LIMITS OF CARBON DIOXIDE IN CAUSING GLOBAL WARMING

Northern California Section
American Nuclear Society

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May 23, 2012

History of the Controversy

The Intergovernment Panel on Climate Change (IPCC), Established 1988 by the UN.

Charter: “Assess the scientific, technical and socio-economic information relative to understanding the risk of human-induced climate change.

Four assessment reports: 1990,1995, 2001 and 2007: with successively increasing claims of the validity of AGW.

Skeptics started early with organizations and publications.

Highly politicized, with sharp dividing line—as between left wing and right wing—a world-wide controversy involving the political leadership of most nations.

Implications for our economic and energy future cannot be underestimated

Major focus of the problem has been on human production of carbon dioxide.

FROM PREVIOUS ANS TALKS

Late 90's: By LLNL speaker:
"all arguments against AGW have been refuted"

Circa 2004: By the late Stephen Schneider, Stanford Nobel Laureate with Al Gore:
"preponderance of evidence supports AGW; proof beyond reasonable doubt not required"

2010: By second LLNL speaker:
"all knowledgeable scientists support AGW"

This talk uses “conservative, engineering” Approach to counter the previous assertions

Conservative: Don’t overestimate supporting evidence or underestimate contravening evidence

Engineering: Use available, proven physics and mathematics tools to obtain useful, reliable answers

“Modtran” and “SpectralCalc” computer codes plus classical physics and mathematics are employed

USE OF LIMITS

Limits easier to establish than precise answers

1. Establish limits on CO2's ability to influence temperature.
2. Establish limits on the level of CO2 that can be achieved in the atmosphere
3. Establish limits that "feedbacks" resulting from CO2 addition have on warming.

With proper limits established, credible conclusions can be made

Nature of the Problem

- Greenhouse gases absorb infrared radiation (IR) from the earth and thereby impede the escape of its heat, frequently compared to a blanket or an overcoat
- The essence of AGW lies with the physics of the interaction of infrared (IR) radiation with the molecules of the atmosphere, with emphasis on CO2

INFRARED CHARACTERISTICS

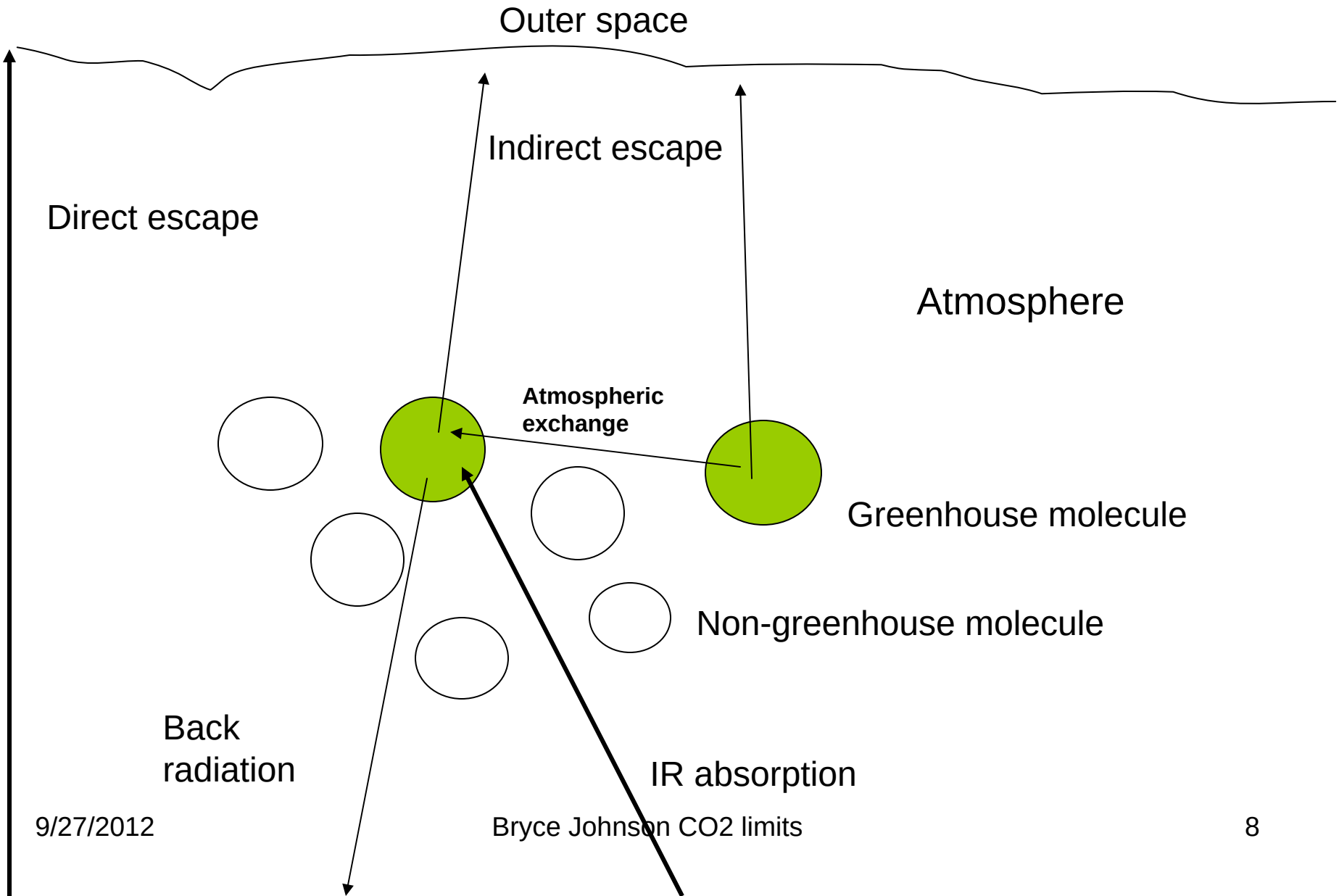
Infrared = Heat

Molecules are heated by IR absorption and cooled by IR emission

There is no direct connection between IR absorption and subsequent IR emission.

After being heated by IR absorption, molecules can lose heat by any transfer mechanism including IR emission.

Fates of IR Photons in the Atmosphere



What happens inside the atmosphere?

- The atmosphere is a roiling mass of molecules undergoing all known mechanisms of heat transfer.
- This study “trusts” that the authors of the “standard” IR transport codes know what they are doing about those mechanisms.
- The CO2 effect is determined by the heat entering and the heat exiting the atmosphere and the effect that CO2 has on each. These are all calculable with standard codes and classical heat transfer mathematics, and can be measured (but with controversial accuracy).

Calculating Temperature Rise Caused by Added CO2

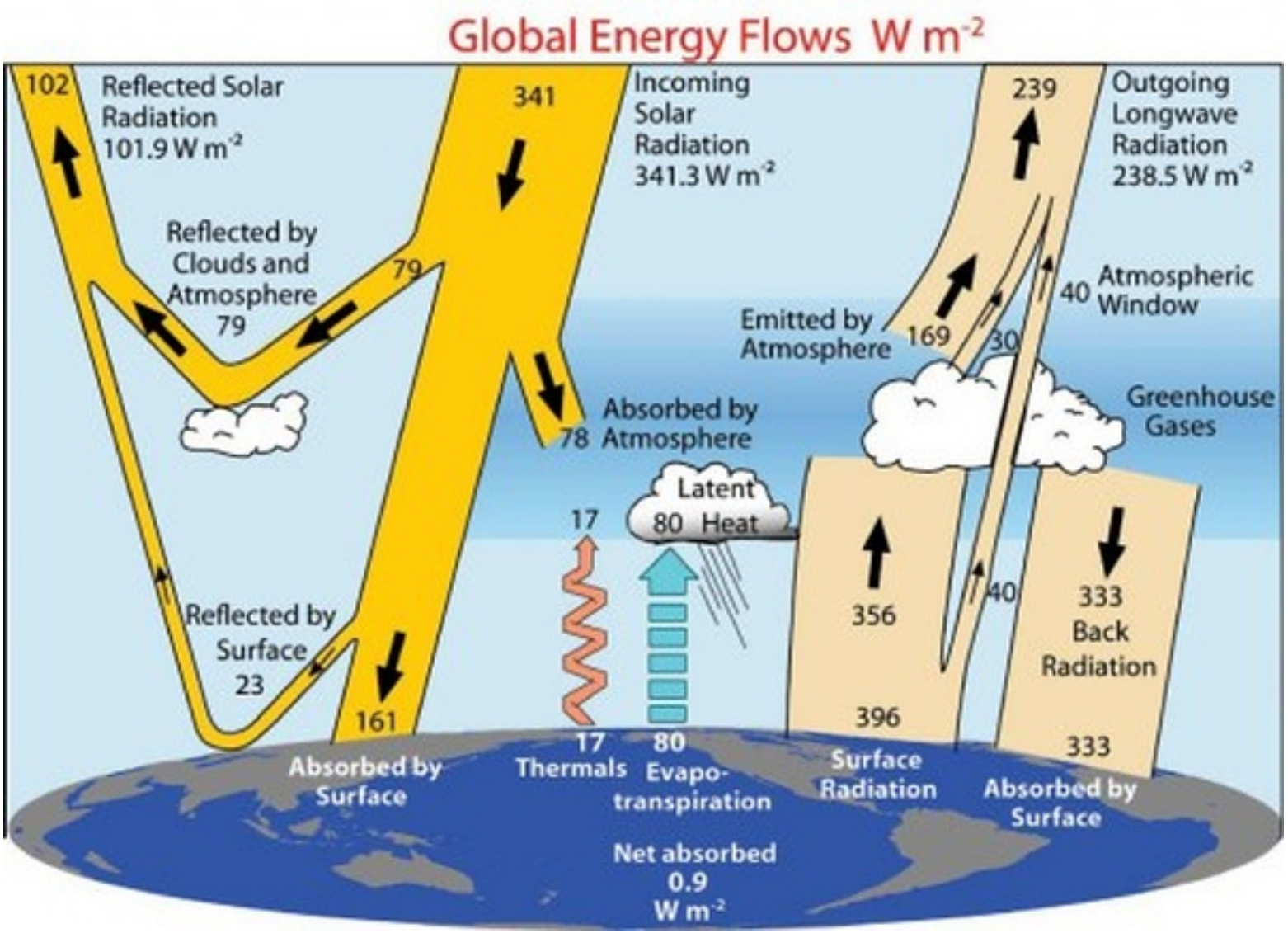
1. Determine entering minus exiting IR energy flux in the atmosphere with the Modtran Code before and after the increased CO2.
2. Add to this difference the heat flux that enters the atmosphere that is not IR to obtain total heat in. From the energy balance of slide 12 this is 175 w/m^2
3. These are **IR(in) – IR(out) +175 = H**
4. Define subscripts b and c as referring to conditions before and after CO2 added, respectively.
5. Equate their ratio to ratio of Stefan-Boltzmann heat out in each case: $\mathbf{H_c/H_b = (c_a T_c^4 - c_o T_o^4)/(c_a T_b^4 - c_o T_o^4)}$, where subscripts a and o refer to atmosphere and outer space, respectively, and **c** is emissivity times the Boltzmann constant.

Calculating temperature rise from CO2, continued

T_o^4 is roughly a ten million times smaller than either T_a^4 or T_c^4 so the second term in the parentheses terms on the right can be ignored to reduce the equation to this much simplified form

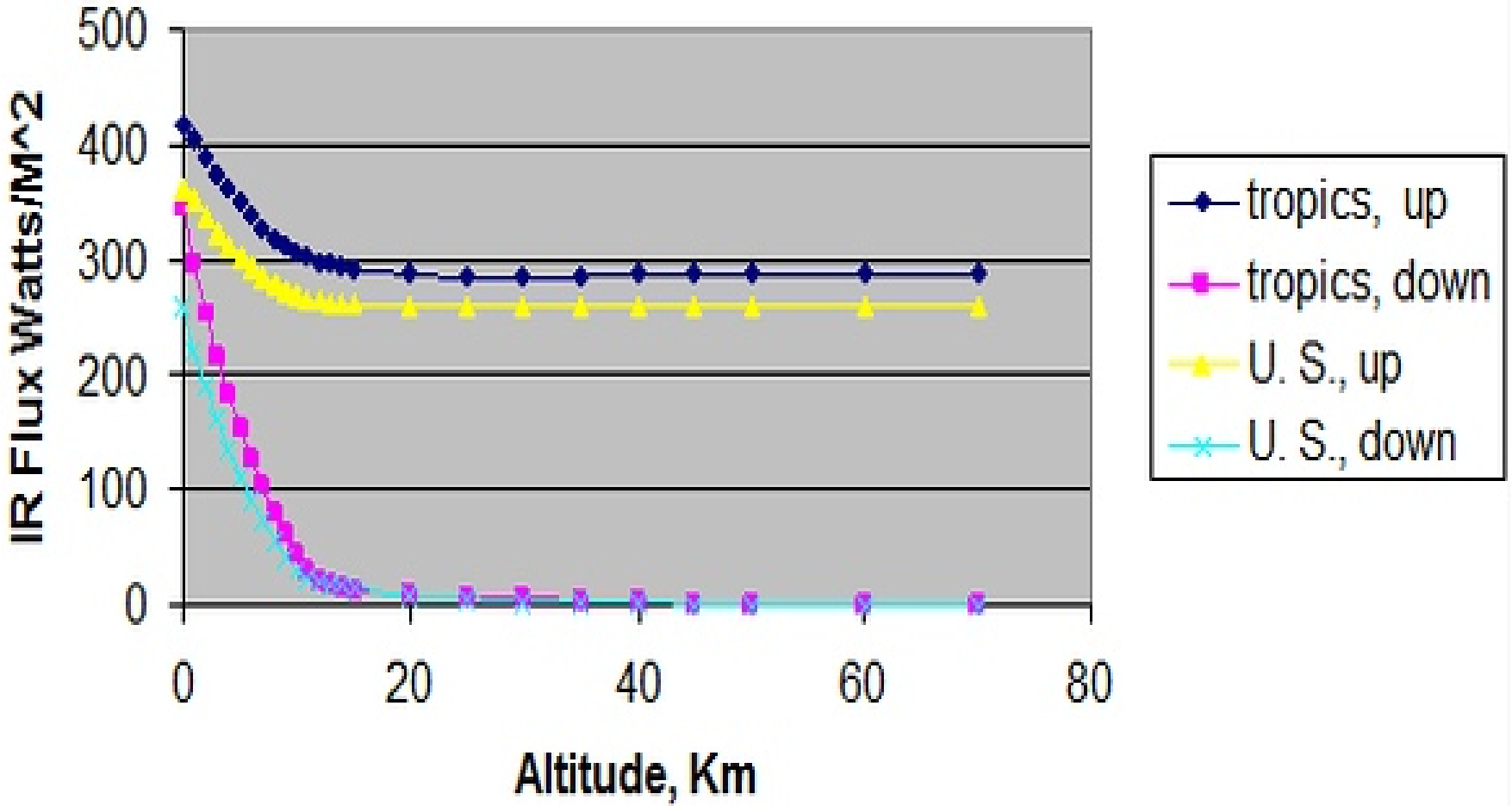
$$\mathbf{T_c = T_b(H_c/H_b)^{1/4}},$$

and the temperature rise, $\Delta\mathbf{T = T_c - T_b}$



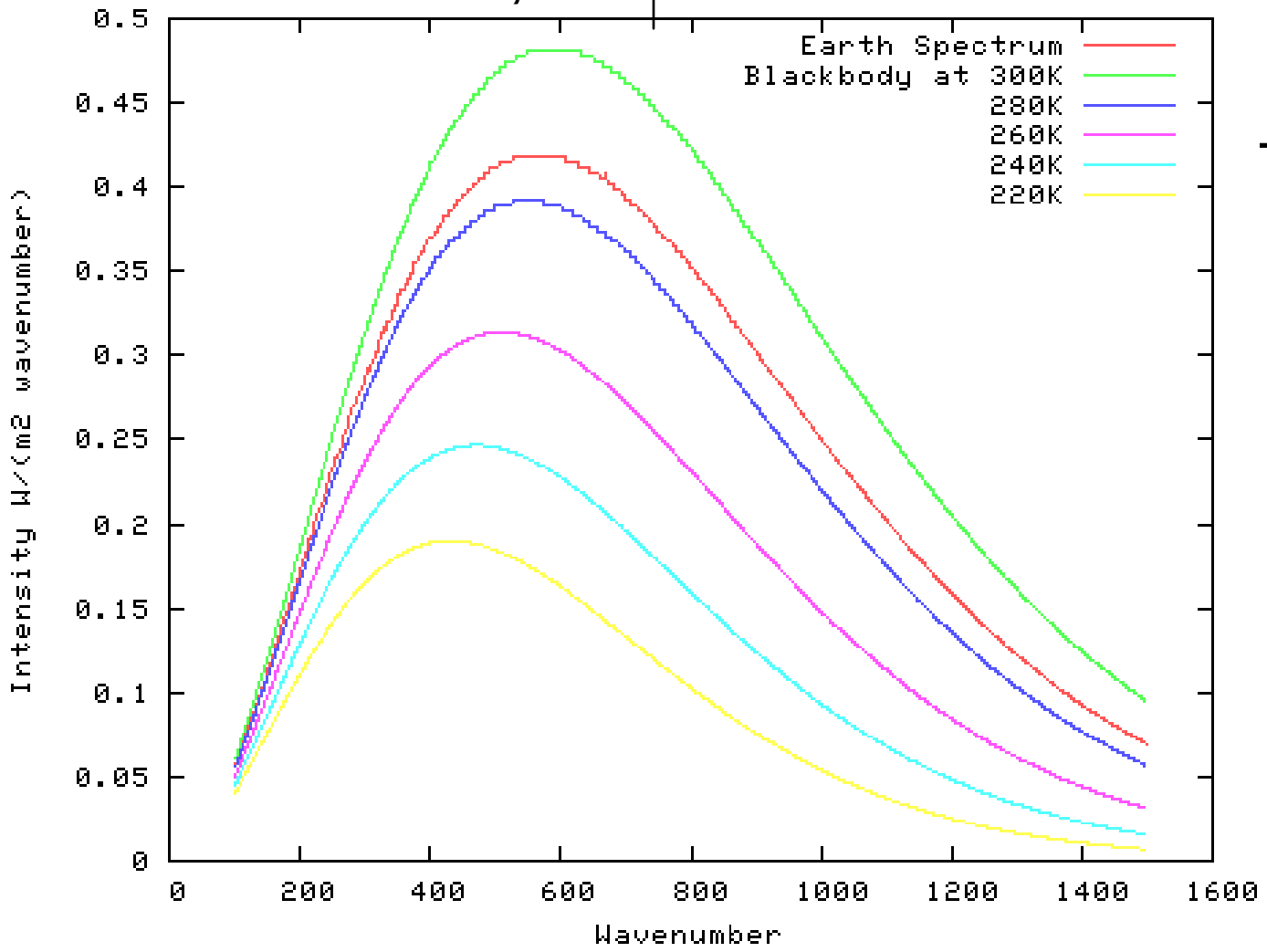
IPCC Earth-Atmosphere Energy Balance

Figure 4. IR Flux Across Atmsophere



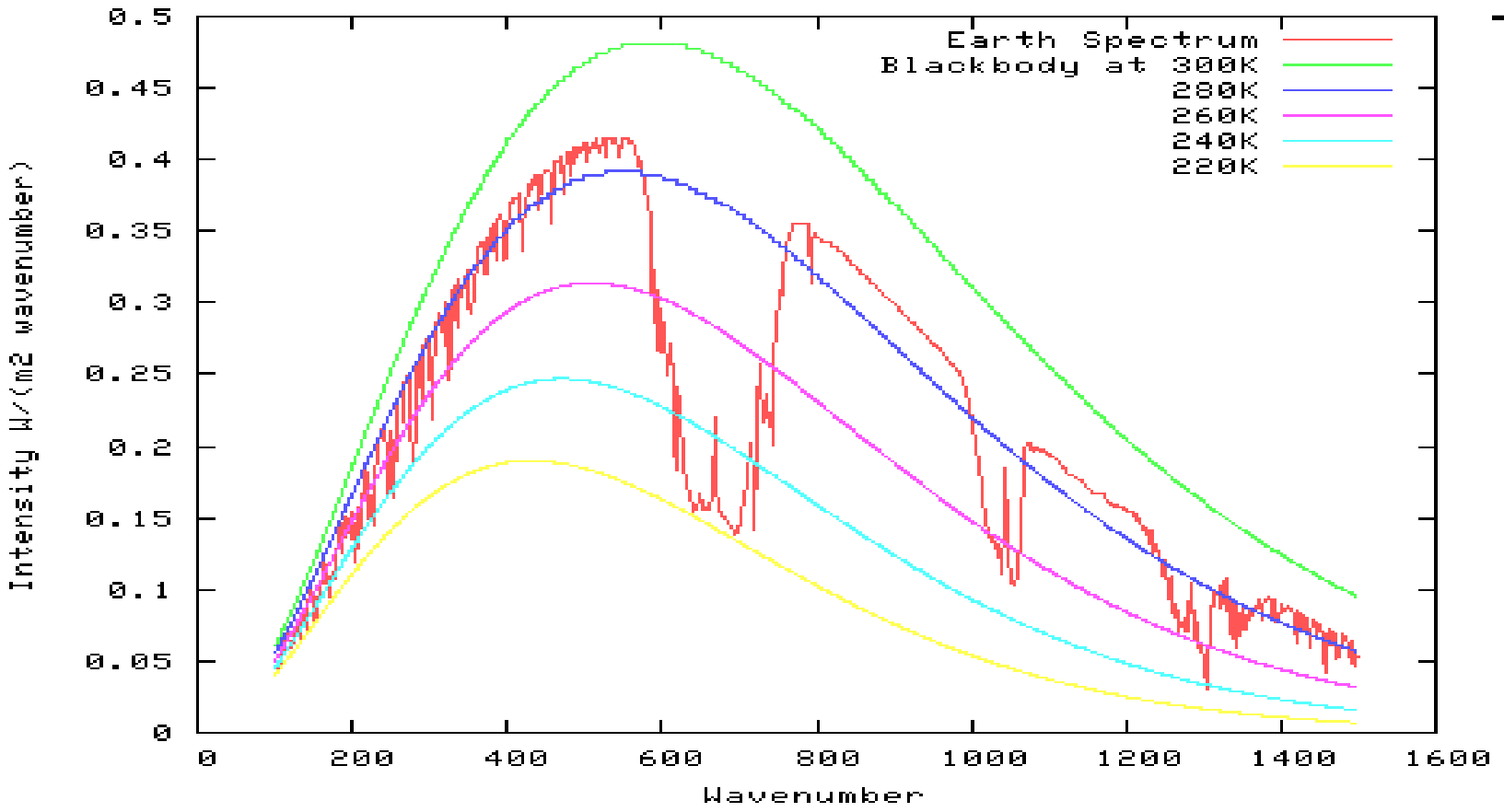
IR Spectrum of Earth Surface (from Modtran)

I_{out}, W / m^2 =	360.47
Ground T, K =	288.20



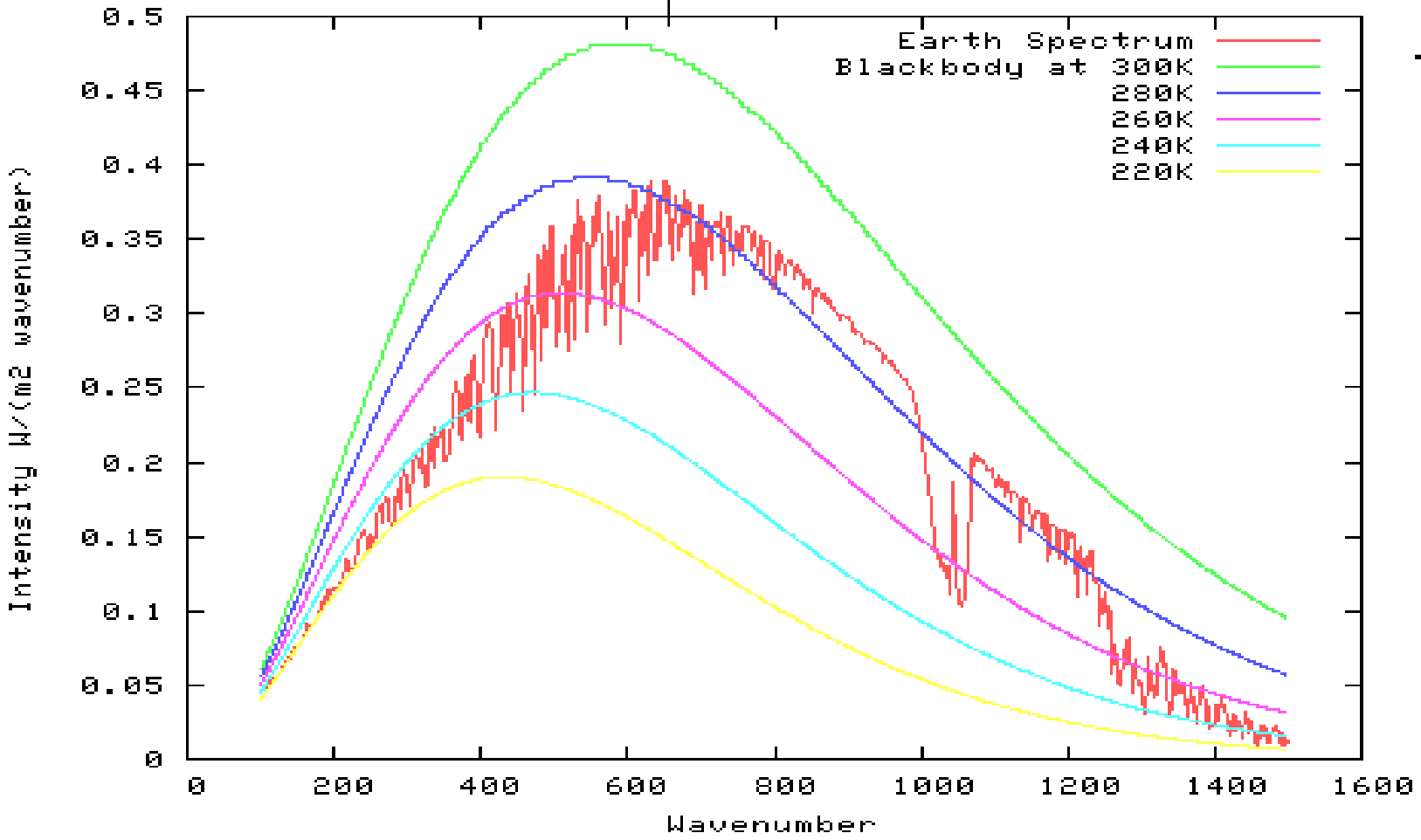
H2O removed, IR Leaving Atmosphere

I_{out}, W / m² =	**303.481**
Ground T, K =	**288.20**



CO2 removed, IR exiting atmosphere

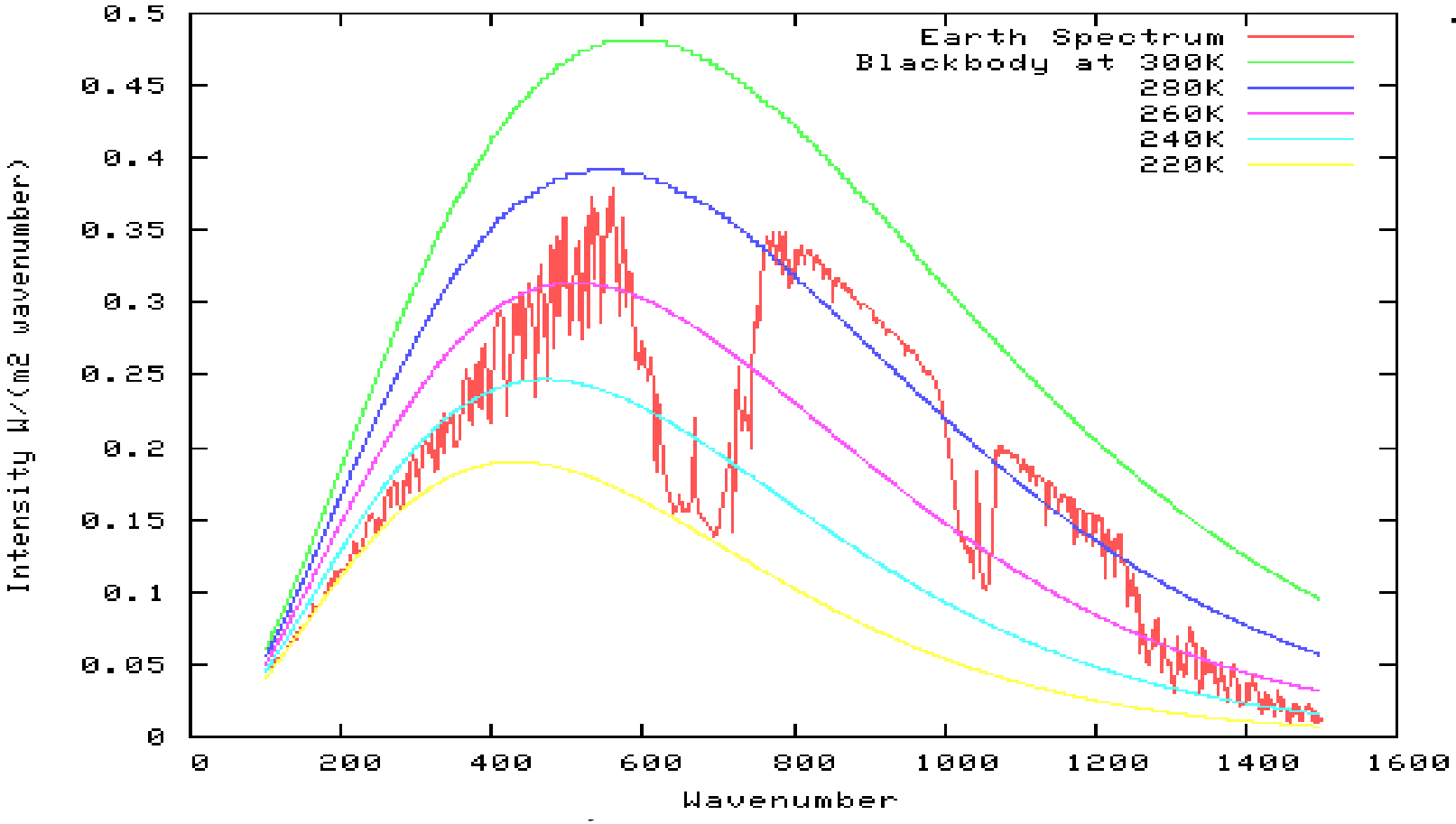
I_{out}, W / m² =	**286.242**
Ground T, K =	**288.20**



All Absorbers Present, IR Exiting Atmosphere

$I_{out,\ W/m^2} = 258.579$

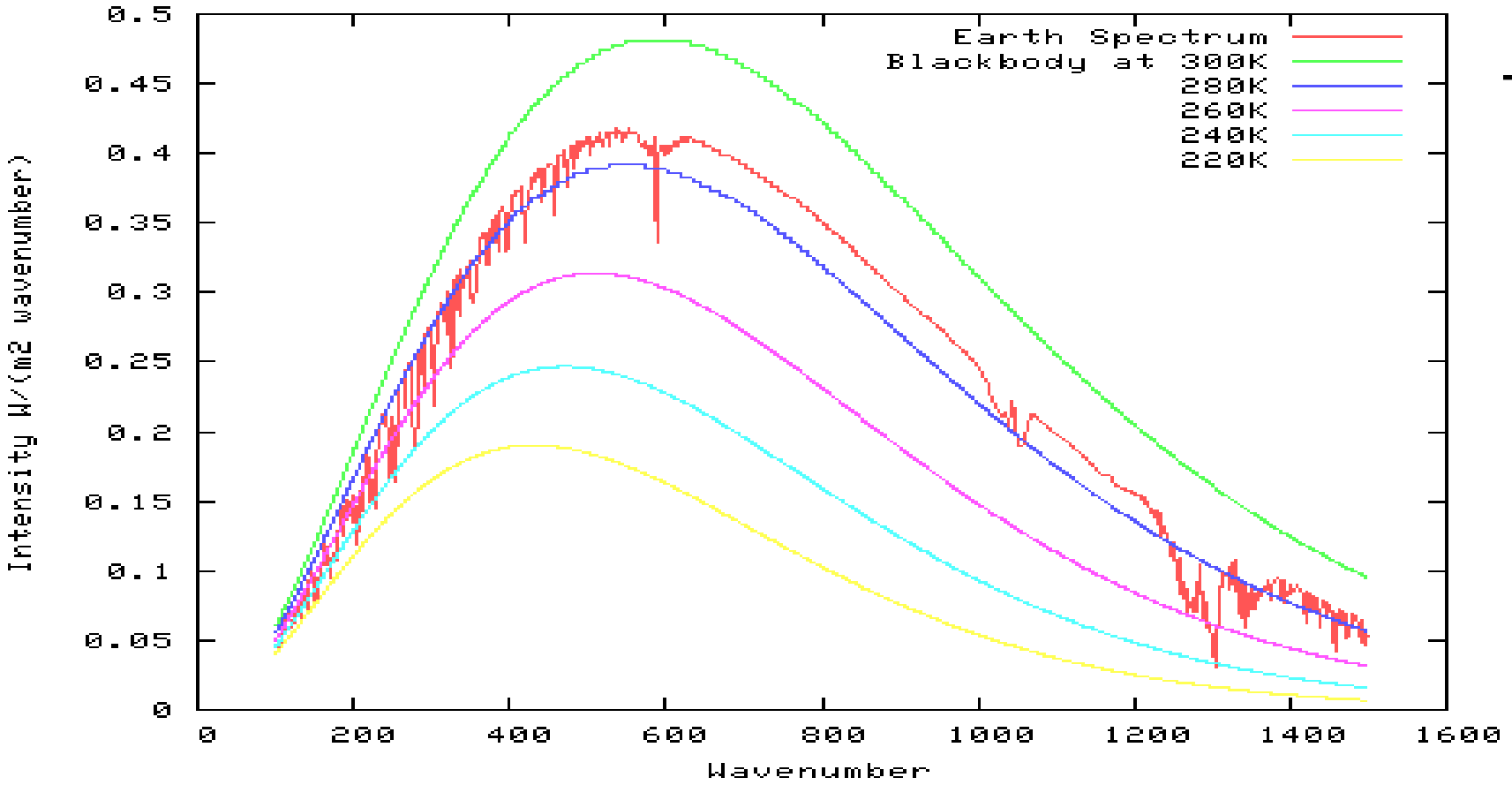
Ground T, K = 288.2



IR Leaving Atmosphere with CO2 and H2O removed

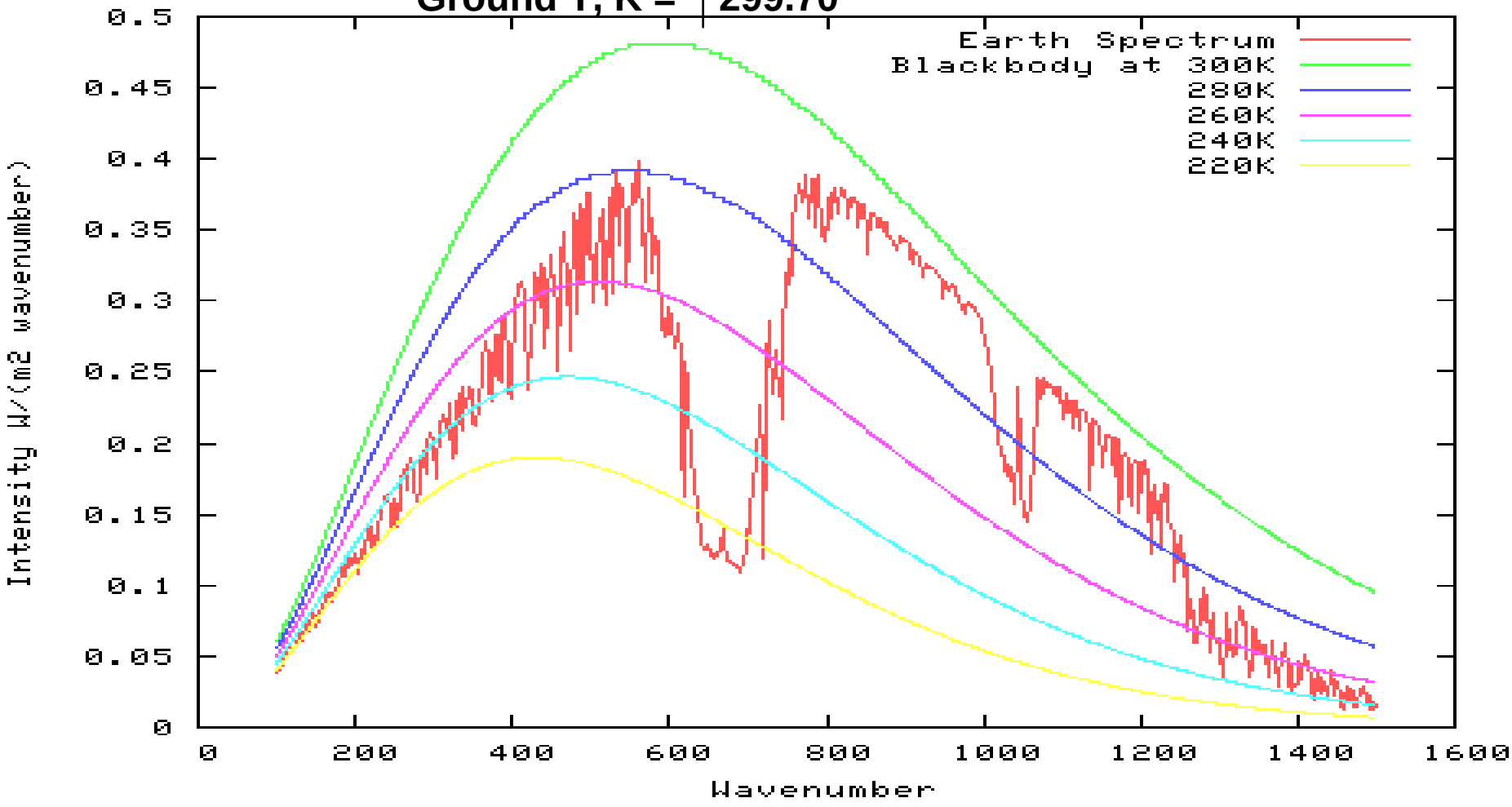
I_{out}, W / m² = 342.888

Ground T, K 288.20



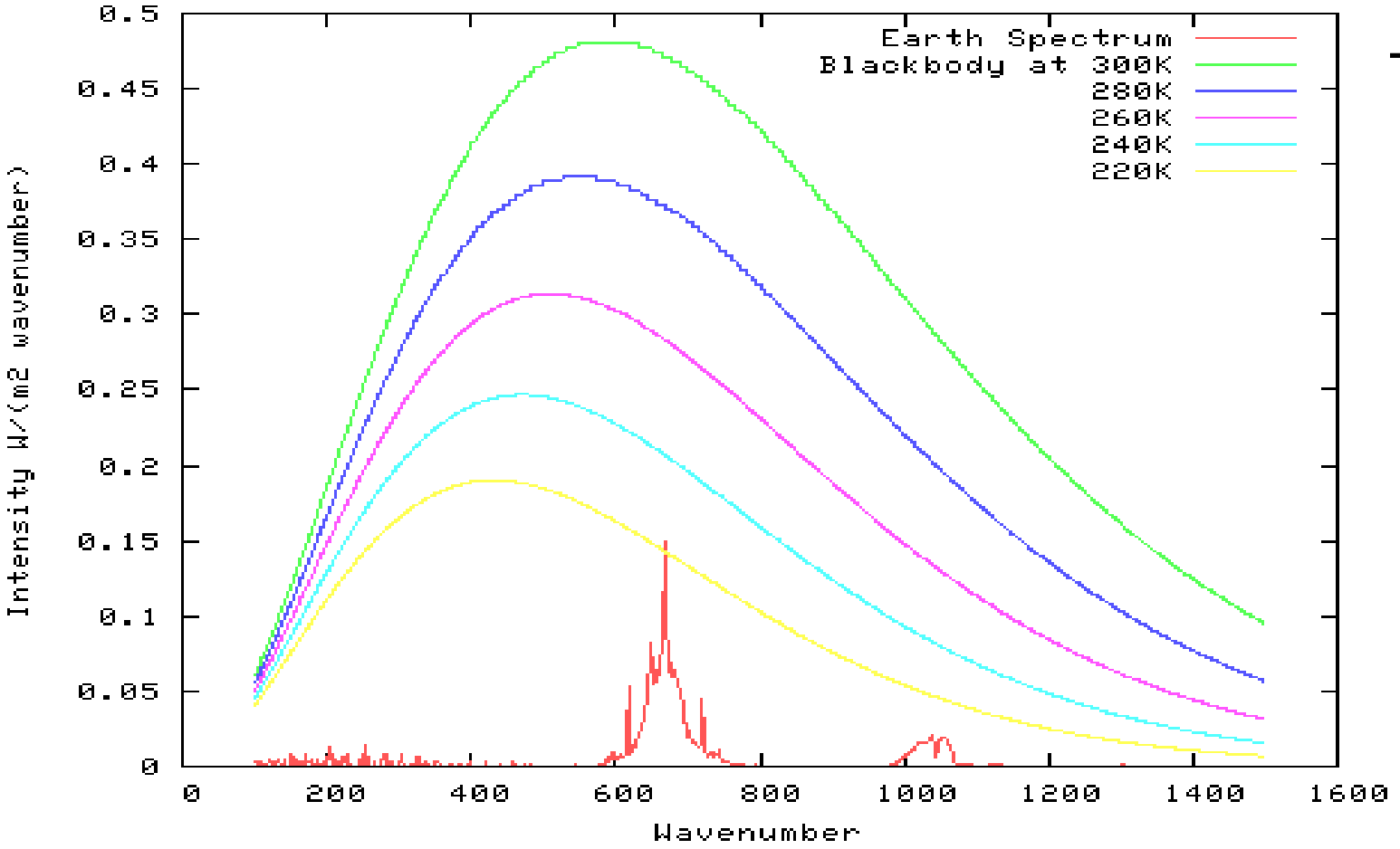
OUT RADIATION AT 25 KILOMETERS

$I_{out,\ W/m^2}$ =	286.431
Ground T, K =	299.70



BACK RADITION AT 25 KILOMETERS

$I_{out,\ W/m^2}$ =	7.05558
Ground T, K =	0.00



PRECEDING SLIDE DUPLICATES IR CROSS SECTION OF CO2. (same frequency distribution for emission and absorption)

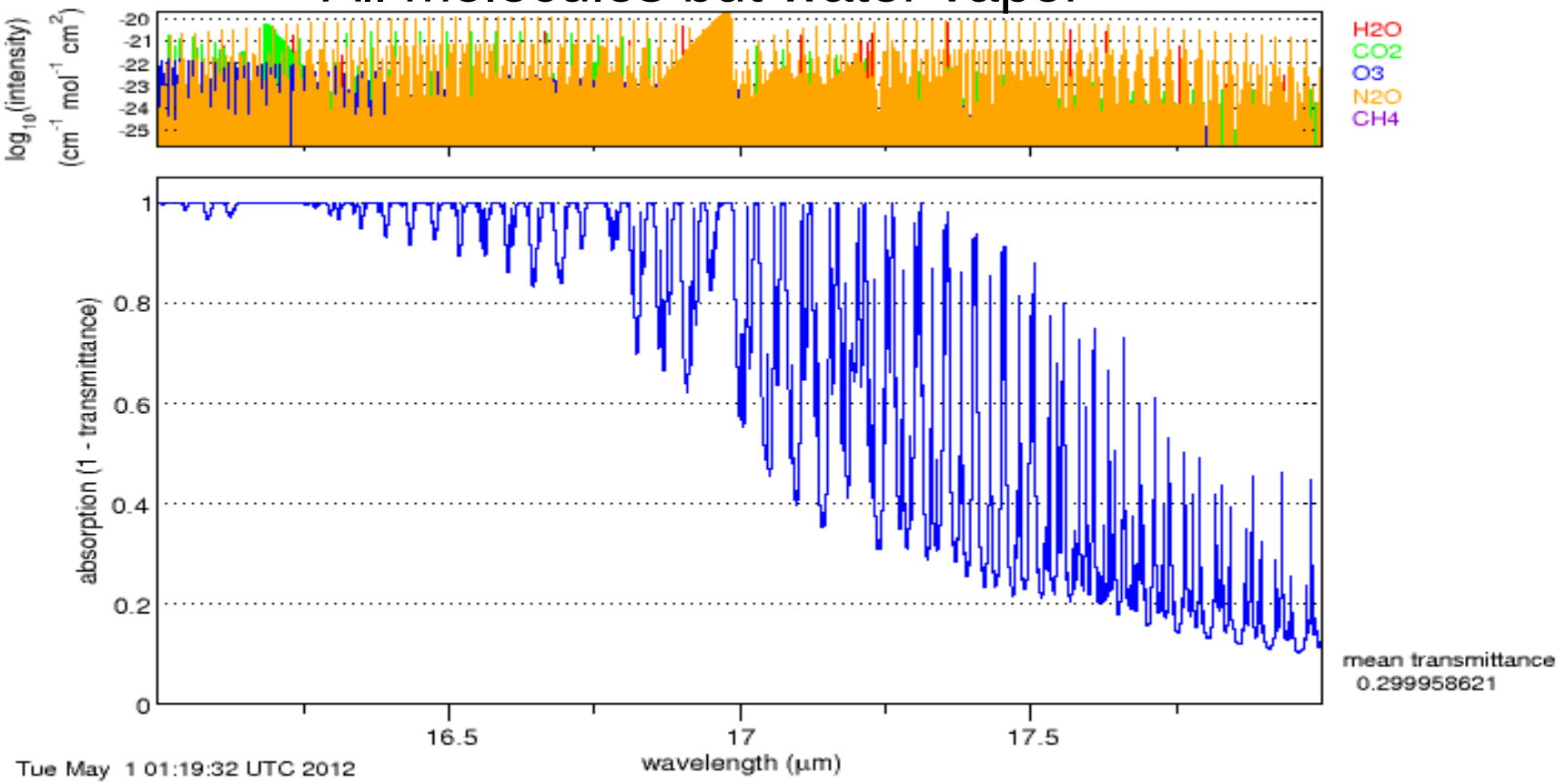
CO2 IS ESSENTIALLY THE ONLY EMITTER AT THAT ALTITUDE.

VERY LOW ATMOSPHERIC DENSITY CAUSES LOW EMISSION.

SHARPLY PEAKED DISTRIBUTION ILLUSTRATES CO2'S HIGH SATURATION RATE WITH INCREASED DENSITY.

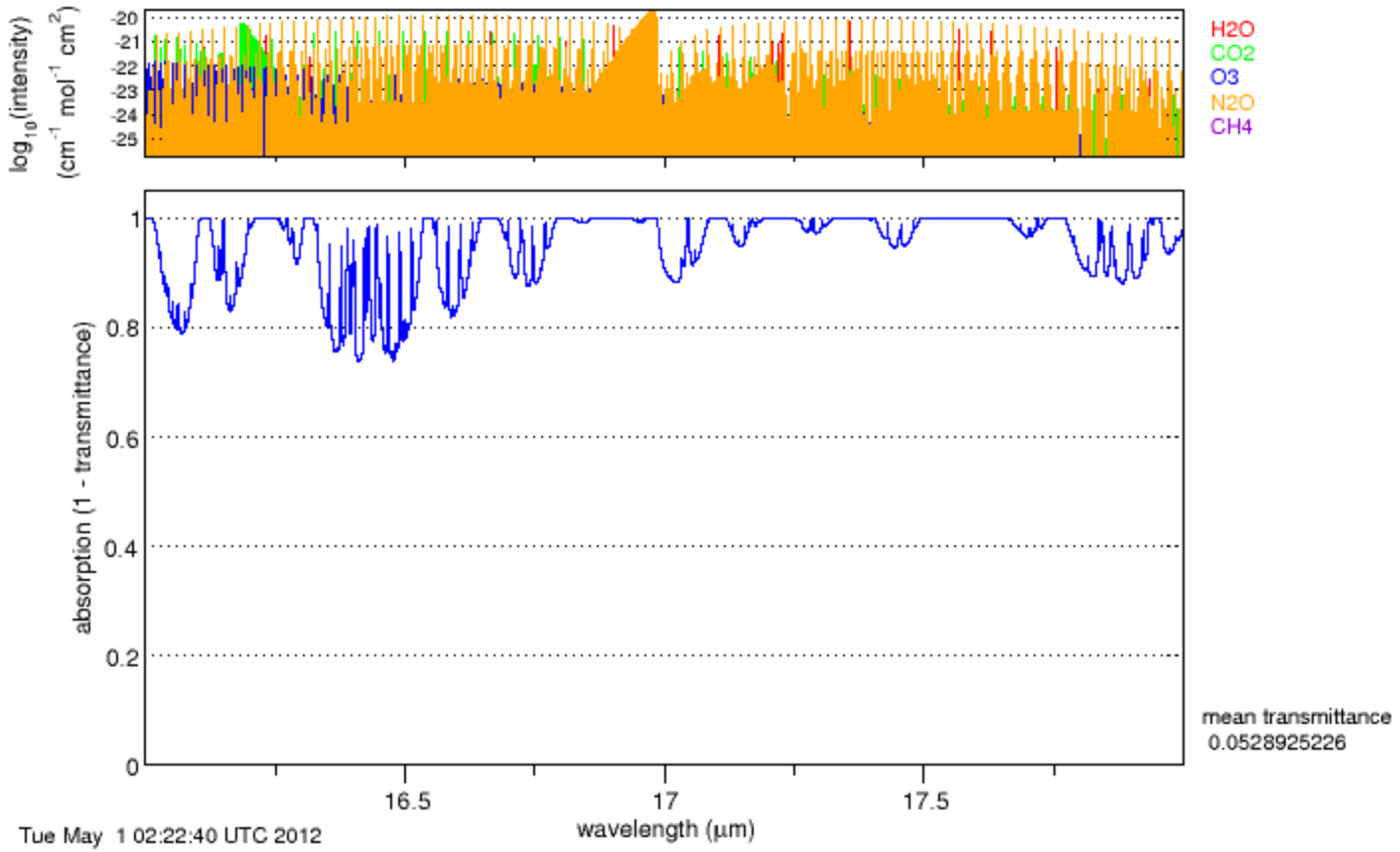
INCREASING CO2 APPROACHES UNIT ABSORPTION PROBABILITY MUCH FASTER THAN H20 WHICH HAS OVERALL BROAD DISTRIBUTION WITH NO HUGE PEAKS.

All molecules but water vapor



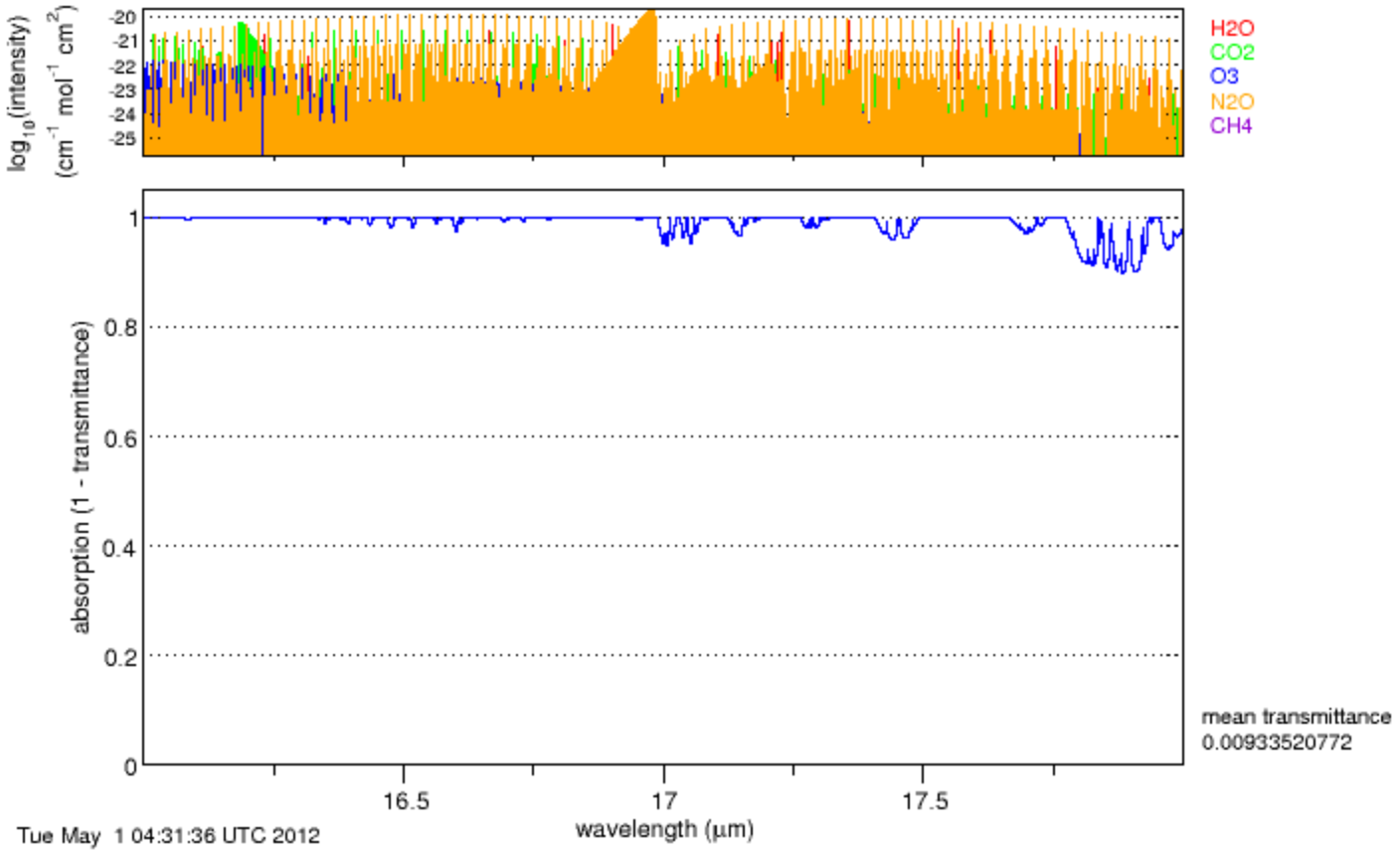
Probability of Absorption in the Atmosphere (from SpectralCalc)

All molecules but carbon dioxide



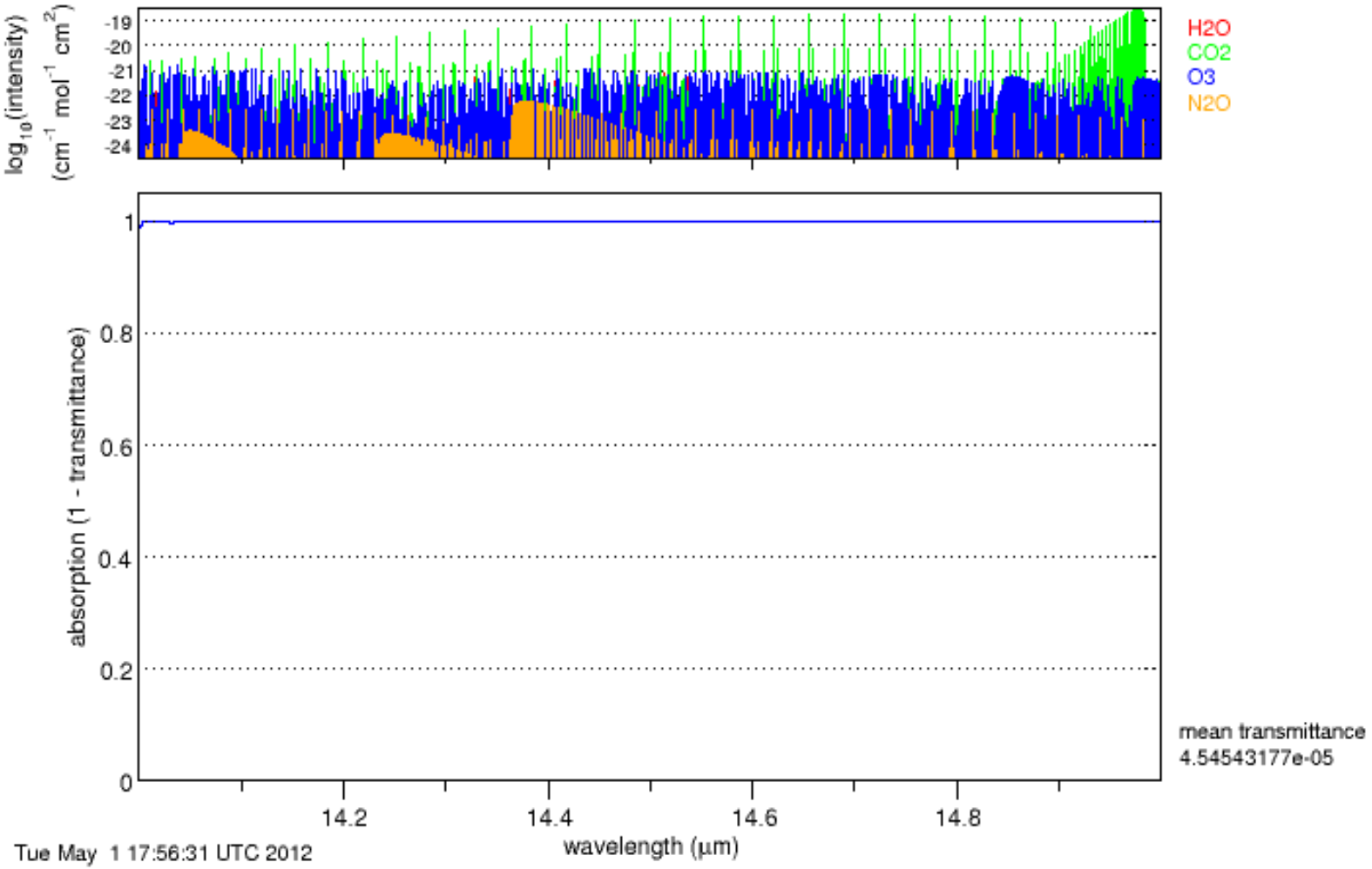
Probability of Absorption in Atmosphere

All Absorbers Present



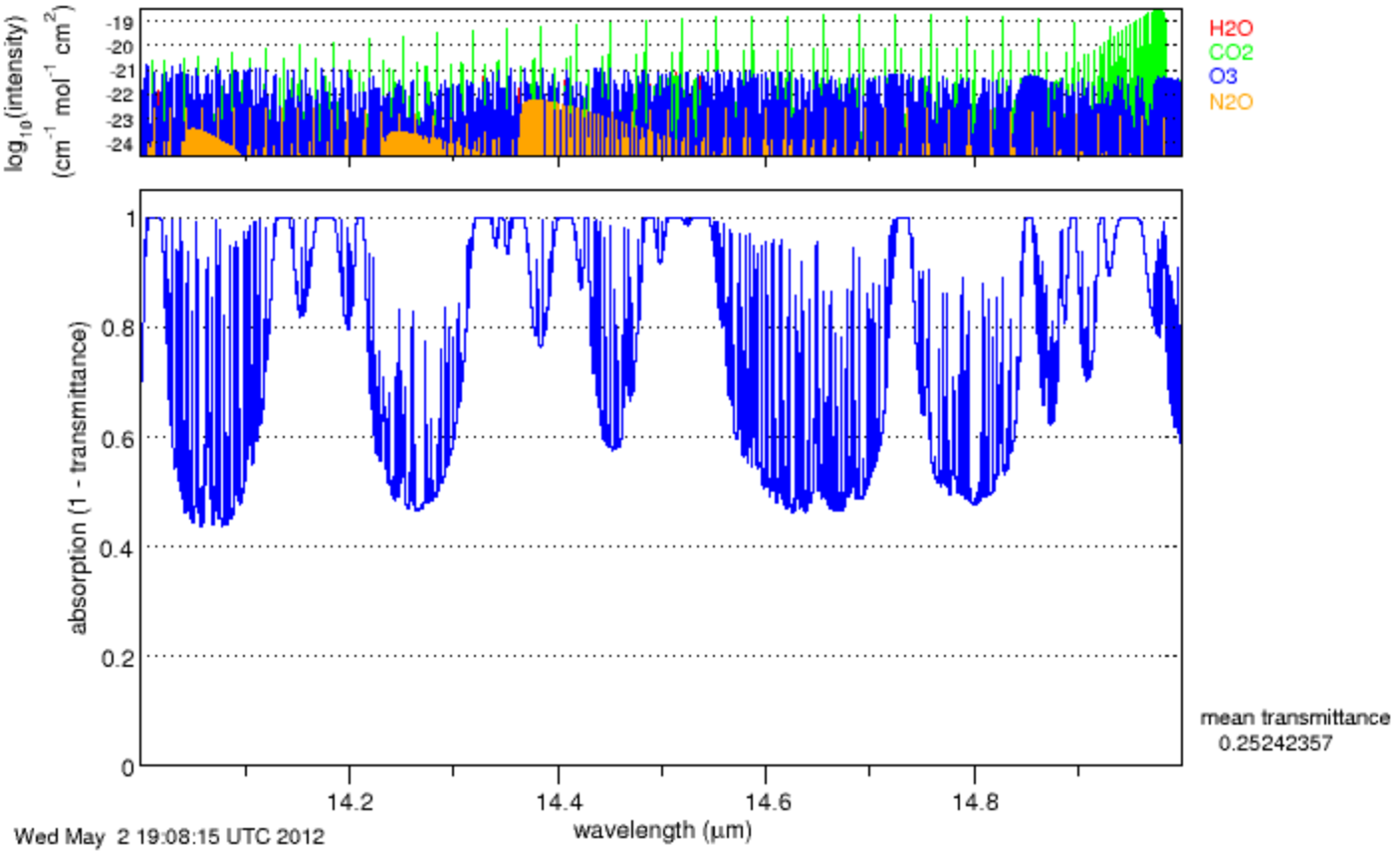
Probability of Absorption in Atmosphere

ALL MOLECULES BUT H2O



Probability of Capture in Atmosphere

ALL MOLECULES BUT CO2



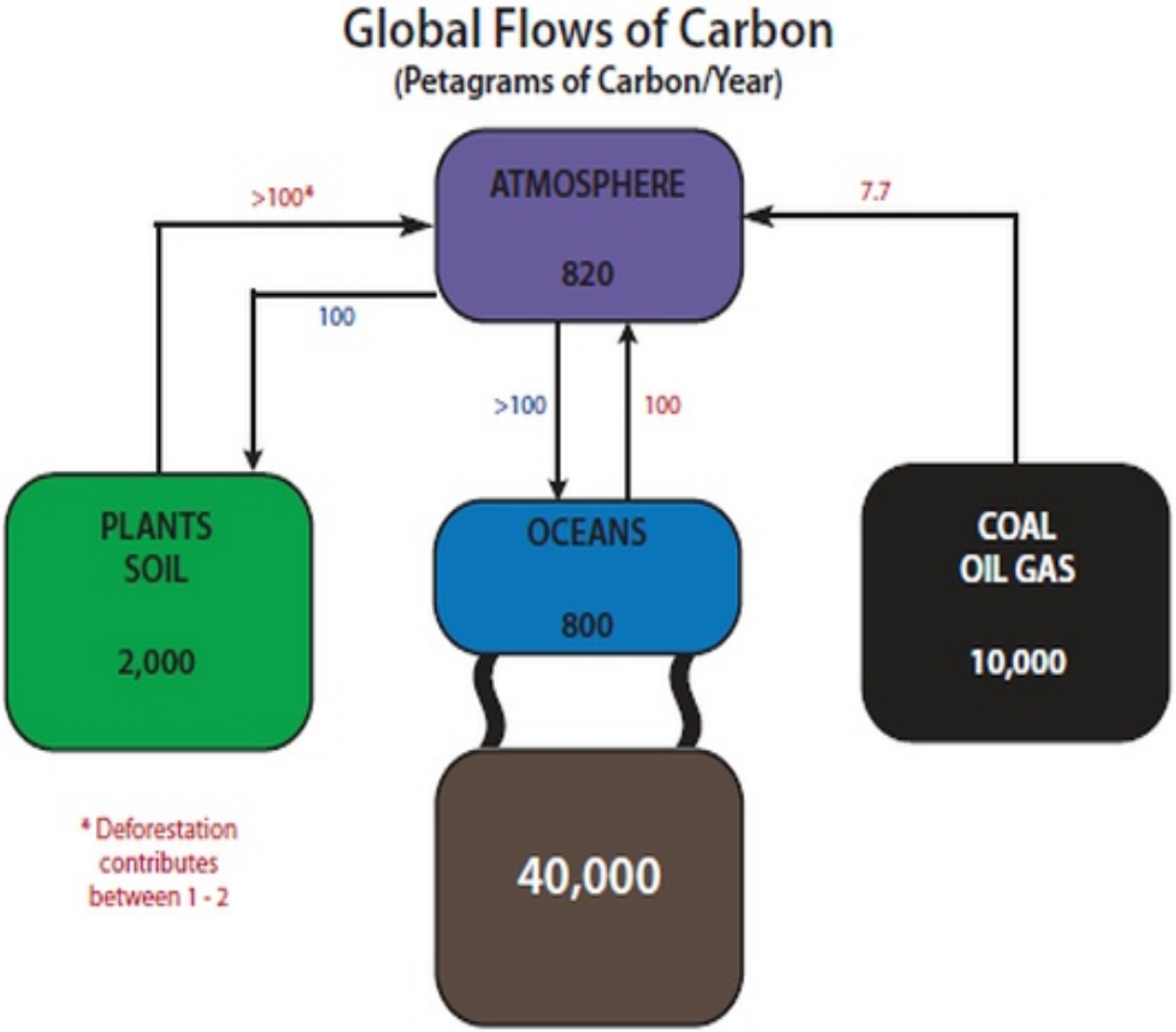
Probability of Absorption In Atmosphere

MESSAGE OF PREVIOUS SLIDES IS THE SYNERGISM OF SATURATION

BOTH H2O AND C2O SATURATE (REACH A POINT WHERE CERTAIN FREQUENCIES HAVE HAD ALL THEIR ENERGY ABSORBED)

CO2 AND H20 AUGMENT EACH OTHER'S SATURATION WHEN THEY OVERLAP

THE TWO TOGETHER PRODUCE MORE SATURATION THAN THE SUM OF THE TWO IF THEY ACTED SEPARATELY (DID NOT OVERLAP)


Global Flows of Carbon
(Petagrams of Carbon/Year)
ATMOSPHERE
820
>100*
7.7
100
>100
100
PLANTS
SOIL
2,000
OCEANS
800
COAL
OIL GAS
10,000
40,000
* Deforestation contributes between 1 - 2

FOUR COUPLED DIFFERENTIAL EQUATIONS RESULT

1. $A'(t) = Fa(t) + La(t) + Ca(t) - Al(t) - Ac(t)$
2. $L'(t) = Al(t) – La(t)$
3. $C'(t) = Ac(t) – Ca(t)$
4. $F'(t) = -Fa(t)$

(‘) Designates differentiation with respect to time

t is time; A, L, C, and F are atmospheric concentrations in atmosphere, land, ocean and fossil fuel, respectively; Ac, Ca, are rates of transfer from A to C, C to A, etc.

FROM VALUES SHOWN IN SLIDE 28, AND THE ASSUMPTION THAT EXPULSION RATE FROM EACH REGION IS PROPORTIONAL TO ITS CONCENTRATION (no physical justification for the assumption), THE FOLLOWING RATES APPLY :

$Al = 0.122A(t)$; $Ac = 0.122A(t)$; $La = 0.05L(t)$; $Ca = 0.002451C(t)$

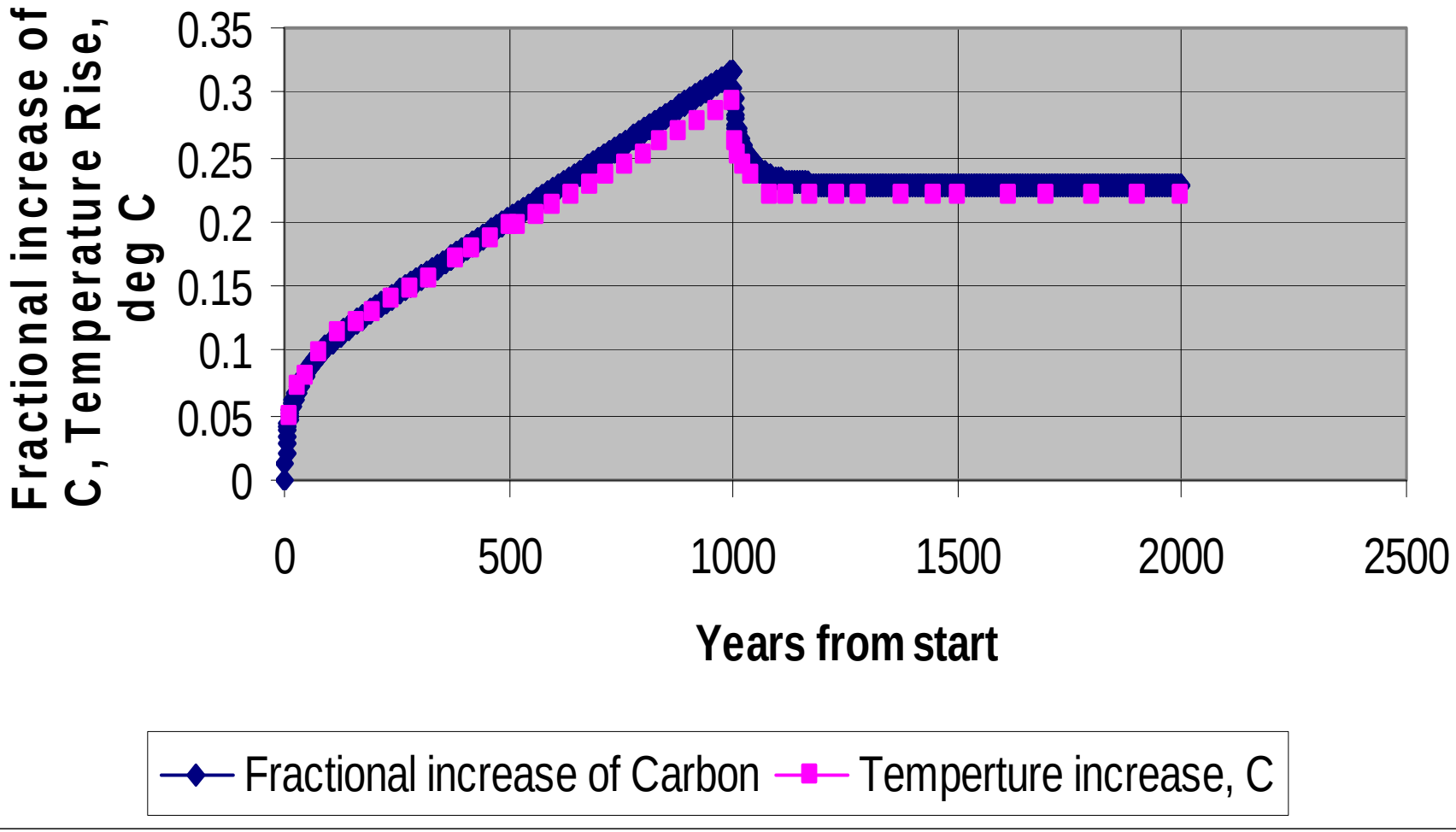
Fa(t) IS ARBITARILY CHOSEN AS THE RATE AT WHICH FOSSIL FUEL DEPOSITS CARBON IN THE ATMOSPHERE AND IT IS INCLUDED WITH THE EQUATION FOR A.

THE EQUATIONS ARE INTEGRATED NUMERICALLY WITH ONE-YEAR TIME INCREMENTS AS ILLUSTRATED IN THE NEXT SLIDE

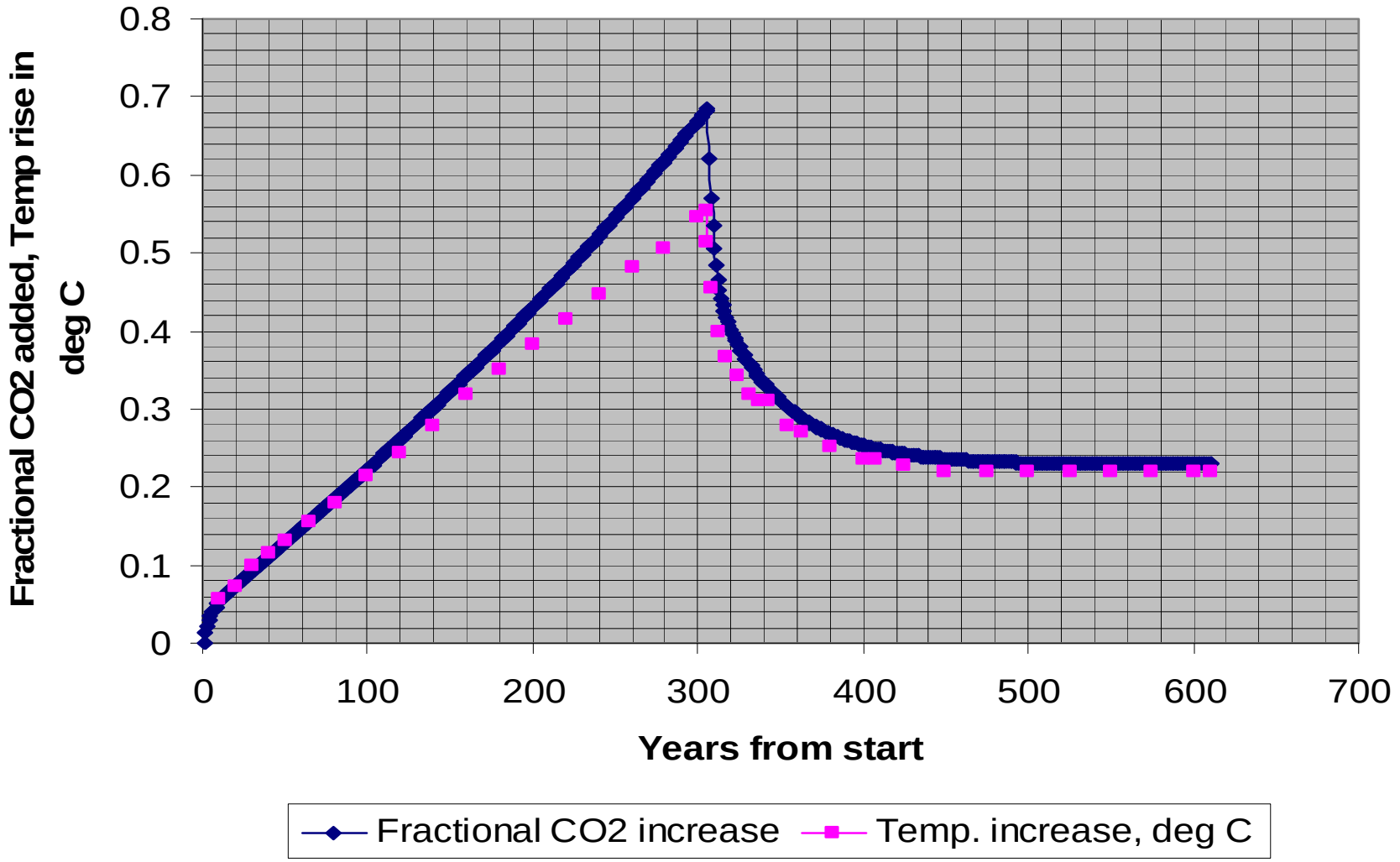
10 years of numerical integration for constant 10 pg annual input

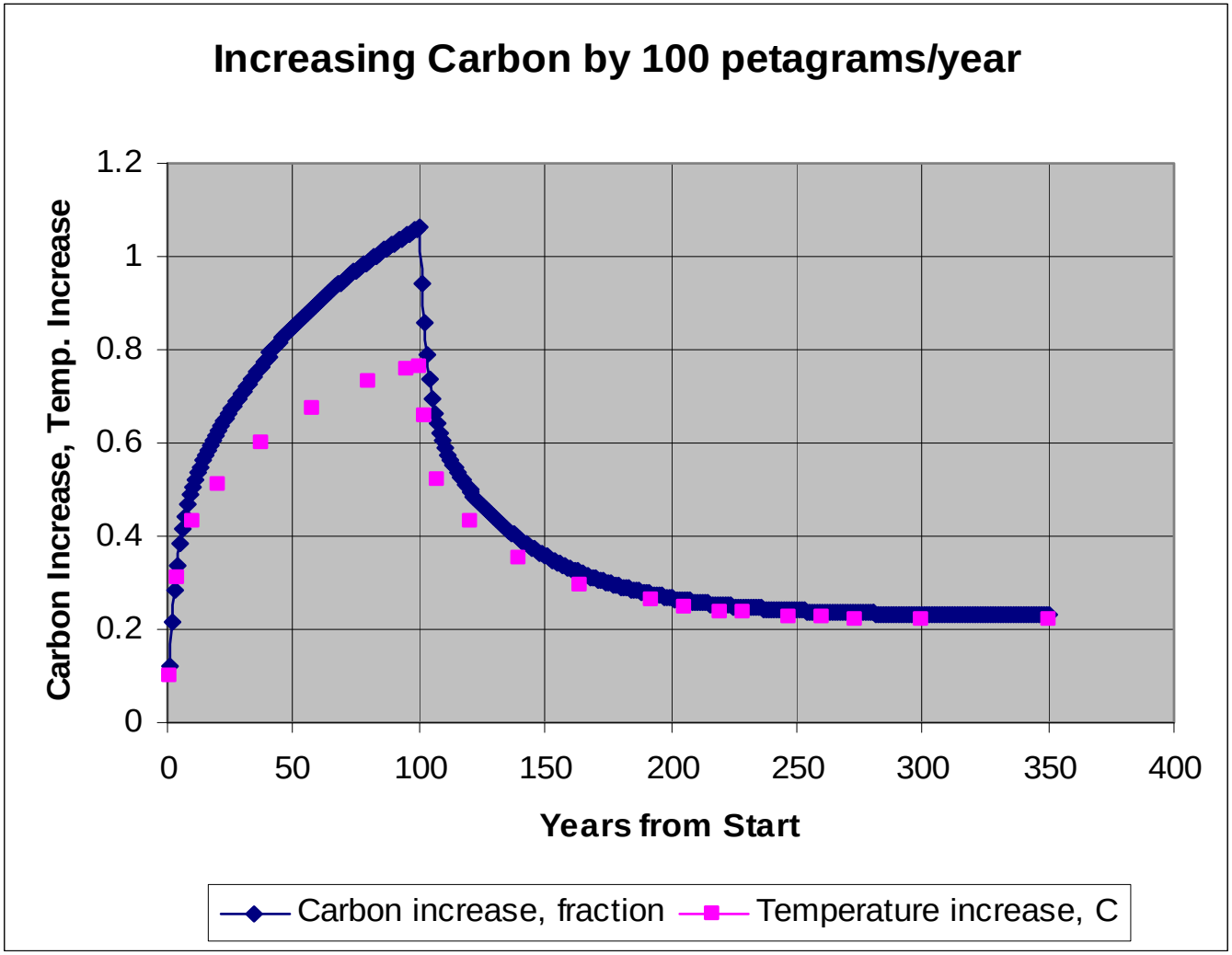
Year	Atm A	Land L	Ocean C
0	820.0000	2000.000	40800.00
1	829.9208	2000.040	40800.04
2	837.4730	2001.288	40801.29
3	843.2980	2003.396	40803.46
4	847.8623	2006.108	40806.33
5	851.5056	2009.242	40809.75
6	854.4751	2012.664	40813.61
7	856.9505	2016.276	40817.82
8	859.0629	2020.011	40822.33
9	860.9076	2023.816	40827.08
10	862.5541	2027.656	40832.04

Results of Depositing 10 pg/year carbon in atmosphere

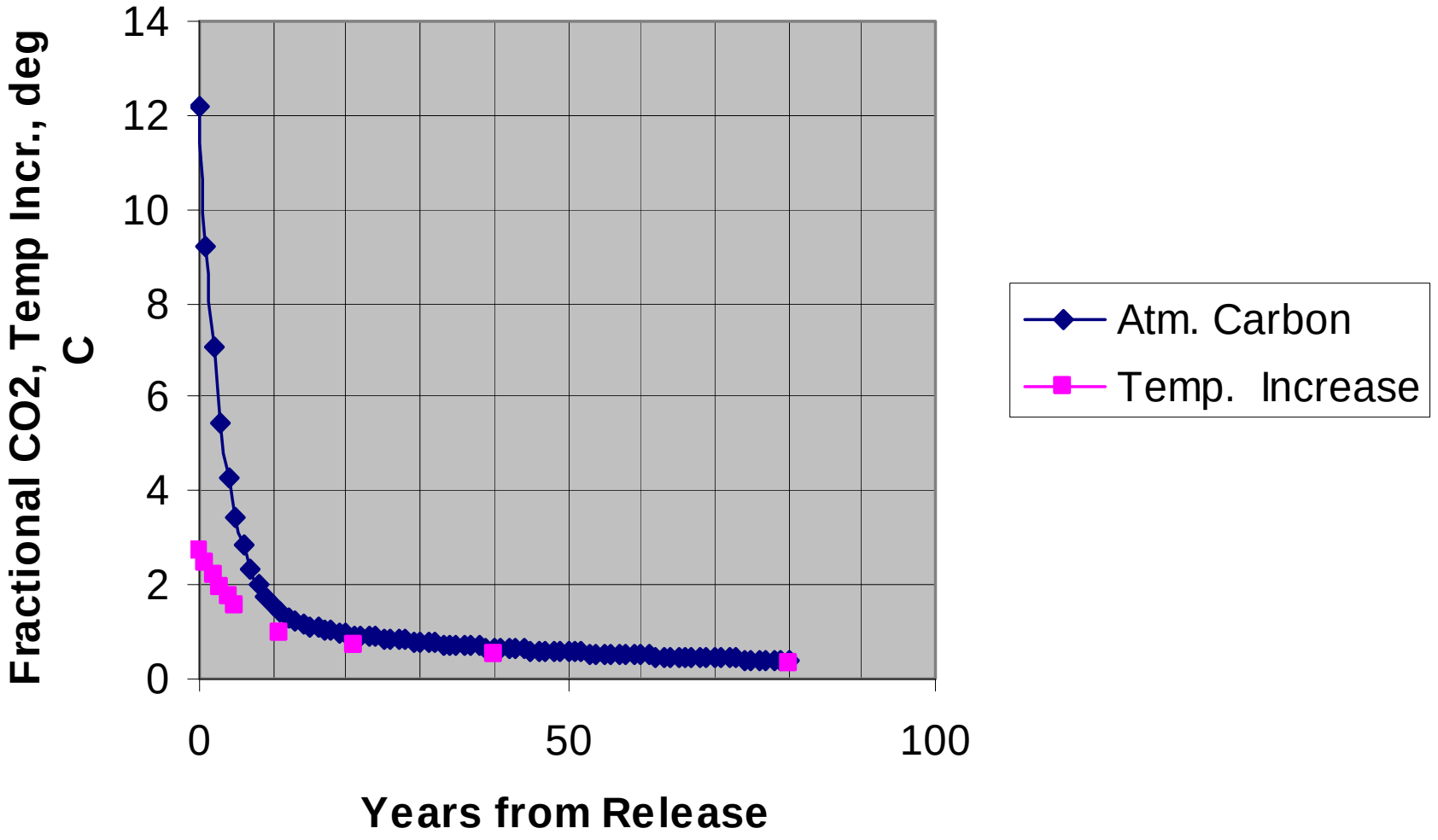


Temperature rise from 1.5% increased CO2 added per year

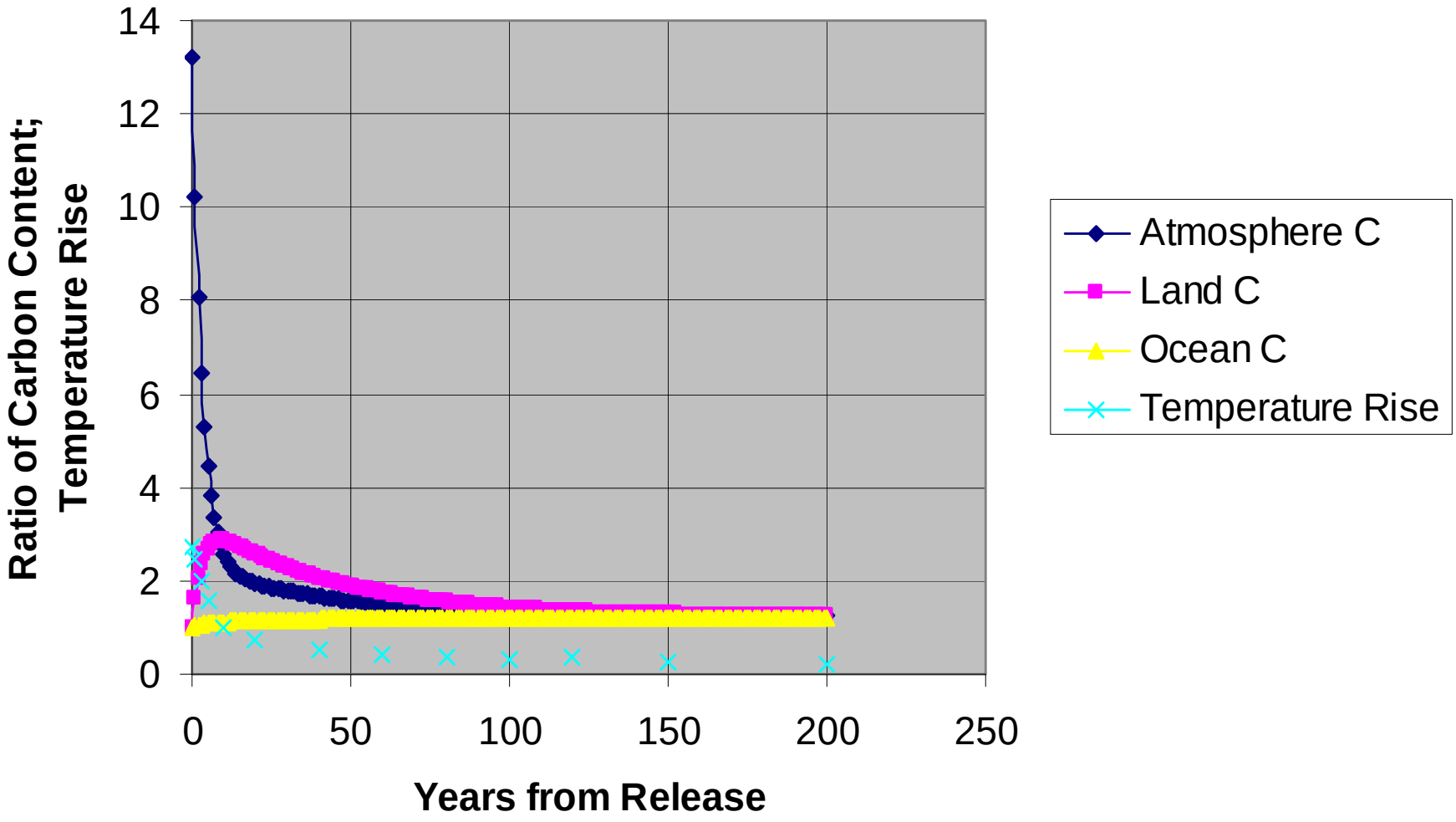



Increasing Carbon by 100 petagrams/year
Carbon Increase, Temp. Increase
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
350
400
Years from Start
Carbon increase, fraction
Temperature increase, C

Instantaneous Release of All Fossil Fuel Carbon



Instantaneous Release of World C in Fossil Fuel as CO2 in Atmosphere



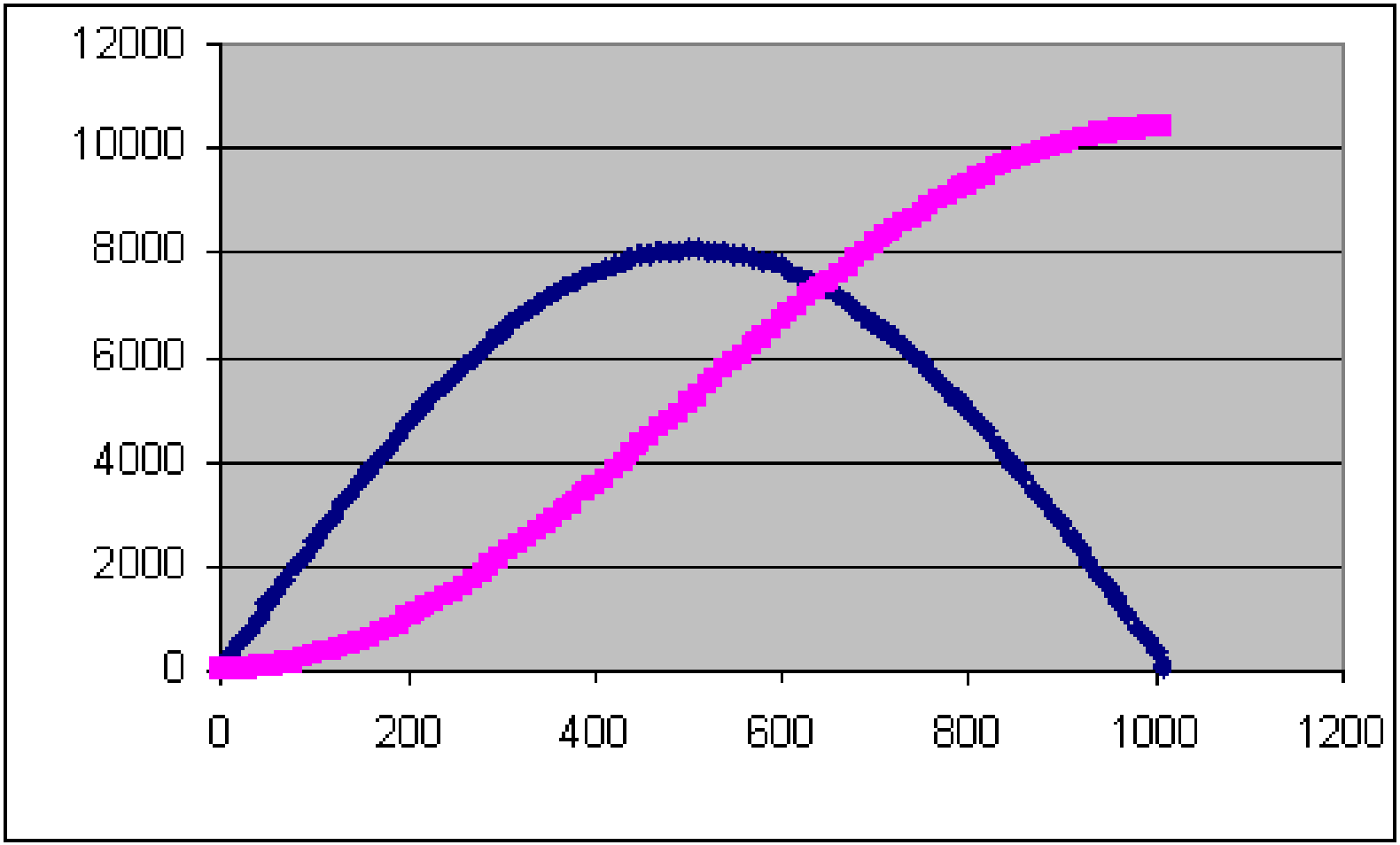
PREVIOUS CALCULATIONS HAVE BEEN BASED ON STEADY, INCREASING OR INSTANTANEOUS CARBON ADDITIONS TO ATMOSPHERE

THAT CHOICE WAS MADE TO ENSURE CONSERVATISM

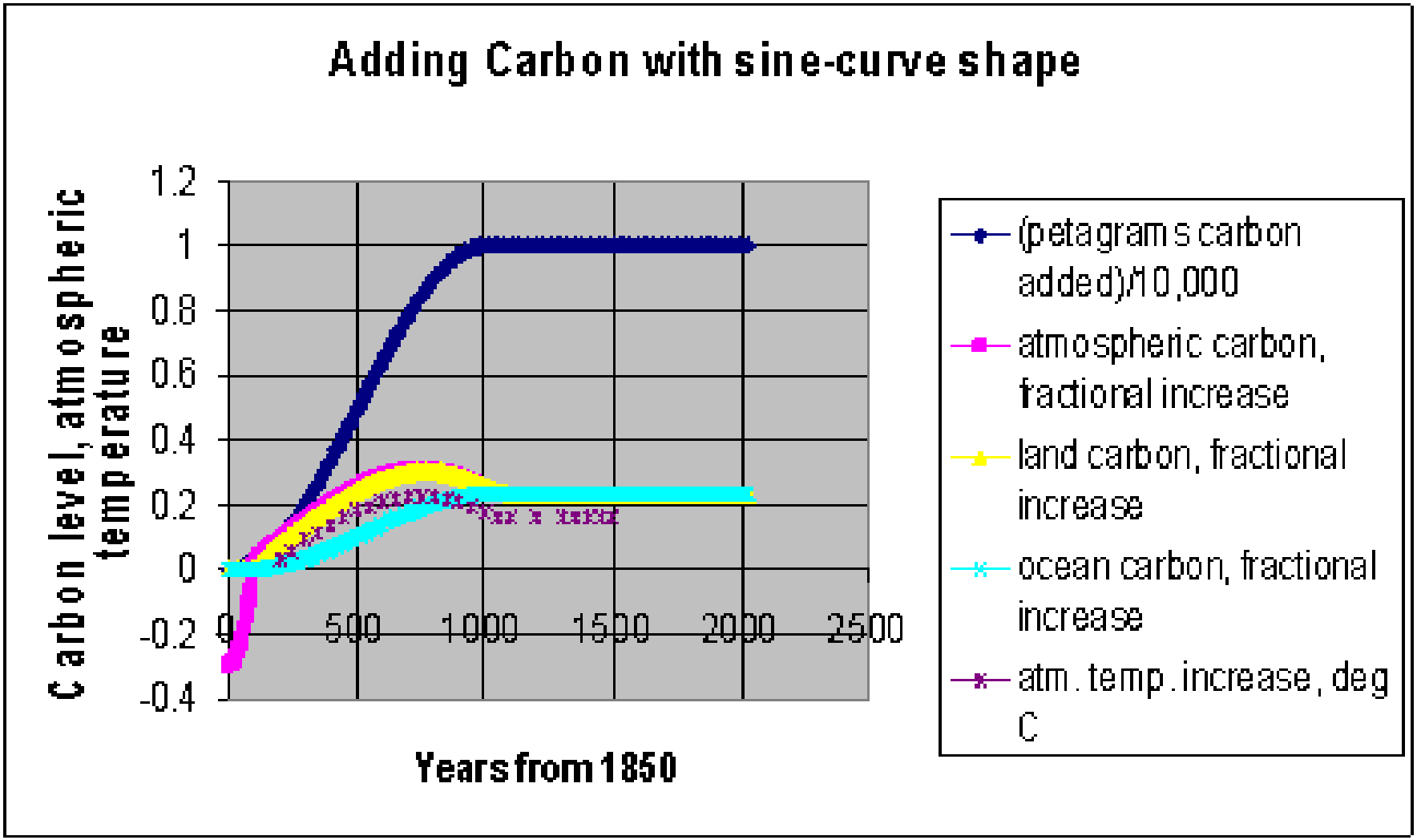
REALISTICALLY, THE INSERTION RATE WOULD INCREASE TO A MAXIMUM AND THEN DECLINE, USUALLY SYMMETRICALLY, AS DEPICTED BY THE HUBBERT CURVE FOR OIL DEPLETION.

OTHER SYMMETRICAL CURVES SUCH AS A GAUSSIAN, A PARABOLA OR HALF A SINE WAVE HAVE BEEN USED. A SINE WAVE WAS CHOSEN TO DEMONSTRATE SUCH A TYPICAL DEPLETION CURVE FOR THIS ANALYSIS.

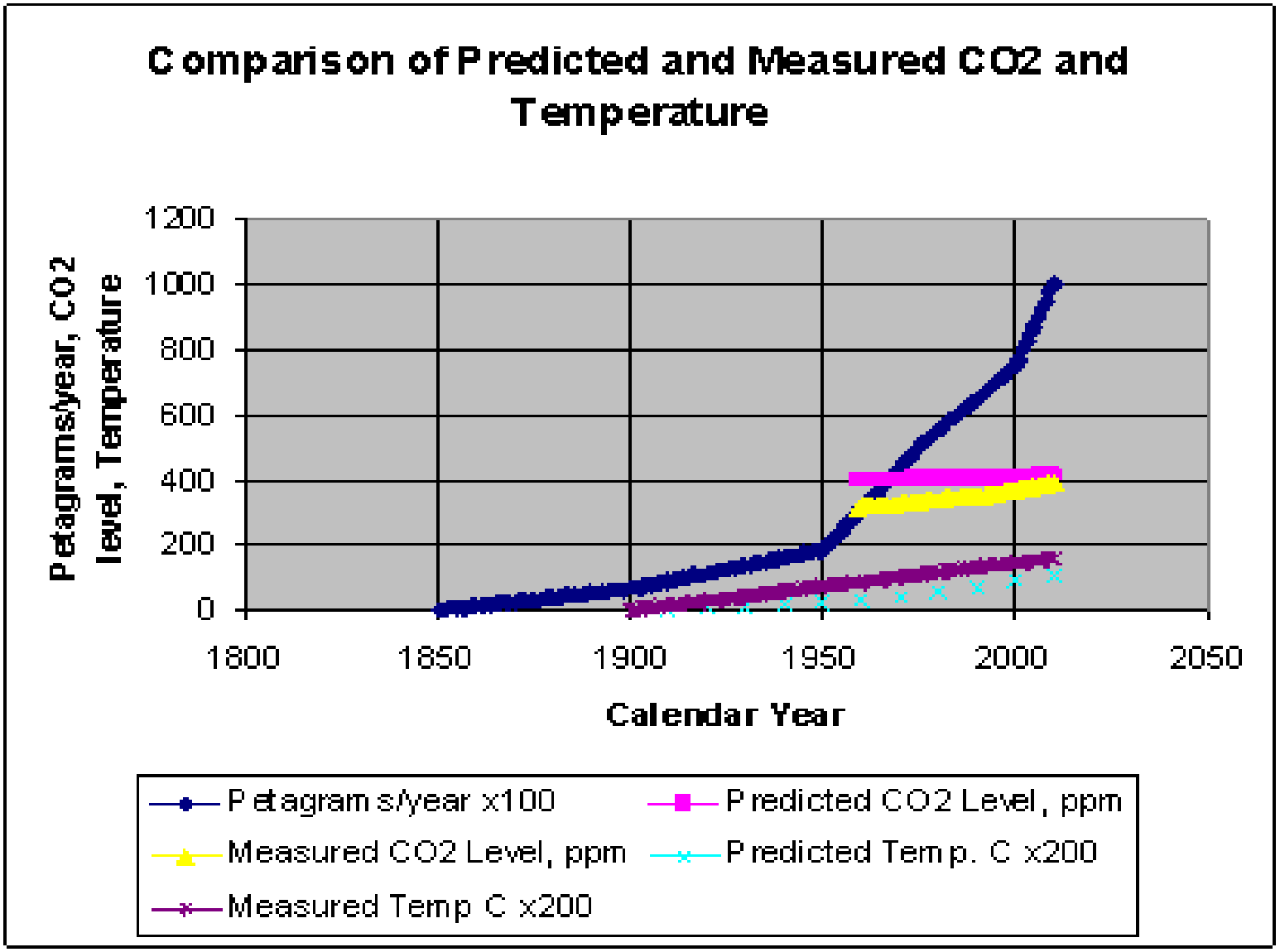
SINE DISTRIBUTION OF CARBON INSERTION IN ATMOSPHERE



Blue is differential, pink is integral



NEGATIVE ATMOSPHERIC INCREASE BELOW 160 YEARS IS BECAUSE INCREASES ARE MEASURED FROM 160 (YEAR 2010). TEMPERATURE INCREASE IS LESS THAN FOR ANY PREVIOUS CASE. (note that all carbon increases stabilize at 0.23, the ratio of fossil carbon to world carbon)


Comparison of Predicted and Measured CO2 and Temperature
Petagrams/year, CO2 level, Temperature
1200
1000
800
600
400
200
0
1800
1850
1900
1950
2000
2050
Calendar Year
Petagrams/year x100
Predicted CO2 Level, ppm
Measured CO2 Level, ppm
Predicted Temp. C x200
Measured Temp C x200

FEEDBACK DEMONSTRATION

In-atmosphere feedback depends on creation of added water vapor.

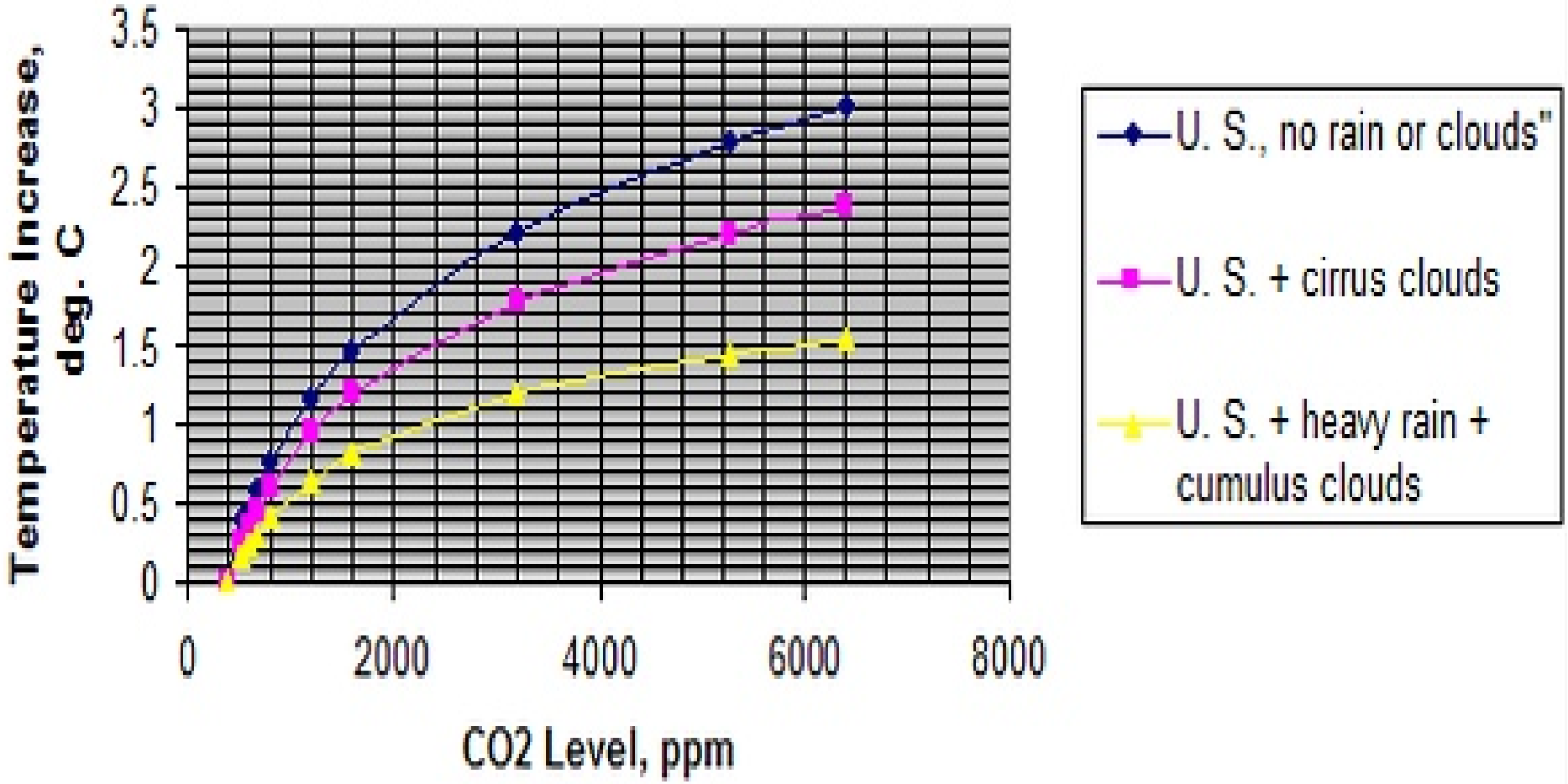
Following slides demonstrate combined effects of added CO2 and H2O with Modtran calculations plus heat transfer calculations to outer space.

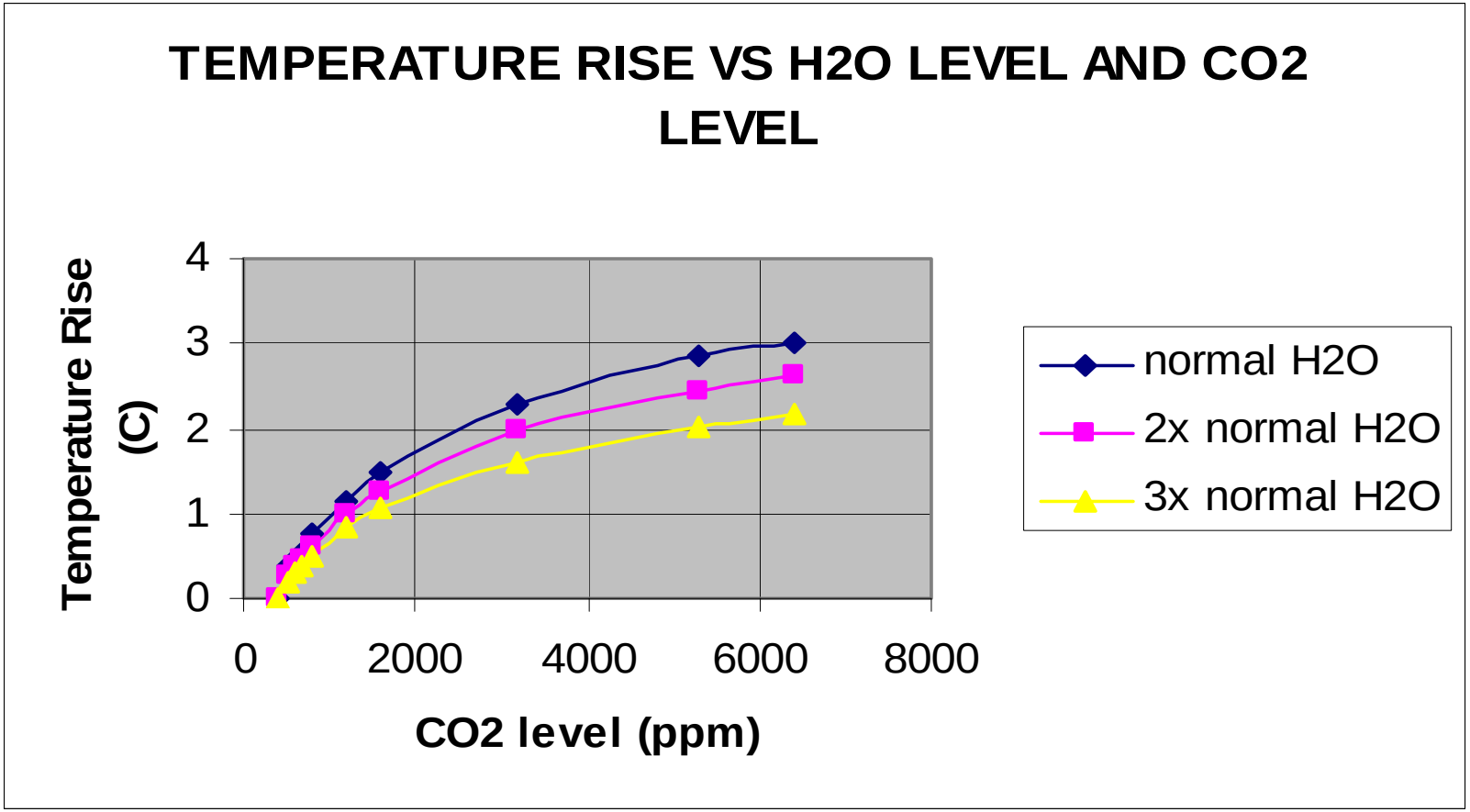
Note that added atmospheric H20 either as vapor, aerosols (clouds) or rain diminishes temperature effect of CO2 in all cases.

As levels of both increase, fractional increases in H2O can reverse the temperature effect of similar increases in CO2.

Cloud cover, by itself, lowers world temperature

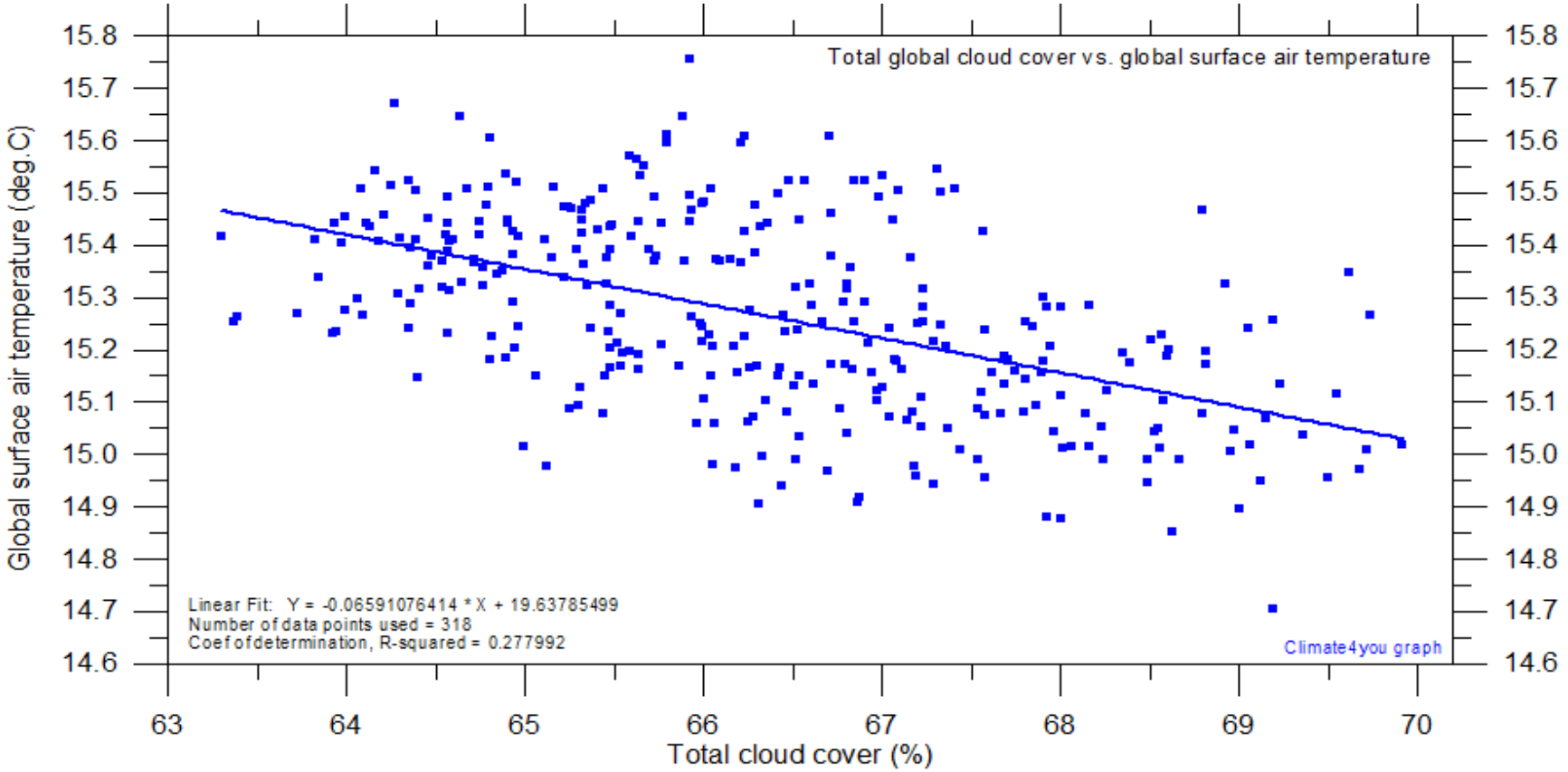
Figure 6. Temperature Increase Vs CO2 Level





THIS SLIDE IS FOR US STANDARD ATMOSPHERE. THE SAME IS TRUE FOR ALL ATMOSPHERES AND WEATHER CONDITIONS AVAILABLE THROUGH MODTRAN. ANY TEMPERATURE INCREASE BY ANY COMBINATION OF CO2 AND H2O IS REDUCED BY INCREASING THE H2O FRACTION.AT THAT COMBINATION.

TYPICAL CLOUD FEEDBACK RESULT FROM IPCC
(all records have shown negative cloud feedback)



Data sources: ***The International Satellite Cloud Climatology Project*** ***and*** ***University of East Anglia's*** ***Climatic Research Unit*****. *Last cloud data used: December 2009. Last figure update: 4 September 2011***

VARIABILITY OF WATER AND CO2 CONTENT

CO2 WELL KNOWN, WATER NOT WELL KNOWN

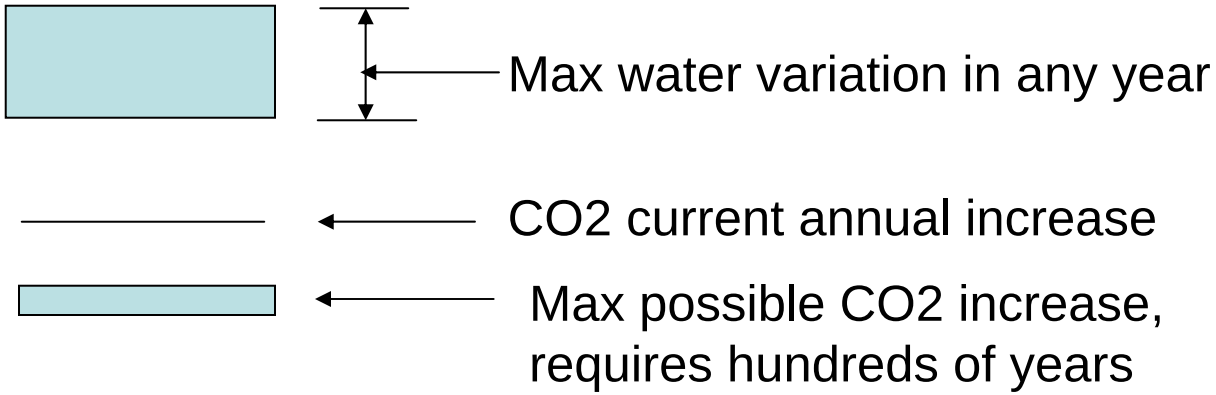
NO RELIABLE DATA AVAILABLE ON WIDE-AREA GEOGRAPHICAL OR TEMPORAL VARIATION OF WATER DUE TO RAPID CHANGES IN BOTH—GREATEST UNCERTAINTY IN THIS ANALYSIS...

USE DATA AVAILABLE FROM PREVIOUS SLIDES TO INFER VARIATION

WATER CAN VARY AS MUCH AS A FACTOR OF 3 IN A MATTER OF HOURS WITH A REPETITION RATE OF SUCH VARIATION OF SEVERAL TIMES PER YEAR

CO2 REQUIRES MANY HUNDREDS OF YEARS TO ACHIEVE A FACTOR OF 2 INCREASE

GRAPHICAL PERSPECTIVE ON VARIABILITY



Variation represented by change in IR heat rate to atmosphere (w/m^2).

Water rate goes up and down, CO2 rate has been steadily upward for 53 years of measurement.

CALVIN WOLFF METHOD FOR WATER VAPOR FEEDBACK

1.DETERMINE TEMPERATURE RISE IN ATMOSPHERE FROM CO2

2. TRANSFER ADDED HEAT TO OCEAN (NEXT SLIDE)

3. CALCULATE FRACTIONAL ADDED OCEAN VAPOR PRESSURE, AND ADD THAT TO THE INPUT WATER VAPOR FOR A NEW CALCULATION

ITERATE THE PROCESS

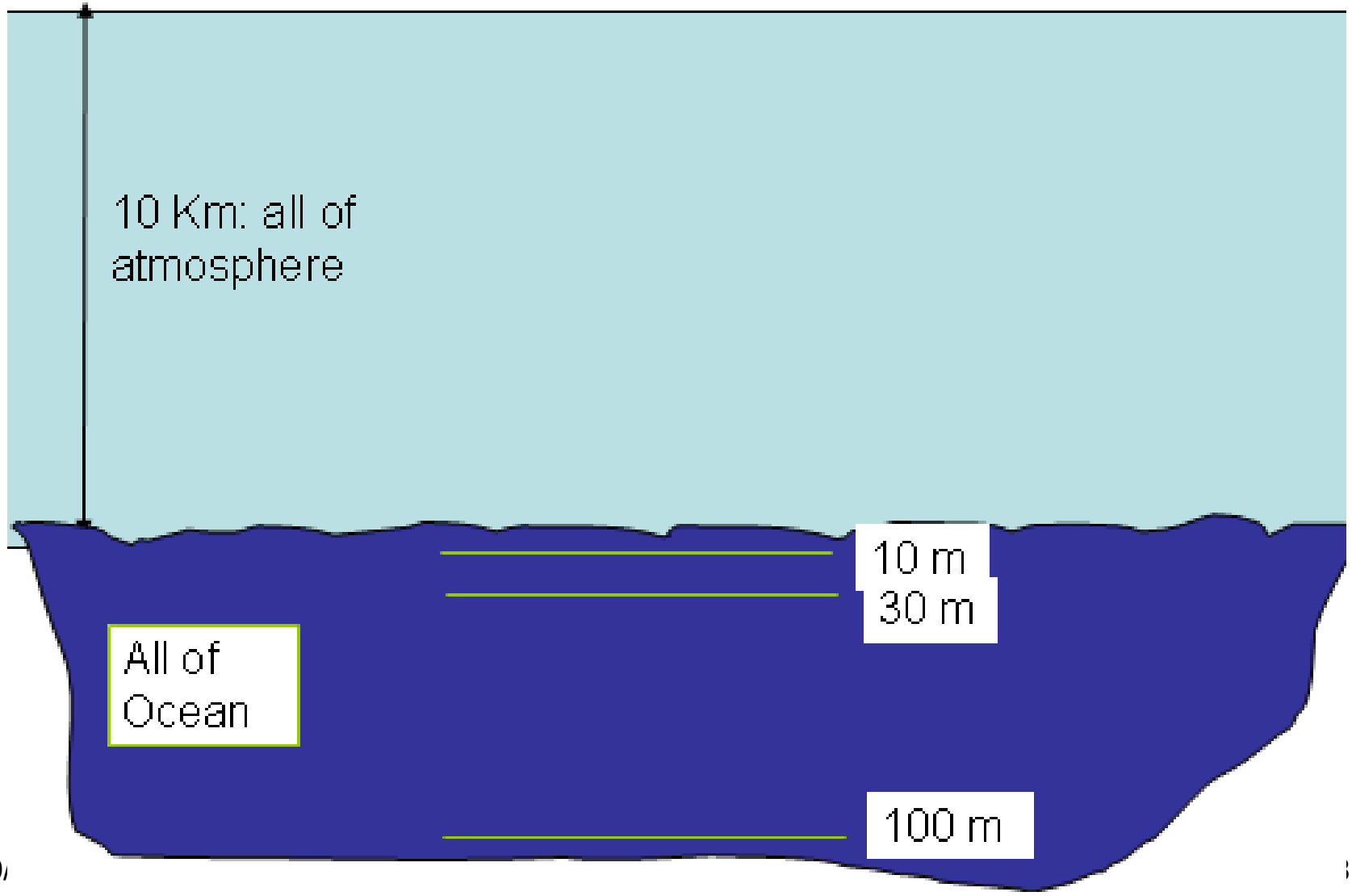
REPEAT STEPS 1-3 TO CONVERGENCE; CONVERGENCE IS RAPID

SUM OF ITERATIONS BOUNDED BY

$A^* (1+R+R^2+R^3+. . . . . R^n) = A/(1-R)$, AS n > INFINITY WITH R< 1; R IS BOUNDED BY 0.2 IN THIS CASE.

THE FEEDBACK TERMINATES; THERE IS NO RUNAWAY.

Graph: Calvin Wolff model for increased water vapor caused by CO_2 heating



CONSERVATISM IN FEEDBACK CALCULATION

ALL HEAT TO ATMOSPHERE FROM CO2 IS ADDED TO OCEAN TO PRODUCE MORE VAPOR

DEPTH OF OCEAN INTERACTION IS CHOSEN TO MAXIMIZE INCREASE IN VAPOR PRESSURE OF OCEAN

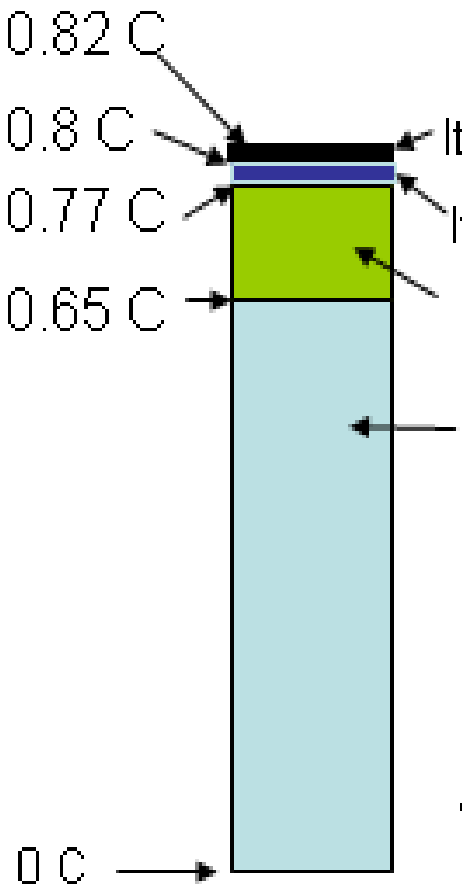
EVAPORATIVE COOLING (PERSPIRATION) IS IGNORED

CLOUD FORMATION (A KNOWN COOLING MECHANISM) IS IGNORED

Increase Temperature ⇄ Increase Water Vapor

Typical iteration converges at about 25% temperature increase.

Applies for all levels of initial temperature increase



Iterations 3, 4, 5 and 6

Iteration 2

Iteration 1

Initial temperature rise (no feedback)

Modtran Code resolution limits iterations to 3, SpectralCalc can do 6, but added temperature beyond third iteration is negligible

NUCLEAR ANALOGY

Warmers' claim: Chernobyl (a runaway reaction)

This analysis shows EBR-2 (self limiting)

SUMMARY OF FINDINGS

Predicted temperature rise much less than IPCC claims

Rise above 3 C is impossible

Rise above 0.5 C is very unlikely

Most likely rise < 0.3 C

Time to reach maximum measured in centuries

Maximum temperature is not sustained (it drops)

Evidence shows that feedback from CO2 induced water vapor is strongly negative

Claimed “runaway” temperature rise is not possible.

CONCLUSIONS

EVIDENCE TO SUPPORT SIGNIFICANT EARTH WARMING FROM ADDED CO2 IS LACKING

PROPOSED EFFORTS TO REDUCE CO2 ARE NOT JUSTIFIED