From: climatescience@googlegroups.com [mailto:climatescience@googlegroups.com]
On Behalf Of John Nicol
Sent: Sunday, 13 July 2008 6:34 PM
To: Climatescience@googlegroups.com
Subject: [ClimateScience Google] Fw: Convection and conduction - effect of wind on surface temperature

Dear All,

I am generally recognised by the obvious fact that I know very little about meteorology and climate although recently Bill Kinninmonth has done a great job in helping me to understand better some of the subtleties in climate behaviour and inputs to the models.

I have been thinking further (sometimes a dangerous thing to do) about this CO2 thing and wondering how the warming of the atmosphere, at lower levels through absorption by a green house gas, compares with warming by direct contact of air with the surface. We all know that a real vacuum flask beats the hell out of one of these cheap things, with carbon and other insulation, for keeping the water hot from early morning until afternoon tea time at a picnic. In the vacuum, the transfer of heat, admittedly between two shiny surfaces, is by radiation only for the most part, while the others, with air movement inhibited, involves some conduction and a lot of convection or conduction through air - which is still a pretty good insulator compared to say, aluminium. We also know that if the motor of a hair dryer dies, the element has a further lifetime of about a millisecond - probably a bit more than that - but in any case its radiation cannot remove the heat anywhere near fast enough to stop it from burning out, an extreme condition to be sure.

There is a similarity here between the temperature of the ground in the tropics, for someone who has run around in bare feet in the middle of the day as a kid, when there is no wind blowing and when there is a breeze which need not be very strong. In the first case there is nothing to do but stand in the shade or get blistered feet. The air in contact must therefore be heating up at a rate which is (much) faster than the heat taken out by radiation alone, plus the possibly small upward convection of the heated surface air. It seems to me then, that at lower levels, the heating of the air by radiation must be much less on average, than the heating by absorption of radiation. Is this so?

Since I believe the absorption by green house gas results overwhelmingly in immediate heating of the air through collisions and that re-radiation is trivial, the heated air is then transported upwards by convection - and the heat energy moves upwards but not by radiation. A tiny fraction will be reradiated but immediately reabsorbed and sent back to heat the surrounding molecules including non-GHG molecules. In the **upper** levels where all gases are at much lower pressure, there will be some radiation taking place in all directions and some may escape upwards while that directed downwards will be re-absorbed long before it gets back to ground level.

Back to the upper levels, where now the warmer air effects, again through contact or collisions, aerosols and droplets of water capable of taking part in black body radiation with a spectrum actually not too different from that at ground level although shifted slightly to longer wavelengths because it is from a slightly cooler body. Radiation from the gases will only be according to their spectral characteristics - not Black body, and because their energy level distribution follows that of the Maxwell-Boltzmann curve, some of their radiation will lie outside greenhouse gas absorption bands being both higher and lower in wavelength, and hence escape as we should hope it would. Some of these particular components to which air is transparent, will, of course, in this case get back down to the ground. In one of the explanations of IPCC type thinking, the greenhouse effect is claimed to cool the effective "outer surface" of the atmosphere and therefore provide lower output of radiation based on the power = sigma T^4 relationship. Is that correct?

It seems to me that the air in the upper layers will actually be very slightly warmer and hence there will be an **increased** rate of radiation to restore the balance, but with minimal to no effect at ground level.

Thus, beyond a certain minimum concentration of greenhouse gas, the effect on temperature of the earth is practically, if not totally, zero. Is this likely to be correct?

My gratitude will be extended to anyone who has the time to answer these, probably simple questions, posed by an atmospherically ignorant lay person.
Yours sincerely,
John

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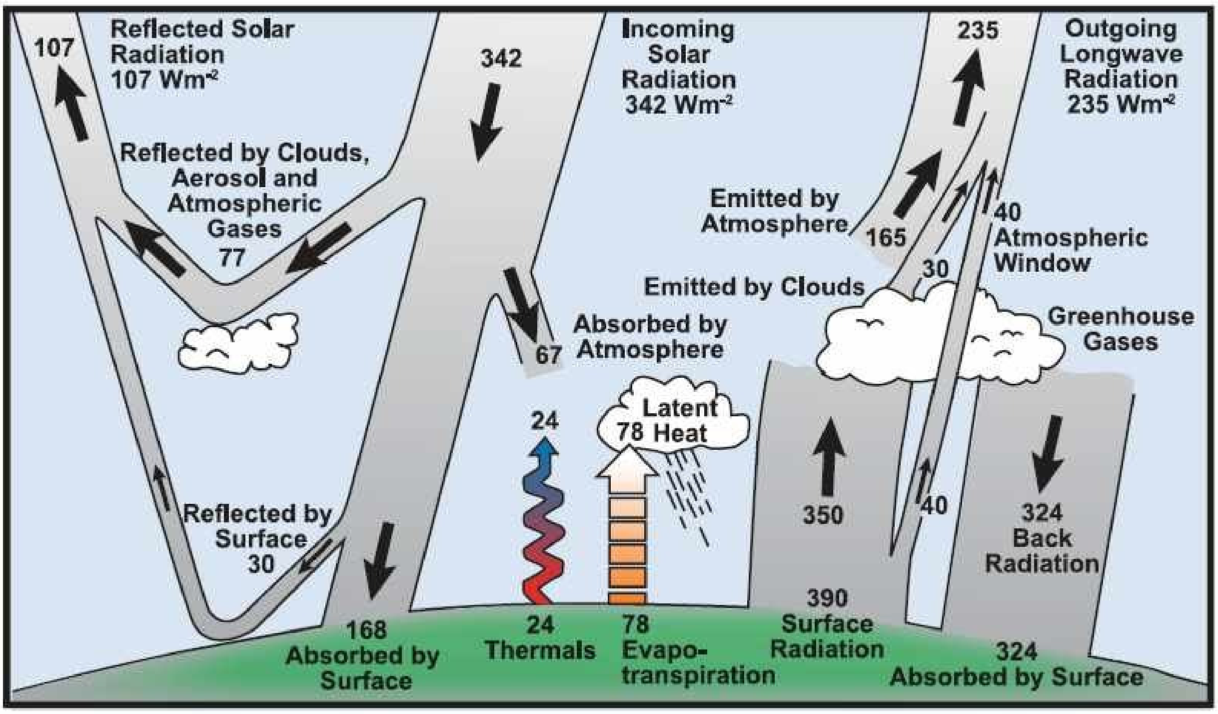
----- Original Message -----
From: William Kininmonth
To: climatescience@googlegroups.com
Sent: Wednesday, July 16, 2008 12:00 AM
Subject: [ClimateScience Google] Re: Fw: Convection and conduction - effect of wind on surface temperature

Dear John,

If I have been helpful then it is time well spent.

The greenhouse effect is not solely a radiation problem! Look at the global energy budget below.



Note that the net IR radiation loss at the surface (i.e., the net upward radiation flux) is 66 Wm-2. At the top of the atmosphere the net upward radiation flux is 235 Wm-2. If we did the calculations at a series of altitudes we would find that the net upward IR radiation flux increases regularly from the

66 Wm-2 to the 235 Wm-2 at the top of the atmosphere. The atmosphere is continually cooling because of the net IR loss of 169 Wm-2. This loss is partially offset by the absorption of 67 Wm-2 of solar radiation leaving a net radiation loss of the atmosphere of 102 Wm-2

If we look at the radiation budget of the surface there is 168 Wm-2 of absorbed solar radiation and a net loss of 66 Wm-2 of IR radiation. That is, a net accumulation of radiation at the surface of 102 Wm-2.

You can clearly see what is coming next: the excess 102 Wm-2 accumulating at the surface is transported to the atmosphere to offset the net IR loss.

The problem, as Herbert Riehl and Joanne Malkus (better known as Joanne Simpson) wrote in 1958, is that the atmosphere a) is a poor conductor of heat and b) is stably stratified (internal plus potential energy per unit mass, or dry static energy, increases with altitude) and so turbulence moves energy downward, not upwards. How does the accumulating energy get from the surface to the atmosphere?

Their solution was to consider moist static energy, the sum of internal energy, potential energy and latent energy. In the tropics, moist static energy is a maximum at the surface, it decreases with altitude as the vapour pressure (latent energy) decreases and then increases according to the dry static energy profile. Boundary layer air, ascending buoyantly in the protected updraughts of deep tropical cumulus clouds, conserves its moist static energy such that latent energy during condensation and heat during expansion are converted to potential energy. Air arrives at the high troposphere that is dry and has the same temperature as the environment, where it stabilises. There is no energy imparted from the ascending air to the environment. Away from the cumulus clouds there is compensating subsidence of the dry environmental air and potential energy is transformed to heat during compression – the descending air warms at the dry adiabatic lapse rate of 10K/km whereas the environmental lapse rate is about 6.5 K/km. The descending environmental air warms and it is this heat that is available to offset the radiation loss.

In terms of the greenhouse effect, there is no buoyant ascent of boundary layer air until the temperature lapse rate of the troposphere exceeds the moist adiabatic lapse rate of -6.5 K/km. The surface has to be warmer than the atmosphere to enable vertical transfer of energy in order to offset radiation loss by the radiationally active gases (water vapour and CO_2). The surface-atmosphere system heats up until the IR loss to space is 235 Wm-2 and offsets the net solar absorption.

The important point to note is that absorption of IR by the active gases of the atmosphere is not the determining process for the greenhouse effect. From a radiation perspective the important processes are absorption of solar radiation at the surface and net emission of IR by the troposphere. These generate the convective instability. It is the need for convective overturning that maintains the temperature of the tropical troposphere at about the moist adiabatic lapse rate of -6.5 K/km and the magnitude of surface temperature greater than the atmosphere.

Regards,

William Kininmonth