GEO335 HYDROGEOLOGY

Lecture 1: Introduction to Surface Water Hydrology

Introduction

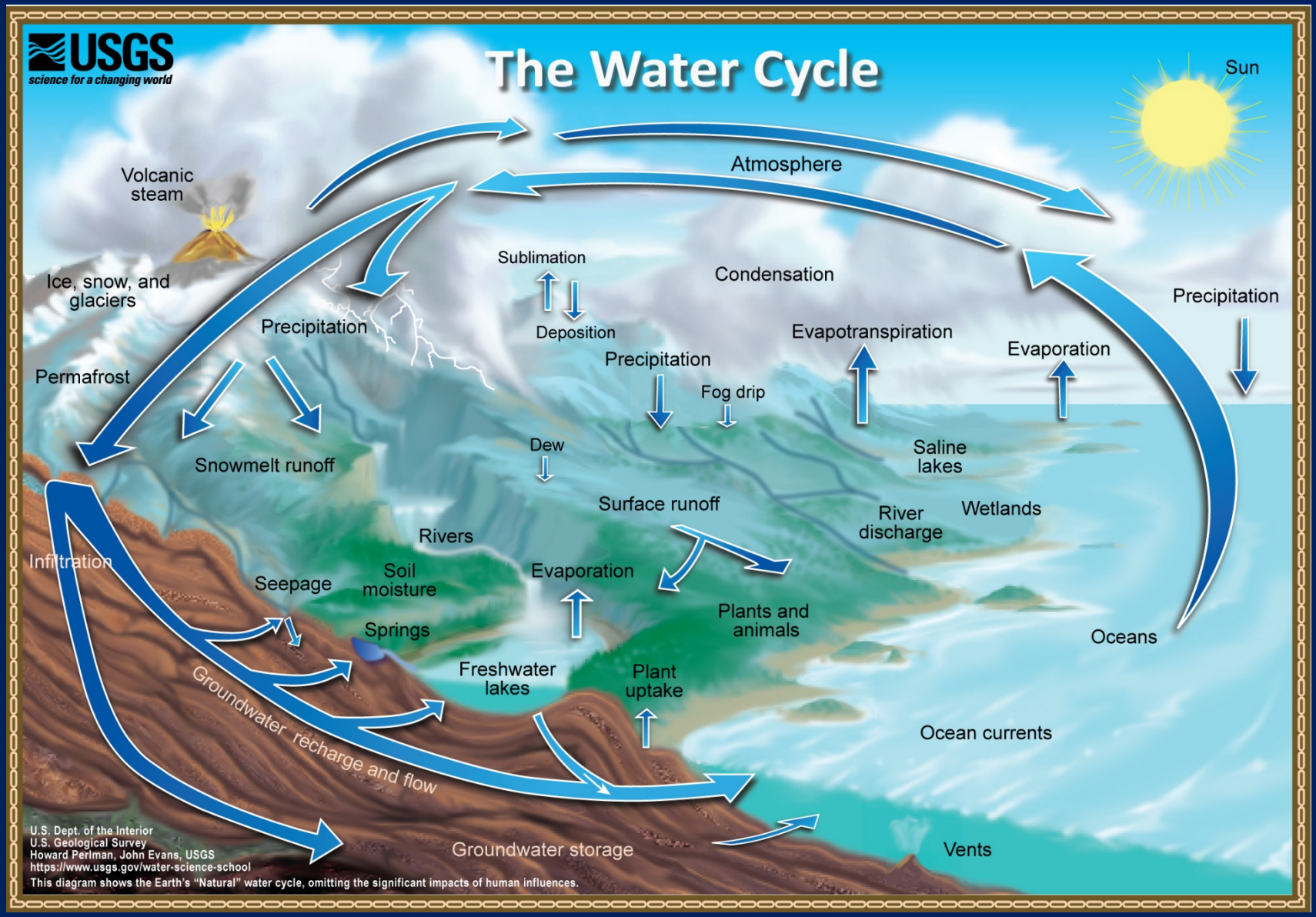
"Hydro" comes from the Greek word for water. Hydrology is the study of water and hydrologists are scientists who study water.

Hydrogeology: studies the interrelationships of geologic materials and processes with water. Hydrogeology deals with the mathematical description of the movement of groundwater and its chemical state.

https://www.usgs.gov/special-topics/water-science-school/science/what-hydrology

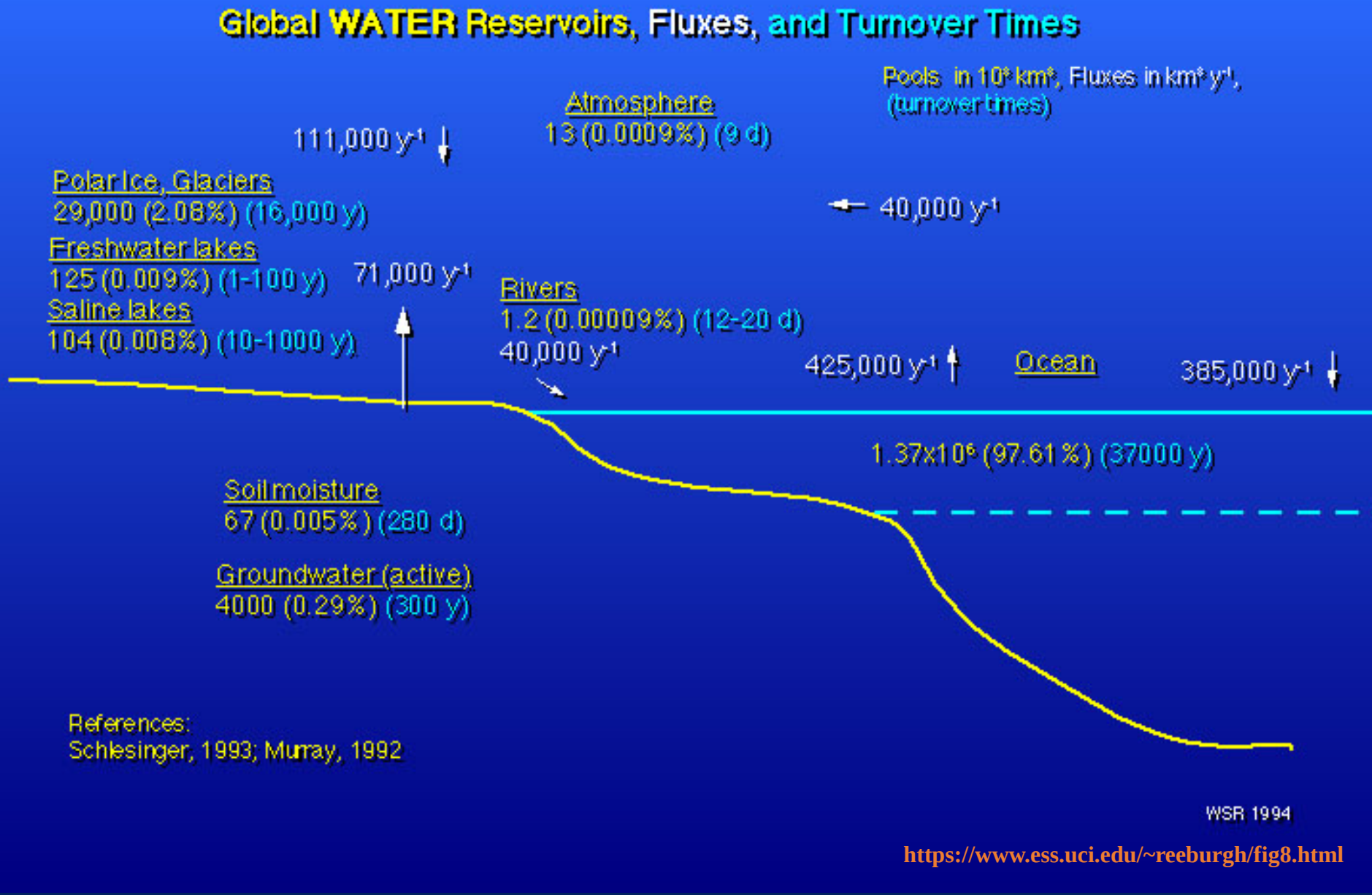
Are we running out of clean water?

https://www.ted.com/talks/balsher_singh_sidhu_are_we_running_out_of_clean_water/transcript?language=tr#t-1562



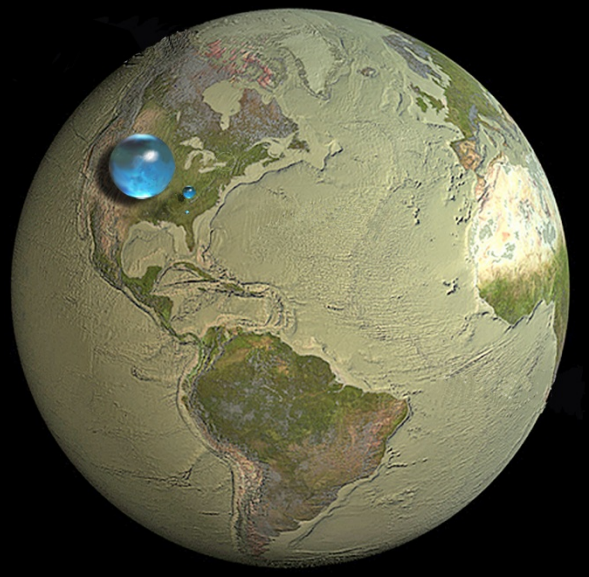
Earth's water is always in movement, and the natural water cycle, also known as the hydrologic cycle, describes the continuous movement of water on, above, and below the surface of the Earth. Water is always changing states between liquid, vapor, and ice, with these processes happening in the blink of an eye and over millions of years.

Source: USGS



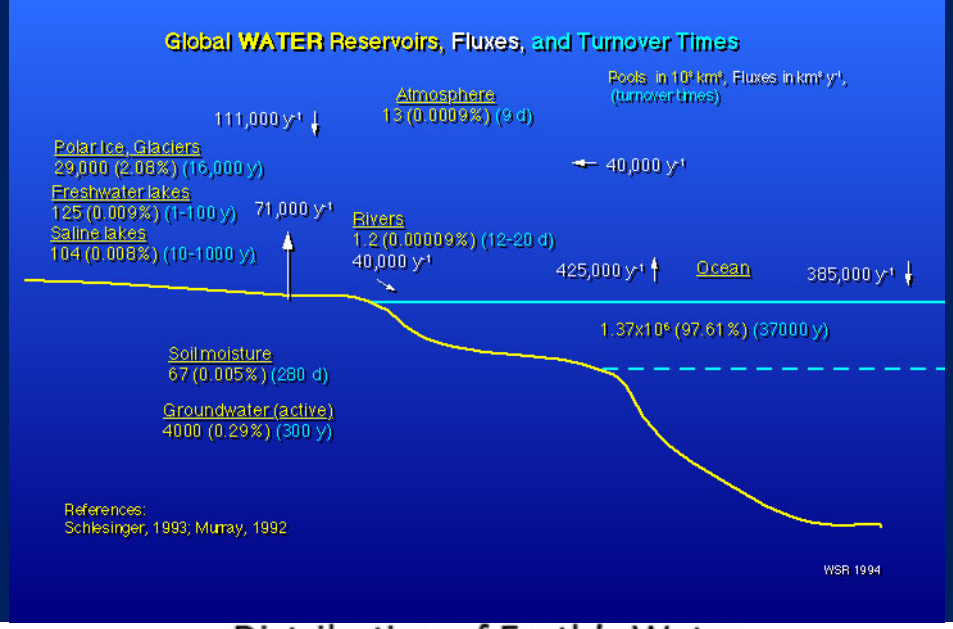
The hydrologic cycle: endless circulation of water between oceans, atmosphere and land. Evaporation, transpiration, evapotranspiration, precipitation

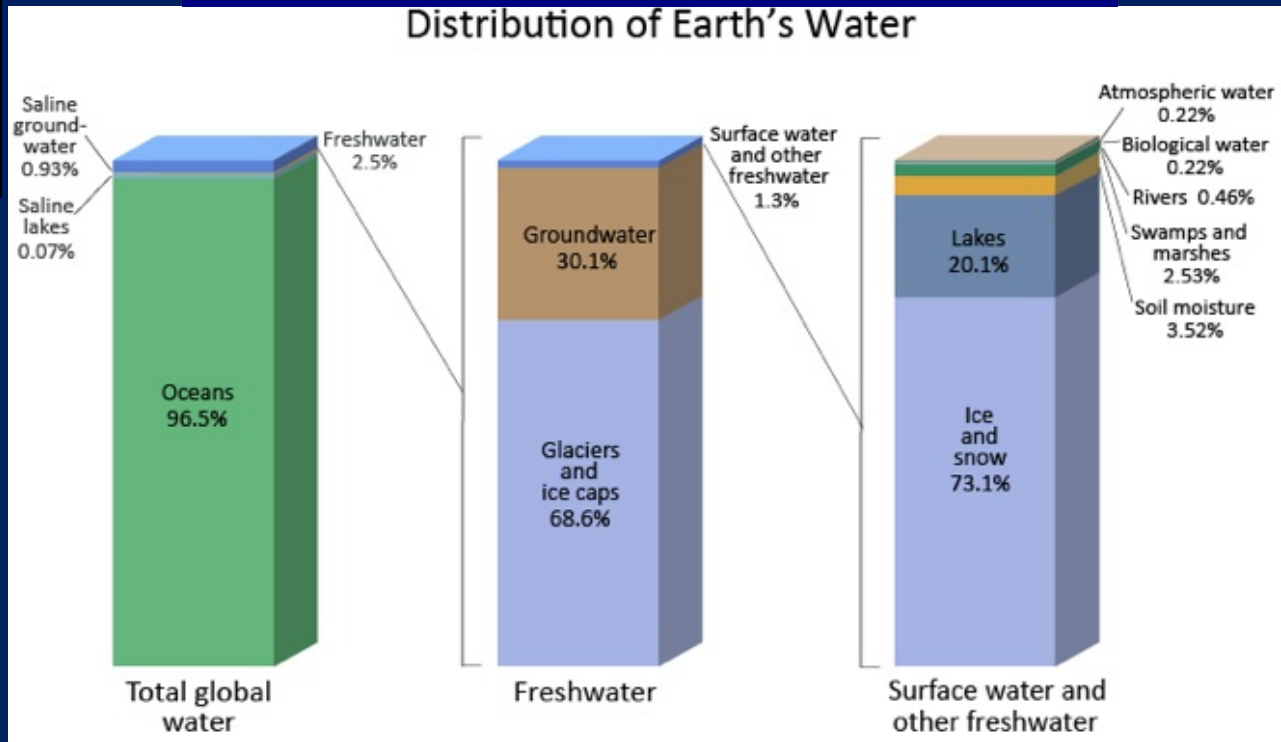
The World's Water



All water on, in, and above the Earth
- Liquid fresh water
- Fresh-water lakes and rivers

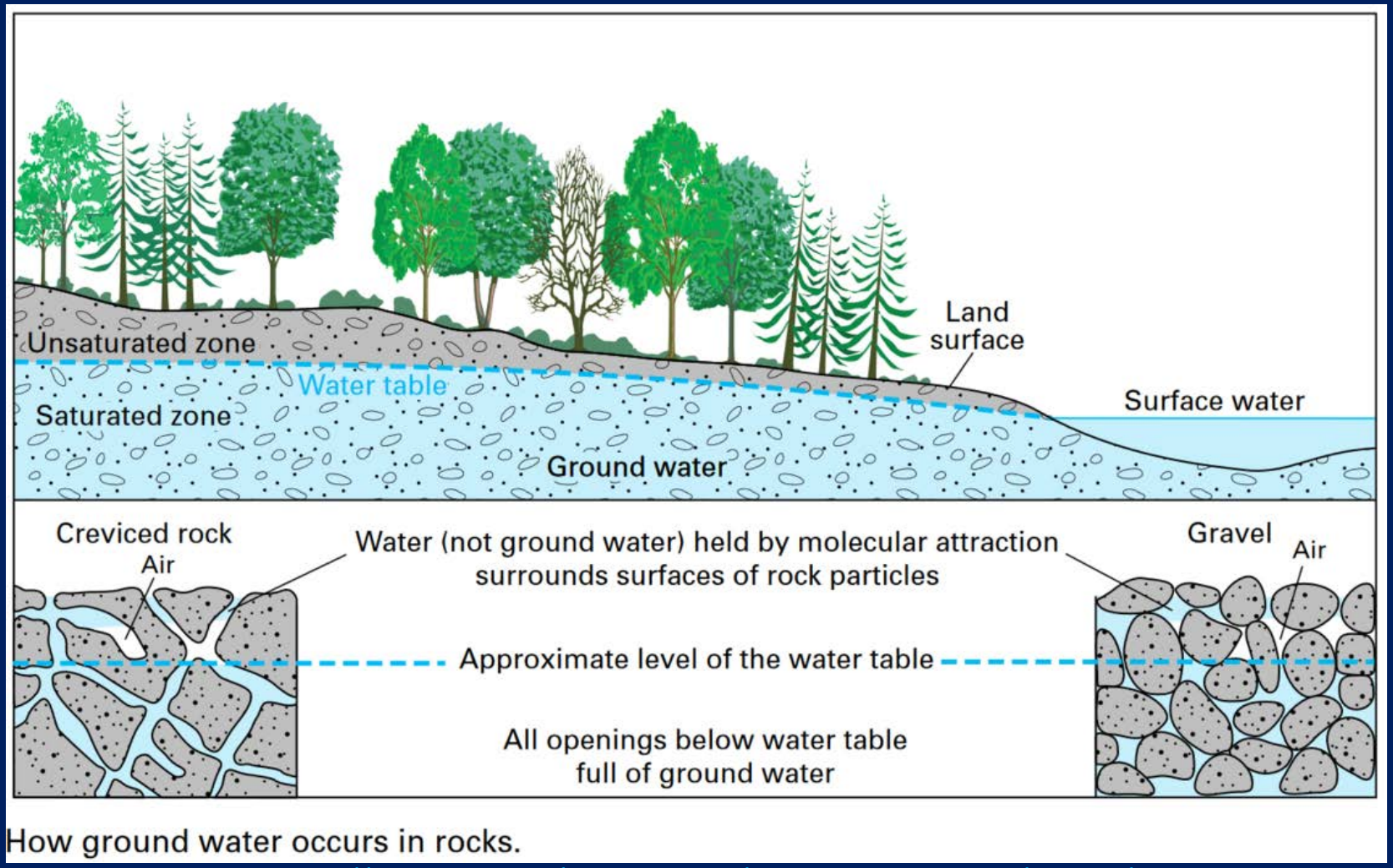
Howard Perlman, USGS;
Jack Cook, Woods Hole Oceanographic Institution;
Adam Nieman
Data source: Igor Shiklomanov
http://ga.water.usgs.gov/edu/earthhowmuch.html





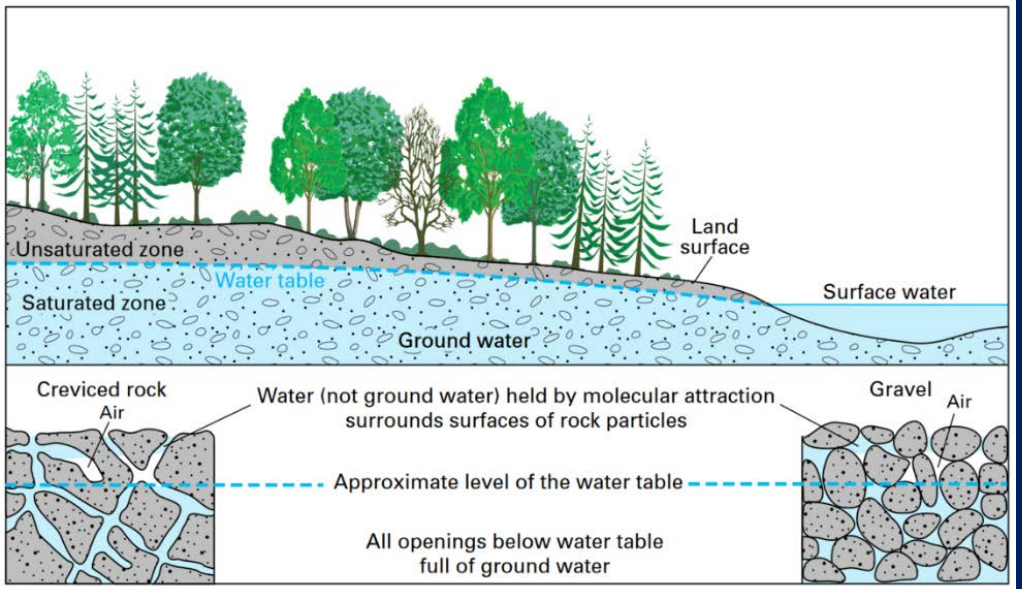
Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources.

Groundwater accounts for 99% of our liquid fresh water, only a fraction of groundwater is accesible without over-pumping aquifers. ONLY a small portion of this reservoir can be used annually without depleting this resource.



How ground water occurs in rocks.

https://www.usgs.gov/special-topics/water-science-school/science/aquifers-and-groundwater



How ground water occurs in rocks.

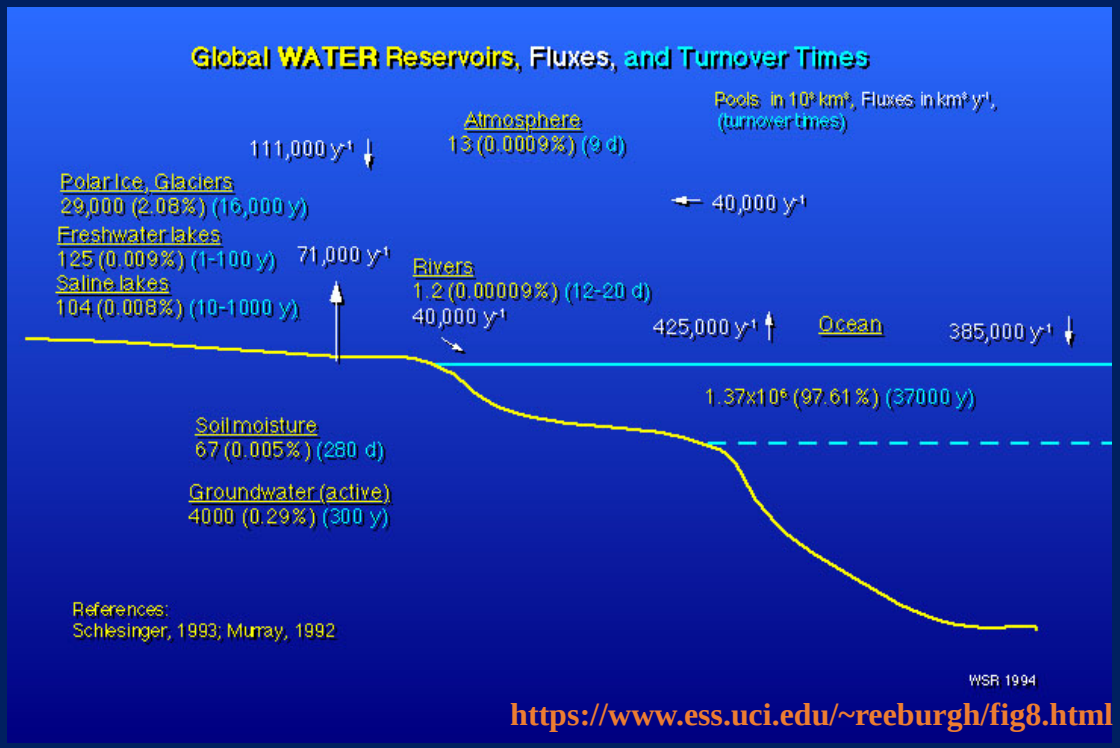
Unsaturated (vadoze) zone:

This is the zone just below the land surface. In this zone, the soil pores contain both air and water. Soils are covered with thin films of water.

Saturated zone: The region below the land surface where the pores of the soil or rock are fully saturated with water. The water stored in this zone is called groundwater.

Water table: The top of the saturated zone.

https://www.usgs.gov/special-topics/water-science-school/science/aquifers-and-groundwater



https://www.ess.uci.edu/~reeburgh/fig8.html

Components of the Hydrologic cycle:

Evaporation

Transpiration

Evapotranspiration

Precipitation

Infiltration

Streamflow (surface runoff)

Groundwater

Evaporation is the transfer of water from the liquid state to the vapor state.
Evaporation will continue until the air mass becomes saturated with moisture.
Vapor pressure of a liquid is directly proportional to temperature.

Absolute humidity of a given air mass is the number of grams of water per cubic meter of air.

Saturation humidity: Maximum amount of moisture that an air mass can hold at any given temperature (proportional to the temperature of air).

Relative humidity: is expressed as percentage. The ratio of the absolute humidity to the saturation humidity (as relative humidity approaches 100%, evaporation stops).

Condenstation occurs when an air mass can no longer hold all of its humidity. This happens when an air mass is cooled and saturation humidity value drops.

Dew point temperature of an air mass is the temperature at which condensation will begin.

If relative humidity= 100% ⟹ Dew point= actual air temperature

The rate of evaporation from open water surface depends on:

Solar radiation (the driving energy force behind evaporation. It warms both the water and the air)

Temperature and absolute humidity of air

Water temperature

Wind speed (wind carries vapor away from the free-water surface and keeps absolute humidity low).

Evaporation takes place from:

Open water surface (lakes, reservoirs etc.)

Soil moisture

Rain/fog intercepted by vegetation

Free-water evaporation is measured by using shallow pans.

Class A evaporation pan (land pan)

In the United States, the National Weather Service has standardized its measurements on the **Class A evaporation pan**, a cylinder with a diameter of 47.5 inches (120.7 cm) that has a depth of 10 inches (25 cm). The pan rests on a carefully leveled, wooden base and is often enclosed by a chain link fence to prevent animals drinking from it. Evaporation is measured daily as the depth of water (in inches) that evaporates from the pan. The measurement day begins with the pan filled to exactly two inches (5 cm) from the pan top. At the end of 24 hours, the amount of water to refill the pan to exactly two inches from its top is measured.

https://en.wikipedia.org/wiki/Pan_evaporation#Class_A_evaporation_pan

Measurements taken from a Class-A pan:

Daily depth of water

Volume of water added to replace evaporated water

Daily precipitation into the pan

Wind speed

Observed Class-A pan evaporation is multiplied by a pan coefficient that is less than 1.0. Why?

Table 2 Class A land pan coefficients for midwestern United States

January	0.62	August	0.75
February	0.72	September	0.73
March	0.77	October	0.69
April	0.77	November	0.63
May	0.78	December	0.58
June	0.77		
July	0.76		
	Annual 0.75		

Source: W. J. Roberts & J. B. Stall, Illinois State Water Survey Report of Investigation *(1967): 57.*

If Class-A pan evaporation data is not available how can we estimate it?

https://en.wikipedia.org/wiki/Pan_evaporation#Class_A_evaporation_pan