

Name: _____
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Conceptual Physics: _____
Date: _____

Unit XI
Meteorology
Need extra help?

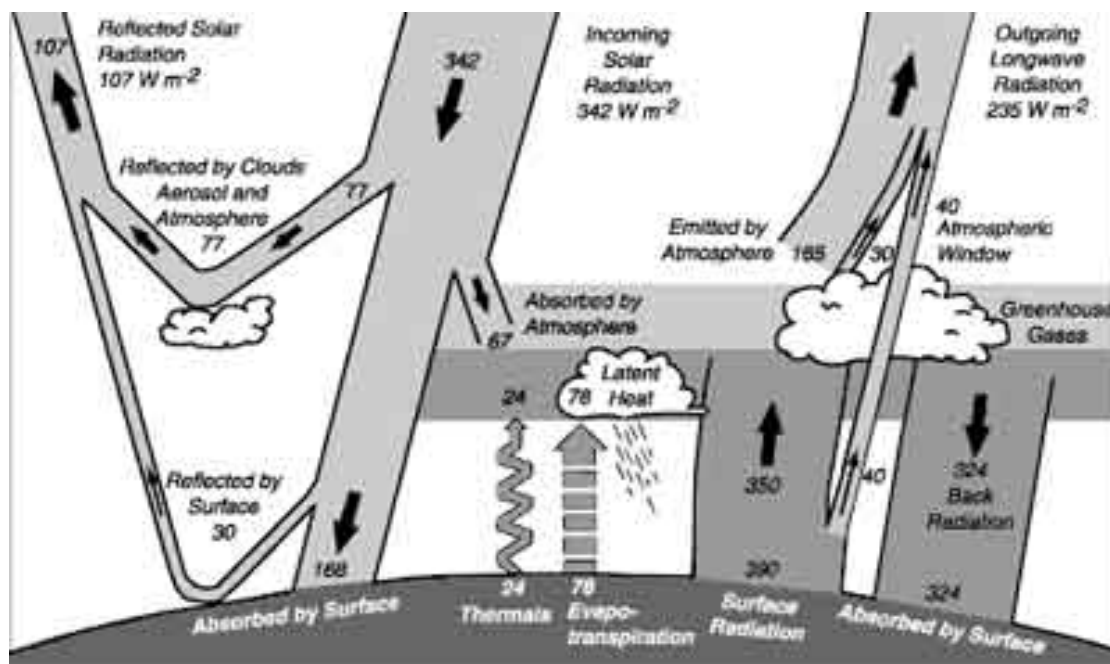
XI

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Ocean and Climate – The Odd Couple

Our global climate has changed drastically and frequently over our planet's lifetime. Some global climate fluctuations are on a human-time scale (check out our El Niño page). So what do the oceans have to do with climate? A lot! The oceans and the atmosphere form a closely linked "dynamic duo." Energy from the sun, plant distributions, and greenhouse gasses in the atmosphere can affect temperature and circulation patterns of this ocean-atmosphere duo.

The sun is Earth's main source of energy. Solar energy is absorbed by both oceans and continents. BUT--because the oceans cover over 70% of Earth's surface and are darker than the continents--they absorb more of the sun's energy. Here's another BIG IDEA! Oceans not only absorb lots of energy from the sun--they can also store lots of solar energy in the form of heat. AND they can do this with very little change in temperature. Scientists believe the way the oceans store and transport heat is related to climate.



The Heat Budget, source Keihl & Trenberth, J. Amer. Meteorological Soc. 78(2): 197-208.

The arrows that you see on this image portray the amounts of incoming and outgoing solar insolation and how the energy interacts with different parts of Earth and its atmosphere. As you can see from this schematic, roughly half of the incoming solar radiation is absorbed by the ocean. In turn this heat energy is stored in the water as it is picked up by winds that blow over the ocean surface. When the wind releases the water as precipitation the heat energy of the water is released into the atmosphere causing an increase in temperature.

The oceans' waters are constantly on the move. These movements are caused by powerful wind-driven currents. Earth's rotation and continents plus "things" going on inside the ocean can create currents or movement of water.

Deep ocean currents, however, are created by density. Density is defined as mass per unit volume of a substance and is measured in grams per cubic centimeter, or g/cm^3 . More simply: The density of seawater (ocean water) is greater than the density of pure water at the same temperature because seawater contains salts.

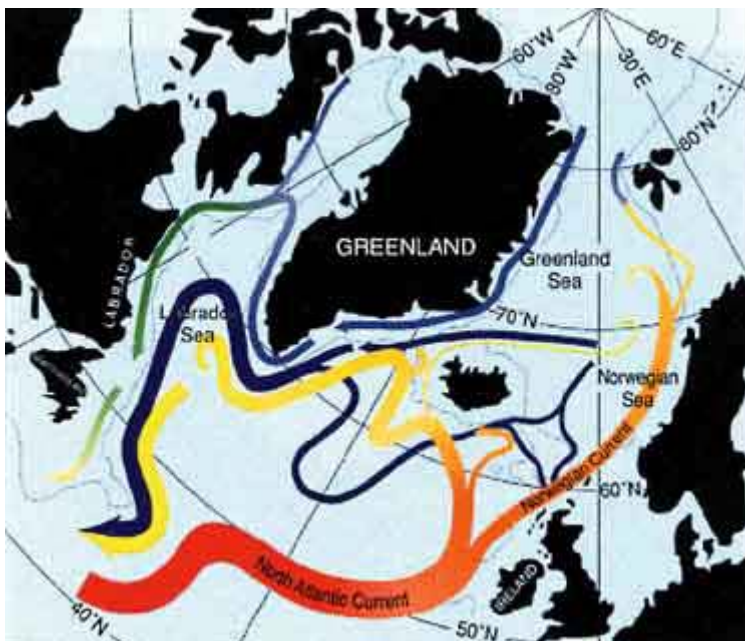
Cold seawater (ocean water) is more dense than warm seawater because the molecules of cold seawater are closer together than the molecules of warm seawater. Less dense substances will float on more dense substances.

Climate's Role in the Odd Couple Affair

Latitude affects the temperature of ocean water. Cold winds blowing across the ocean at high latitudes cool and evaporate the water. If it is cold enough, sea ice will form. The sea ice is fresher water than the sea water. Since the salts are left behind when the sea ice forms, the cold water becomes more dense and sinks deep into the ocean. This sinking of cold dense water at high latitudes is due to temperature and salinity differences. The sinking and spreading of cold water is known as –here come the big words– the Thermohaline Circulation or the Meridional Overturning Circulation.

The existence of this very cold water in the ocean basins has been known about for a long, long time. There is much more of this deep water than there is of the surface water. The currents in the deep water are not as strong as those of the surface water.

So what does the atmosphere have to do with deep ocean movement? Picture this. Clouds, which are part of the atmosphere, block the sun's rays from the ocean. The ocean cools. These same clouds could also bring rain, which is fresh water. The fresh water reduces the salinity of the ocean. Winds blow in and evaporate some of the ocean water. The water goes up and the salt stays behind. Let's see if we got that. Temperature, precipitation, and wind can affect density, which affects deep ocean movement.



*North Atlantic Part of the Global Conveyor Belt
(Courtesy Woods Hole Oceanographic Institution)*

Ocean's Role in the Odd Couple Affair

We've seen how the atmosphere affects the oceans. Now, how do the oceans affect the atmosphere? Remember, we said this was a "dynamic duo." The oceans are main reservoirs of readily available carbon dioxide (CO_2), an important greenhouse gas. The cold, deep water in the ocean is the main reservoir of dissolved CO_2 . TRY THIS: Shake a hot can of coke and open it. Shake a cold can of coke and open it. What happened? What does this experiment demonstrate? Need I say more? (Check the activity page for an explanation of the demonstration.)

The oceans carry heat from the tropics, that's the area near the equator, to the higher latitudes, the area near the poles, to maintain Earth's temperature. They also take carbon dioxide and hide it from the

atmosphere. Here's how it happens. Sunlight warms the surface of the ocean in the tropics. Wind-driven surface currents carry the heat toward the poles. In the North Atlantic, the warm currents from the tropics feed the North Atlantic Current shown in red in the figure. As the current flows northward toward Norway and Greenland, it loses heat to the atmosphere and cools down. In winter the water near Norway and Greenland gets so cold and dense it sinks all the way to the bottom of the ocean. The cold bottom water feeds bottom currents shown in blue and green. Eventually, mixing brings the bottom water back to the surface in other parts of the ocean, sometime as far away as the North Pacific. When the water gets to the surface, sunlight warms the water, and the cycle starts over.

The deep circulation shown in the picture is important for two reasons:

- ✗ Cold water carries carbon dioxide deep into the ocean, taking it away from the atmosphere and...
- ✗ Surface currents that sink and feed deep currents carry much more heat toward Europe than currents that stay on the surface. As a result, Norway at 60° N is far warmer than southern Greenland and northern Labrador which are at the same latitude.

Questions:

1. Why do temperatures differ at different latitudes? i.e. 0° (equator) vs. 40° N
2. Why do temperatures vary at different locations at the same latitude? i.e. Norway and Northern Labrador--both at 60° N
3. Which has a greater capacity to store heat--the oceans or the atmosphere?
4. Which has a greater heat capacity--water or land? Why?
5. In what way/s does the atmosphere influence the ocean?
6. In what way/s does the ocean influence the atmosphere?

Critical Thinking Questions:

1. What is the atmosphere's source of heat? (Be careful, this one could be tricky!)

2. How would our global climate be different if 71% of Earth was covered by continents and 29% by water? (The name of our planet, Earth, would be more appropriate for one thing.)