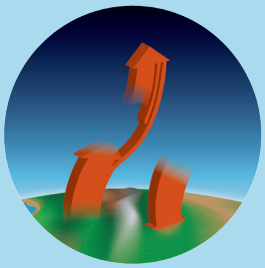
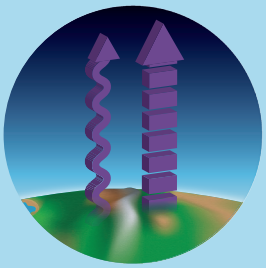
The Story of Energy in the Earth *System*

- The Sun is the source of energy for the Earth system. This energy reaches the Earth primarily in the form of visible light, although it also includes some infrared energy (heat), ultraviolet energy, and other wavelengths of the electromagnetic spectrum. Taking into account night and day and the seasons, on average about 340 Watts of energy enter every square meter of the Earth system. This is slightly less than the energy that six 60 Watt light bulbs would produce, again, for every square meter of the Earth.
- As it reaches the Earth system, some of the sunlight is reflected back to space by clouds and the atmosphere (particularly dust particles or aerosols in the atmosphere). A little more sunlight is reflected to space from the Earth surface, particularly from bright regions such as snow- and ice-covered areas. In total, about 30% of sunlight is reflected directly back to space. This percentage is called the albedo.
- About 70% of the sunlight is absorbed by the Earth system (atmosphere and surface) and heats it up.



- The elements of the Earth system (surface, atmosphere, clouds) emit infrared radiation according to their temperature, following the Planck function (http://phet.colorado.edu/simulations/sims.php?sim=Blackbody_Spectrum). Cold objects emit less energy; warm objects emit more. This infrared radiation is emitted in all directions.
- One net effect of all the infrared emission is that an amount of heat energy equivalent to ~70% of the incoming sunlight leaves the Earth system and goes back into space. This is because the Earth system constantly tends toward equilibrium between the energy that reaches the Earth from the Sun and the energy that is emitted to space. Scientists refer to this process as Earth's "radiation budget.", and it happens because the system tends toward equilibrium.
- Another net effect of the infrared emission is that about 340 Watts of infrared energy is directed back to the surface from the atmosphere. This is called the greenhouset effect, and is due mainly to water vapor in the atmosphere. Carbon dioxide, methane and other infrared-absorbing gases enhance this effect. Without an atmosphere, the Earth would have an average temperature of -18 °C, too cold for life as we know it.



- At the surface, two additional heat transfer mechanisms operate to balance the system, in addition to the radiation transfer: 1) convection and conduction in the form of thermals (which create weather), and 2) a change of state of water through evapotranspiration (which also feeds weather).

Bottom Line:

According to the best available data from the CERES satellite instrument, along with information from other data sources, the radiation budget at the top-of-atmosphere was not balanced during the five years from 2000-2005. Approximately 0.85 Watts of energy were added to the Earth system, on average, for each square meter of the Earth's surface. A continued imbalance of the radiation budget would mean a change in Earth's climate.