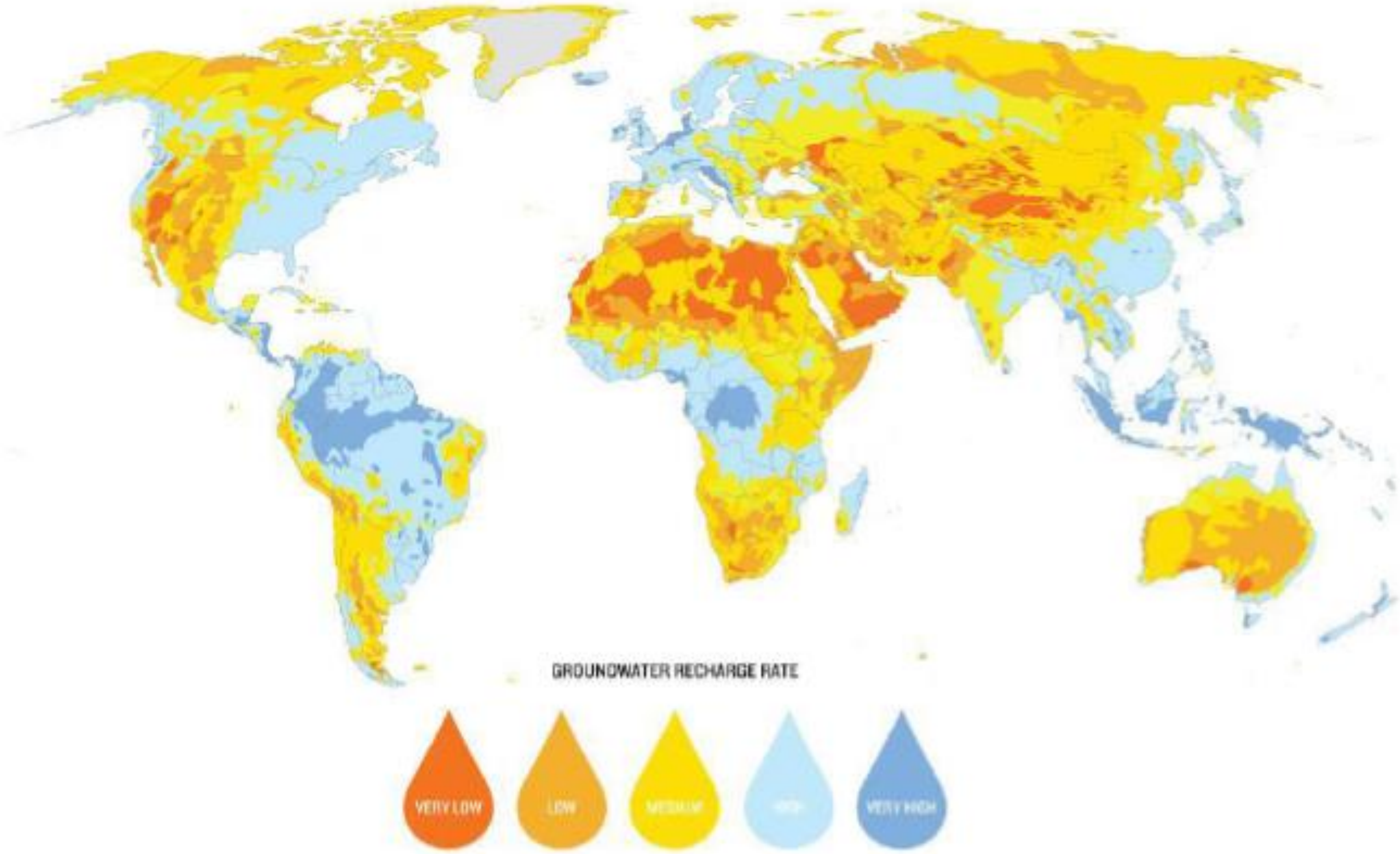
Type of surface	Impermeability / %
water-tight roof surfaces	70–95
asphalt paving in good order	85–90
stone, brick and wooden block pavements: with tightly cemented joints with open or uncertain joints	 75–85 50–70
inferior block pavements with open joints	40–50
tarmacadam roads and paths	25–60
gravel roads and paths	15–30
unpaved surfaces, railway yards, vacant land	10–30
parks, gardens, lawns, meadows – depending on the surface slope and character of the sub-soil	5–25

The result of urbanization	Potential hydrological response
removal of trees and vegetation	• decreased EVT and interception
initial construction of houses, streets, and culverts	• decreased infiltration and lowered groundwater table • increased storm flows and decreased base flows during dry periods • increased stream sedimentation
development of residential, commercial and industrial areas	• greatly increased volume of run-off and flood damage potential
construction of storm drains and channel improvements	• local relief from flooding • concentration of floodwaters may increase flood problems downstream
drainage density	• basins with a high drainage density (e.g. urban basins with a network of sewers and drains) respond very quickly • networks with a low drainage density have a very long time lag
land use	• land uses which create impermeable surfaces, or reduce vegetation cover, decrease interception and increase overland flow
porosity and impermeability of 'artificial surface' rocks and soils	• urban areas contain large areas of impermeable surfaces which cause more water to flow overland; this causes greater peak flows • rocks such as chalk and gravel are permeable and allow water to infiltrate and percolate; this reduces peak flow and increases the time lag • sandy soils allow water to infiltrate, whereas clay is much more impermeable and causes water to pass overland

Desertification

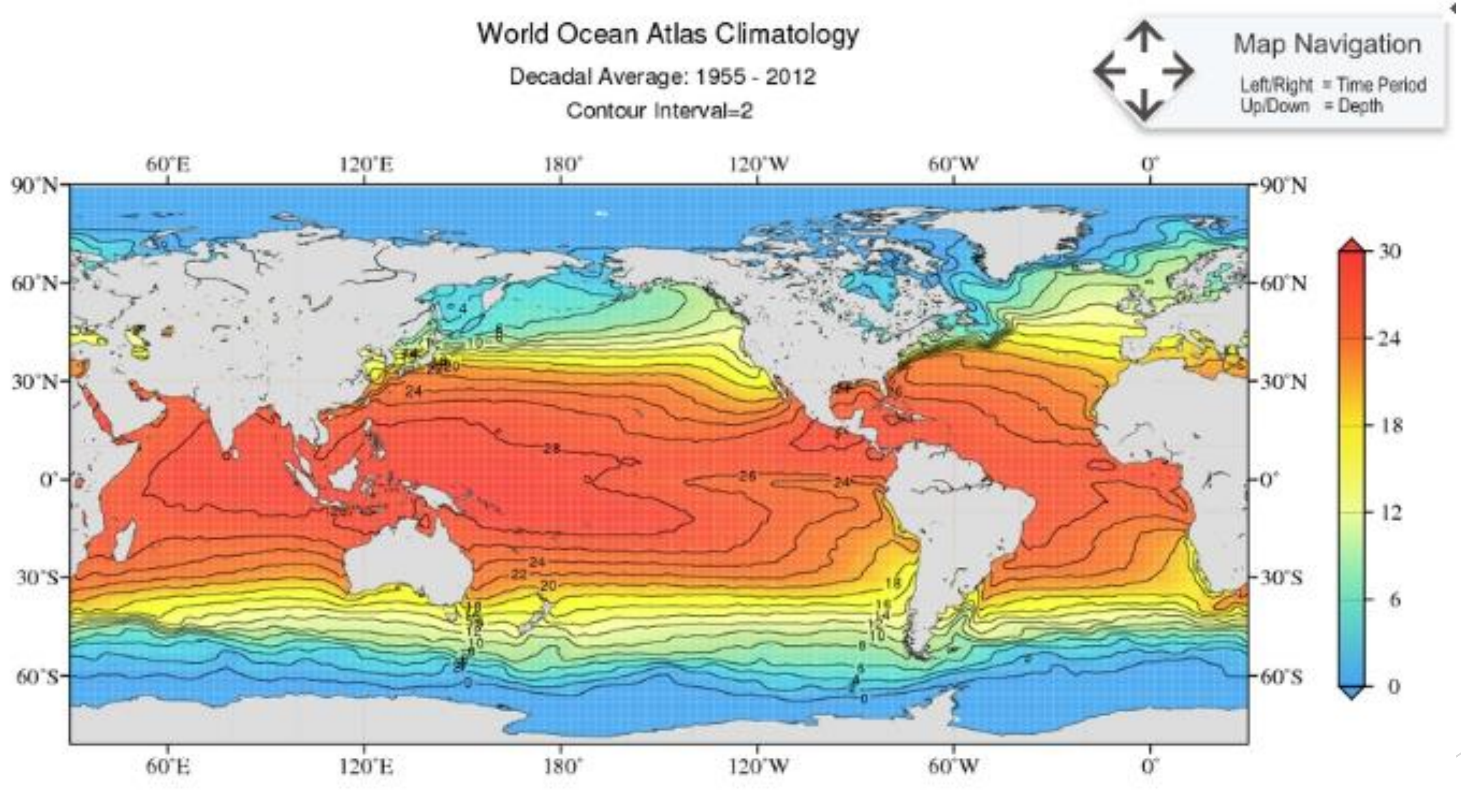
- A type of land degradation land in which a relatively dry land region becomes increasingly arid, typically losing its bodies of water as well as vegetation and wildlife. It is caused by a variety of factors, such as climate change and human activities

Groundwater Recharge Rates



Temperature

Temperature varies considerably at the surface of the ocean.



Annual temperature [°C] at the surface (quarter-degree grid)

There is little variation at depth.
In tropical and subtropical areas, sea surface temperatures in excess of 25 °C are caused by insolation.
From about 300 to 1000 m, the temperature declines steeply to about 8–10 °C. Below 1000 m, the temperature decreases to a more uniform 2 °C in the ocean depths.
The temperature profile is similar in the mid-latitudes (40–50° N and S), although there are clear seasonal variations.

Summer temperatures may reach 17 °C, whereas winter sea temperatures are closer to 10 °C.

Density

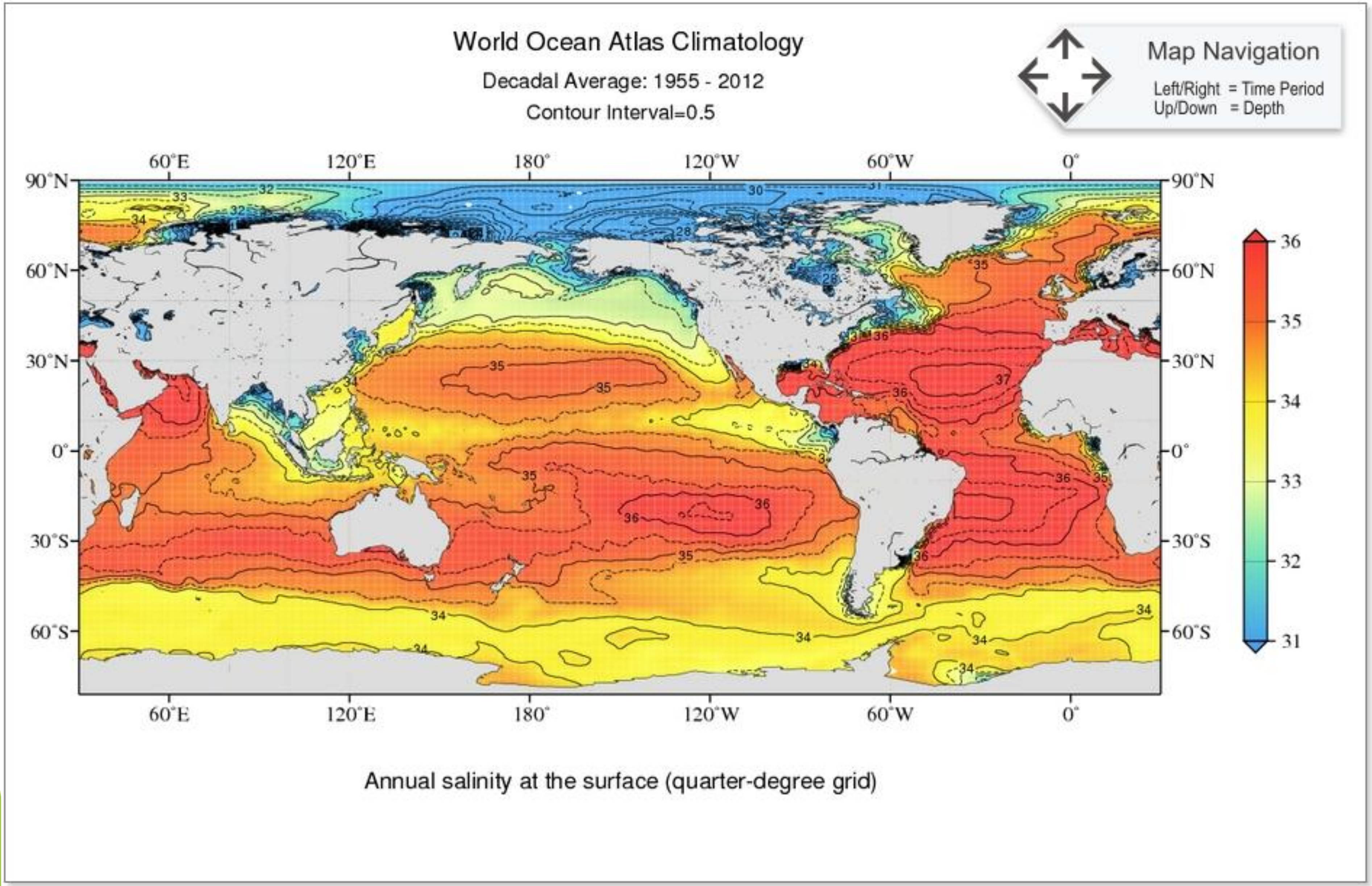
As temperature increases, water becomes less dense. As salinity increases, water becomes more dense. As pressure increases, water becomes more dense. A cold, highly saline, deep mass of water is very dense, whereas a warm, less saline, surface water mass is less dense. When large water masses with different densities meet, the denser water mass slips under the less dense mass. These responses to density are the reason for some of the deep ocean circulation patterns.

Salinity

The predominant mineral ions in seawater are chloride (54.3 %) and sodium (30.2 %), magnesium and sulfate ions.

Average salinity is about 35 parts per thousand (ppt).

Annual salinity



How do freezing and melting affect salinity?

The melting of large icebergs decreases salinity, while freezing of seawater increases the salinity temporarily.

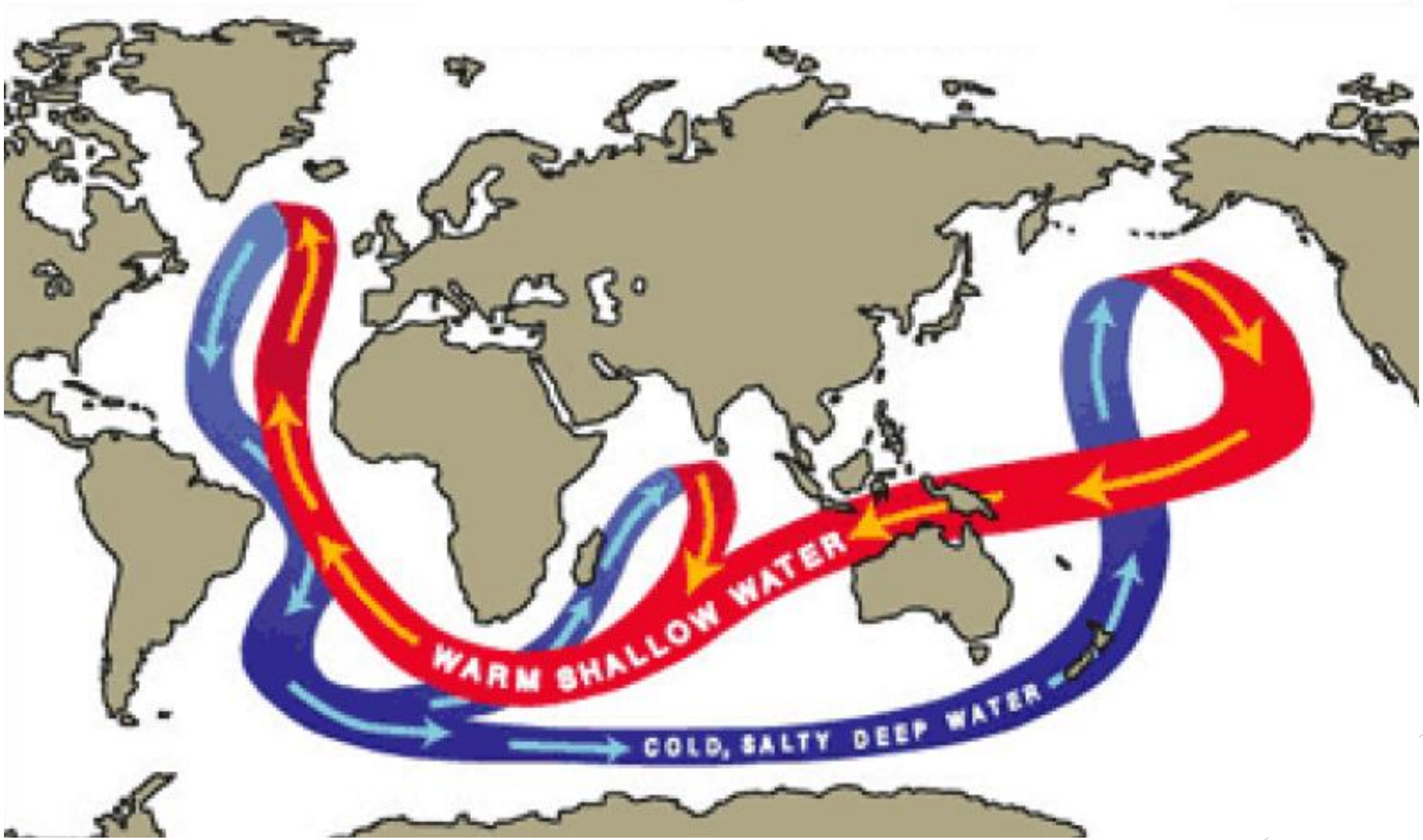
How does water salinity change with depth?

In tropical seas, salinity decreases sharply with depth.

How does water temperature affect salinity?

The melting of large icebergs decreases salinity, while freezing of seawater increases the salinity temporarily.

Great oceanic conveyor belt



How is energy transferred on the Earth (abiotic ways)?

transfer of energy by **wind**

transfer of energy by **ocean currents**

transfer of energy by **deep-sea currents**

The oceanic conveyor belt is a global thermohaline circulation.

The North Atlantic is warmer than the North Pacific, so there is more evaporation there. The water left behind by evaporation is saltier and therefore much denser, which causes it to sink. Eventually the water is transported into the Pacific where it mixes with warmer water and its density is reduced.

Specific heat capacity

The specific heat capacity is the amount of energy it takes to raise the temperature of a body. It takes more energy to heat up water than it does to heat land. However, it takes longer for water to lose heat.

The specific heat capacity is 4,18 J/g

This is why the land is hotter than the sea by day, but colder than the sea by night. Places close to the sea are cool by day, but mild by night. With increasing distance from the sea this effect is reduced.

Questions ?