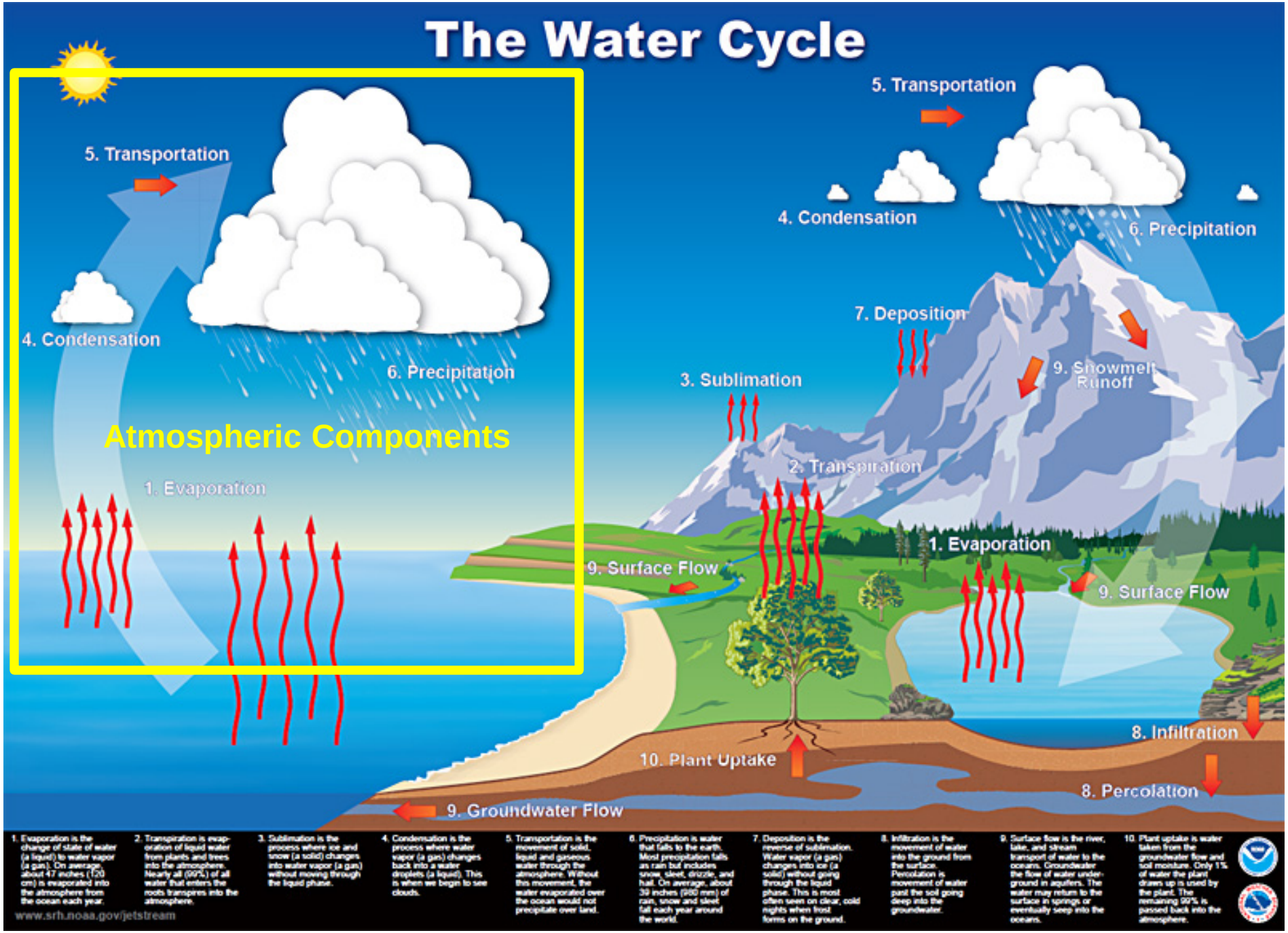
The Water Cycle



1. Evaporation is the change of state of water (a liquid) to water vapor (a gas). On average, about 47 inches (120 cm) is evaporated into the atmosphere from the ocean each year.

2. Transpiration is evaporation of liquid water from plants and trees into the atmosphere. Nearly all (99%) of all water that enters the roots transpires into the atmosphere.

3. Sublimation is the process where ice and snow (a solid) changes into water vapor (a gas) without moving through the liquid phase.

4. Condensation is the process where water vapor (a gas) changes back into a water droplets (a liquid). This is when we begin to see clouds.

5. Transportation is the movement of solid, liquid and gaseous water through the atmosphere. Without this movement, the water evaporated over the ocean would not precipitate over land.

6. Precipitation is water that falls to the earth. Most precipitation falls as rain but includes snow, sleet, drizzle, and hail. On average, about 39 inches (980 mm) of rain, snow and sleet fall each year around the world.

7. Deposition is the reverse of sublimation. Water vapor (a gas) changes into ice (a solid) without going through the liquid phase. This is most often seen on clear, cold nights when frost forms on the ground.

8. Infiltration is the movement of water into the ground from the surface. Percolation is movement of water past the soil going deep into the groundwater.

9. Surface flow is the river, lake, and stream transport of water to the oceans. Groundwater the flow of water underground in aquifers. The water may return to the surface in springs or eventually seep into the oceans.

10. Plant uptake is water taken from the groundwater flow and soil moisture. Only 1% of water the plant draws up is used by the plant. The remaining 99% is passed back into the atmosphere.

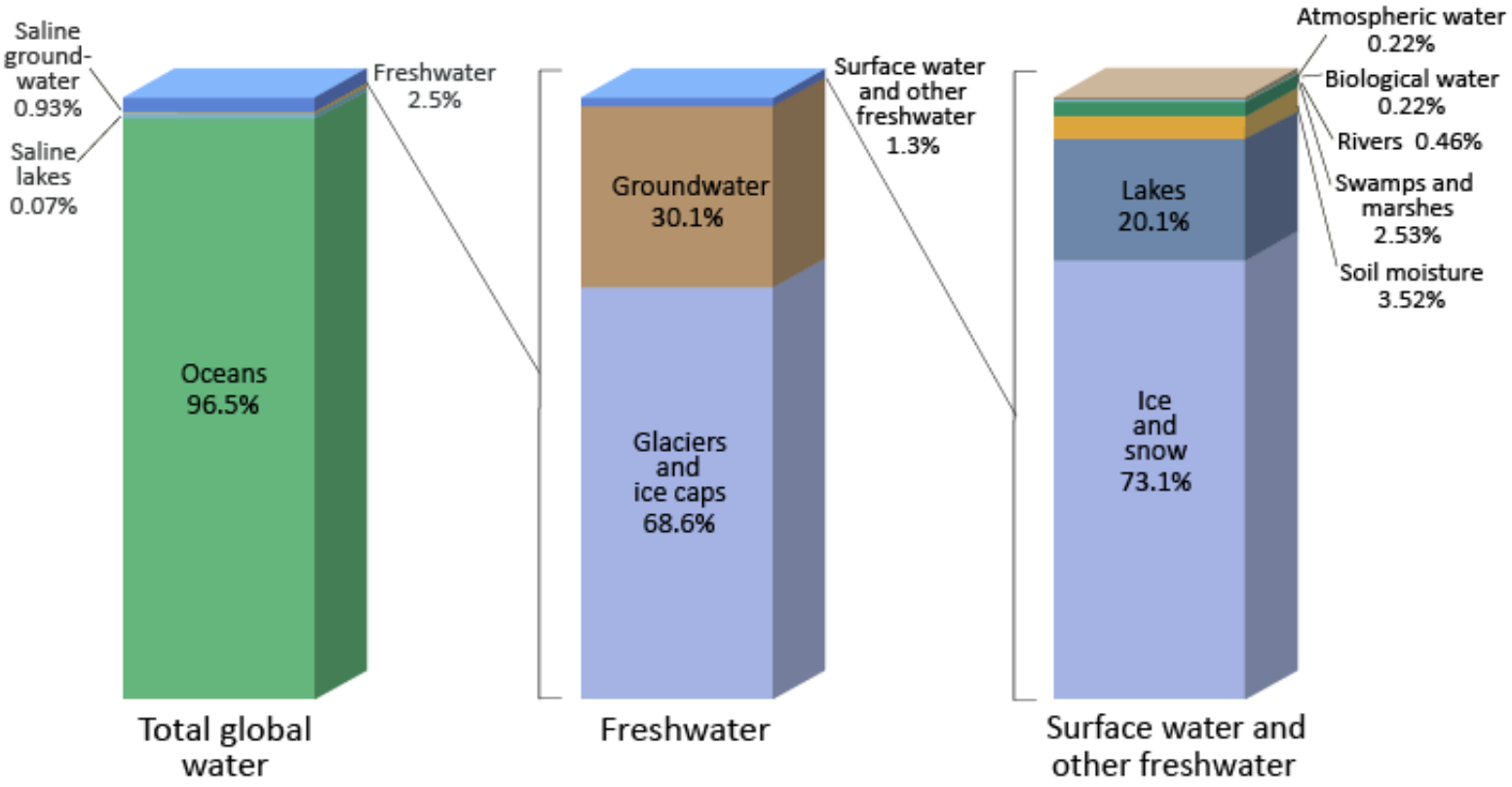
www.srh.noaa.gov/jetstream

Global Water Distribution—Fresh Water and Total Water Including the Oceans

Water source	Water volume, in cubic miles	**Percent of total freshwater**	**Percent of total water**
Atmosphere	3,094	**0.04%**	**0.001%**
Total global fresh water	8,404,000	**100%**	**2.5%**
Total global water	332,500,000	--	**100%**

Source: Gleick, P. H., 1996: Water resources. In Encyclopedia of Climate and Weather, ed. by S. H. Schneider, Oxford University Press, New York, vol. 2, pp.817-823.

Distribution of Earth's Water



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.

How much water is in the atmosphere?

At any moment, the atmosphere contains 37.5 million billion gallons of water. This is enough water to cover the entire surface of the Earth (land and ocean) with one inch of rain.

This amount of water is recycled 40 times each year in what is known as the hydrological cycle.

That means a water vapor molecule has an average residence time in the atmosphere of only nine days: the raindrop that fell yesterday on average had evaporated into the atmosphere nine days before.

This water is processed through an endless cycle of evaporation, condensation, and precipitation all over the globe.

Modified from: http://whyfiles.org/2010/how-much-water-is-in-the-atmosphere/

Aerosols

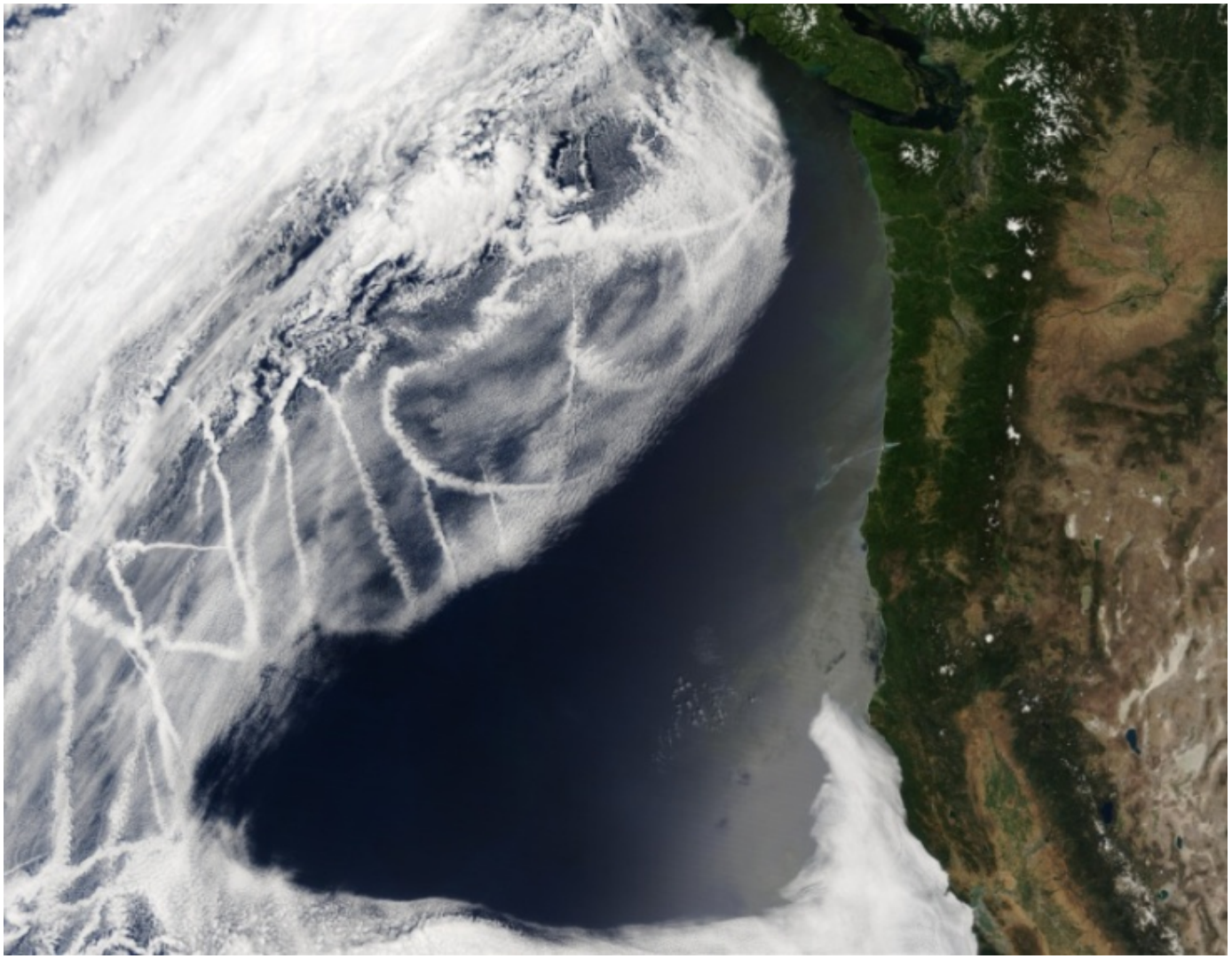
- Aerosol – is colloid of fine solid particles or liquid droplets in air or another gas
- Aerosols can be **natural** or **anthropogenic** in their origin. They can have primary sources or be formed in the atmosphere through photochemical processes
- Examples of **natural** primary aerosols are sea pray, volcanic emissions, and mineral dust, while a good example of secondary aerosol production is a blue haze, a phenomenon commonly observed over the Smoky Mountains
- Examples of **anthropogenic** primary aerosols are (smoke and soot), while a photochemical smog, often observed over large cities is a good example of secondary aerosol production

Various resources at:
http://seasaltaerosol.wordpress.ncsu.edu/resources-2/

Cloud Condensation Nuclei (CCN)

- CCN are aerosols that act as the initial sites for condensation of water vapor into cloud droplets
- Virtually all cloud droplets in the atmosphere are formed on aerosols
- Without aerosols suspended in the air, no clouds can be formed in the atmosphere
- Addition of aerosols to clouds can changes the cloud reflectivity and the lifetime

Ship stack smoke initiating cloud formation by injecting fine particles above the marine boundary layer



Satellite image of cloud streaks resulting from ship stack smoke off the west coast of the United States

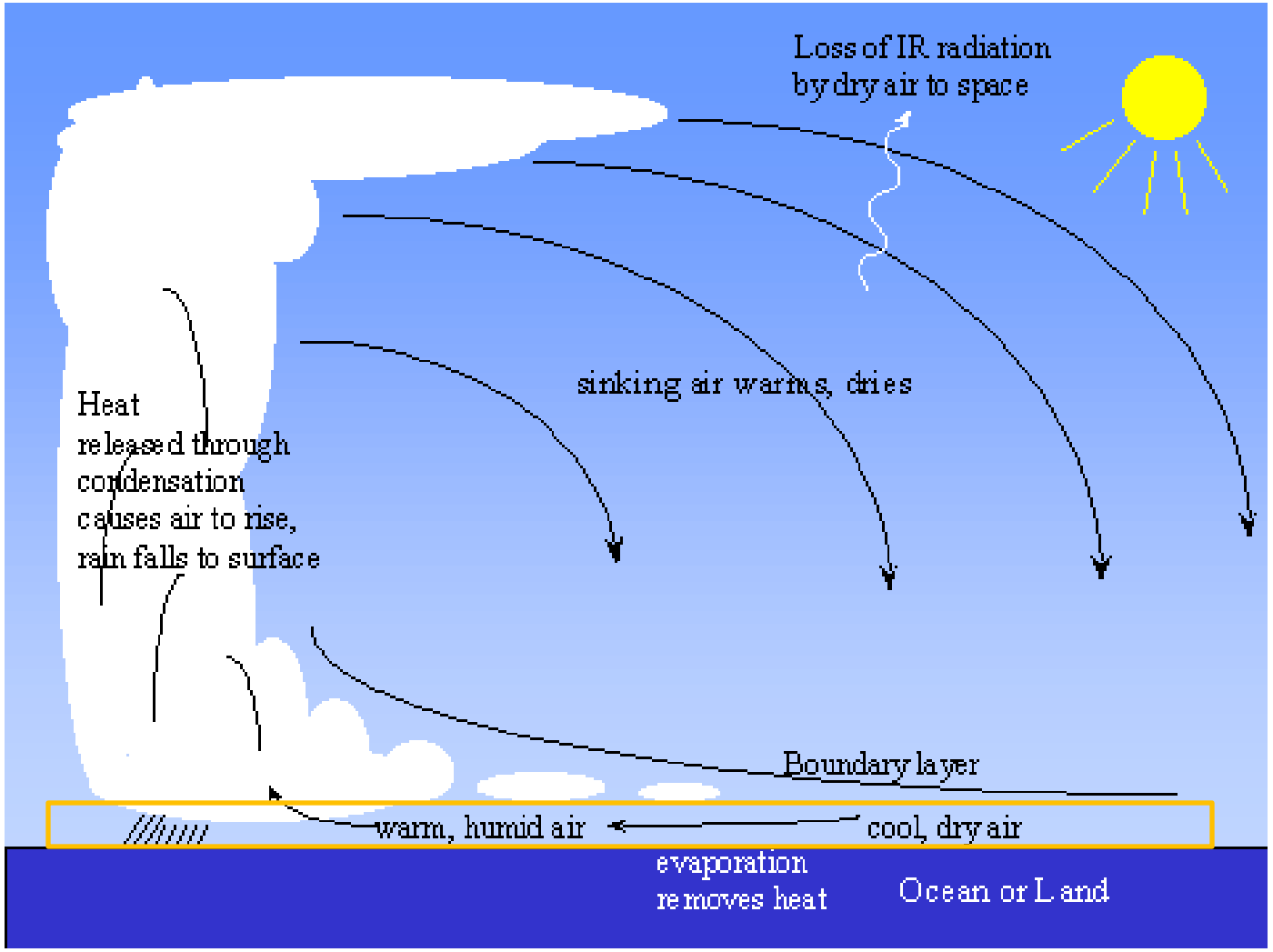


Diagram of the Marine Boundary Layer and Thunderstorm Formation

Marine Boundary Layer in the Neuse Estuary, NC. Note arrow: MBL is from base of cloud to water/land surface

Marine Boundary Layer in the middle of the Gulf of Mexico. Note arrow: MBL is from base of clouds to water level