Further Modification of JB's criticism of the FM Paper in E & E

This is a shortened and updated version of my criticism of FM's paper [THE STABLE STATIONARY VALUE OF THE EARTH'S GLOBAL AVERAGE ATMOSPHERIC PLANCK-WEIGHTED GREENHOUSE-GAS OPTICAL THICKNESS by Ferenc M. Miskolczi]. It includes what I consider to be the most important arguments.

FM's ABSTRACT

By the line-by-line method, a computer program is used to analyze Earth atmospheric radiosonde data from hundreds of weather balloon observations. In terms of a quasi-all-sky protocol, fundamental infrared atmospheric radiative flux components are calculated: at the top boundary, the outgoing long wave radiation, the surface transmitted radiation, and the upward atmospheric emittance; at the bottom boundary, the downward atmospheric emittance. The partition of the outgoing long wave radiation into upward atmospheric emittance and surface transmitted radiation components is based on the accurate computation of the true greenhouse-gas optical thickness for the radiosonde data.

JB: Radiosonde data do not contain spectroscopic information.

FM: New relationships among the flux components have been found and are used to construct a quasi-all-sky model of the earth's atmospheric energy transfer process. In the 1948-2008 time period the global average annual mean true greenhouse-gas optical thickness is found to be time-stationary. Simulated radiative no-feedback effects of measured actual CO_2 change over the 61 years were calculated and found to be of magnitude easily detectable by the empirical data and analytical methods used. The data negate increase in CO_2 in the atmosphere as a hypothetical cause for the apparently observed global warming. A hypothesis of significant positive feedback by water vapor effect on atmospheric infrared absorption is also negated by the observed measurements. Apparently major revision of the physics underlying the greenhouse effect is needed.

JB: This is the most controversial paper in the Special Edition and is completely wrong in its treatment of optical thickness/optical density/optical path as I hope to show. No revision of greenhouse physics is needed.

The crucial equation of FM's is the one equating optical depth, τ, with the value of $\ln(S_U/S_T)$:

$$\tau = \ln(S_U/S_T)$$

S_U is the flux density of terrestrial radiation emitted by the Earth's surface; S_T is that which is directly transmitted to space. The general understanding of S_T is that it represents the flux density of radiation escaping to space through the infra-red window; 750-1250 cm^{-1}. FM calculates the value of τ by analysing radiosonde data and by simulating the terrestrial spectrum using his HARTCODE programme which can offer line-by-line resolution.

Both methods produce the same answer; $\tau = 1.868$. This means that $S_U/S_T = 6.475$ and the equivalent percentage transmission is 15.4%. FM claims that this value is a constant term and that if the atmospheric concentration of CO_2 increases, that of water vapour will decrease to preserve the constancy.

General understanding of the spectroscopy of the atmosphere is that the main bands of CO_2, centred at 667 cm^{-1} actually define the low wavenumber boundary of the IR window with the participation of some weak water vapour bands. An increase in the concentration of CO_2 will slightly narrow the window; more of the terrestrial radiation will be absorbed causing an enhancement of the greenhouse effect. In FM's terms the value of τ will be unchanged and S_U/S_T will be unchanged as the result of the water vapour concentration decrease. From the general understanding of the spectroscopy, if S_T did decrease as the result of an increase in concentration of CO_2 the value of S_U would have to decrease by an identical factor to ensure the constancy of the ratio S_U/S_T. But, radiative transfer theory indicates that if S_T were to decrease, the value of S_U would increase because the system would be warmer. From the conventional physics viewpoint this aspect of FM's paper is wrong.

The second method of arriving at a value of τ is the line-by-line calculation of quantities in the following equations.

...and the Earth's global average IR optical depth (τ_A) :

$$\bar{T}_A(\Delta\nu,\mu)=\frac{1}{\Delta\nu}\int_{\Delta\nu}\exp\left[-\sum_{l=1}^{L}\sum_{i=1}^{N}\left[c^{i,l}+k_{\nu}^{i,l}\right]\frac{u^{i,l}}{\mu^{l}}\right]d\nu$$

$$\tilde{T}_A(\Delta\nu)=\int_{2\pi}\bar{T}_A(\Delta\nu,\mu)d\omega\,.$$

$$T_A=\frac{1}{\sigma t_A^4}\sum_{j=1}^{M}\pi B(\Delta\nu_j,t_A)\tilde{T}_A(\Delta\nu_j)\quad\longrightarrow\ \tau_A=-\ln(T_A)$$

$$\boxed{\tau_A=1.868}$$

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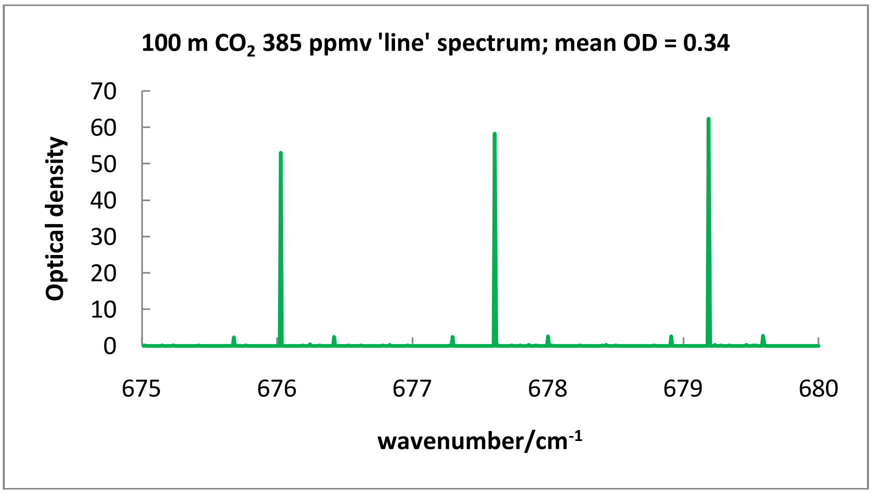
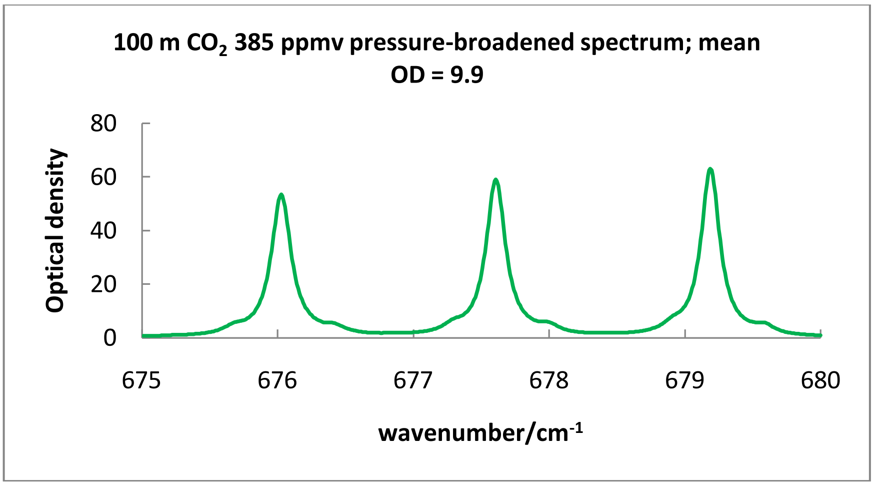
FM's calculations of both T_A values, the ones with straight and wiggly toppings are quite legitimate. The straight one is the mean of proper transmissions based solely upon absorption properties. It represents the exact application of Lambert's Law to the atmosphere. The result expresses the general greyness of the atmosphere. The wiggly one is also legitimate in that it is the mean of the straight values taken over all angles. Again, it is based on absorption-only information. The 'Planck weighting' is used to represent the calculated optical densities in proportion to their relevance to the absorption properties of the atmosphere over the relevant part of the spectrum. This is a very doubtful procedure. Essentially it entails the multiplication of a transmission value by a factor that depends upon the intensities of both the transmitted and incident radiation. Such variations are already 'built-in' to the proper calculations of optical density at specific frequencies. The incident intensities are given by the value of the Planck equation.

The misinterpretation of the calculated value of $\ln(S_U/S_T)$ is possibly best explained by dividing the spectrum into three parts; 0-750 cm^{-1} in which the major gases absorb, H_2O and CO_2, 750-1250 cm^{-1}, the IR window through which the flux is 40 W m^{-2} (according to the K/T energy budget), and 1250-1600 cm^{-1} where there are overlapping spectra of H_2O, CH_4 and N_2O. Using mean values for optical densities in the three parts, that for the 0-750 cm^{-1} region is very high, and so is that of the 1250-1600 cm^{-1} region. Only in the window region is the optical density, by definition of the window zero; in reality the optical densities are near zero. The mean value of optical density for the whole spectrum is therefore very high indeed. HITRAN calculations on a 100 m thick layer of the standard atmosphere with 385 ppmv CO_2 produced results that are very different from those of FM. The overall mean optical density was 957, that for the 0-750 cm^{-1} region was 1911, that for the window region was 0.36, and that for the 1250-1600 cm^{-1} region was 306. All the values are very far from being 1.868.

One possible reason for the vast discrepancy outlined above is that FM's calculation made use of un-broadened lines. That makes a very large difference in the results. The spectrum that follows is for a 100 m path length of 385 ppmv CO_2 in terms of its 'lines,' the line centres in the HITRAN database which have zero width, but indicate the 'strength' of the absorption in terms of an absorption coefficient. The wavenumber range was chosen to be only 5 cm^{-1} to avoid problems with resolution.



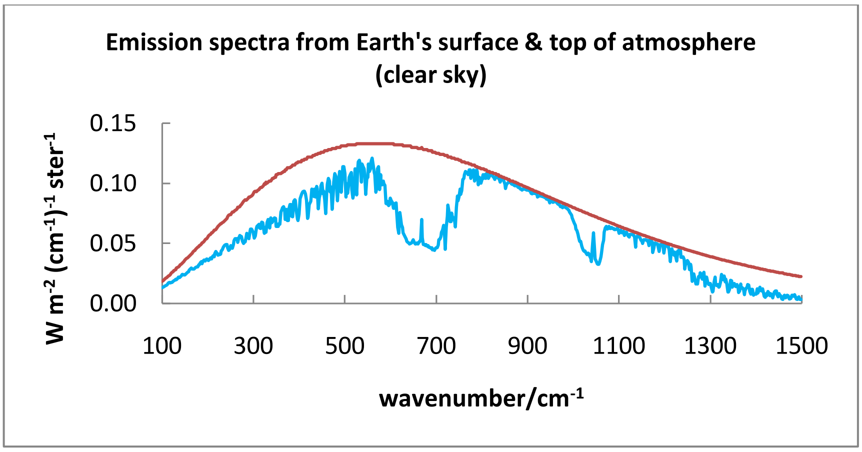
The three major lines are part of the R-branch of the fundamental vibrational bending mode. Their individual 'optical densities' are 53, 58 and 62 respectively, but the mean optical density for the range of wavenumbers is only 0.34. The next spectrum is for the same sample, but using line broadening appropriate for 1 atmosphere total pressure.



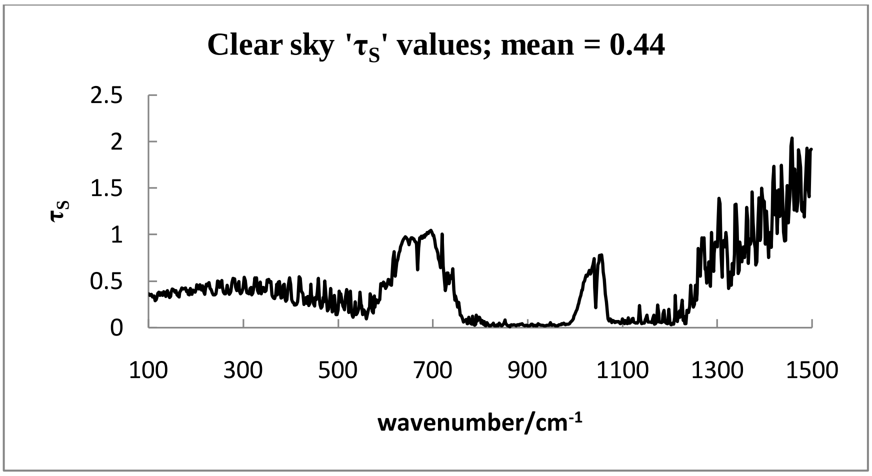
As indicated on the spectrum the mean optical density is now 9.9 and shows how line broadening increases the value compared to the non-broadened case by a factor of 9.9 /0.34 = 29.

In the real atmosphere there are many broadened lines from the greenhouse gases and they overlap to prevent any photons from the surface escaping to space except for those in the window region.

In radiative transfer theory it is important to distinguish between '*transmission*' and '*transfer*'. Transmission is that fraction of the photons emitted by the surface that actually pass into space. Transfer refers to the energy released to space in the form of photons, but these are thermally produced and do not necessarily originate at the surface. The **transfer** of any particular frequency through the atmosphere is governed by the Schwarzchild equation that takes into account the Beer-Lambert Law reduction in flux density with altitude *and* the enhancement of flux density with altitude from thermal radiation [given by the Planck equation]. Thus, for any particular frequency there is a ratio for the flux density emitted by the atmosphere to space including the thermal emission and the flux density emitted by the surface that may be transformed into an 'optical depth', τ_S [S for Schwarzchild] that may be estimated using the MODTRAN programme.



The above diagram shows the 'blackbody' emission from the surface in red and the thermal emission to space for a clear sky atmosphere. Individual τ_S values may be calculated at each frequency and these are shown in the next diagram.



As indicated, the mean value of the τ_S values is 0.44, nowhere near the FM value for his τ_A of 1.868 which is for optical densities in any case. The window region is included, but if this were to be excluded the mean value would still fall short of the FM value. One difference between my calculations of τ_S and FM's calculation of his τ_A arises because my calculations include thermal emission, which increases the apparent transmission values and FM's exclude thermal emission by definition.

Optical density or optical thickness?

The two terms are used interchangeably by some authors, but they can be reserved for the property of individual specific frequencies [optical depth] and the integrated values of optical depth over a range of frequencies [optical thickness]. In neither case are the values inclusive of thermal emission terms. In these terms FM's τ_A values are given by $-\ln(S_T/S_U) = 2.28$ are estimates of optical thickness. FM's calculation of T_A in the equations quoted above includes the optical depths for each frequency in the range, modified by the *B* term that accounts for the 'Planck weighting', all integrated over the frequency range, the answer not being given. In practice this optical thickness is offset by thermal emissions and in FM's terms, using the K/T values would be given by ln[350/195] leading to an overall optical thickness of 0.58, quite close to the mean produced by MODTRAN; that is 0.53 after taking cloud cover into account. The idea that this quantity should be a constant is just not credible. Additionally, the $-\ln(S_T/S_U)$ approach to the optical density/thickness ignores the possibility that the true optical densities in the non-window regions are enormous for the whole atmosphere. It takes no account of their values at all. The fraction of blackbody radiation emitted by the surface through the window region is 30% for clear skies and assuming a cloud cover of 62% this figure is reduced to only 11.3%. So, 11.4% of the true optical densities will be zero and FM has no information about the true optical densities in the remaining 88.7% of the relevant spectrum.

The whole FM approach is bottom-up based on absorption properties only and as such is bound to fail; more so with errors in computing optical densities.

JB: This is a brief account of conventional global warming theory as background to my criticisms of the papers in the *Special Edition of E & E*, **21**, 171, 2010.

For each and every spectral line or band of the greenhouse gases there is an emission level from which photons escape to space. This is the altitude where the probability of a photon emitted towards space has a greater chance of escape than that of being absorbed. The level is determined by the magnitude of the relevant optical path (optical density) as measured from the top of the atmosphere. Radiative transfer theory indicates that the emission level is the altitude where the optical path is two-thirds, 0.67 and equivalent to a transmittance of 51%. An increase in the concentration of a GHG will cause the emission levels of its individual lines/bands to move to higher altitudes. In the stratosphere where the emission levels of the very strong absorbers are found the higher levels are at higher temperatures and lead to a higher intensity of emission. This causes the stratosphere to cool. In the troposphere the opposite situation pertains. The higher emission levels occur at lower temperatures and the reduction in the rate of transfer of radiation to space causes the troposphere to warm. The consequences of the stratospheric cooling and tropospheric warming include a higher surface temperature. Such warming would be less than that in a solely radiative planet because of non-radiative energy transfers from the surface to the atmosphere.

FM's paper ignores the real reasons for the effects of GHGs upon the temperatures of the troposphere and stratosphere. The two regions of the atmosphere are ignored, but they have very different reactions to radiative forcing.