CO2 has hardly any effect on the surface temperature

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Introduction

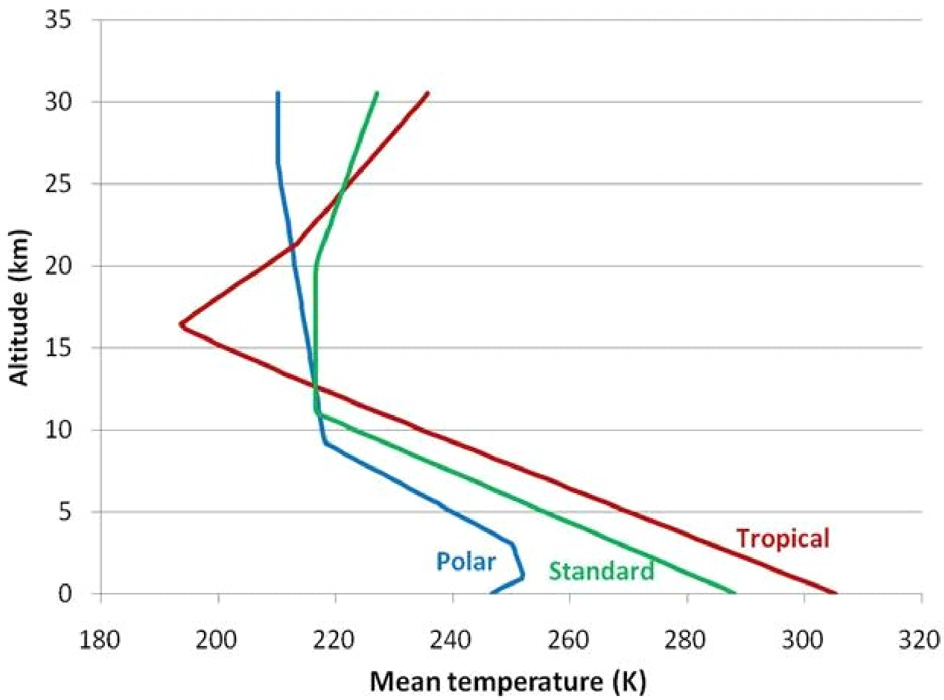
In earlier papers **[1,2]** the author has described models to analyze the evacuation of heat from the surface of the planet, representing the atmosphere by semi-transparent grids. In those papers the one-stream heat flow formulation is used without the non-physical back-radiation, from cold to warm, and thereby non-physical huge LW surface radiation. IPCC (International Panel for Climate Change) authors have adopted the Schwarzschild procedure, en vogue in astronomy, with a two-stream formulation. Unfortunately IPCC authors interpret radiation always as radiation of heat, with the non-physical back radiation of heat. The astronomer Ferenc Miskolczi (FM) uses the two-stream formulation. But FM speaks about "Global average radiative equilibrium structure with constant optical height", and not about back-radiation of heat **[3]**.
In **[1]** the author has used the one-stream stack model to carry out a sensitivity analysis of doubling CO_2 concentration. For a model of 10 km height, a surface temperature increase $\delta Ts = 0.03$ K was obtained. In this paper the sensitivity analysis is repeated for a model with an height of 30 km, in order to take into account the traces of CO_2 at those heights. The sensitivity from zero to 400 ppm is 0.04 K or 1e-4 K/ppmCO_2.
Two-stream formulation authors do not agree on the CO_2 sensitivity with each other. FM **[3]** uses the line-by-line computer program HARTCODE and speaks about a to be neglected effect of CO_2, although weather balloons measurements show, according to FM, a decrease in average water vapor for an increase in CO_2 concentration.
But IPCC authors give what they call CO_2-forcing or $\delta OLRco2 = -3.5$ W/m^2, obtained from computer programs where the effect of CO_2 is obtained by artificially broadening the CO_2 line in the spectrum [8].With the variation of OLR due to surface temperature dOLR/dTs = 3.4 W/m^2/K, the value for surface temperature increase becomes a factor 25 too big.   IPCC: $\delta Ts = -\delta OLRco2/(dOLR/dTs) = 3.5/3.4 = 1.0$ K.

The stack model does not confirm the suggestion of Kyoji Kimoto **[9]** that a variation of the lapse rate could be an alternative to the fixed lapse rate sensitivity analysis.

Sensitivity Analysis

The stack model is based on the measured temperature distribution in the troposphere, defined by gravitation and the specific heat of air, giving rise to lapse rates: the dry adiabatic lapse rate , DALR = $-g/c_p$ = -9.8 K/km, and the measured environmental lapse rate, ELR = -6.5 K/km, depending also on the latent heat of wet air and convection.
In **figure 1** the temperature profiles for three different climate zones are given.

Figure 1 from the Public Domain Aeronautical Software **[4]**



We observe the parallel lines in the temperature profiles in the troposphere for the various zones, with a slope equal to the environmental lapse rate, ELR = -6.5 K/km.
The slope remains constant, since it is defined by gravity and the specific heat of air and the latent heat. Only the surface temperature varies, due to the variation of sun power, higher in the tropical zone and lower in the polar zone: an average value of Ts=288 K for the standard profile with an OLR of 240W/m^2.
For the various climate zones different surface temperatures are established because the evacuation mechanisms of heat, - radiation but mainly convection - ,from the surface to outer-space, depend on the temperature distribution *i.e* OLR = 240 W/m^2 for the standard atmosphere with ELR -6,5 K/km with surface temperature Ts=288 K.
The basic relations of the stack model are written in matrix form, (**bold** symbols stand

for matrices or vectors), representing the heat balances by LW radiation between the surface of the planet and lower grids and for grids at higher height to outer-space **[1]**.

$$\mathbf{K}*\theta = \mathbf{rhs} \qquad (1)$$

K : System matrix of order NxN, to be modified by boundary conditions. It is generated for water vapor and for CO_2, respectively **Kh2o** and **Kco2**

θ : Vector of unknowns, W/m^2, of order N, typical 60 for a height of 30 km. The variables represent temperature, $\theta i = \sigma Ti$^4

rhs : Right hand side vector of fluxes q , W/m^2, into the system, of order N

To solve the system of equations **(1)** , boundary conditions are needed.
At the surface of the planet at node 1: T_1=Ts, or $\theta_1 = \sigma Ts$^4.
For outer-space at node N: $\theta_N = 0$.
For a known matrix **K** and known right hand side vector **rhs,** the relation **(1)** gives the possibility to calculate the temperature distribution **θ** in the atmosphere.
Examples are given in **[2]** for a **rhs=0,** so to speak a stack on the moon**,** or as if the stack in the atmosphere of the Earth, representing the IR-active trace gases, were isolated from the bulk of the atmosphere, 99% O_2 and N_2.
But for a stack on the real planet Earth the loading vector **rhs** should contain the effect of heat transport by convection, which is not obvious.
However with known measured temperature profiles of **figures 1**, mainly defined by gravity, we look to the reversed equations:

$$\mathbf{qh20} = \mathbf{Kh2o}*\theta \qquad \text{and} \qquad \mathbf{qco2} = \mathbf{Kco2}*\theta \qquad (2)$$

Kh2o , Kco2 : system matrices of order NxN (in the sensitivity analysis N=60). They represent the contributions of water vapor H_2O and of CO_2.

θ : vector of N known temperature parameters**.**

qh2o , qco2 : vectors of to be calculated fluxes, into the system, of order N, W/m^2.

The calculated vectors **qh2o** and **qco2** in **(2)** consist each of N components:

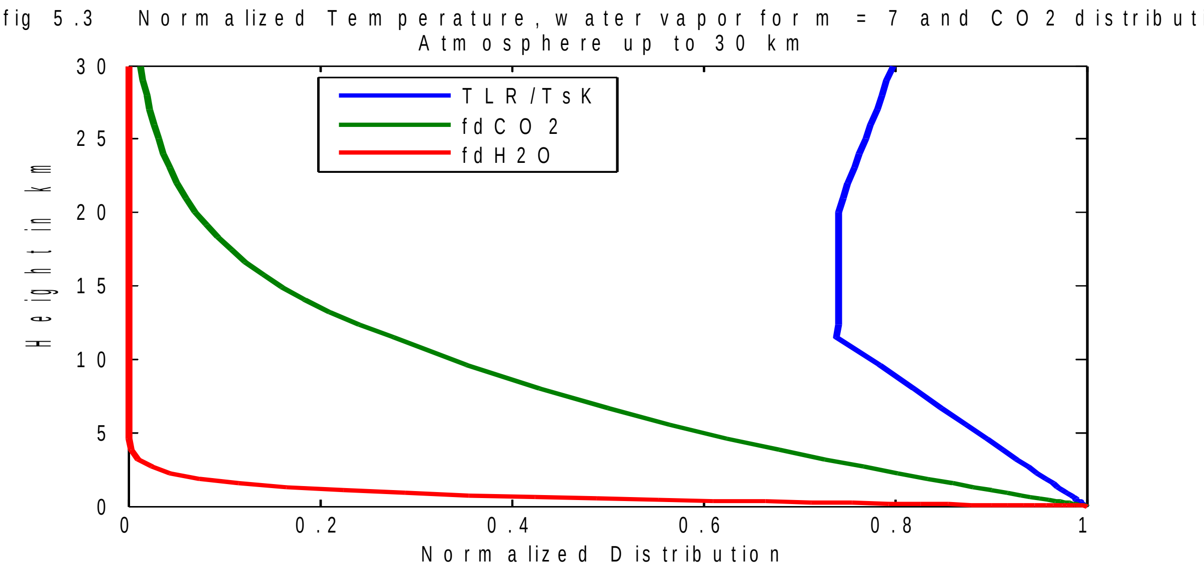
qh2o(1) , qco2(1) : LW surface fluxes

qh2o(N) , qco2(N) : - OLRh2o , - OLRco2 , outgoing LW radiations

The remaining terms, i=2:N-1, represent heat input at the various axial stations in a column of air due to mechanisms other than LW radiation: convection of latent and sensible heat and absorption by the atmosphere of incoming SW radiation.

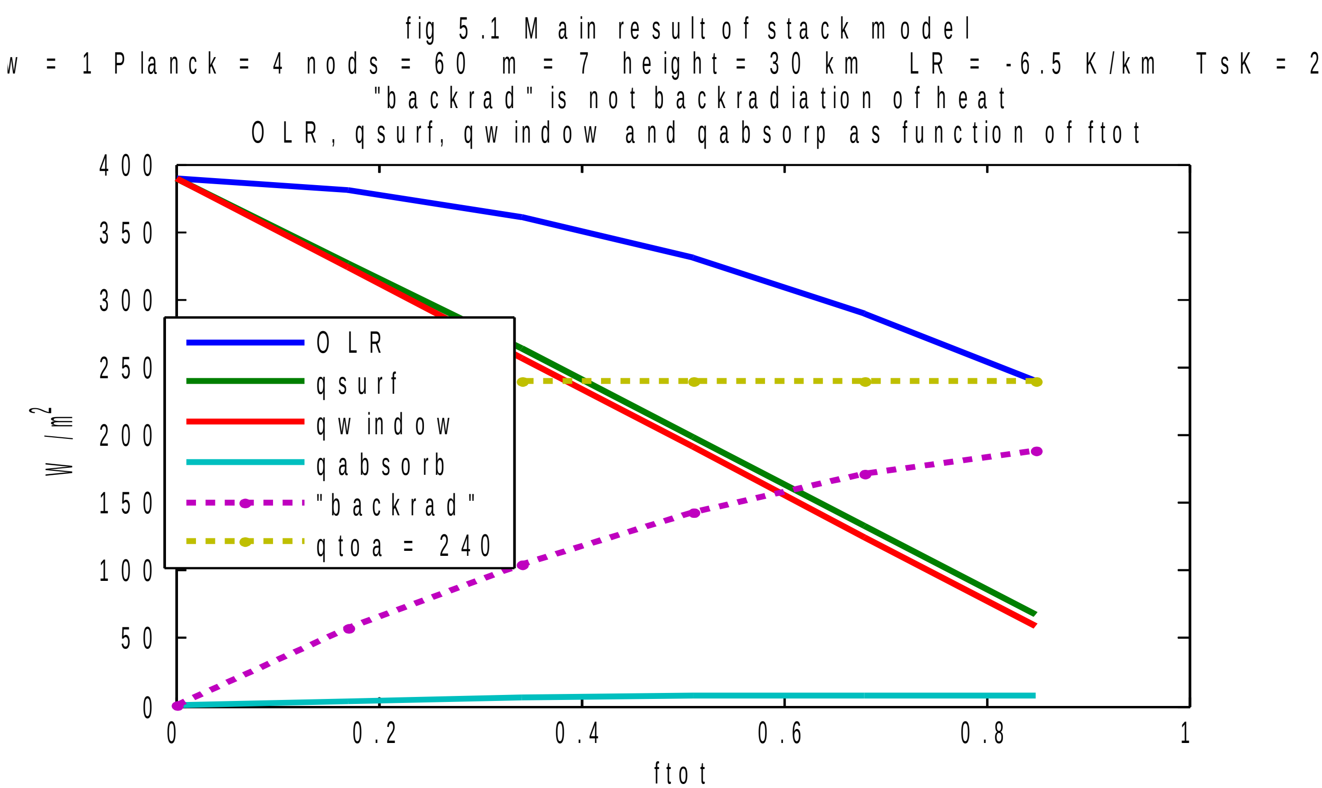
The radiation matrices **Kh2o** , **Kco2** depend on the distribution of the traces of IR-active gases, such as water vapor H_2O and CO_2.
The distribution of water vapor H_2O and CO_2 have been discussed in detail in [**1**].
The temperature in **figure 2** correspond to the standard atmosphere of **figure 1**.

Figure 2



The main results of the stack-model, **q=K*θ**, are represented in **figure 3.**

Figure 3



The equilibrium point is for ftot= ftoth2o +ftotco2 = 0.849 :

OLR=240 , LW qsurf = 67 of which qwindow=59 and qabsorb =8.

In **Appendix 1** these results are compared in detail with those of Ferenc Miskolczi **[3]**.
The results of **figure 3** are for a surface temperature TsK=288.
The variations of the surface temperature TsK between climate zones and thereby variation of OLR, surface flux and window flux are given in **figure 4.**

Figure 4

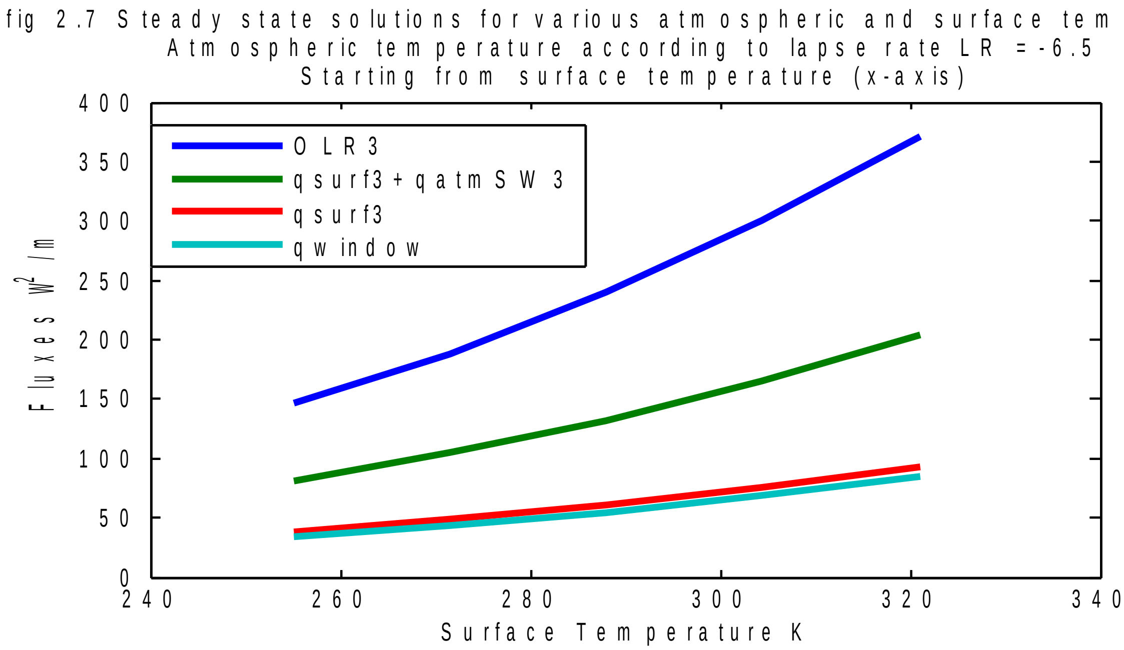
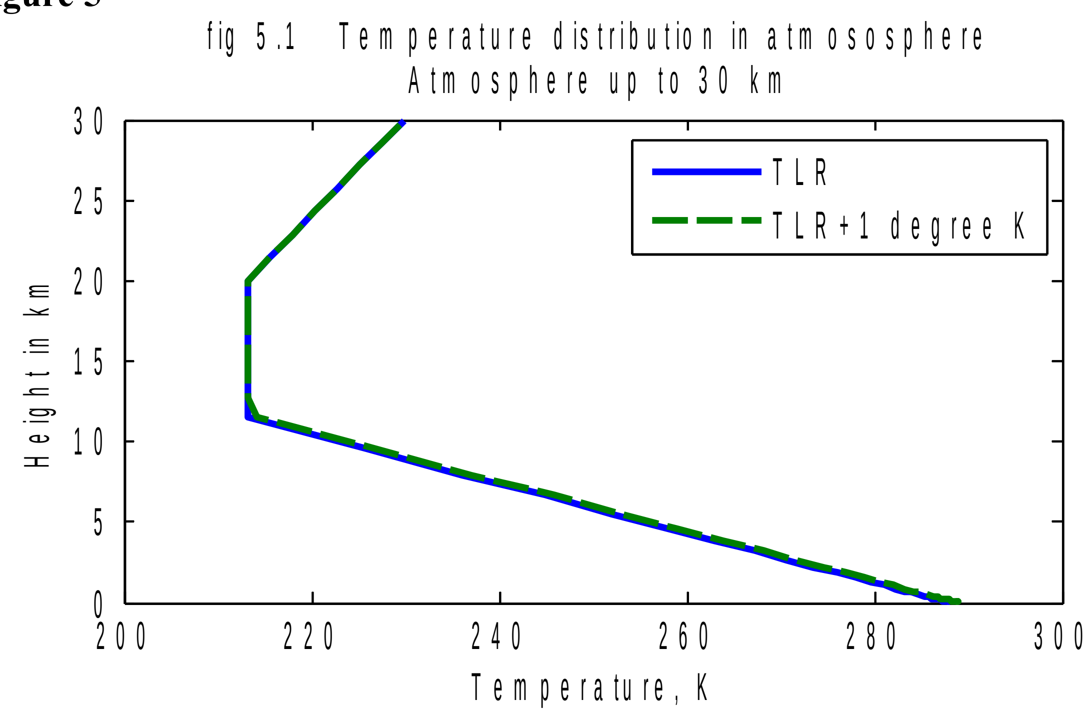


Figure 5



The variations of temperature and OLR with variations of CO_2 concentrations are much smaller than the differences between the climate zones depicted in **figures 1** and **3.** IPCC authors claim 1.0 K for doubling the CO_2 concentration from 400 to 800 ppm. The translation of the temperature profile is hardly visible as can be seen from **figure 5** for a δTsK=1K.We will show that the variation of surface temperature for CO_2 doubling is even much smaller: δTs=0.04 K.

For the sensitivity analysis we have to look in detail to the system equations **(2)** and doing some algebra on them:

$$\mathbf{qh20 = Kh2o^*\theta} \quad \text{and} \quad \mathbf{qco2 = Kco2^*\theta} \qquad \mathbf{(2bis)}$$

The outgoing long wave radiations OLRh2o and OLRco2 are represented by the components -qh2o(N) and -qco2(N).
With **knodsco2** and **knodsh2o** representing the rows N = nods (=60) of respectively **Kco2** and **Kh2o,** the individual, standalone, outgoing LW radiations become:

$$\text{OLRco2} = \mathbf{-\ knodsco2^*\theta} \quad \text{and} \quad \text{OLRh2o} = \mathbf{-\ knodsh2o^*\theta} \qquad \mathbf{(3)}$$

For concentrations ftotco2 and ftoth2o of the IR-active gases zero, and when dealt with separately OLRco2 and OLRh2o are both equal to the surface flux εσTs^4 = ε θ(1). The individual forcings from CO_2 and H_2O become, respectively

$$\Delta\text{OLRco2} = \varepsilon\,\theta(1) - \text{OLRco2} = \varepsilon\,\theta(1) + \mathbf{knodsco2^*\theta} \qquad \mathbf{(4)}$$

$$\Delta\text{OLRh2o} = \varepsilon\,\theta(1) - \text{OLRh2o} = \varepsilon\,\theta(1) + \mathbf{knodsh2o^*\theta}$$

The OLR from simultaneously present CO_2 and H_2O concentrations becomes:

$$\text{OLR} = \varepsilon\,\theta(1) - \Delta\text{OLRco2} - \Delta\text{OLRh2o}$$

$$= -\ \varepsilon\,\theta(1) - (\mathbf{knodsco2 + knodsh2o})^*\boldsymbol{\theta} \qquad \mathbf{(5)}$$

In **(5)** we have defined the resulting outgoing LW radiation of the components defined by the system equation of the two contributions from **(3)**. The relation becomes easier to write down and to program, when the scalar surface emission ε is converted to a row vector **ε** with only the first component not equal to zero: **ε** = [ε , 0, 0 …...0]
The combined OLR becomes:

$$\text{OLR} = -(\boldsymbol{\varepsilon} + \mathbf{knodsco2 + knodsh2o})^*\boldsymbol{\theta}$$

$$\mathbf{= -}\ (\mathbf{knodsco2} + (\boldsymbol{\varepsilon} + \mathbf{knodsh2o}))^*\boldsymbol{\theta} \qquad \mathbf{(6)}$$

Taking the constant **ε** row vector together with the **knodsh2o** row vector has an advantage in the variation procedure of CO_2 concentration with a constant H_2O concentration.
With the chain rule:

$$\delta OLR = - \delta(\mathbf{knodsco2})*\boldsymbol{\theta} - (\mathbf{knodsco2} + (\boldsymbol{\varepsilon} + \mathbf{knodsh2o}))*\delta\boldsymbol{\theta} \qquad \mathbf{(7)}$$

We see that the OLR variation depends on the concentration of IR-active gases CO_2 and H_2O through the 2 times 60 components of **knodsco2** and **knodsh2o** and the 60 temperature parameters through the 60 components of **θ** and the variation thereof.
In a sensitivity analysis OLR remains constant, an increase in one term is compensated by a decrease in the other term, in such a way that δOLR=0.
It is assumed that **knodsh2o** does not change with a variation of CO_2, although Ferenc Miskolczi **[3]** has observed, by means of weather balloons, that water vapor concentration decreases for an increase in CO_2 concentration.
The first term in the right hand side of **(7)** becomes:

$$\delta(\mathbf{knodsco2})*\boldsymbol{\theta} = - \mathbf{knodsco2}*\boldsymbol{\theta} - \sigma\, Ts\hat{\ }4 = \delta OLRco2 \qquad \mathbf{(8)}$$

It is the variation of OLR from zero to the present value of 400 ppm which is the same as from the present variation to 800 ppm.
We see that **(8)** is the equivalent of **(4).**

The variation δ**θ** is calculated from**:**

$$\delta\boldsymbol{\theta} = \delta(\sigma\, \mathbf{T.\hat{\ }4}) = 4\, \sigma\, \mathbf{T.\hat{\ }3}\, \delta(\, Ts+ELR*\mathbf{z.})$$

$$= 4\sigma\, \mathbf{T.\hat{\ }3}\, (\delta Ts + ELR*\mathbf{z.}) = \boldsymbol{\Psi}\, \delta Ts + \boldsymbol{\Phi}\, \delta ELR \qquad \mathbf{(9)}$$

$$\boldsymbol{\theta} = [\theta_1,, \theta_2 \,.........\, \theta_N]' = \sigma\, [T_1\hat{\ }4 \,,\, T_2\hat{\ }4 \,......\, T_N\hat{\ }4]'$$

$$\boldsymbol{\Psi} = [\Psi_1,, \Psi_2 \,.......\, \Psi_N]' = 4\, \sigma\, [T_1\hat{\ }3 \,,\, T_2\hat{\ }3 \,......\, T_N\hat{\ }3]'$$

$$\boldsymbol{\Phi} = [\Phi 1, \Phi 2, ... \Phi_N]' = 4\, \sigma\, [z_1 T_1\hat{\ }3 \,,\, z2 T_2\hat{\ }3 \,......\, z_N T_N\hat{\ }3]'$$

The apostrophe means that the column vectors are written as row vectors: transpose.
In **(9)** not only the variation of the surface temperature is taken into account but also an eventual variation of the lapse rate ELR.

Influence of the surface temperature

The second term in the right hand side of **(7)** for a variation δTs becomes:

$$(\mathbf{knodsco2} + (\varepsilon + \mathbf{knodsh2o}))*\mathbf{\Psi}\ \delta Ts = (dOLR/dTs)\ \delta Ts \qquad \mathbf{(10)}$$

The derivative $dOLR/dTs$ **=** $(\mathbf{knodsco2} + (\varepsilon + \mathbf{knodsh2o}))*\mathbf{\Psi}$ represents the slope of OLR in **figure 4** at the point Ts=288 K.
For the equilibrium point, ftot = 0.849 and OLR =240:

$$dOLR/dTs = 3.4\ W/m^2/K \qquad \mathbf{(11)}$$

Note: The derivative of OLR with respect to surface temperature Ts is sometimes approached by $dOLR/dTs= d(\sigma T_s^4)/dTs = 4 \sigma T_s^3 = 5.42\ W/m^2/K$
The value 3.4 W/m^2/K of **(11)** takes into account temperature and distribution of IR-active gases, CO_2 and H_2O, in the atmosphere by **(9)**.

With (8) and (11) the variation of the surface temperature becomes:

$$\delta Ts = -\ \delta OLRco2/(dOLR/dTs) \qquad \mathbf{(12)}$$

We analyze values of the present ftotco2 between 0.1% and 3% of the total present ftot = ftoth2o + ftotco2.
In **table 1** are given for different ratios ftotco2/ftot the results of the sensitivity analysis of the stack model:

Table 1 CO_2 sensitivity as function of assumed ratio of effect of 0.04% CO_2 versus 4% H_2O

ftotco2/ftot %	δOLRco2 W/m^2	δTs_{2xCO2} K	δTs K/ppmCO_2
0.1	-0.13629	0.04	1 e-4
1	-1.3717	0.4	10 e-4
2	-2.763	0.83	21 e-4
2.5	-3.47	1.04	26 e-4

In **table 1** is given a great gamma of entries for ftotco2/ftot from 0.1% to 2.5%.
The reason is that we want to draw the attention on the fact that the stack model is nearly completely linear! Indeed, **table 1** does not show the strange IPCC logarithmic dependence on the magnitude of the concentration of traces of IR-active gas CO_2, probably a result of the artificial broadening of the CO_2 line in MODTRAN. **[7]**
Since Ferenc Miskolczi with the line-by-line HARTCODE analyses of weather balloon measurements, reports a negligible effect of CO_2, the lower value obtained by the contribution 0.1% of ftot is retained: CO_2-sensitivity δTs = 1 e-4 K/ppmCO_2

Influence of the lapse rate ELR

In a recent paper by Kyoji Kimoto [9] , it was suggested that the variation of the lapse rate ELR with the CO2 concentration could be an alternative to the variation of the surface temperature and a fixed lapse rate.

The second term in the right hand side of **(7)** for a variation δELR becomes**:**

$$(\mathbf{knodsco2} + (\varepsilon + \mathbf{knodsh2o}))^{*}\mathbf{\Phi}\ \delta ELR = (dOLR/dELR)\ \delta ELR \qquad \mathbf{(13)}$$

With **(8)** and **(13)** the variation of the surface temperature becomes:

$$\delta ELR = -\ \delta OLRco2/(dOLR/dELR) \qquad \mathbf{(14)}$$

In table 2 the numerical results are given for dOLR/dELR, δELR , δT_{toa}.

Table 2 ELR sensitivity as function of assumed present effect of CO_2 versus present effect of H_2O

ELR= - 6.5K/km , ztoa=11km, δT_{toa} = δELR*ztoa

%	W/m^2	W/m^2/(K/km)	K/km	K/km	K	K
ftotco2/ftot	δOLRco2	dOLR/dELR	δELR	ELR+δELR	δT_{toa}	δT_s
0.1	-0.13629	2.39	0.057	-6.44	0.63	0
1	-1.3717	2.49	0.44	-6.06	4.84	0
2	-2.763	2.67	1.03	-5.47	11.37	0
2.5	-3.47	2.74	1.26	-5.24	13.88	0

We see that the numerical results of the stack model do not confirm the suggestion of Kyoji Kimoto **[9]**, the necessary variation of the lapse rate and temperature variation at TOA are far too big. The standard atmosphere for the different climate zones, depicted in **figure 1**, shows for the variation of the OLR from tropical to polar zones a nearly constant lapse rate ELR = - 6.5 K/km.

Conclusion

The finite element stack model based on an one-stream formulation of heat radiation from warm to cold gives clear answers for both the global heat balance as well as the sensitivity of doubling the CO_2 concentration.
In the global balances there is no place for the non-physical back-radiation of heat and thereby huge LW surface radiation, to be absorbed by the atmosphere in order to be radiated back, according to the two-stream heat flow formulation.
The evacuation of heat is mainly by convection from the surface of the planet to higher layers and only from thereon by radiation to outer-space.

The stack model gives an increase of 0.04 K for doubling of the present 0.04 % CO_2 in the atmosphere by assuming that the effect of CO_2, is 0.1% of the effect of 4% water vapor in the atmosphere. The total absorption coefficient of the atmosphere for OLR =240 is ftot = 0.849 and the contribution of CO_2 is ftotco2 = 0.000849.
The result is $\delta Ts_{2xCO2} = 0.04$ K or $\delta Ts = 1$ e-4 K/ppmCO_2.

Ferenc Miskolczi claims a negligible CO_2 sensitivity, also due to the measured decrease in water vapor for an increase in CO_2. FM uses the line-by-line HARDCODE computer program, avoiding the artificial broadening of the CO_2 line in the spectrum of programs like MODTRAN and HITRAN. IPCC authors give as CO_2-forcing -3.5 W/m^2, which corresponds to a sensitivity for CO_2 doubling: $\delta Ts_{2xCO2} = 1.0$ K

A factor 25 higher as compared to the results of the stack model.
The reason of this difference is the artificial broadening of the CO_2 spectrum line in the software used by IPCC authors.

Acknowledgment

The author wants to thank in particular Claes Johnson who inspired him to write this paper. The author interpreted his ideas by writing Stefan-Boltzmann always for a **pair** of surfaces: it opens the concept of standing waves.

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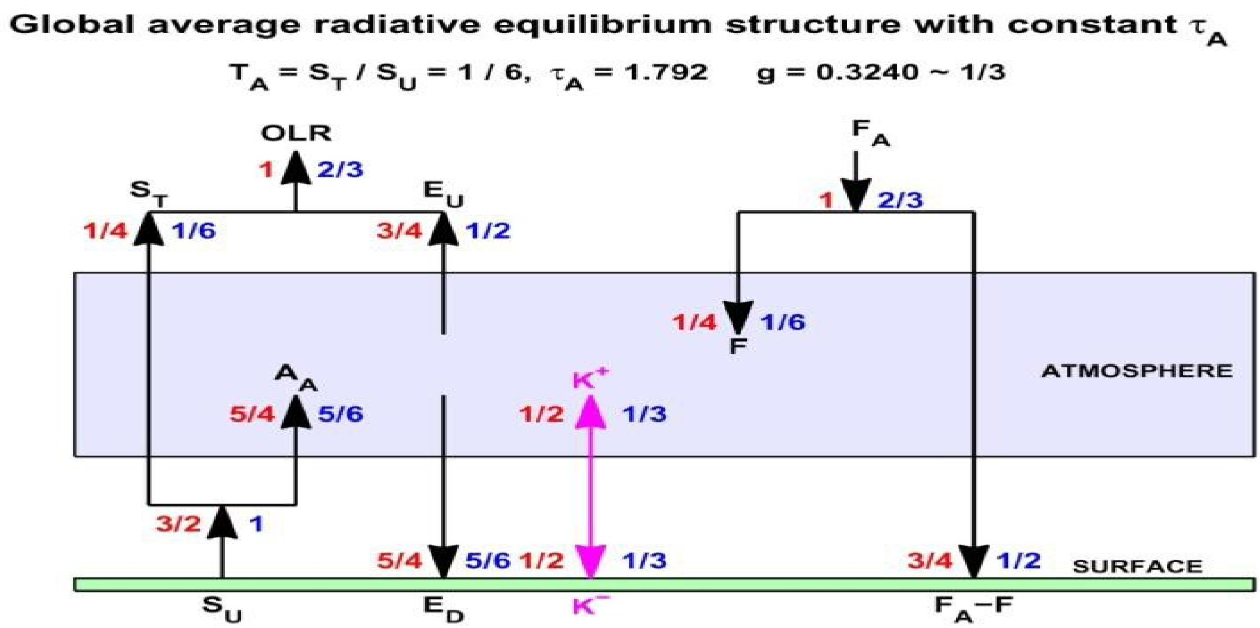
Appendix 1

Comparison of stack model and Miskolczi model

Ferenc Miskolczi, FM, **[3]** has presented a global average energy budget.
It is reproduced here as **figure A1**, a copy of **figure 24** in **[3]**.
FM uses the two-stream formulation of LW radiation and comes up with huge absorption in the atmosphere, huge LW back-radiation, huge LW surface flux! Typical non-physical two-stream issues, like IPCC authors.

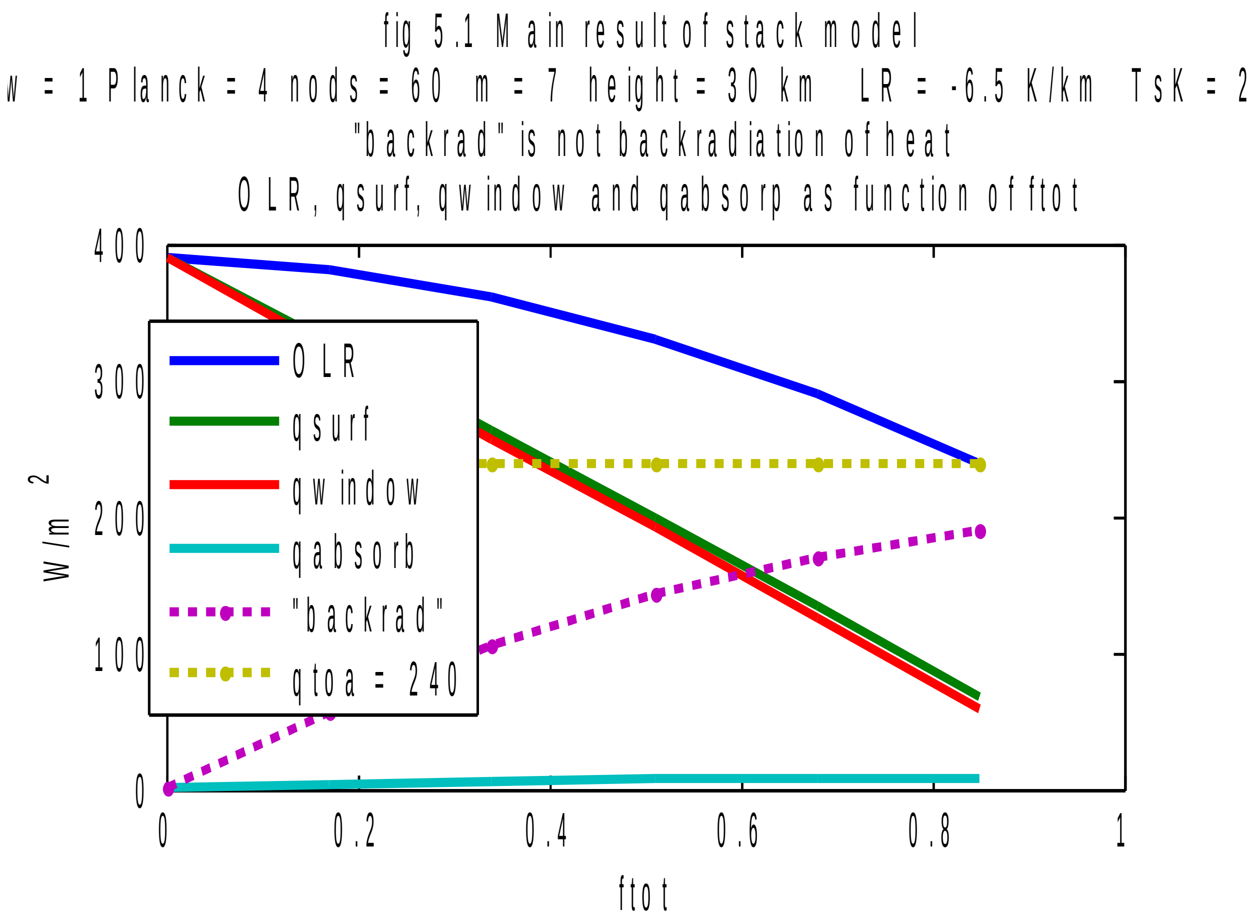
Figure A1 copied from figure 24 of **[3]**.



In **figure A1** the red numbers correspond to *normalized value OLR=1* and the blue figures to *SU =1*.
The red numbers are multiplied with 240 to obtain in Table A1 real FM fluxes in W/m^2 for a comparison with the corresponding numbers of the global energy budget of the stack model.

In figure A2 the results of the main equation of the one-stream stack model are represented. The equilibrium point is for ftot = 0.849:
OLR =240, LW surface flux =67 of which 59 through the window and 8 absorbed by the atmosphere.

Figure A2



The curve “back-rad” is dotted, it are numbers which in the one-stream formulation appear in algebraic expressions with a negative sign. They do not have a physical meaning, they do not represent heat flow from cold to warm. See **[1 , 2]**

Table A1 fluxes		**fig A1**	**W/m^2**		figA2 **W/m^2**
			FM		stack + FM
Outgoing LW Radiation	OLR	(1)	240	calculated	240
Incoming SW at TOA	FA	(1)	240	imposed	240
Flux through window	ST	(1/4)	60		59
Atmospheric Absorption	AA	(5/4)	300		8
Back-radiation	ED	(5/4)	300		0
SW absorption in atmosphere	F	(1/4)	60		60
SW absorption in surface	FA-F	(3/4)	180		180
LW surface flux	SU	(3/2)	360		67
Convection	K	(1/2)	120		113 = 180 - 67

In **Table A1** the results of FM are compared with those of the stack model, without the back-radiation and without the huge LW surface flux, typical for the two-stream formulation of Schwarzschild.

In **figure A3** is given the global and annual mean heat budget obtained with the stack model and with the experimental data according to FM from **figure A1** and **table A1**. Apart from the back-radiation and the Prevost type of LW surface flux in the FM data (both huge values 300), there is a difference is the convection term, 120 for FM and 113 for the stack model which. In the stack model, the number 113 for convection follows from the difference of incoming SW heat absorbed by the surface and the outgoing LW surface flux, presented in the last three lines of **table A1**.

Figure A3 **Global and annual mean heat budget in W/m^2.**
Stack Model with Miskolczi data, but without back-radiation.