

The Setting And Maintaining

Of Earth's

Equilibrium Temperature

by

Stephen Wilde

Introduction

This issue is at the very heart of climate science and due to environmental concerns it is also at the heart of global politics and economics.

It is proposed that human activity has destabilised the Earth's equilibrium temperature for a significant long term warming effect with potentially catastrophic outcomes in due course. As will appear below the whole issue has been misunderstood due to omission of the oceans and the water cycle from the established descriptions as to how the Earth's equilibrium temperature has been set and how it might be changed.

Some 30 years ago experienced climatologists were on the right track but then it all went askew:

<http://joannenova.com.au/2011/05/climate-scientists-who-were-right-30-years-ago/>

That was the way real climate science was going at the time but a group of state supported astrophysicists (and other miscellaneous non-climate scientists) mostly involved in the space race via an overfunded NASA decided that there was a new ice age on the way and thus impliedly did not accept that there would be a late 20th century warming spell.

They came to dominate climate science, ignored all that had gone before and went on about the imminent ice age that human aerosols were to cause.

Then, when the established climate scientists turned out right, and the late 20th century warming began, those very same non-climate scientist types wouldn't admit any error, continued to sideline real climate science and flip flopped to human induced global warming from CO2 emissions.

Then the established climate scientists turned out right again as that warming trend stalled from around 2000 so again they declined to acknowledge error and (in my humble opinion) turned their attention to political influence (the Al Gore movie 'An Inconvenient Truth'), misinformation (ignoring previously established climate science), suppression of data (Climategate) and social pressure (the labeling of skeptics as 'deniers') to defer criticism of their failures for as long as possible.

That will be the epitaph for climate science in the late 20th century.

As things now stand it is proposed by many in positions of authority (who have been taken in) that not only is it our fault that climate changes are occurring but also that by taking certain measures we might be in a position to control and maintain a stable climate system by our own efforts.

Unfortunately the steps required have potential consequences that many believe will amount to a cure worse than the disease so it is vitally important that the matter be clarified and soon.

The Conventional Understanding

This has been neatly explained here:

<http://wattsupwiththat.com/2011/05/30/skeptic-strategy-for-talking-about-global-warming/>

A. Basic Climate Science – Water vapor (H₂O), carbon dioxide (CO₂), and other “greenhouse” gases cause the Earth Surface to be warmer than it would be if the Atmosphere was just nitrogen.

1. Light energy from the Sun warms the Earth System, which consists of our Atmosphere and the Surface. Based on satellite measurements, the Sun provides 1366 Watts per square meter (W/m²) at the Top of the Atmosphere. After accounting for the Earth's spherical shape and albedo (reflectiveness), the absorbed energy *averages* out to about 240 W/m² for each square meter.
2. To maintain a relatively constant mean temperature, Output Energy must equal Input Energy, so the Earth System must emit about 240 W/m² out to Space, which it does.
3. We call the Input Energy “light” because we can see (much of) it. We call the Output Energy “heat” because we can feel it. However, whether it is “short wave” energy from the very hot Sun, or “long wave” from the more moderate Earth System, we know that energy is fungible. 240 W/m² of one type is equal, power-wise, to 240 W/m² of the other. A Watt is a Watt, no matter what :^)
4. But, there is an “issue” – if we consider the Earth System as a “black body”, according to the laws of physics, for the Earth System to emit 240 W/m², it would have to be at a temperature of only 255 Kelvin, where Kelvins are degrees Celsius above absolute zero. (The Earth System is not exactly a black body, but it is close enough for our purposes here.)

5. You may remember that anything above absolute zero emits radiant energy and that 0.0 Kelvin corresponds to -273°C or -460°F . The “issue” is that the Earth Surface has a mean temperature closer to 288 Kelvin, corresponding to about $+15^{\circ}\text{C}$ or $+59^{\circ}\text{F}$. In other words, the Surface is about 33°C or 58°F warmer than the “black body” formula would indicate. How to explain this added warmth?

6. The generally accepted explanation is the Atmospheric “greenhouse effect”. This is true science, but the name is somewhat misleading because a glass greenhouse works mostly by restricting convection while the Atmospheric effect works mostly by restricting radiation. I use “scare quotes” around “greenhouse” to acknowledge this semantic issue.

7. The Atmosphere passes most of the “short wave” energy from the Sun and absorbs most of the “long wave” energy from the Surface. The absorbed energy warms the Atmosphere and is re-emitted in all directions at a variety of “long wave” wavelengths. A portion of radiation from the Atmosphere passes out the Top of the Atmosphere to Space. A portion is emitted in the downward direction and is absorbed by the Surface. This absorbed radiant energy accounts for most of the extra 33°C or 58°F .

8. A variety of gases in the Atmosphere, primarily water vapor (H_2O) and carbon dioxide (CO_2), absorb and re-emit “long wave” radiation. These are called “greenhouse gases”.

It will be noted that there is no mention of the oceans and the water cycle yet it is the oceans that dictate the temperature of the air so I will now go on to correct that omission and see where logic leads us.

The Alternative Proposition.

i) We are not just dealing with a so called black body which is a non- reflective smooth sphere but nor are we dealing with a black body surrounded by an atmosphere.

We are dealing with a reflective rough-surfaced body covered 71% by water with an atmosphere above that. Critically, the water and the air each behave quite differently as regards their respective responses to incoming solar energy.

The standard approach is therefore inadequate but inverted pyramids of climate theory have recently been constructed on top of it.

We need to go back to first principles and create a more accurate overview.

ii) A substantial portion of incoming energy from the sun (solar shortwave often referred to as SW) goes straight through the air and into the oceans up to 200 metres in depth depending on the energy of the photons. Shorter wavelength means higher energy. That energy clearly by

passes the conventional atmosphere based description and is stored by the oceans until the oceans reach a high enough temperature for the energy to be released back to the air again as fast as it comes in.

That is the point at which the oceans reach an equilibrium temperature and it is that ocean temperature which then controls the temperature of the air above and NOT the Greenhouse Effect. The real arbiter of the Earth's equilibrium temperature is instead what I have termed The Hot Water Bottle Effect.

iii) Meanwhile the physical properties of the air lead to a very different scenario. The air is heated by all the other less energetic solar wavelengths (longwave, often referred to as IR or infra red) that do not enter the water PLUS the energy released back to the air by the oceans once the oceans have reached their temperature equilibrium PLUS additional energy bouncing around in the air (the greenhouse effect) as a result of molecules in the atmosphere slowing down the rate of energy loss to space (primarily water vapour but also some CO₂ and other trace greenhouse gases).

iv) The equilibrium temperature of the Earth as a whole is a result of the combined outcome and clearly, internal system variability will be generated both by movements of air and water. As regards the air such internal system variability will be weak and short lived due to the low density of the air but the internal system variability from the oceans is long lived and substantial due to the high density of water. Indeed there may be internal ocean induced internal system variability on timescales as long as 1000 to 1500 years because that is the length of the course of the thermohaline circulation within the oceans.

v) For present purposes we can ignore internal system variability and instead look at the processes directing the speed of the average background energy flow from sun to sea to air and then to space.

vi) It is reasonable to assert that in the absence of the oceans the equilibrium temperature of the air alone would of course be set by the composition of the atmosphere. That is what the standard greenhouse theory says. In that case the quantities of greenhouse gases would be the primary determinant of that equilibrium temperature second only to total atmospheric density.

Note that both Venus and Mars have about 90% CO₂ but the atmospheres are at very different temperatures due to their density and pressure differences.

It is not reasonable to ignore the Earth's oceans in attempting to explain why the Earth's atmosphere is warmer than it 'should' be.

The next step therefore is to ascertain how the Earth's oceans reach THEIR equilibrium temperature because they control the equilibrium temperature of the air and as we shall see that is a whole different story which to date has been ignored as a result of the shenanigans described in my introductory paragraph.

The Equilibrium Temperature Of The Oceans

i) Solar shortwave energy penetrates past the evaporative layer at the top of the oceans and accumulates within the oceans until the temperature of the oceans reaches a point where it is high enough to be exactly offset by outward energy. That is the equilibrium temperature of the oceans but what determines it?

It cannot be determined by the energy content of the air because under an open sky warm air above cool water just increases evaporation for a net cooling effect which cancels out the extra warmth in the air.

It cannot be determined by the amount of energy bouncing about in the air as a result of greenhouse gases because when such energy (invariably longwave IR) hits a water molecule it just brings forward the timing of evaporation of that molecule sufficient to cancel out the extra IR and convert it to latent heat which is then whisked away upward by wind and convection.

Indeed ANYTHING that adds energy to or takes energy from the air just above the ocean surface merely adds to or subtracts from the rate of evaporation (not affecting the background energy flow from water to air at all) and is converted to or from latent heat in the air in the process. Of course conduction from water to air and upward radiation are also involved but the energy taken up by them simply reduces the energy available for evaporation.

The equilibrium temperature of the oceans is in fact determined by the combination of atmospheric pressure and the physical properties of the molecular bonds between liquid water molecules and water vapour molecules. Critically it is dependent on the energy cost or gain of the switch between liquid to vapour and back again. I need to explain that in some detail.

ii) At this point we must consider the concept known as ‘the enthalpy of vaporisation’. Essentially the specific energy value of the enthalpy of vaporisation in a particular water based scenario places a value on the energy cost of evaporation and thereby controls the rate at which energy can be extracted from water to air for a given level of energy input at a given atmospheric pressure.

It therefore controls the equilibrium temperature of any body of water for any given amount of energy input and atmospheric pressure and as we have seen the only relevant form of energy input is solar shortwave because any other form of energy fails to get past the evaporative barrier and merely changes the surface air pressure distribution to restore the sea surface and surface air temperature equilibrium. Invariably it is the air temperature that changes because the system changes the rate at which energy is transported upward in the form of latent heat. The equilibrium temperature of the water remains unchanged if the rate of solar input or the atmospheric pressure does not change.

That is because the additional energy needed for the enhanced evaporation is taken more from the air if the air gets warmer than the water (for example as a result of the greenhouse effect).

Extra evaporation induced by events in the air can never increase or decrease the energy flow from the oceans beyond that permitted by the rate set by the level of solar input combined with the energy value of the enthalpy of vaporisation at any given level of atmospheric pressure.

Even faster evaporation from increased windiness from extra greenhouse induced energy in the air alone would not do it because the extra energy needed for evaporation would come increasingly from the air and as the air cooled back toward sea surface temperature the windiness would decrease once more and the evaporation rate would decline back towards the background level.

Here is a description of the enthalpy of vaporisation for water under existing Earthly atmospheric pressure:

http://en.wikipedia.org/wiki/Enthalpy_of_vaporization

“the molecules in liquid water are held together by relatively strong hydrogen bonds, and its enthalpy of vaporization, 40.65 kJ/mol, is more than five times the energy required to heat the same quantity of water from 0 °C to 100 °C ($c_p = 75.3 \text{ J K}^{-1} \text{ mol}^{-1}$). ”

Water boils away at 100 degrees C so in other words the process of evaporation removes from the local environment (in the form of latent heat) over **five times the amount of energy required to induce that evaporation.**

In the face of that energy imbalance the extra longwave IR radiation in the air from more greenhouse gases has no opportunity to heat up anything other than the specific water molecules that then evaporate earlier than they otherwise would have done. Nothing is left to add energy to the oceans, it all disappears as latent heat and the background energy flow from oceans to air continues undisturbed.

The process is even self- limiting because, if the flow of downward IR were to stop, the rate of evaporation would simply fall back to the normal background rate set by atmospheric pressure, solar input and the energy value of the enthalpy of vaporisation.

The effect of downwelling infrared (IR) from the air is always to use up all the infrared in increasing the temperature of the ocean surface molecules whilst leaving nothing in reserve to provide the extra energy required (over five times as much) when the change of state occurs from water to vapour. That extra energy requirement is taken from the medium (water or air) in which it is most readily available. If the water is warmer most will come from the water. If the air is warmer most will come from the air. However over the Earth as a whole the water is nearly always warmer than the air (due to solar input) so inevitably the average global energy flow is from oceans to air via that latent heat of evaporation into the air and the energy needed is taken from the water. This leads to a thin (1mm deep) layer of cooler water over the oceans worldwide and below the evaporative region that is some 0.3C cooler than the ocean bulk below. The evaporative process extracts energy faster from the oceans than it can be drawn up from below and added from above otherwise that cool layer could not be present.

That 1mm deep 0.3 cooler layer is a critical diagnostic indicator but as far as I can tell it has never been recognised as such. It is disturbed by diurnal and seasonal variations and by changes in wind speed but on average over time it is a permanent fixed feature of our ocean surfaces.

The point where that cooler layer is in contact with the ocean bulk below is the physical location where the equilibrium temperature of the oceans is set and maintained.

Higher atmospheric pressure or higher solar shortwave input would make that layer shallower and less cool with the equilibrium temperature of the ocean bulk rising. Lower atmospheric pressure or lower solar shortwave input would make that layer deeper and cooler with the equilibrium temperature of the ocean falling.

Note that water boils at a lower temperature at the top of Everest. Thus at the top of Everest where air pressure is lower the energy cost of provoking vaporisation is also lower (up there the enthalpy figure is MORE than at the sea surface so energy in water can be extracted even faster into latent form for any given input of energy).

The air pressure at the ocean surface sets the energy cost of the evaporative process. High surface pressure gives a high energy cost of vaporisation and low surface pressure gives a low energy cost. Out in space with zero pressure water vaporises instantly with no energy input needed and then the vapour freezes just as instantly.

Human induced changes in CO₂ quantities are many magnitudes too small to significantly change atmospheric pressure yet that is what it needs to do to change the equilibrium temperature of the oceans.

Therefore at current atmospheric pressure at the sea surface the energy value/cost of the enthalpy of vaporisation is set by basic physical laws acting with the properties of water molecules and that determines the background rate at which energy can be extracted from the oceans in latent form for any given level of solar shortwave input. That is what sets the equilibrium temperature of the oceans and the ocean surface temperatures then control the equilibrium temperature of the air above.

But What Happens Above The Oceans?

Extra energy in the air from whatever source other than solar shortwave cannot enter the oceans to affect the equilibrium temperature of the oceans so instead it affects the surface air pressure distribution which then shifts to prevent a divergence between sea surface and surface air temperatures.

So the issue is whether that effect from a little more CO₂ is at all significant in the natural scheme of things.

It appears that there were huge changes in air mass distribution between the Mediaeval Warm Period, the Little Ice Age and the Current Warm Period. The main jet stream tracks altered by 1000 miles or more latitudinally as they worked to maintain sea surface and surface air temperature equilibrium against the external forcing of changed levels of solar activity and of internal system forcing from oceanic variations. There were no significant human influences in those days.

It would be surprising if our extra CO₂ would shift the air circulation systems by more than a mile or two to compensate for the additional energy in the air. It has been suggested that the pre 2000 poleward drift of the jetstreams and associated widening of the tropical belts was a consequence of human influence. However since 2000 the process seems to have gone into reverse so that is now open to challenge.

In effect it would be just a fraction warmer at the top of a natural warming spell and a fraction less cold at the bottom of a cooling spell and a generally more pleasant world in between times.

That assumes that we are largely responsible for that extra CO₂. It is quite possible that much if not all of the rise in CO₂ is due to the warmed oceans reducing their uptake of CO₂ (because warm water holds less CO₂ than cold water) and the effect of a more active biosphere releasing CO₂ faster to the air.

The Dominance Of Negative Feedbacks.

The idea that humans affect climate significantly depends largely on positive feedbacks amplifying the effects from more CO₂.

Many are pointing out that the feedback from more energy in the air seems to be negative (more convection, rainfall and clouds in particular) rather than positive and the observed climate shifts over the past ten years (more atmospheric 'blocking' events causing the surface pressure systems to shift around more and producing more meridional/equatorward jet streams) seem to be confirming that view since the temperature trend is increasingly diverging from that expected from more CO₂ emissions.

On the basis of the fixed ocean equilibrium temperature and the oceanic dominance over air temperature it must follow that the effect of a shift in air circulation systems is ALWAYS a negative response damping down any divergence of air temperatures (whether warming or cooling) from the ocean temperature equilibrium (which is set ONLY by solar shortwave input combined with atmospheric pressure and the energy value of the enthalpy of vaporisation).

Changes in the speed of the water cycle are invariably negative so that the water cycle slows down if the differential between sea surface and surface air temperatures decreases and the water cycle speeds up if the differential between sea surface and surface air temperatures increases.

The air mass distribution changes imperceptibly relative to natural changes so as to expel from the system faster the extra energy in the air from more greenhouse gases thereby preventing a significant long term or extensive divergence of surface air temperatures from sea surface temperatures.

Conclusions:

- i) The Earth's equilibrium temperature is set by the Hot Water Bottle Effect of the oceans and not by The Greenhouse Effect.
- ii) Greenhouse gases can ONLY affect the energy content of the air, not the oceans.

iii) If the air temperature tries to diverge from the temperature set by the ocean surfaces the surface pressure distribution shifts to changes the speed of the water cycle thereby eliminating any such divergence.

iv) The change in surface pressure distribution to dispose of the effects of more CO₂ would be unmeasurable and unnoticeable compared to the observed historical shifts from solar and oceanic variability.

v) There is no prospect of anything that mankind could do or not do that would **reliably** scale up to the degree necessary to exert a significant effect on the natural surface air pressure distribution.

vi) The Earth does not have a climate, only a temperature. It does however have climate zones and temperatures vary greatly between them. Furthermore they shift about a great deal from natural causes on multiple timescales. I can see no prospect of ever achieving a technology that could control or even moderate shifts in the surface pressure distribution so as to predictably stabilise changes in the size and location of climate zones.

This article is the second part of a planned trilogy of articles setting out a new climate description that is capable of accounting for all observed climate phenomena whilst still complying with the most basic laws of physics.

The first article can be found here:

<http://climaterealist.com/index.php?id=6645>

where I deal with the mechanisms whereby solar variability exerts a top down influence on the surface air pressure distribution by interacting with the chemical constituents of the atmosphere, especially ozone.

The final part will be entitled 'The Climate Matrix' wherein I will deal with the complex ways that the top down solar and bottom up oceanic variations interact in an ever changing dance to produce the myriad climate changes and climate phenomena that contribute to the richness of our planet.