What Determines Earth's Temperature

by ***Bill Rizer***

At a high level, it is not difficult to understand what controls the earth's temperature as described in a brief article by Rebecca Lindsey (2007) of NASA. If you go to the top of the earth's atmosphere (Figure 1), about 100 km above the surface, and measure the amount of incoming radiation and subtract from that the amount of outgoing radiation, what is left, the net radiative flux, is what determines earth's temperature.

That is simple indeed. However, what happens below 100 km is what determines how many photons reach the surface and how many photons radiating back from the surface and atmosphere actually make it all the way out to space. The Sun's radiation incident on the earth is high energy and short wavelength (Figure 2). The photons that are not reflected back by the molecules and particles in the atmosphere are absorbed by the surface causing the surface to warm. The warming surface, in turn, emits photons but at much shorter wavelengths and lower energy than the visible light of the Sun (Figure 2). That is why molecules and particles that have little effect on incident visible light can block the heat radiating back the surface. We know these molecules as greenhouse gasses, and CO_2 is quite good at turning back heat.

Figure 1. At an altitude of about 100 km the earth's atmosphere is so thin that it essentially does not exist. This is where the net radiative flux (photons in minus photons out) is measured. Astronaut photograph ISS013-E-54329 courtesy NASA, JSC.

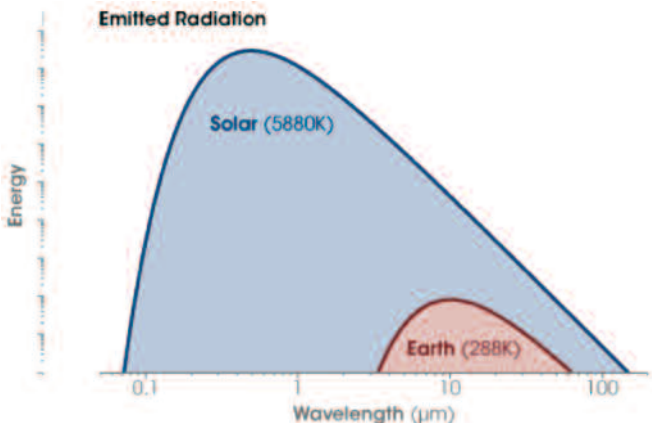

Figure 2. Energy vs. wavelength plots for incident solar radiation and the energy (heat) radiated back from the earth.

What Determines Earth's Temperature *continued on page 68*

What Determines Earth's Temperature

continued from page 59

Most of us are aware that the current warming that is occurring globally has decreased the amount of ice and snow on the planet's surface. For example the decline in sea ice since satellites began to observe it has declined dramatically (Figure 3). Most models predicted that the increased temperatures would cause a decrease in sea ice that, in turn would cause a further increase in temperature. This positive feedback is called the ice-albedo feedback and should cause a decrease in the net energy flux measured at the top of the atmosphere. Measurements, however, showed little change.

Now scientists know that the loss of surface ice and therefore the loss in surface reflectivity was compensated by an increase in cloud cover caused by the increase in available moisture due to melting. Unfortunately, this is likely to be only a temporary fix. The loss of ice will eventually start accelerating because of the ice-albedo feedback. ■

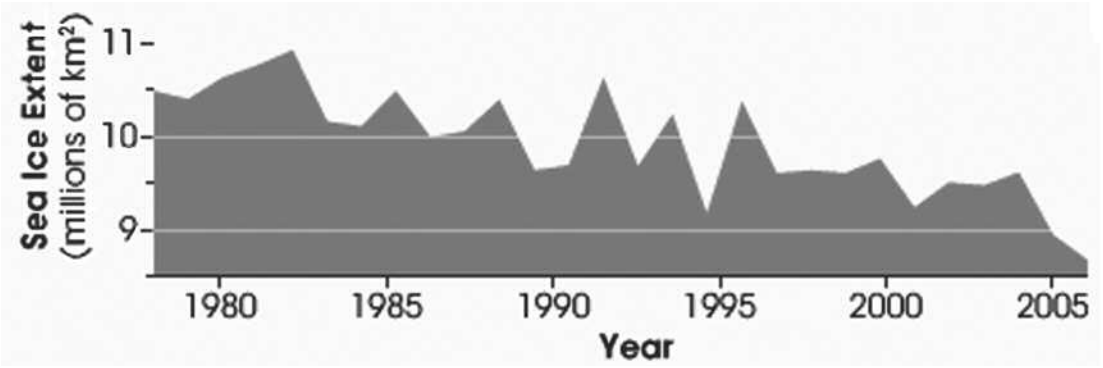

Figure 3. Decline of sea ice since 1978. Graph by Robert Simmon, can be viewed at http://earthobservatory.nasa.gov/Study/ArcticReflector/printall.php

Reference

Lindsey, Rebecca, 2007: Arctic Reflection, Clouds replace snow and ice as solar reflectors, Earth Observatory, NASA, can be viewed online at http://earthobservatory.nasa.gov/Study/ArcticReflector/printall.php