The stable stationary value of the Earth’s global average atmospheric infrared optical thickness

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PLANETARY GREENHOUSE EFFECT LINKED TO ATMOSPHERIC IR ABSORPTION

Greenhouse effect: $\Delta t = t_s - t_E$  
Greenhouse factor: $G = \sigma t_s^4 - \sigma t_E^4 = S_U - OLR$

$G_{\text{MARS}} = 7 \text{ Wm}^{-2}$
$G_{\text{USST}} = 130 \text{ Wm}^{-2}$

Spectral OLR and $S_U$, mW/(m² cm⁻¹)

Wavenumber, cm⁻¹
THE $G = S_U - OLR$ GREENHOUSE FACTOR IS NOT THE DIRECT MEASURE OF ATMOSPHERIC IR ABSORPTION
NEED TO QUANTIFY THE ROLE OF THE GHG’s IN GLOBAL WARMING

CLEAR-SKY RADIATIVE TRANSFER MODEL

**GREENHOUSE EFFECT:**
\[ G = S_G - \text{OLR} \]
\[ G_N = G / S_G \]

**All-sky measurements:**
\[ S_G = 391 \text{ Wm}^{-2} \]
\[ \text{OLR} = 235 \text{ Wm}^{-2} \]
\[ G_N \approx 0.4 \]

**QUESTIONS:**

What is the mechanism of the greenhouse effect?

What are the theoretical relationships among the global average IR flux density terms?

**NET ATMOSPHERE:**
\[ F + P + K + A_A - E_D - E_U = 0 \]

**NET SURFACE:**
\[ F^0 + P^0 + E_D - F - P - K - A_A - S_T = 0 \]
\[ F^0 + P^0 = \text{OLR} \]
GLOBAL SCALE LBL SIMULATIONS

INPUT DATA SET

RADIOSONDE OBSERVATIONS ARE FROM A SUB-SET OF THE TIGR COMPILATION (A. Chedin and N. Scott 1983)

PROCESSING LBL CODE

High-resolution atmospheric radiative transfer code HARTCODE (F. Miskolczi, M. Bonzagni and R. Guzzi, 1990)

SPECTROSCOPIC DATA SET

TRUE INFRARED FLUX OPTICAL THICKNESS

\[
S_T = S_U \exp(-\tau_A)
\]

\[
\tau_A = -\ln \left[ \frac{1}{\sigma t_A^4} \sum_{j=1}^{M} \pi B(\Delta v_j, t_A) \sum_{k=1}^{K} w^k T_A(\Delta v_j, \mu^k) \right]
\]

\[
T_A(\Delta v_j, \mu^k) = \frac{1}{\Delta v_j} \int \exp \left[ -\sum_{l=1}^{L} \sum_{i=1}^{N} \left[ c^{i,l} + k^{i,l}_v \right] \frac{u^{i,l}}{\mu^{l,k}} \right] dv
\]

\( M=3490 \) is the total number of spectral intervals, \( K=9 \) is the total number of streams, \( w^k \) is the hemispheric integration weight associated with the \( k \)-th direction (stream), \( T_A \) is the directional mean transmittance over a suitable short wave number interval,

\[
\mu^{l,k} = \cos(\theta^{l,k}) / dz^l
\]

\( \theta^{l,k} \) is the local zenith angle of a path segment, \( dz^l \) is the vertical layer thickness, \( N=11 \) is the total number of major absorbing molecular species, \( L=150 \) is the total number of layers. \( u^{i,l}, c^{i,l} \) and \( k^{i,l} \) are the absorber amounts, and the continuum and line type absorption coefficients.
TIGR 2 mean hemispheric transmittance

Full altitude range: 0–70 km, spectral resolution: 1 cm\(^{-1}\),

Gray: 1–3490 cm\(^{-1}\), Red: 660–680 cm\(^{-1}\), Blue: 1000–1100 cm\(^{-1}\), Black: mean
Anisotropy in directional radiances
Global average TIGR 2 atmosphere

Limb angles

$S_U$  $E_D^i$  $E_D$  $E_U$  $S_T$  $A_A$  OLR

Radiance, W/(m² sr)

Viewing angle, degree
## TIGR2 SIMULATION RESULTS

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Global Average</th>
<th>GAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_A$</td>
<td>232.25</td>
<td>309.62</td>
<td>285.34</td>
<td>286.04</td>
</tr>
<tr>
<td>$S_U$</td>
<td>164.98</td>
<td>521.10</td>
<td>381.88</td>
<td>379.64</td>
</tr>
<tr>
<td>$u$</td>
<td>0.0507</td>
<td>6.836</td>
<td>2.533</td>
<td>2.637</td>
</tr>
<tr>
<td>$E_U$</td>
<td>83.74</td>
<td>256.71</td>
<td>188.94</td>
<td>192.7</td>
</tr>
<tr>
<td>$E_D$</td>
<td>103.35</td>
<td>429.69</td>
<td>308.70</td>
<td>310.49</td>
</tr>
<tr>
<td>$T_A$</td>
<td>0.0497150</td>
<td>0.391204</td>
<td>0.173344</td>
<td>0.15422</td>
</tr>
<tr>
<td>$S_T = S_U T_A$</td>
<td>22.246</td>
<td>111.92</td>
<td>61.094</td>
<td>58.54</td>
</tr>
<tr>
<td>$OLR = E_U + S_T$</td>
<td>150.64</td>
<td>297.62</td>
<td>250.05</td>
<td>251.25</td>
</tr>
<tr>
<td>$\tau_A = - \ln (T_A)$</td>
<td>0.9385</td>
<td>3.0014</td>
<td>1.8736</td>
<td>1.8693</td>
</tr>
</tbody>
</table>

$t_A : K; S_U, E_U, E_D, S_T, OLR : \text{Wm}^{-2}; u : \text{prcm}; T_A, \tau_A : \text{dimensionless}$

**GAT** : global average TIGR2 profile
IR radiative structure of the atmosphere from TIGR2

Atmospheric Kirchhoff rule

Radiative equilibrium rule

Energy conservation rule

Atmospheric virial rule

EMPIRICAL FACTS
SATELLITE OBSERVATIONS ARE CONSISTENT WITH THE ATMOSPHERIC RADIATIVE EXCHANGE EQUILIBRIUM RULE

Annual Mean Downward Longwave Flux as Function of Mean Upward Flux Separated by Climate Type for Land

From: Longwave Surface Radiation and Climate; Lou Smith, Anne Wilber, David Kratz, Shashi Gupta and Paul Stackhouse, NASA LARC
KIRCHHOFF LAW AND RADIATIVE EXCHANGE EQUILIBRIUM

Contribution density functions
Profile 3: TiGR2–853, nasu, ASCA = −10, Δ Z = 80–250 m, h₂O = 1.7601 prcm

\[ E_D = A_A \text{ at 2.028 km} \]

\[ T_S = T \text{ at 2.026 km} \]

\[ dA_A/dz - dE_D/dz, \text{ Wm}^{-2}\text{m}^{-1} \]

Temperature, K
THEORETICAL CONSIDERATIONS

\[ A_A = E_D \]
\[ S_U = \frac{3}{2} OLR \]
\[ f = \frac{2}{2 + \tau - A} \]
\[ OLR = E_U + S_T \]
\[ A_A = S_U (1 - \exp(-\tau_A)) \]

SIMULTANEOUS SOLUTION OF THE **FOUR EQUATIONS**:

\[ g = 1 - f = \frac{2A}{5} \quad \rightarrow \quad \tau_A = 1.867 \]
TIGR2 and NOAA Simulations

\[ f = \frac{2}{1 + \tau_A + e^{-\tau_A}} \]

- Theoretical expectation
- GAT profile
- TIGR2
- TIGR2 global average
- NOAA

\[ \tau_A = 1.867 \]
Linear trends in the flux absorption between 1948 and 2008, $A = 1 - e^{-\tau}$

NCEP/NCAR R1 Reanalysis data from http://www.cdc.noaa.gov

Global mean IR absorption does not follow the CO$_2$ increase

Average of 61 global annual mean : $A = 0.8456841$

Average from the TIGR-2 archive : $A = 0.8469$

Theoretical expectation : $A = 0.8455$
Greenhouse effect and the 21.6% increase of CO$_2$ in the last 61 years are unrelated. Atmospheric H$_2$O does but CO$_2$ does not correlate with the IR optical depth.

7 different NOAA annual mean time series – NCEP/NCAR R1

![Graph showing IR optical depth and H$_2$O column amount over years from 1950 to 2000.](image)

- **H$_2$O prcm**
- **IR optical depth**
  - 1948 – 2008 (61 year mean)
  - 1959 – 2008 (50 year mean)
  - 1948 – 1997 (50 year mean)
  - 1973 – 2008 (36 year mean)
  - 1948 – 1972 (25 year mean)
  - 1977 – 2008 (32 year mean)
  - 1948 – 1976 (29 year mean)

Theoretical: 1.87

Mean profile values
NOAA NCEP/NCAR R1
Trendline correlation coefficient summary

ATMOSPHERIC CO$_2$ INCREASE
CAN NOT BE THE REASON OF GLOBAL WARMING

<table>
<thead>
<tr>
<th>Time period</th>
<th>Centre</th>
<th>Years</th>
<th>Altitude</th>
<th>Temperature</th>
<th>H$_2$O</th>
<th>CO$_2$</th>
<th>Tau</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948–2008</td>
<td>1978</td>
<td>61</td>
<td>0.7931</td>
<td>0.8183</td>
<td>-0.2841</td>
<td>0.9839</td>
<td>0.06488</td>
</tr>
<tr>
<td>1959–2008</td>
<td>1983.5</td>
<td>50</td>
<td>0.8059</td>
<td>0.8349</td>
<td>0.04499</td>
<td>0.9937</td>
<td>0.2976</td>
</tr>
<tr>
<td>1948–1997</td>
<td>1972.5</td>
<td>50</td>
<td>0.6621</td>
<td>0.6625</td>
<td>-0.4843</td>
<td>0.9827</td>
<td>-0.2284</td>
</tr>
<tr>
<td>1973–2008</td>
<td>1990.5</td>
<td>36</td>
<td>0.6947</td>
<td>0.7987</td>
<td>0.1148</td>
<td>0.9974</td>
<td>0.3491</td>
</tr>
<tr>
<td>1948–1972</td>
<td>1960</td>
<td>25</td>
<td>-0.005748</td>
<td>0.1731</td>
<td>-0.5907</td>
<td>0.983</td>
<td>-0.4184</td>
</tr>
<tr>
<td>1977–2008</td>
<td>1992.5</td>
<td>32</td>
<td>0.58</td>
<td>0.7424</td>
<td>0.03992</td>
<td>0.9973</td>
<td>0.267</td>
</tr>
<tr>
<td>1948–1976</td>
<td>1962</td>
<td>29</td>
<td>0.001769</td>
<td>0.0584</td>
<td>-0.6048</td>
<td>0.9804</td>
<td>-0.4396</td>
</tr>
</tbody>
</table>

IR optical depth has no correlation with time.
The strong CO$_2$ signal in any time series is not present in the
in the IR optical depth data.
GREENHOUSE THEORY:
Atmosphere must have a unique global average IR optical thickness which is consistent with all the observed empirical facts and the associated theoretical relationships.

Definition: \( S_T / S_U = T_A = e^{-\tau} \)

\[ \text{OLR}/(\varepsilon S_U - 4S_T) \]

\[ \text{OLR}/(E_U - S_T) \]

\[ -\ln(1 - E_D / (\varepsilon S_U)) \]

\[ S_U = E_U / (f - T_A) \]

\[ S_U = 2E_U \]

\[ -\ln(T_A) \]

\[ S_U = \text{OLR}/f \]

\[ S_U = 3\text{OLR}/2 \]

\[ 3 + 2T_A = 5 \]

\[ \text{OLR}/S_U \]

\[ \text{OLR}/(E_D - 3S_T) \]

TIGR 2000 archive – profiles were adjusted to fit to satellite observations

Theoretical IR optical thickness estimates

IR optical thicknesses were computed from observations using first principles. No assumptions, arbitrary constants, GCMs, and feedbacks are involved.
The dynamics of the greenhouse effect depend on the dynamics of the absorbed solar radiation and the space-time distribution of the atmospheric humidity. The global distribution of the IR optical thickness is fundamentally stochastic. The instantaneous effective values are governed by the turbulent mixing of H$_2$O in the air and the global (meridional) redistribution of the thermal energy resulted from the general (atmospheric and oceanic) circulation.

According to the simple-minded or ‘classic’ view of the greenhouse effect the global average greenhouse temperature change may be estimated by the direct application of the Beer-Lambert law moderated by local or regional scale weather phenomena (R. Pierrehumbert, A. Lacis, R. Spencer, R. Lindzen, A. P. Smith, H. deBruin, J. Abraham et al., J. Hansen et al., and many others)*. This is not true.

The greenhouse effect is a global scale radiative phenomenon and can not be discussed without the explicit quantitative understanding of the global characteristics of the IR atmospheric absorption and its governing physical principles.

\[ \tau^O = \frac{\text{OLR} / (S_U - 4 S_T)}{1 - 4 T_A} = f / (1 - 4 T_A) \]

\( \tau^O \): optical thickness required by an opaque atmosphere

\( \tau^k \): contribution to \( \tau^O \) from turbulent mixing