SIO 40 Fall 2007 Homework 3 **Due Oct 19th**

This homework covers materials presented in lectures 7,8 and 9, as well as the accompanying reading assignments for those lectures (see syllabus). These are primarily short answer questions. In most cases, a few sentences should suffice. Please try to answer all questions in the space provided, use the back of the page if you have to. Be careful to answer each part of multi-part questions. **Note:** Homeworks will be graded on the basis of a *random subset* of these questions – so your best strategy will be to answer all the questions to the best of your ability.

1) Earth's energy balance depends on i) receiving incoming radiation from the sun; ii) reflection of the sun's radiation by the Earth; and iii) emission of radiation by the Earth. For each of these components in the energy balance (i, ii, and iii), is the radiation in question shortwave (ie. roughly visible range) or longwave (ie. infrared)?

i) Shortwave
ii) Shortwave
iii) Longwave

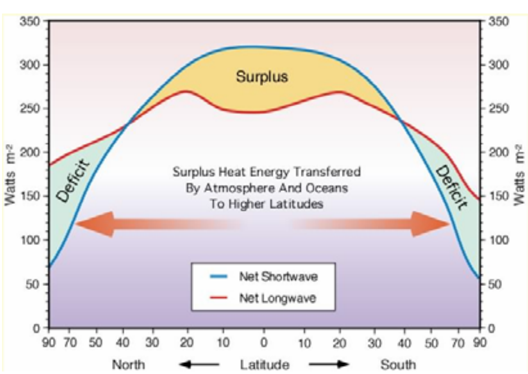
2) Is there any *one* gas present in the Earth's atmosphere that has *all* of the following properties? Yes, ozone (O_3)

- Effective greenhouse gas
- Relatively short atmospheric residence time
- Vertical distribution of this gas in the atmosphere shows a pronounced maximum in the stratosphere
- Seasonal depletion, especially in the southern hemisphere
- Thought to have been introduced into Earth's atmosphere primarily as a consequence of oxygenic photosynthesis

3) Do aerosols in general have a positive or negative effect on cloud albedo? Explain.

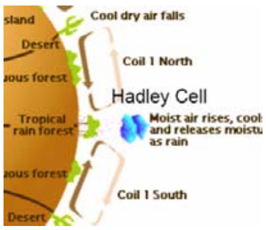
In general the effect of aerosols on clouds results in an increase in cloud albedo because the aerosols increase the concentration of available nucleation sites for water droplets, resulting in a cloud composed of more, smaller water droplets. These clouds are more reflective than clouds composed of fewer, larger water droplets. Aerosol effects can be more complex, however, depending on the type of aerosol.

4) Draw a diagram showing the variation of incoming solar energy and outgoing infrared radiation with latitude. Indicate the regions of energy surplus and energy deficit. Explain why this distribution is important for atmospheric circulation.



Uneven distribution of heat over Earth's surface (excess at equator, deficit at poles) requires redistribution of heat via warming the atmosphere, ocean currents, and latent heat. Uneven heating causes global-scale spatial differences in atmospheric pressure, which creates wind and causes atmospheric circulation.

5) Draw a diagram to describe a Hadley atmospheric circulation cell and where it occurs. What is the ITCZ?



Hadley cell – warm moist air rises at the equator, drops moisture, moves poleward and comes down as cool dry air around 30° N/S latitude. The ITCZ –Intertropical Convergence Zone, an area of low pressure and high precipitation located near the equator at the convergence of the NE and SE Trade Winds. The ITCZ migrates north and south across the equator over the course of the year, making it the primary means of interhemispheric mixing of the troposphere.

6) What is the Coriolis effect, and how does it help determine the global pattern of atmospheric circulation?

The Coriolis effect is caused by Coriolis Force – due to the Earth's rotation and the fact that the equator is rotating slightly faster than the poles, an air mass in motion will undergo an apparent deflection (right in the N. Hem, left in the S. Hem) relative to an observer on the surface of the Earth. The Coriolis effect is significant to atmospheric circulation because it operates on a global scale to change the pathway taken by air masses by causing them to deflect left or right (depending on the hemisphere).

7) What is latent heat? Explain why latent heat is important for the redistribution of energy.

Latent heat is heat absorbed by conversion of liquid water to water vapor. Water vapor formed at the equator via evaporation moves poleward through the atmosphere and condenses, releasing latent heat at high latitudes and facilitating the distribution of heat energy over Earth's surface from the equator to the poles.

8) As part of the hydrologic cycle, water moves between various reservoirs (eg. ocean, atmosphere, lakes, groundwater, etc.), but is not lost from the earth's surface. Why then are we concerned about conserving our fresh water supply, especially groundwaters?

Water is generally conserved on Earth, but certain forms of water (like fresh liquid water) are most useful to humans and that portion is only a tiny amount of the water in the system. Obtaining water from other sources (eg. glaciers, seawater) takes significant energy and resources. Groundwaters are an important source of water to humans, but groundwater replacement time is relatively long and we are using it up faster than it can be replaced.

9) Explain the relationship between air temperature and water vapor content at a given atmospheric pressure. How might this relationship contribute to a positive feedback loop in terms of climate warming?

The warmer air is, the more water vapor it can hold (at a given atmospheric pressure). The relationship is exponential, so even a relatively small temperature increase means a big increase in the ability of air to hold water (ie. decreasing relative humidity). A positive feedback loop can be envisioned this way: As temperature increases, so does the water vapor content of the air. Because water vapor is a greenhouse gas, this tends to warm up the atmosphere further. This will in turn increase the water vapor content, which will in turn enhance greenhouse warming, etc. etc……..

10) Wind blowing over the ocean surface creates ocean currents. Do ocean currents just move in the same direction as the wind? Explain.

As wind blows over the ocean surface, water is moved by friction with the wind. Coriolus force deflects that water about 45° to the right of the wind direction in the northern hemisphere (to the left in the southern hemisphere). Going down into the upper water column, as each successive layer of water is set into motion by friction with the layer above, it too is deflected further to the right (N. hem) by the Coriolus force. Ultimately, the net direction of surface water transport is about 90° to the right of the wind in the northern hemisphere. Additional currents are created due to the need of water to redistribute itself and counter-act the motions of wind-driven currents.

11) What is the oceanic pycnocline, and what role does it play in determining the vertical structure of the ocean?

The pycnocline is the strong gradient in density that separates the surface ocean from the deep ocean and inhibits mixing between the two. The pycnocline is primarily due to the temperature difference between the surface and deep ocean, with the surface being warmer and less dense, and the deep ocean being colder and more dense.

12) Why are Atlantic Ocean surface waters saltier than Pacific surface waters, and what are the basic consequences of this situation for oceanic thermohaline circulation?

The balance of evaporation and precipitation over the two ocean basins is such that there is a net export of freshwater from the Atlantic to the Pacific. This makes the Atlantic the saltier of the two oceans. This is significant for thermohaline circulation because the saltiness of the surface waters in the far North Atlantic makes them more dense and likely to sink when water temperatures decrease. This drives deepwater formation in the North Atlantic, which in turn drives the larger oceanic “conveyor belt” circulation of deepwaters.