The influence of surface emission of the planet

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Introduction

In earlier papers **[1]** to **[6]** the author has analyzed the evacuation of heat from the planet using the one-way heat flow formulation, simulating the traces of IR-active gases, those with three or more atoms per molecule, such as H_20, $C0_2$..., by means of a stack of grids of "black" wires. It has turned out that the planet, in SS (steady state) condition, evacuates heat from the surface of the planet not that much by means of radiation, as advocated by IPCC authors (International Panel of Climate Change) , but rather by means of convection from the surface to higher layers in the atmosphere, and only further on by radiation to outer-space.
The process is modeled by means of the finite element method (FEM).
In the present paper the results of the stack model are compared with those of Ferenc Miskolczi **[7]** and of IPCC authors. As compared to the previous validation in **[1]** and **[6]** here the results of updated input parameters concerning the water vapor distribution, the view factors and the surface emission coefficient are discussed including an updated CO_2 sensitivity analysis.

The listing of the corresponding MATLAB program is given in a separate paper **[8]**. Indeed, the philosophy of Principal Scientific International, PSI, is to be transparent. The tools which we develop are distributed freely such that everybody can experiment with them.

Heat radiation through a stack of semi transparent grids

We consider a stack of N-2 grids of very thin wires.
The grids have a cross-section f <<1 , defined by the diameter of the wire multiplied by its length per unit area. It is a function of the height z and it can be interpreted as an absorption coefficient.
In **figure 1** the stack is depicted. The ground surface is at node 1, outer- space is at node N. The nodal parameters are temperature T(i), absorption coefficients f(i), and input fluxes q(i).To facilitate the editing and the analysis we introduce alternative nodal parameters θ(i):

$$\theta(i) = \sigma T(i)^4 \qquad \textbf{(1)}$$

where σ = 5.67 e-8 is the Stefan-Boltzmann constant.
For heat transport between two fully opaque plates **[2]** we can write for T(i) > T(j) :

$$q(i\rightarrow j) = \sigma(T(i)^4 - T(j)^4) = \theta(i) - \theta(j) \qquad q(j\rightarrow i) = 0 \qquad \textbf{(2)}$$

The parameters θ(i) with dimension W/m^2 represent temperatures but sometimes they have to be interpreted as heat fluxes. It follows from the context.
The surface is at node 1, outer-space at node N. Typical value for a height of 10 km at z(N-1) is N = 40, more nodes do not increase the accuracy **[2]**.
For the sensitivity analysis of CO2 , the model has an height of 30 km with N=60 **[6]**.

Figure 1 A stack of semi-transparent grids

—————— outer- space node N, f (N) = 1, T(N) = 0, θ(N) = σT(N)^4

– – – – node N-1, f (N-1), T(N-1), θ(N-1) = σT(N-1)^4

– – – – node i, f (i), T(i), θ(i) = σT(i)^4

— — — node 2, f (2), T(2), θ(2) = σT(2)^4

—————— surface node 1, f (1)= ε_{LW}, T(1) = Ts, θ(1) = σT(1)^4

The stack has N-2 nodes with absorption coefficients f(i), i=2:N-1.
The ground surface at node 1 has a surface temperature Ts and
f(1) = ε_{LW}, LW surface emission coefficient.
Outer-space at node N at a temperature zeroK = 0 and f(N)=1.
For the analysis of the heat transport by radiation through the semi-transparent grids, we use the finite element method, FEM, as given in **figure 2**

Figure 2 Basic finite element for heat radiation between grids i and j.

q(j)→ – – – – – – – – – – – – – f(j), θ(j)

element heat flux ↑ fe*(θ(i)-θ(j))

q(i) → – – – – – – – – – – – – – f(i), θ(i)

Grids i and j are not necessarily adjacent, other grids can be in between.
The upward arrow for element heat flux is for θ(i)>θ(j) .
In case θ(j) < θ(i) the arrow of heat flux is downwards.

The nodal parameters are:

– absorption coefficients f
– to temperature related parameters θ = σT^4
– thermal loads into the element q

The constitutive relation of this radiation finite element is represented by the effective absorption **[2]**:

$$fe = f(i)*viewfactor(i,j)*f(j) \quad \textbf{(3)}$$

The viewfactor component (i , j) expresses the window between two levels i and j, not necessarily adjacent **[2]**. For adjacent grids the viewfactor component = 1.
The basic radiation matrix for the finite element defined by nodes i and j in terms of the effective absorption fe of the element is shown below, giving a relation between the nodal parameter vector **θ** and the nodal thermal load vector **q** :

$$\begin{vmatrix} fe & -fe \\ -fe & fe \end{vmatrix} \begin{vmatrix} \theta_i \\ \theta_j \end{vmatrix} = \begin{vmatrix} q_i \\ q_j \end{vmatrix} \qquad \textbf{(4)}$$

For a stack of N levels, including the ground level 1 and the outer-space level N**,** there are N(N-1)/2 finite elements, which are assembled as shown in Figure **3**, by superimposing elements.

$$\mathbf{K*\theta = rhs} \qquad \textbf{(5)}$$

K **:** system matrix of order NxN**,** to be modified by boundary conditions.

θ **:** vector of unknowns, W/m^2, of order N

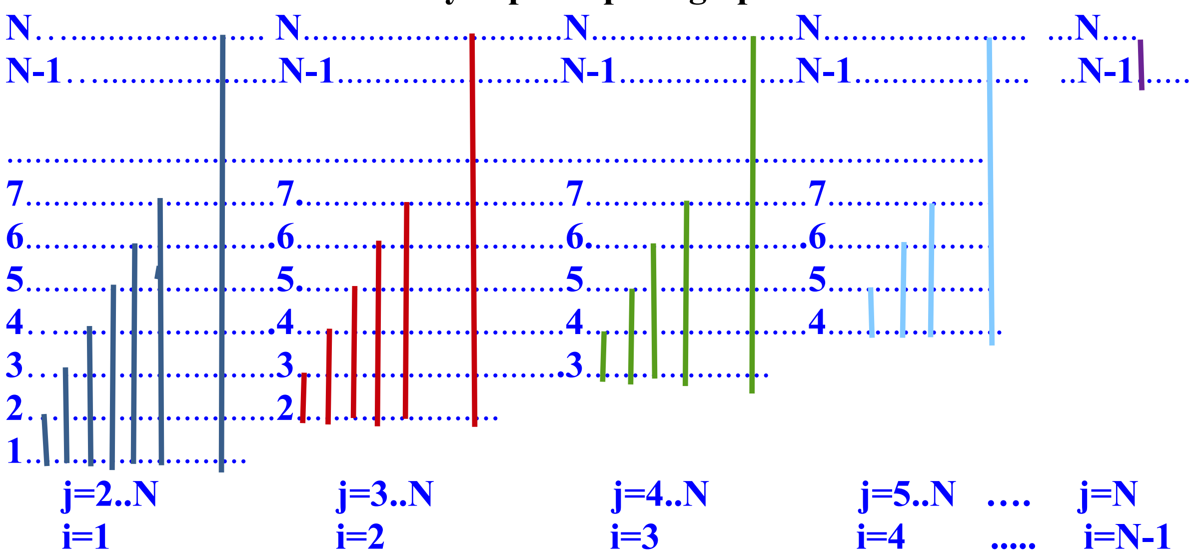
rhs **:** right hand side vector of heat flux , W/m^2, into the system, of order N

The system equation **(5)** is used in reversed order:

$$\mathbf{q = K*\theta} \qquad \textbf{(5a)}$$

In this relation the vector **q** is determined for given temperature distribution, represented by **θ.** The measured temperature distribution is defined by gravity, and expressed by the surface temperature and the environmental lapse rate:
TsK =288 K and ELR = -6,5K/km

Figure 3 Illustrative scheme of N(N-1)/2 finite elements (i , j) to be assembled by superimposing upon each other



The assemblage scheme shows the advantage of the finite element method.
It gives the possibility to take into account the heat transfer by radiation between nodes not adjacent to each other and to analyze the parallel streaming of heat.
The Schwarzschild two-stream formulation of the early 1900's, en vogue in astronomy, is based on first order differential equations for the two, artificially split, in upward and downward components of the radiation. The splitting up gives the possibility to write down analytical solutions in the form of closed integrals. Quadrature techniques were available at the time to give numerical solutions.
The Schwarzschild solutions are compared to the finite element techniques in **[3]**.

Validation of the stack model

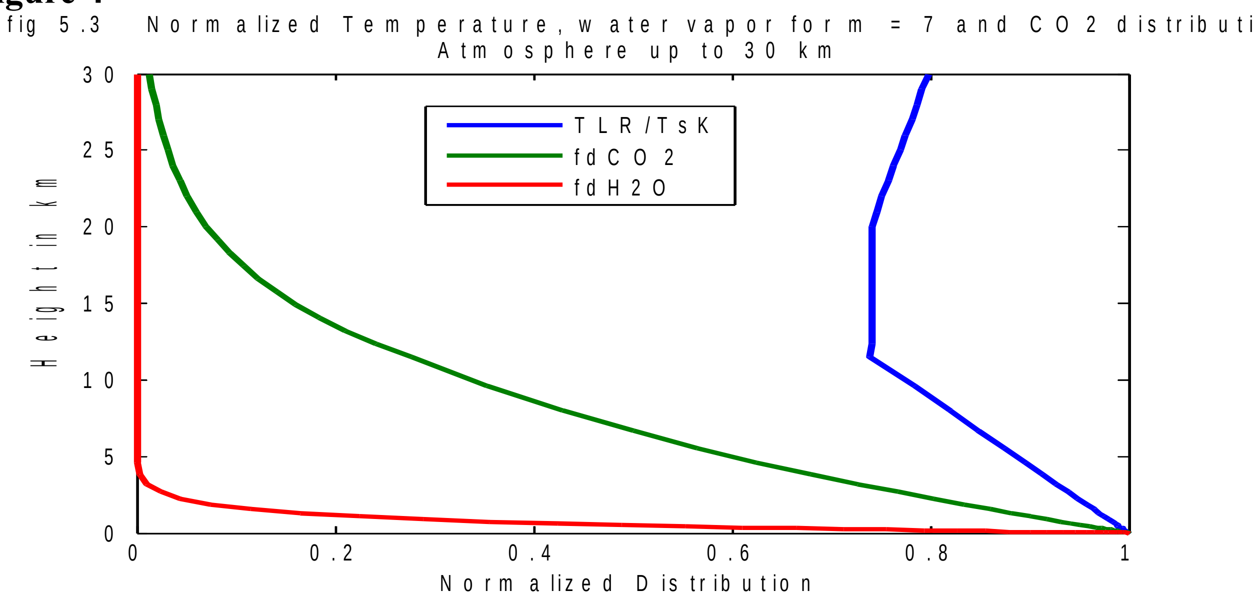
Distribution of water vapor

In the very first paper **[1]** on the stack model, the validity of a stack of semi-transparent grids to represent IR-active trace gases has been carried out by comparison with published results of IPCC authors(K&T, van Dorland of KNMI in the Netherlands) and the earlier papers of Ferenc Miskolczi.
The distribution of water vapor in the stack model is determined by a parameter study of the expression:

$$fdh2o(i) = \exp(-m*z(i)/5000) \quad \textbf{(6)}$$

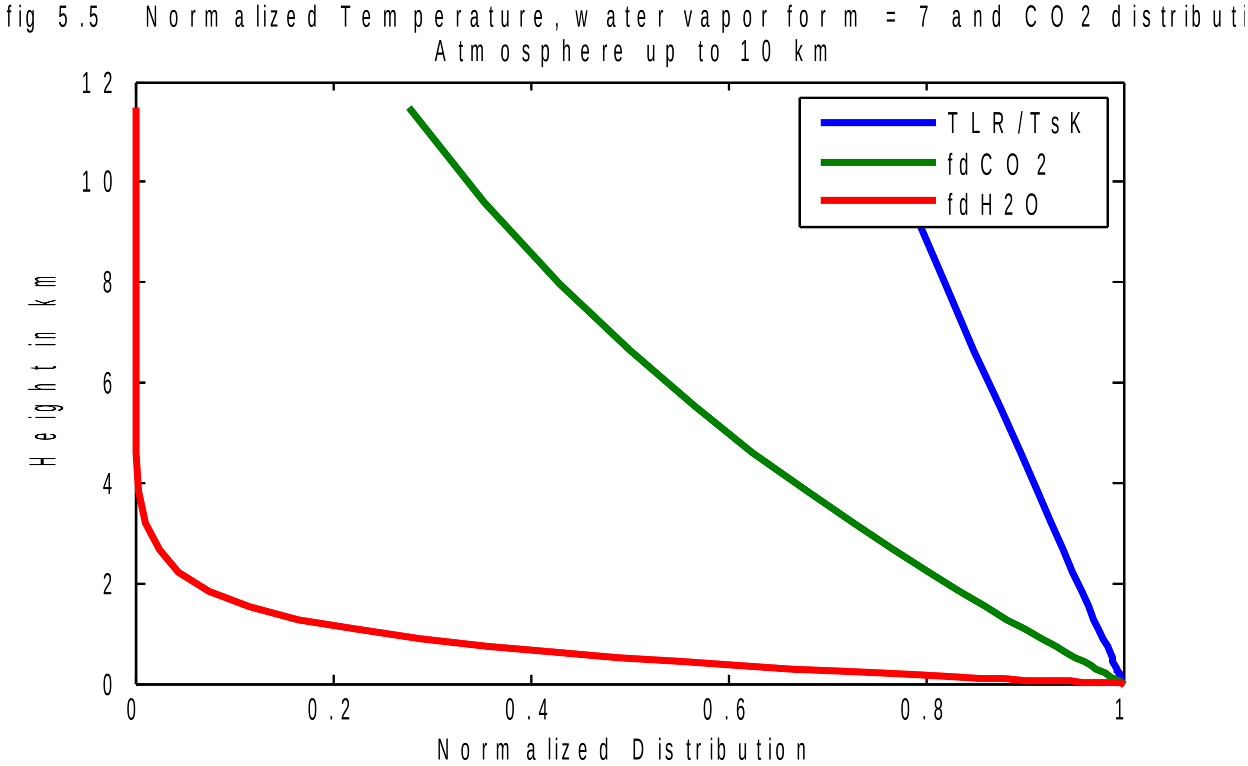
The optimum input parameter was found in **[1]** to be m=9.
In **[6]** the newer results of Ferenc Miskolczi suggested a better value: m=7.
In **figure 4** the normalized distribution is depicted for a height of 30 km for the CO_2 sensitivity analysis and in **figure 5** for a height of 11km, sufficient to determine the global mean energy budget, showing in more detail the water vapor distribution.

Figure 4



The CO_2 distribution is proportional to the density distribution

Figure 5



Viewfactors

In **[3]** the viewfactor matrix, which has been introduced in the FEM version**[2]**, has been discussed.
For the one-stream FEM formulation:

$$\text{viewfactorF}(i,j) = 1 - \sum_{k=i+1}^{k=j-1} f(k) = 1 - f(i+1) - f(i+2) \ldots f(j-1) \qquad \textbf{(7)}$$

For the two-stream Schwarzschild formulation:

$$\text{viewfactorS}(i,j) = \prod_{k=i+1}^{k=j-1} (1-f(k)) = (1 - f(i+1))(1 - f(i+2)) \ldots (1-f(j-1)) \qquad \textbf{(8)}$$

In **(7)** and **(8)** it is assumed that the atmosphere is mono-chromatic, which is not true. For a multi-chromatic atmosphere the viewfactors remain nearly all 1, since in **(7)** and **(8)** the absorption coefficients, which should be accounted for, are those of the absorption bands. In the limit between the atmospheric viewfactors become all one, only the viewfactors involving the surface remain as given in **(7)** and **(8)**.
They have no influence on OLR since only the last column has an effect on OLR:

$$\text{OLR} = \sum_{i=1}^{i=nods-1} f(i)*\text{viewfactor}(i,nods)*f(nods)*(\theta(i) - \theta(nods))) \qquad \textbf{(9)}$$

With f(nods)=1 and θ(nods) =1 and viewfactor(i,nods)=windowF(i):

$$OLR = \sum_{i=1}^{i=nods-1} f(i)*windowF(i)*\theta(i) \qquad \textbf{(10)}$$

For the one stream FEM formulation:

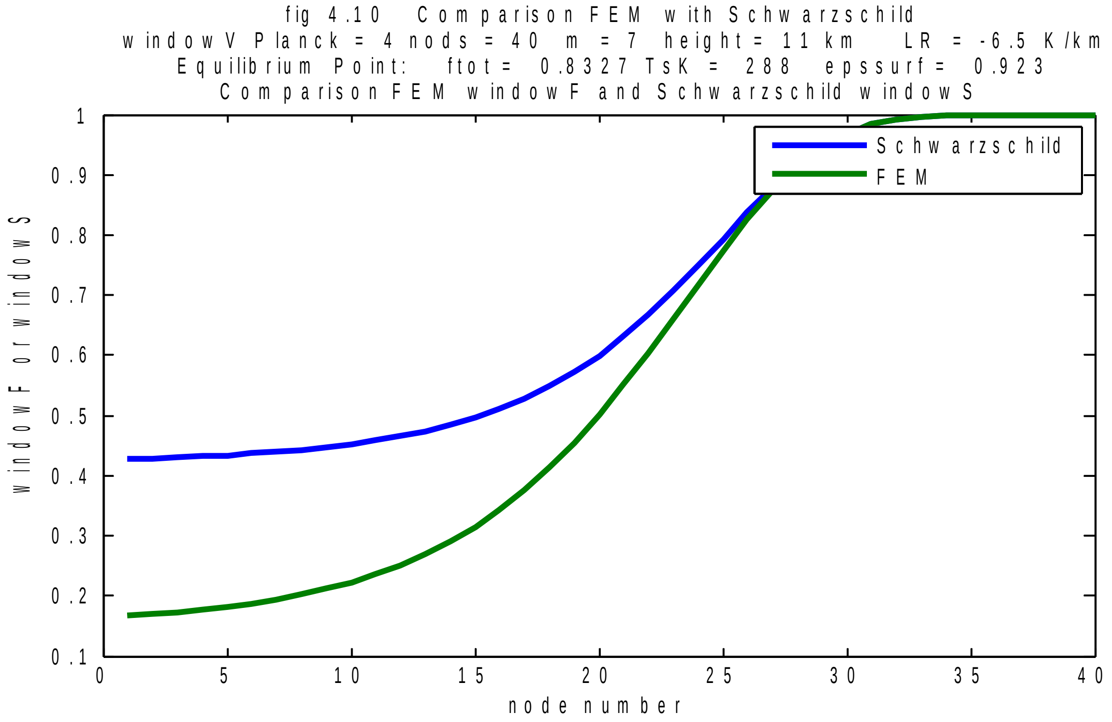
$$windowF(i) = 1 - \sum_{k=i+1}^{k=nods-1} f(k) = 1- f(i+1) - f(i+2) \,..f(nods-1) \qquad \textbf{(11)}$$

For the two-stream Schwarzschild formulation:

$$windowS(i) = \prod_{k=i+1}^{k=nods-1}(1-f(k)) = (1- f(i+1)(1 - f(i+2) \,..(1-f(nods-1)) \qquad \textbf{(12)}$$

In **figure 6** the window vector for the FEM formulation and the Schwarzschild formulation are depicted.

Figure 6



We see a difference of more than a factor 2 for node 1, see **[3]** for more details. In the one stream FEM formulation windowF(1,nods) represents the atmospheric window, representing the fraction of the surface radiation bypassing all the IR-sensitive trace gases, going straight to outer-space.

For the stack model a viewfactor matrix, reduced to a windowF vector, has no influence on OLR. From **figure7a** we see that the LW absorption from the surface into the atmosphere with windowF is 19 W/m^2 and the "backrad" is 310W/m^2. It is not back-radiation of heat , it is the term with a negative sign in the element fluxes with a surface node.

Figure 7a new window factor

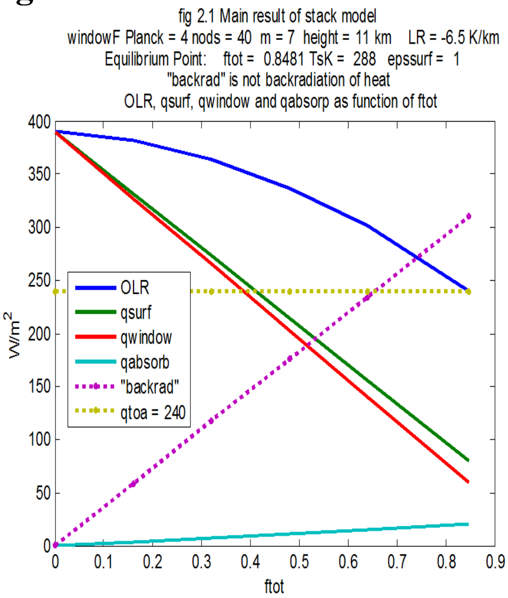
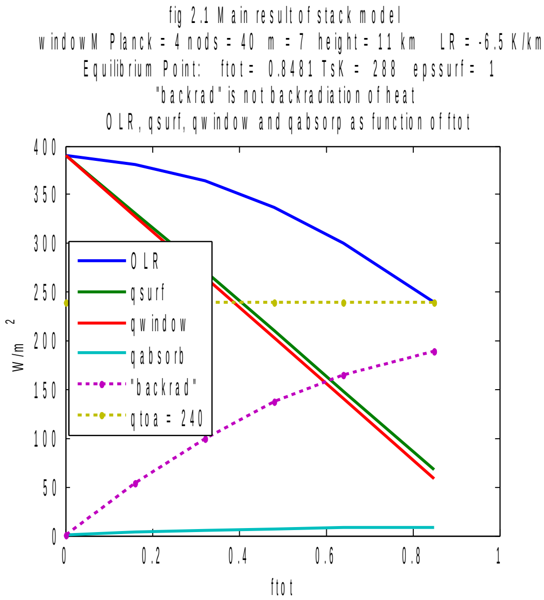


Figure 7b old windowfactor



In figure 7b are depicted the values for the old viewfactor matrix, LW surface absorption = 6W/m^2 and calculated “backrad”=189 W/m^2.
We notice that the “backrad” is not back-radiation of heat, but the negative part of fluxes in elements with a node at the surface.

Surface emission coefficient

The LW surface emission coefficient is hardly adressed by IPCC authors.
It seems also that OLR has as yet not been measured.
The OLR satellite measurements will be available by spring 2016.
Why OLR instrumentation has not been put on the space shuttles?
They have been cruising above the planet for many years!
Or is it too difficult to measure OLR from the space shuttles?

It is suspicious that IPCC authors claim to have measured back-radiation of heat, a quantity which does not exist, since it is only due to an artificial splitting up of the LW radiation in a upgoing part U and a downgoing part D. The latter is interpreted by IPCC authors as back-radiation of heat, which is non-sense.
IPCC authors put the LW surface emission to 390 W/m^2 according to the first term in the Stefan Boltzmann Law $q=\varepsilon_{LW}\sigma$(Ts^4 – some atmospheric T^4):

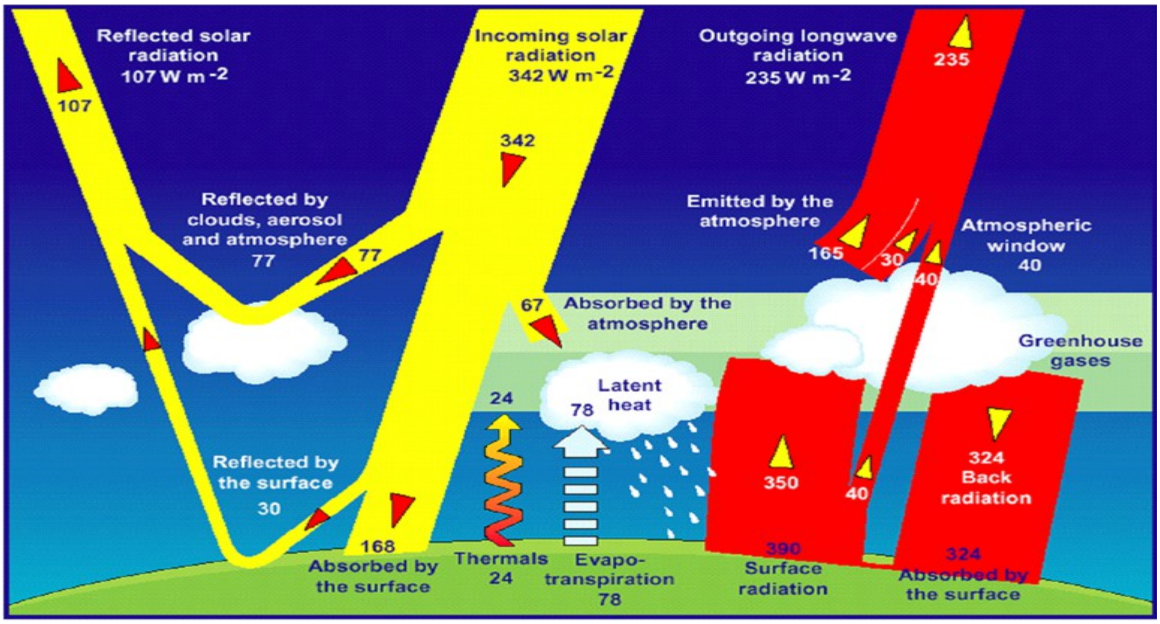
- Prevost flux $q=\varepsilon_{LW}\sigma$Ts^4, which gives 390 W/m^2 for

LW emission coefficient ε_{LW}=1, Ts=288 and σ = 5.67 10^-8.

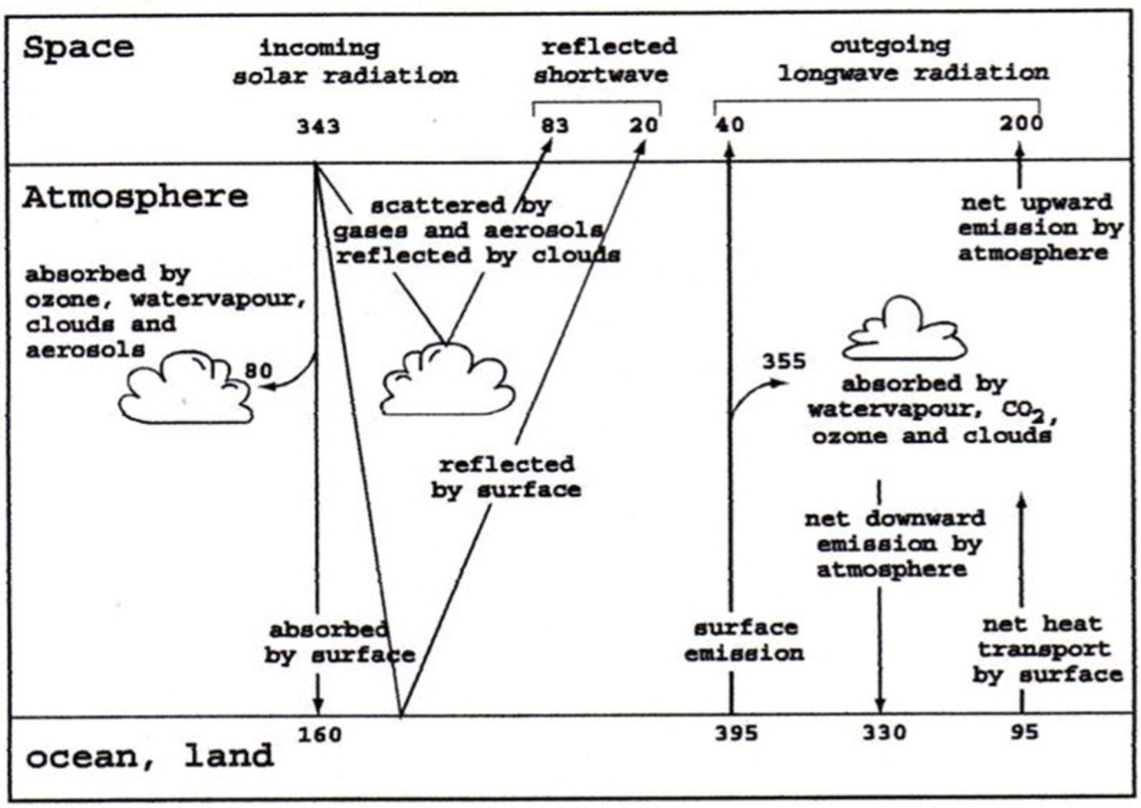
Ferenc Miskolczi **[7]** does not interpret the Prevost flux as a flux of heat.
He uses a value of 360 W/m^2 for a surface temperature of Ts=288 K, yielding a value for the LW surface emission coefficient ε_{LW}= 360/390 = 0.923.

We will compare the new stack results with the published results of two-stream formulation papers.

Global annual mean energy budget
Figure 8, K&T, 1997



Rob van Dorland
Figure 9, RVD, 1999
From "Radiation and Climate. From Radiative Transfer Modeling to Global Temperature Response" by Rob van Dorland, doctoral thesis November 1999, University of Utrecht, Netherlands. Fig 2.3; Global and annual mean energy balance of the climate system in W/m^2



The IPCC authors of **figure 8** and **9** seem not to understand the Schwarzschild proposal from the beginning of the 1900's. This old fashioned technique used in astronomy to calculate temperatures in stars was suggested by a famous astronomer, the late Carl Sagan, to deal with radiation in a semi-transparent atmosphere. Schwarzschild in 1909 proposed to split up the radiation in an upward and in a downward component, because the resulting first order differential equations, with variable coefficients, could be solved analytically by a coordinate transformation, giving rise to the concept of so-called optical thickness. Solutions are obtained as closed integrals. The closed integrals could be solved by quadrature techniques based on the Simpson rule, because digital computers were not available in 1909.
The IPCC authors make the fundamental error giving a physical interpretation to the the mathematical trick of Schwarzschild, by considering the two fluxes as heat flow:

- an upward one, defined by the Prevost term $\varepsilon\sigma T_s$^4, being the first term in the Stefan-Boltzmann relation. This huge heat flux is absorbed by the atmosphere according to the IPSS authors.
- a downward component is introduced to evacuate the absorbed heat from the colder atmosphere to the warmer surface.

A crime against the 2nd Law of Thermodynamics

One can accept the mathematical trick of splitting up the radiation: it gave at that time the astronomers the possibility to estimate temperature distributions in stars.
In the atmosphere, in an one dimensional model we don't need to calculate the vertical temperature distribution, it is defined by gravity, giving rise to an environmental lapse rate ELR = -6.5 K/km.
Although the Schwarzschild procedure can determine the correct temperature distribution in semi-transparent media, it gives rise to spurious absorption, as has been demonstrated in **[1]**.

The spurious absorption is due to the imposed Prevost type of LW surface flux of the order of $\varepsilon_{LW}\sigma T_s$^4 = 390 W/m^2 for ε_{LW}=1.
IPCC authors above speak explicitly in the global and annual heat budgets about this huge amount of heat absorbed by the atmosphere and emitted by the colder atmosphere as so-called back-radiation to the warmer surface.
Figure 8 of K&T shows explicitly the 390 arrow going into the clouds and the 324 send back to the surface, and for **figure 9** of RVD respectively 355 and 330.

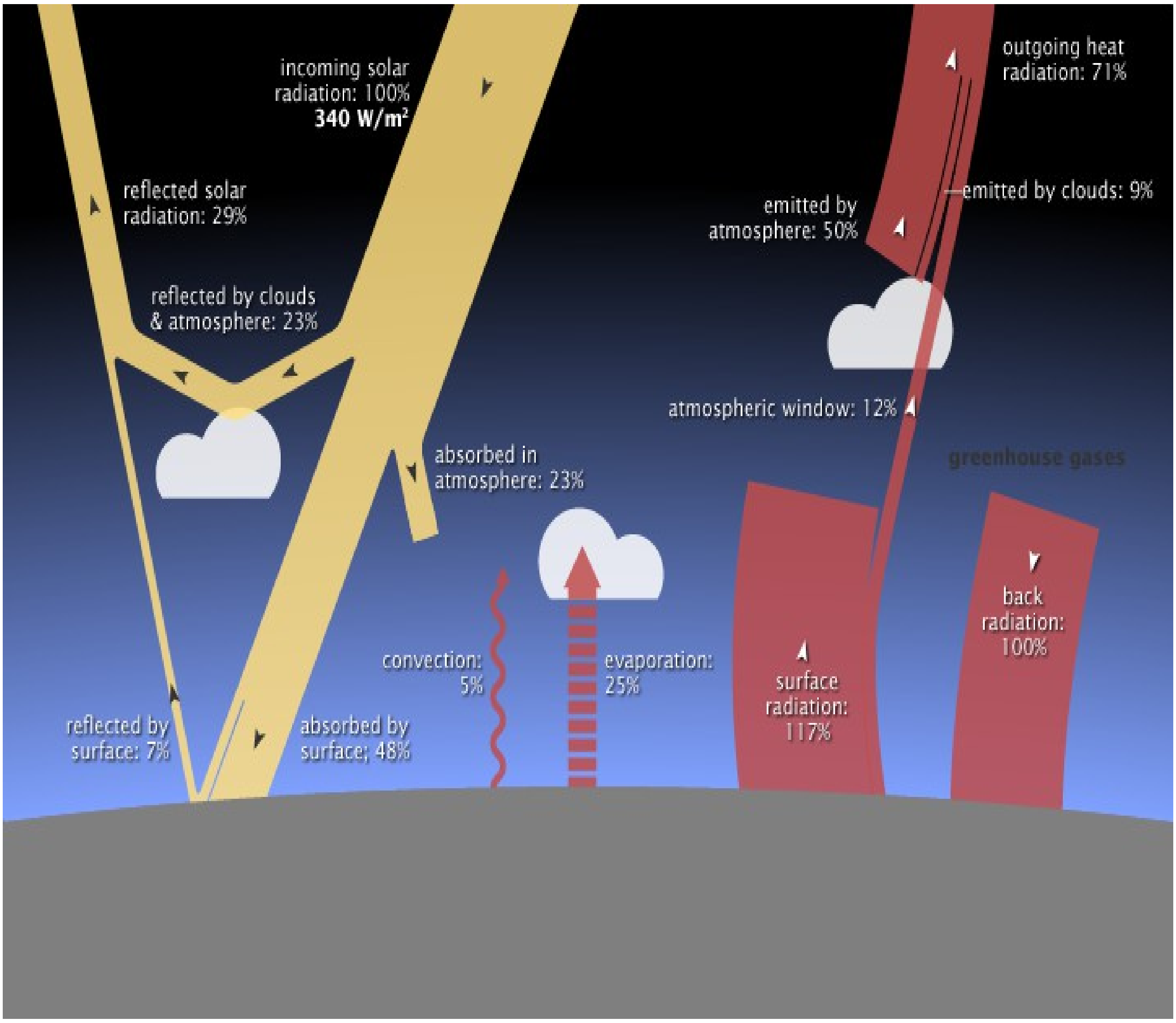
The LW surface flux is 79 W/m^2 of which 60 through the so-called atmospheric window and only 19 of the LW surface radiation is absorbed by the IR-active trace gases and, in SS condition, emitted immediately towards higher layers or to outer-space.
In the one-stream stack model **pairs** of emitters and absorbents are identified with heat transfer by radiation: the radiation finite element **[2]**.
These radiation finite elements can be assembled as an overlay, in a way that radiation can be described from the surface to the very adjacent layer, to nearby

higher layers as well as to outer-space.
This is a case where FEM is not solving differential equations for physical balances of adjacent nodal points, but balances are made up by assembling radiation elements between adjacent nodal points or nodal points further away or even at infinity: an "infinite finite element".

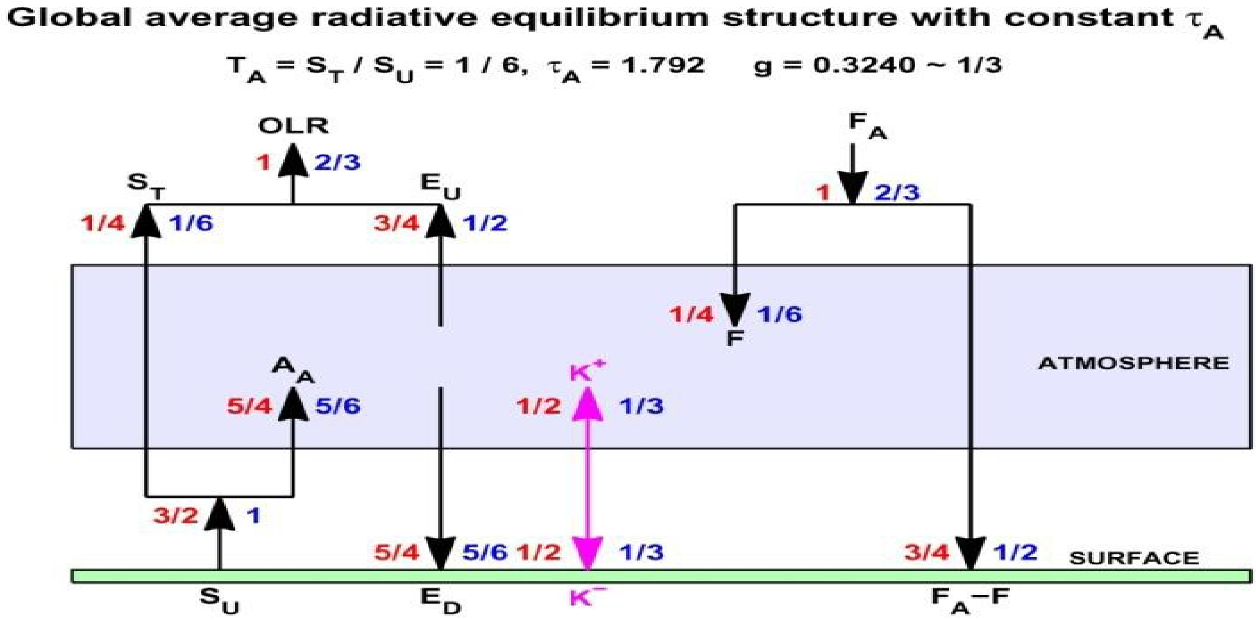
In the following two other examples of the two-stream formulation are given where the authors are aware of the fact that Schwarzschild only proposed a mathematical trick to calculate temperature distributions in semi-transparent media.

Norman Loeb, NL 2007
Figure 11, copied from Wikipedia

117% = 398   100% = 340   71% = 241   48% = 163 29% = 99
23% =   78   12% =   41   7% =   24   5% =   17

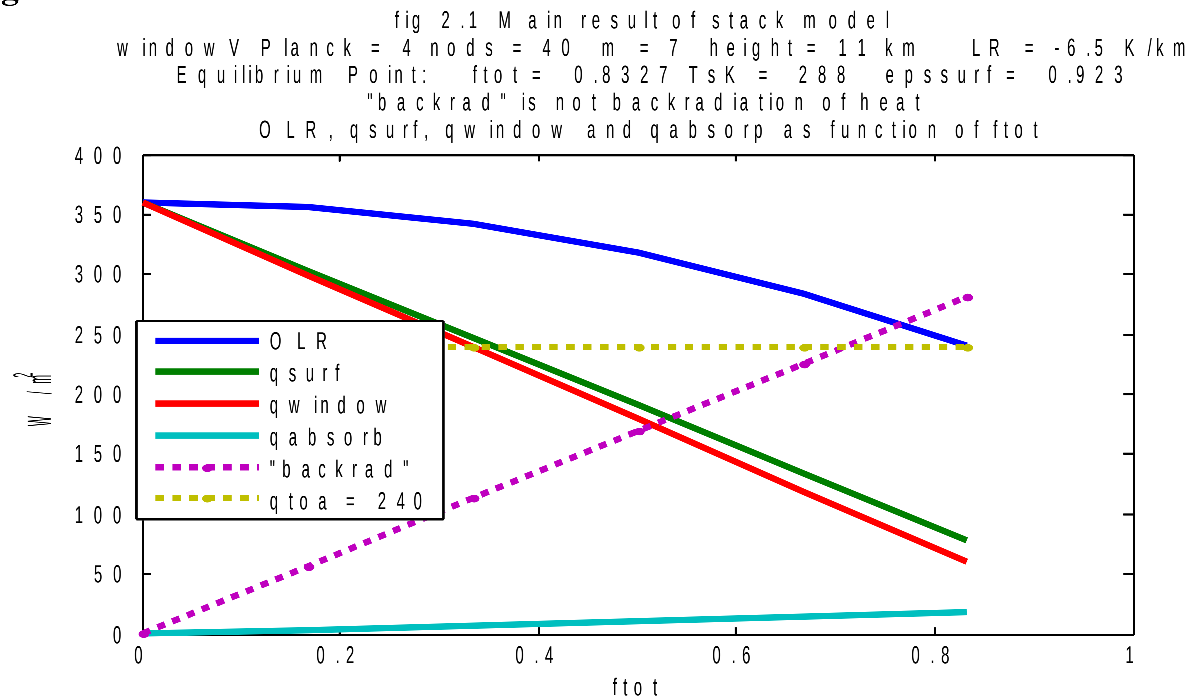


Ferenc Miskolczi, FM 2014
Figure 10 copied from figure 24 of **[7]**.



In **figure 10** the red numbers correspond to *normalized value OLR=1* and the blue figures to *SU =1.*
The red numbers are multiplied by 240 to obtain in **Table 1** real FM fluxes in W/m^2 for a comparison with the corresponding numbers of the global energy budget of the stack model.
Ferenc Miskolczi, trained as an astronomer, uses also the two-stream formulation but does not make the error of IPCC authors. He does not speak of global heat balances, but “global average radiative equilibrium structure”.

Stack Model
figure 11



In **figure 11** are given the results of the one-stream stack model with the latest input based on the results of Ferenc Miskolczi.
The difference with earlier papers are discussed above:

- m=7 for the water vapor distribution, **(6)** and **figure 5**
- windowV vector, **(10)** and **figure 6**
- surface emission according to FM, ε_{LW}= 0.923

The equilibrium point is for: ftot = 0.8327, OLR =240, TsK=288, ε_{LW}= 0.923
LW surface flux =79 of which:

- 60 through the window, and
- 19 absorbed by the atmosphere.

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]**
Appendix 1 gives other numerical results for these updated input of the stack model based on data of Ferenc Miskolczi.

In **Table 1** the results of K&T, RVD, NL and FM are compared with those of the stack model, without the back-radiation of heat and without the huge LW surface flux, typical for the two-stream formulation of Schwarzschild in the other 4.
Note the highlighted lines in **Table 1** showing clearly the huge atmospheric absorption and thereby back-radiation of the two-stream Schwarzschild formulation, as compared to the values 19 for LW absorption and 0 for back-radiation for the one-stream formulation of the stack model.

Table 1 Fluxes W/m^2 SW and LW surface emission coefficients
Comparison of results from K&T, RVD, NL, FM with
stack model, **figure 11,** with input FM data of **figure 10**

		1997	1999	2007	2014	Oct 2015
		K&T	RVD	NL	FM	stack + FM
Outgoing LW Radiation	OLR	240	235	241	240	240
Incoming SW at TOA	FA	240	235	241	240	240
Flux through window	ST	40	40	41	60	60
Atmospheric Absorption	AA	350	355		300	19
Back-radiation	ED	324	330	340	300	0
SW absorption in atmosphere	F	67	80	78	60	60
SW absorption in surface	FA-F	168	160	163	180	180
LW surface flux	SU	390	395	398	360	79
Convection	K	102	95	102	120	101
LW coefficient ε_{LW}		1	1	1	0.923	0.923
IncomingSWsurface		198	180	203	187	187
SWsurface reflection		30	20	24	23	23
SW reflection coefficient r		0.152	0.125	0.113	0.122	0.122
SW emission coefficient ε_{SW}		0.848	0.875	0.887	0.878	0.878

In **Table 2** the SW surface reflection is compared for the different authors.

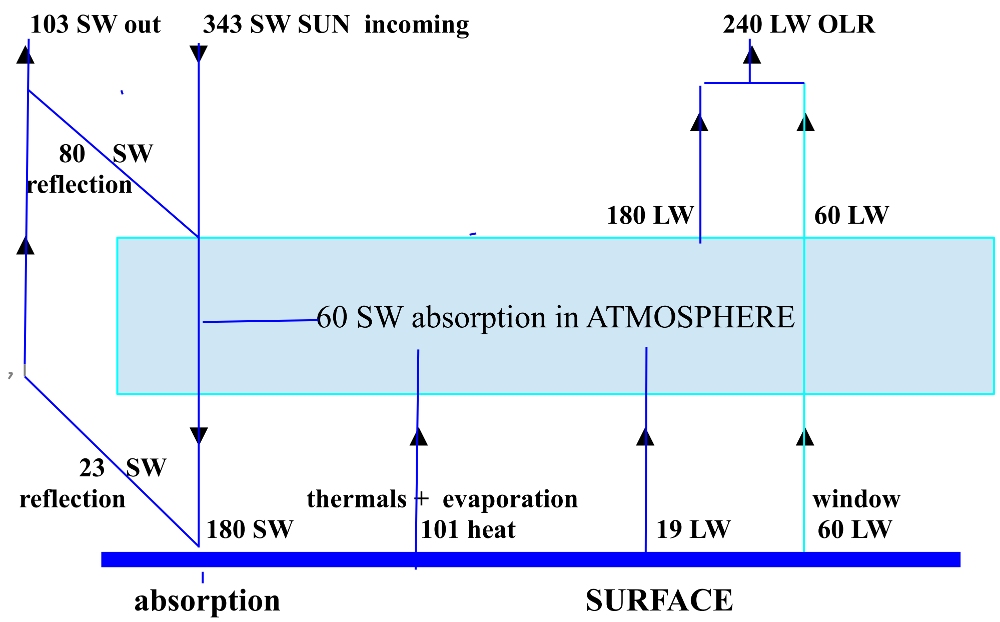
Table2 Incoming and reflected SW surface radiation.
reflection coefficient r_{SW} and emission coefficient ε_{SW}

	Incoming SW	reflected SW	r_{SW}	($\varepsilon_{SW} = 1 - r_{SW}$?)
K&T	198	30	30/198 = 0.152	0.848
RVD	180	20	20/180 = 0.125	0.875
FM	203	23	23/203 = 0.113	0.887
NL	187	24	24/197 = 0.122	0.878

There is not another “magic Kirchhof law” to claim that these SW-emission coefficients - derived from the reflection on the basis of Kirchhof- are equal to the LW-emission coefficient.
But both the SW emission coefficient and the LW emission coefficient are related to the albedo in the sense that albedo is the reflection of aerosols and clouds in the atmosphere and (1- ε_{SW}) could be called the albedo of the surface.
It is not at all clear that what is called albedo is only the albedo of the atmosphere or that more albedo has to be attributed to the surface, which would give a smaller ε_{SW},

In **figure 12** is given the global and annual mean heat budget obtained with the stack model and with the experimental data according to FM from **figure 11** and **table 1**. Back-radiation and the Prevost type of LW surface flux, huge values 300 respectively 360 in the FM data, are replaced with zero back-radiation and from the total 79 W/m^2 LW heat surface flux only 19 is absorbed in the atmosphere and the remaining 60 leaves the planet through the so-called atmospheric window.

Figure 12 Global and annual mean heat budget in W/m^2.
Stack Model with Miskolczi data, but without back-radiation.



Sensitivity Analysis

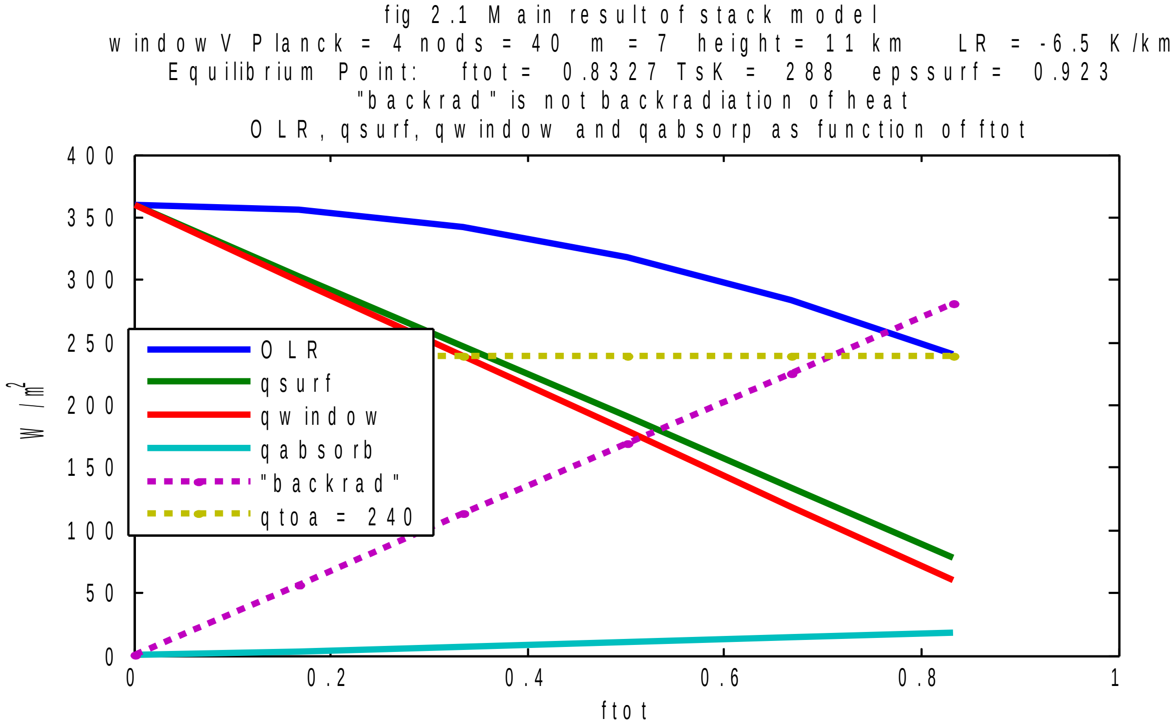
We repeat the results of the previous paper on the subject of sensitivity **[6].**
The results were obtained for the full viewfactor matrix and ε_{LW}=1, of which the stack results are given in **figure 7b.**
We have added the water vapor forcing δOLRh2o which is determined from:

$$\delta OLRh2o = qtoa - Prevost = qtoa - \varepsilon_{LW}\sigma TsK^4 = 240 - 390 = -150\ W/m^2$$

Table 2 CO_2 sensitivity as function of assumed ratio of effect of present CO_2 versus present H_2O
full viewfactor matrix, windowM, and ε_{LW}=1 September 2015

ftotco2/ftot	δOLRco2	δOLRh2o	δTs $_{2xCO2}$	δTs
%	W/m^2	W/m^2	K	K/ppmCO_2
0.1	-0.13629	-150	0.04	1 e-4
1	-1.3717	-150	0.4	10 e-4
2	-2.763	-150	0.83	21 e-4
2.5	-3.47	-150	1.04	26 e-4

In **figure 13** we repeat the results of **figure 11** and **12** with the value ε_{LW}=0.923
Figure13 Results of the stack model with Miskolczi input data, October 2015



.
The dotted line "backrad" is not back-radiation of heat but it represents the negative part in the algebraic expressions for fluxes in elements with a node on the surface.
The atmospheric effect $\delta OLRh2o = qtoa - \varepsilon_{LW}\sigma TsK^4 = 240 - 360 = -120\ W/m^2$.
This value is different from the -150 value for ε_{LW} = 1.
The difference is taken from the convection mechanism (OLR - qsurf), because in the stack model the convection is determined by the radiation mismatch.

Table 3 gives the CO_2 sensitivities for the updated input with ε_{LW}=0.923.
The lower value for ftotco2/ftot = 0.1% is to be retained because of:

- the 1% ratio of CO2 and H2O concentrations
- the fact that CO_2 is active for a very narrow frequency band while H_2O is active for many frequencies, giving another factor 10 or more
- the fact that Ferenc Miskolczi who uses the line by line HARTCODE reports a negligible CO2 effect **[7]**.

The value for ftotco2/ftot =2.5% with as suggested by IPCC is a factor 25 too high due to the artificial broadening of the band in the CO_2 line in MODTRAN **[11]**.

Table 3 CO_2 sensitivity as function of assumed ratio of effect of present CO_2 versus present H_2O
data with windowV vector and Miskolczi ε_{LW}=0.923, October 2015

ftotco2/ftot %	δOLRco2 W/m^2	δOLRh2o W/m^2	δTs $_{2xCO2}$ K	δTs K/ppmCO_2
0.1	-0.109	-120	0.032	0.8 e-4
1	-1.095	-120	0.324	8.1 e-4
2	-2.209	-120	0.657	16.5 e-4
2.5	-2.773	-120	0.826	20.7 e-4

Conclusion

The validation process of the simple stack model with the elaborate studies of Ferenc Miskolczi has shown that the stack model is a fast tool to check new experimental data and/or results from other models.
Ferenc Miskolczi has reported nearly zero influence from CO_2 , based on analyses of measurements by means of world wide weather balloons, using the line by line computer program HARTCODE.
The present paper confirms that the IPCC value for CO_2 forcing is about a factor 25 too high.

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.

The efficient help of Hans Schreuder to edit and to host my papers on his site and give them a broader distribution is appreciated as well as the suggestions by the peer reviewers which Hans has called upon.

Thanks also to John O'Sullivan at Principia Scientific International for the publication of this paper.

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[3] http://www.tech-know-group.com/papers/Planckabsorption.pdf

[4] http://www.tech-know-group.com/papers/Prevost_no_back-radiation-v2.pdf

[5] http://www.tech-know-group.com/papers/vacuum.pdf

[6] http://www.tech-know-group.com/papers/sensitivity.pdf

[7] http://www.seipub.org/des/Download.aspx?ID=21810

[8] http://www.tech-know-group.com/papers/Reynen-MATLAB-listing.pdf

[9] http://claesjohnson.blogspot.fr/

[10] http://claesjohnson.blogspot.fr/search/label/IPCC%20Trick

[11] http://folk.uio.no/gunnarmy/paper/myhre_grl98.pdf

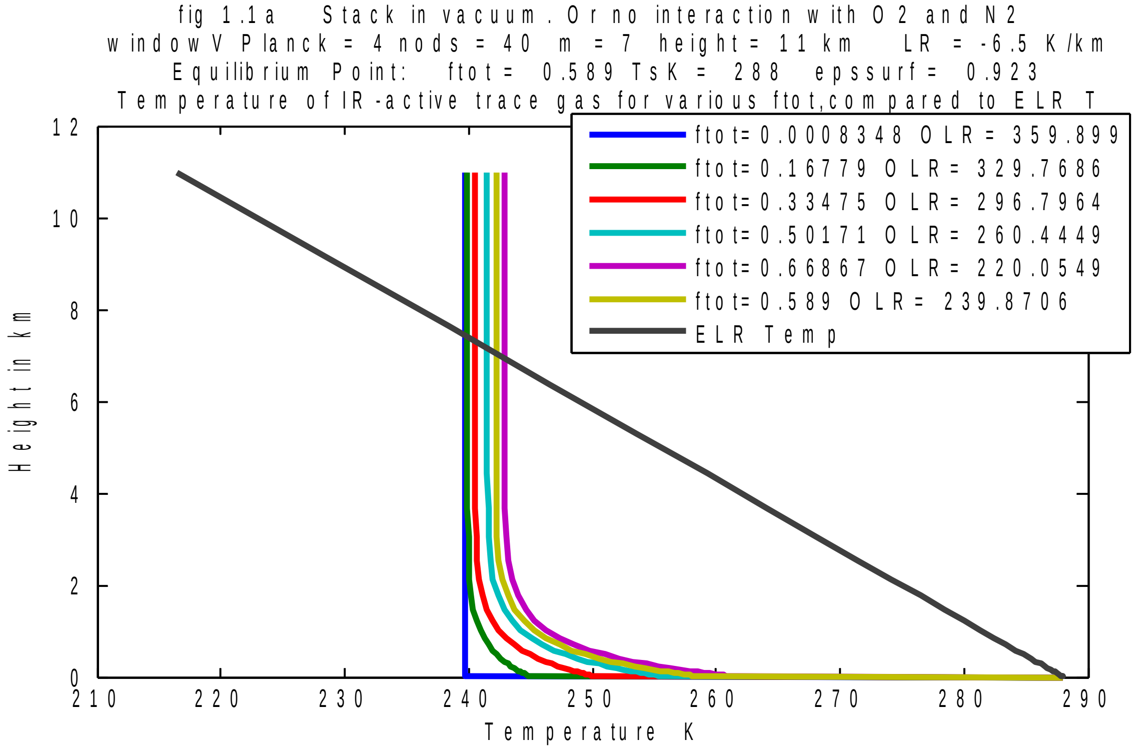
Appendix 1

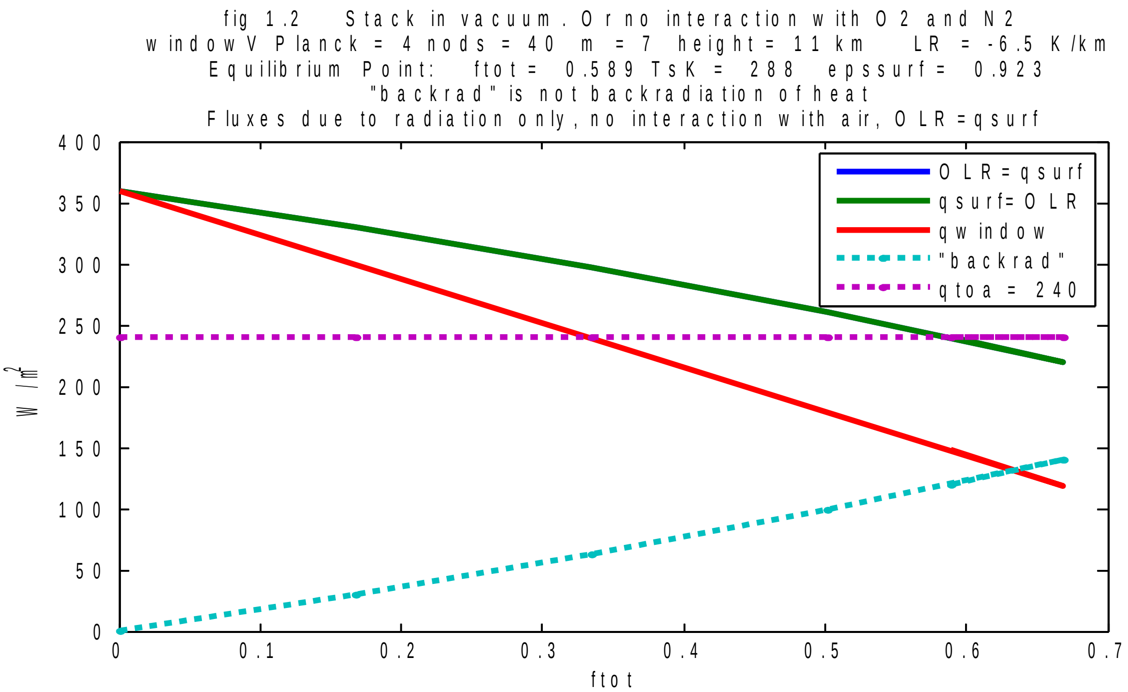
In the main text an update is given of the input parameters based on the Miskolczi data The corresponding figures for option 1 (stack in vacuum) and option 2 (stack in atmosphere) are repeated here.

OPTION 1 see also **[5]**.

In this option the solution of **K*θ =rhs** is given with **rhs=0** and boundary condition: $\theta(1) = \varepsilon_{LW}\sigma TsK^4$ en $\theta(N)$ = zeroK.

For height < 7.5 km the IR-active trace gases are colder than ELR temp if there were an atmosphere.





NB No convection, OLR=qsurf. “Backrad” is not back-radiation of heat.

OPTION 2

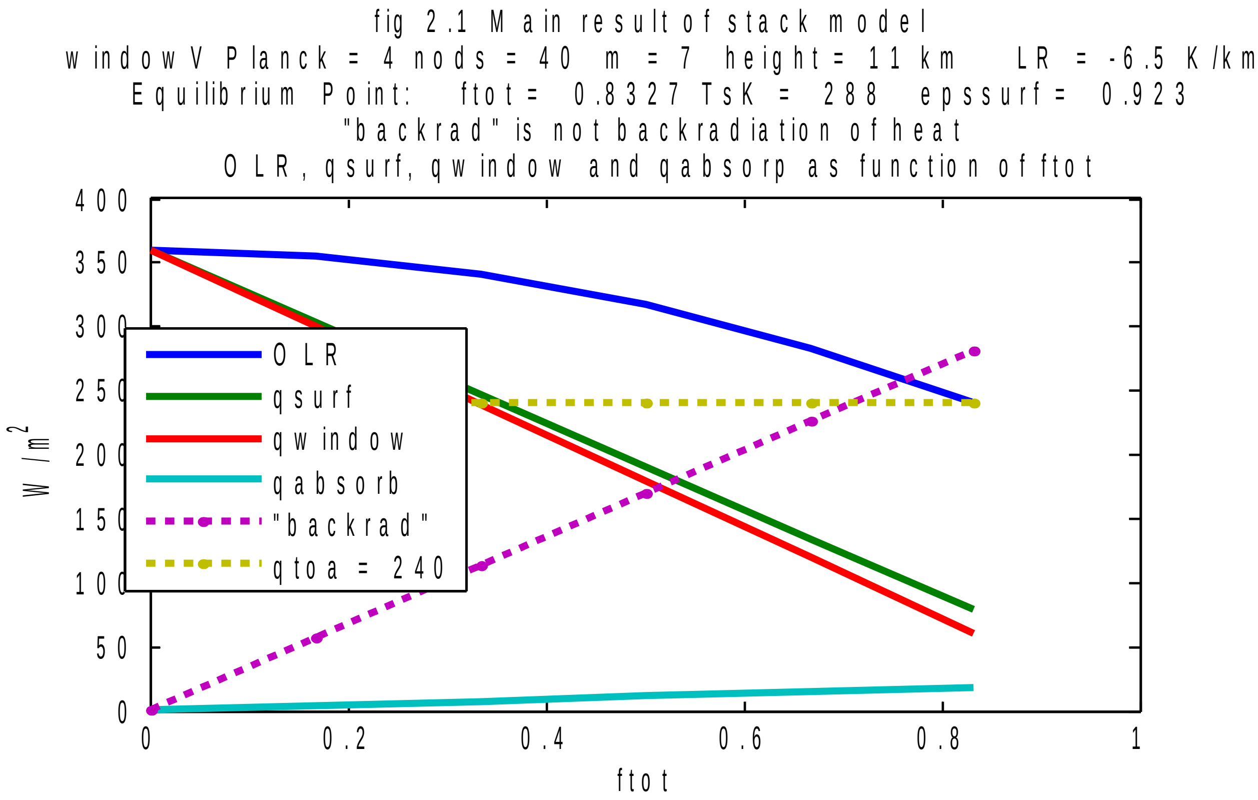


fig 2.1 Main result of stack model
windowV Planck = 4 nods = 40 m = 7 height = 11 km LR = -6.5 K/km
Equilibrium Point: ftot = 0.8327 TsK = 288 epssurf = 0.923
"backrad" is not backradiation of heat
OLR, qsurf, qwindow and qabsorp as function of ftot
OLR
qsurf
qwindow
qabsorb
"backrad"
qtoa = 240
W/m2
ftot
0
50
100
150
200
250
300
350
400
0
0.2
0.4
0.6
0.8
1

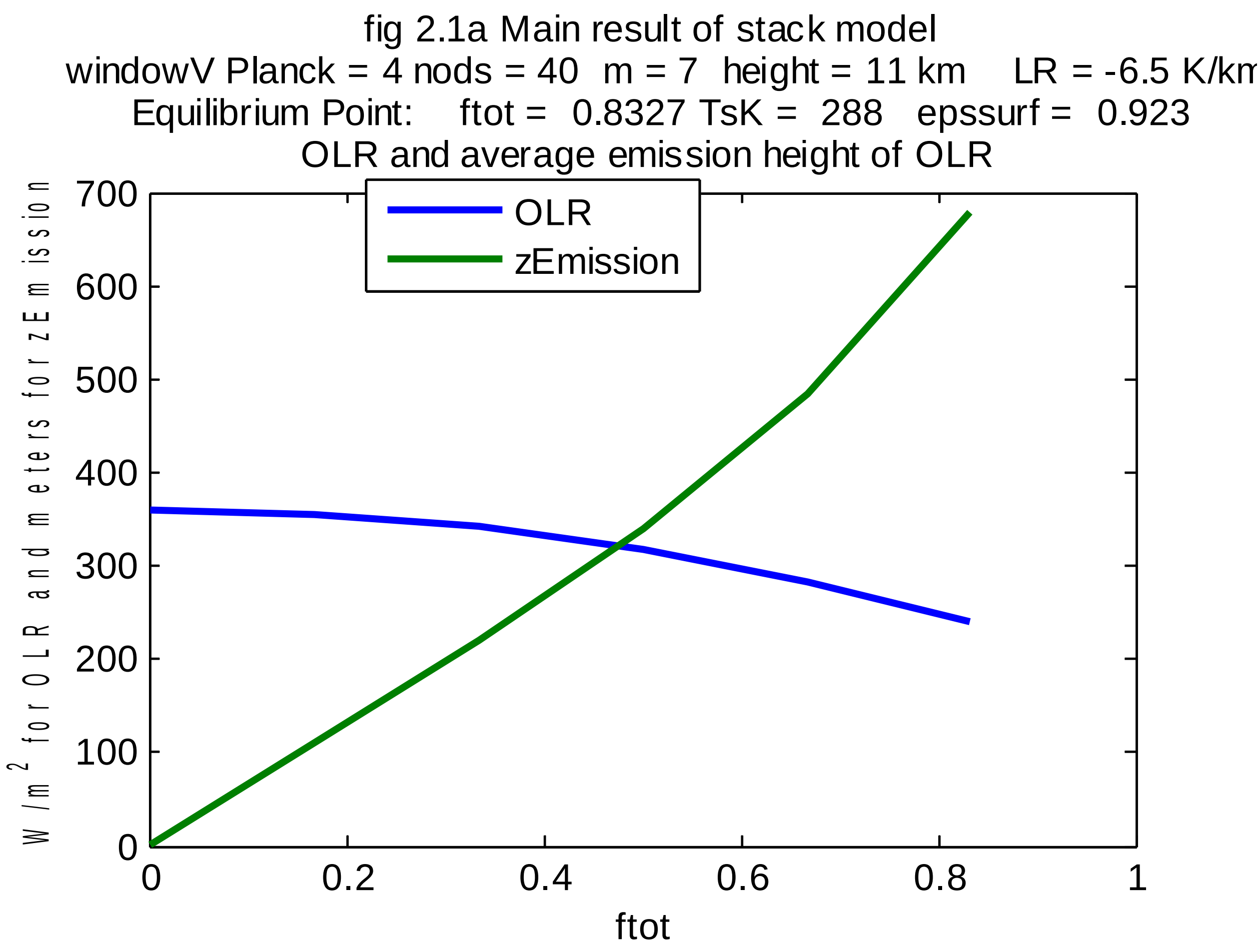


fig 2.1a Main result of stack model
windowV Planck = 4 nods = 40 m = 7 height = 11 km LR = -6.5 K/km
Equilibrium Point: ftot = 0.8327 TsK = 288 epssurf = 0.923
OLR and average emission height of OLR
OLR
zEmission
W/m2 for OLR and meters for zEmission
ftot
0
100
200
300
400
500
600
700
0
0.2
0.4
0.6
0.8
1

OPTION 2

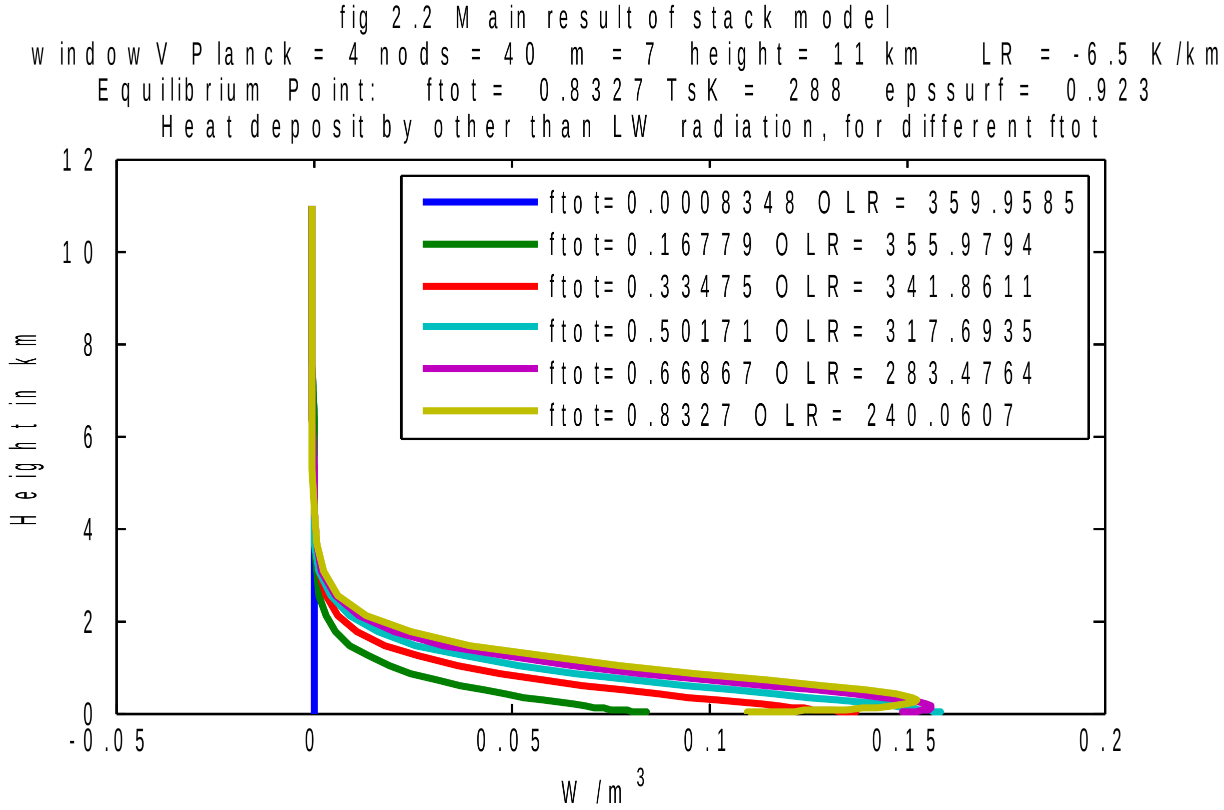


fig 2.2 Main result of stack model
windowV Planck = 4 nods = 40 m = 7 height = 11 km LR = -6.5 K/km
Equilibrium Point: ftot = 0.8327 TsK = 288 epssurf = 0.923
Heat deposit by other than LW radiation, for different ftot
ftot=0.0008348 OLR = 359.9585
ftot=0.16779 OLR = 355.9794
ftot=0.33475 OLR = 341.8611
ftot=0.50171 OLR = 317.6935
ftot=0.66867 OLR = 283.4764
ftot=0.8327 OLR = 240.0607
Height in km
W /m 3
12
10
8
6
4
2
0
-0.05
0
0.05
0.1
0.15
0.2

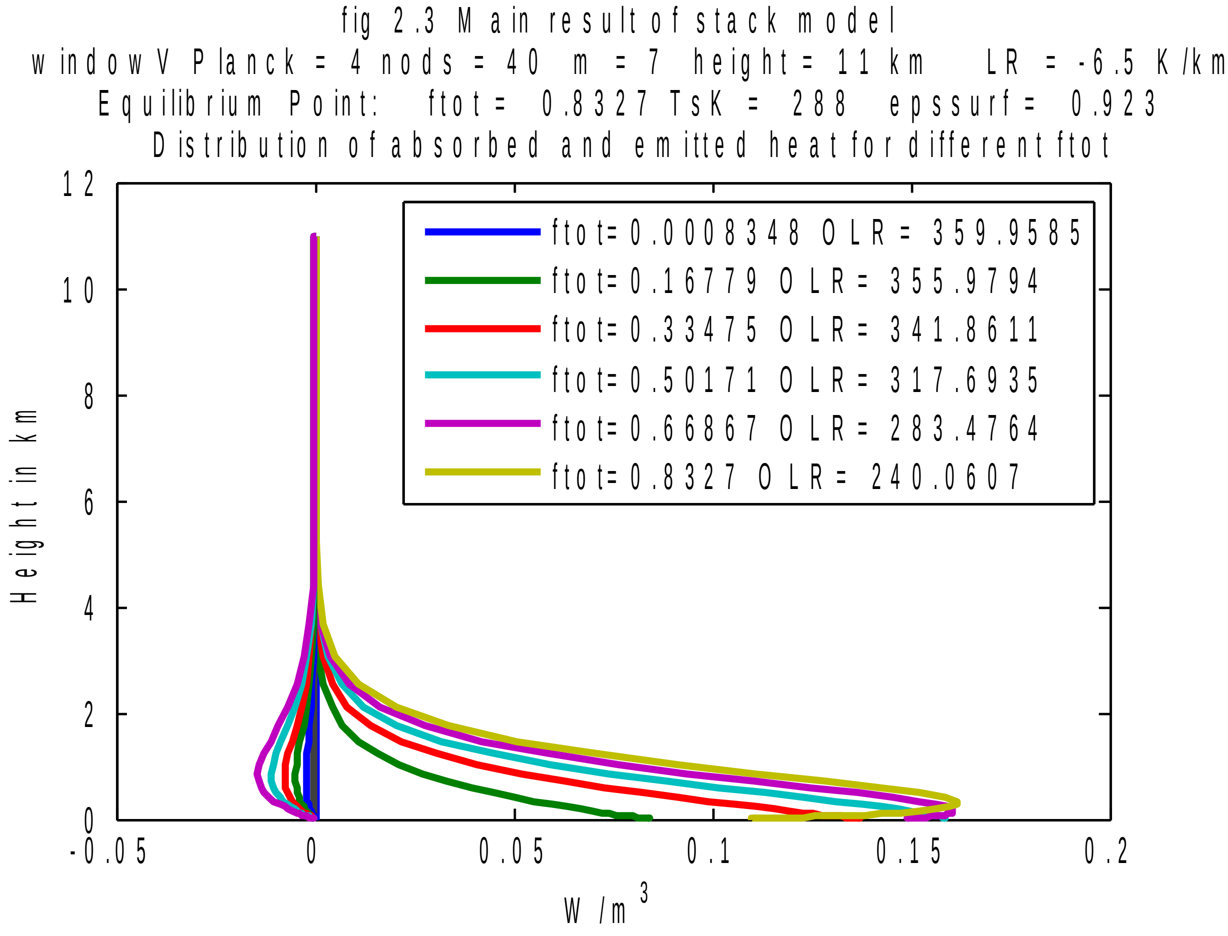
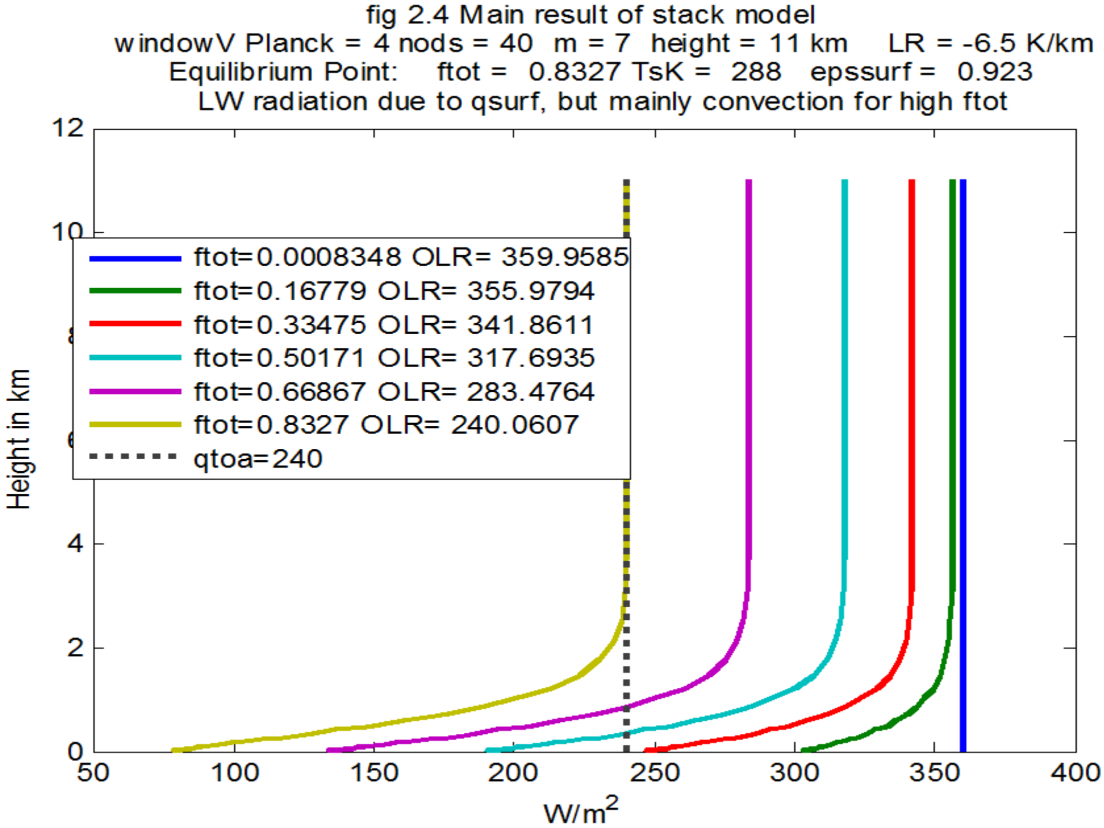


fig 2.3 Main result of stack model
windowV Planck = 4 nods = 40 m = 7 height = 11 km LR = -6.5 K/km
Equilibrium Point: ftot = 0.8327 TsK = 288 epssurf = 0.923
Distribution of absorbed and emitted heat for different ftot
ftot=0.0008348 OLR = 359.9585
ftot=0.16779 OLR = 355.9794
ftot=0.33475 OLR = 341.8611
ftot=0.50171 OLR = 317.6935
ftot=0.66867 OLR = 283.4764
ftot=0.8327 OLR = 240.0607
Height in km
W /m 3
12
10
8
6
4
2
0
-0.05
0
0.05
0.1
0.15
0.2

OPTION 2



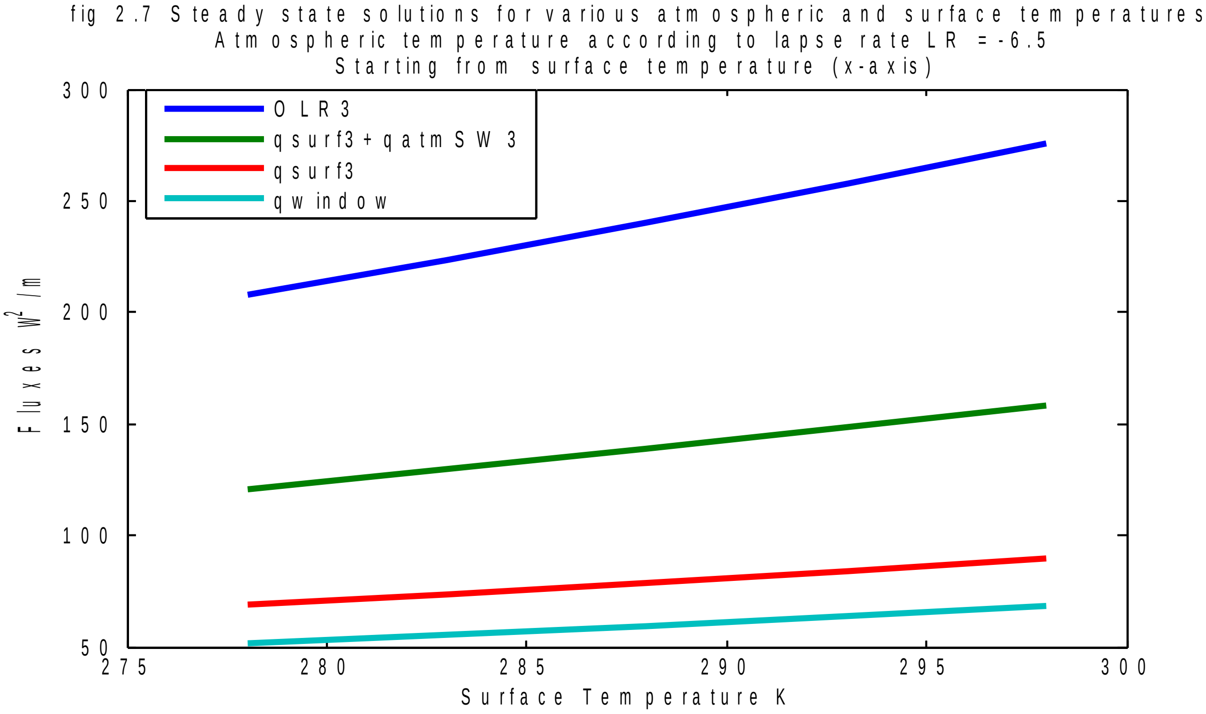


Figure 2.7 gives the result of the stack model for surface temperature variations between +10 and -10 around TsK=288 K, but constant lapse rate ELR = -6.5 K/km. The slope of the blue curve represents dOLR/dTs = 3.37 W/m^2/K.