MAR 110 LECTURE #9
Earth’s Heat Budget / Atmosphere Dynamics

The Earth’s Overall Heat Budget

–HEAT IN = HEAT OUT

The Earth’s globally-averaged temperature, that is also averaged over the year, is virtually constant. This is so because the total amount of infrared energy radiated away from the Earth (short arrows around the globe) equals the total amount of solar energy absorbed by the Earth. (UWaC)
Different types of energy in the universe is transported by waves with spectrum of wavelengths; stretching from gamma rays with extremely small wavelengths (i.e., a millionth of a micrometer – the size of an atom) to radio waves with very large wavelengths (i.e., 100 million micrometers – the size of a tall building). The temperature of the source of radiation determines the wavelength of the radiation. For example, the 6000°K sun produces visible “short wave” solar radiation. (UWaC)
Temperature – A Digression

(LEFT) Temperature is molecules in motion. (RIGHT, left) The Kelvin temperature scale measures absolute temperature ranging upward from the coldest possible temperature (at 0 K all molecular motion stops!). (middle) The Celsius temperature scale is more convenient in that it is referenced to the melting point temperature of ice at 0°C and boiling water at 100°C. NOTE: 0°C = 273.16 K. (right) The Fahrenheit temperature scale is referenced to the ice melting point, which is at 32°F = 0°C ( = 273.16 K) and boiling water at 212°F = 100°C. (ItO??)

“Long Wave” Infrared Energy

The Earth with its relatively lower temperature of ~290°K, produces relatively uniform “long wave” infrared radiation (invisible) over its entire surface (see Figure 13.2) This uniformity results because the variations of the absolute temperature over the Earth’s surface are so small. (UWaC)
Solar Heat Flux Varies with Latitude
Equal amounts of incoming solar energy (represented by the black bands) are spread over larger areas of the Earth at polar latitudes and smaller areas at equatorial latitudes; as illustrated by the flashlights to the left. The heat energy per unit area - called heat flux- associated with solar radiation is thus larger in equatorial regions than in polar regions. It follows that the larger the heat flux the larger the warming. (UWaC)
Atmospheric & Oceanic Heat Transport
The combined atmospheric and oceanic circulations transport the net excess heat of the tropics towards the poles where there is a net deficit of heat. (??)
Convective Overturning Cells
Vertical convection results when the lower part of the atmosphere becomes unstable. Daily solar heating of the land creates a pocket of hot air that, because it is less dense than the adjacent air, rises vertically in an “updraft”; cooling as it rises. In other places (to the sides), pockets of colder, relatively more dense air accumulates at elevation sink. When the sinking air is rewarmed by the land and begins to feed the updraft, a convection cell is formed and the atmosphere is said to overturn. Overturning convection cells also occur in the ocean waters. (UWaC?)
Earth Rotation Makes Single Cell System Unstable
The earth's rotation makes the single cell (one in each hemisphere) system unstable and breaks each hemisphere up into three cells. (UWaC)
Earth Rotation
The Earth rotates counterclockwise as seen from the North Star. (ItO)

Coriolis Deflection
The apparent and actual paths of a ball thrown between two people riding horses on a merry-go-round.
The Coriolis Effect
The west to east (CCW) rotation of the earth causes the path of this plane, which is moving almost straight southward in the northern hemisphere to curve towards the right. (??)

To a Northern Hemisphere Earthbound Viewer
Clockwise Rotation of Stars

NH Rotation - Counterclockwise
Because of the rotation of the planet, the stars overhead appear to rotate clockwise overhead. (??, ??)
Coriolis Force-Induced Deflections
The magnitude of the deflection of particles moving along a trajectory is relative to how far from the equator the particle is and increases as the particles approach the poles. The particles deflect towards the right of their motion in the northern hemisphere and to the left in the southern hemisphere with no deflection at the equator. (??)
Earth Rotation Makes Single Cell System Unstable
The earth’s rotation makes the single cell (one in each hemisphere) system unstable and breaks each hemisphere up into three cells. (UWaC)

Single Cell Winds
One might think that the two convection cells that would exist on a non rotating earth would just circulate with net movement towards the east but… (UWaC)
The Global Jet Stream
The jet stream is a narrow band of strong winds that snakes its way around the globe along the polar front between the polar and subtropical zones. The location of the jet stream loops strongly influence the tracks of high and low pressure storm systems at lower levels. (UWaC)

The Jet Stream
(top) The jet stream is a narrow band of strong winds that snakes its way around the globe along the polar front between the polar and subtropical zones. (bottom) The location of the jet stream strongly influences the tracks of high and low pressure storm systems (see above) that are confined to the tropospheric layer below it. (UWaC)