The Diurnal Smoothing Effect

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The Greenhouse Effect was originally assumed to be what was raising our average surface temperature to 15C from the cold temperature it would be if the Earth had no atmosphere. The equatorial moon, by contrast, has a mean temperature of -60C. This was assumed because no alternative effect was apparent.

In 2009 the NASA moon mission with its DIVINER sensors mapped the surface temperatures of the moon and demonstrated the effect of diurnal smoothing caused by the moon's rocky surface absorbing heat and cooling the surface during the lunar day, and reversing the process warming the surface at night. This process of surface thermal buffering also takes place on Earth, but it is exceeded by the daytime cooling and night-time warming of our atmosphere.

It seems counter-intuitive that smoothing the Earth's diurnal temperature cycle should raise the mean surface temperature, but the explanation is quite simple. We don't need supercomputers to demonstrate the Diurnal Smoothing Effect (DSE). A simple spreadsheet using basic undergraduate level physics is enough.

It comes from a simple and well-established law of thermodynamics, the Stefan-Boltzmann law, which states that a solid body radiates heat in proportion to the fourth power of the temperature (in absolute ˚Kelvin = ˚Celcius + 273). That is $E = \varepsilon\sigma T^4$, where the terms are defined in Figure 1 which shows the effect of cooling the daytime surface temperature and raising it at night by 10˚K. The net effect is a radiative imbalance of -32 W/m^2. Since more heat from the sun is incident than the surface is emitting, the surface temperature will rise until equilibrium is reached.

	T °K	E W/m^2	difference W/m^2
Day max.			
Max T	360.4	937.5	
Max - 10	350.4	837.7	-99.8
Night min.			
Min T	307.4	496.2	
Min + 10	317.4	564.0	67.8
		Imbalance =	-32.0
Stefan–Boltzmann law $E = \varepsilon\sigma T^4$			
E	Radiated energy (W/m^2)		
ε	Emissivity of surface (0.98)		
σ	Boltzman constant (5.7×10^{-8})		
T	Temperature (K°)		

Figure 1: illustration of Stefan-Boltzmann law

My Open Climate Modeller (OCM) package calculates this over a daily cycle for a variety of atmospheres. Figure 2 illustrates this for an approximately realistic atmosphere.

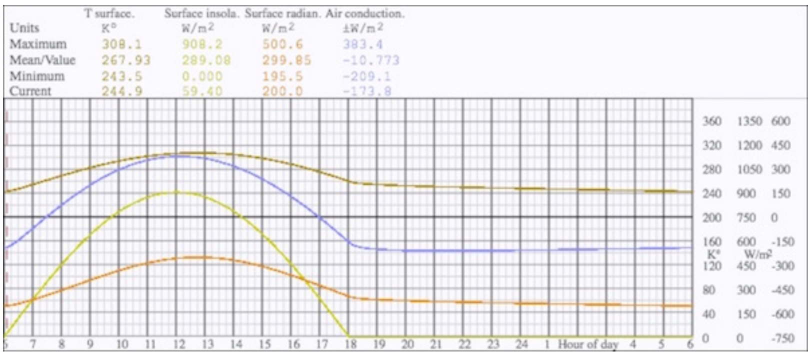

Figure 2: OCM daily cycle

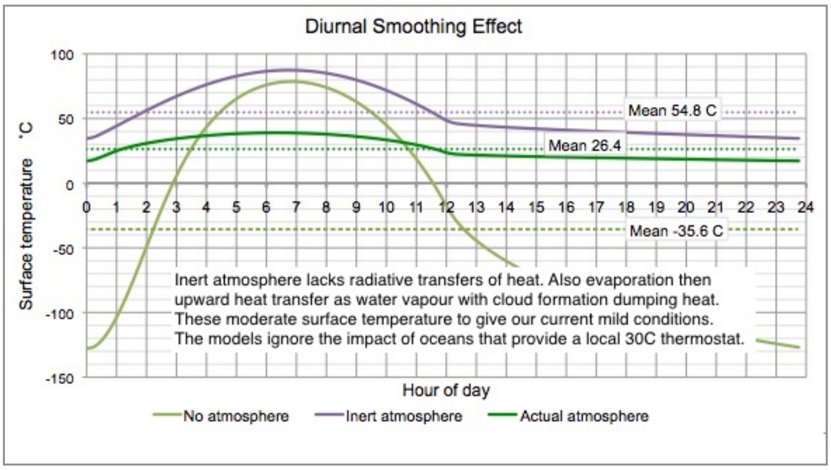

Figure 3: comparing several different equatorial atmosphere options

Figure 3 illustrates two major advantages that our atmosphere provides: firstly lifting the mean temperatures to levels that sustain the complex ecosystems we enjoy, and also reducing the diurnal temperature cycle, though not as muck at higher latitudes than the equatorial region of the diagram.