15A.4 THE ASSOCIATION OF OUTGOING RADIATION WITH VARIATIONS OF PRECIPITATION – IMPLICATIONS FOR GLOBAL WARMING

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1. INTRODUCTION

Global warming scenarios from CO_2 increases are envisioned to bring about rainfall enhancement and resulting upper tropospheric water vapor rise. This initial water vapor enhancement has been hypothesized and programmed in climate models to develop yet additional rainfall and water vapor increase. This causes an extra blockage of IR energy to space (a positive feedback warming mechanism). This additional rainfall and IR blockage is modeled to be approximately twice as large as the additional rainfall needed to balance the increased CO_2 by itself. The reality of this additional warming and extra IR blockage has been questioned by many of us. This study analyzes a wide variety of infrared (IR) radiation differences which are associated with rainfall differences on different space and time scales. Our goal is to determine the extent to which the positive rainfall feedbacks as are included in the climate model simulations are realistic.

We have analyzed 21 years (1984-2004) of ISCCP (International Satellite Cloud Climatology Project) outgoing solar (albedo) and outgoing longwave infrared (IR) radiation (often referred to as OLR) on various distance (local to global) and time scales (1 day to decadal). We have investigated how radiation measurements change with variations in precipitation as determined from NCEP-NCAR Reanalysis data on a wide variety of space and time scales (Figure 1). We have stratified our radiation and rainfall data into three latitudinal sections and six distinctive longitudinal areas (Figure 2). Infrared and albedo changes associated with rainfall variations by month (January to December) and by yearly periods for the globe (70°N-70°S; 0-360°) as a whole and separately for the tropics (30°N-30°S; 0-360°) have been studied. This analysis shows they are not realistic.

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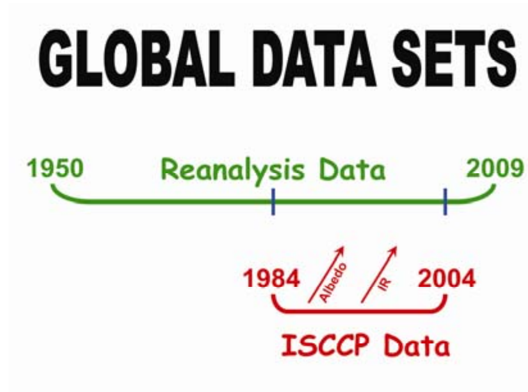


Figure 1. Data sets and their periods of study. Reanalysis data was used over a longer period.

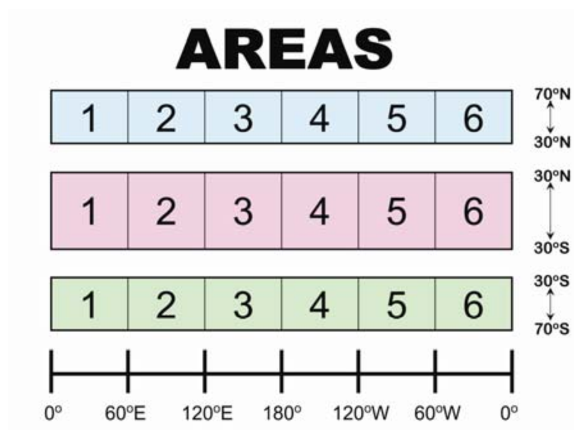


Figure 2. Areas of study.

For each month and region we divide our 21 years of ISCCP radiation data into the 10 highest average monthly rainfall values and subtract the 10 lowest average monthly rainfall values. We analyzed IR and albedo differences between these 10 highest versus 10 lowest precipitation months. These rainfall differences were typically between 4-6 percent of the total rainfall. For the 10 highest yearly minus 10 lowest yearly values rainfall differences amount to about three percent of total rainfall.

A second rainfall stratification involves comparing the rainfall and associated IR and albedo differences for variations in rainfall for the years of 1995-2004 versus the years of 1984-1994. The later 10 years had approximately two percent more average annual rainfall than the earlier period. The individual monthly differences for the earlier and latter period were in the range of 3-4 percent of the mean rainfall values.

2. FINDINGS

a) The albedo increase occurring over the top of strong precipitation and cloudy regions rises at a greater rate than does the rate of decrease of IR within these rainy and cloudy areas. Rainy and cloudy areas are local places of enhanced net radiation to space (Tables 1 and 2 and in idealized form in Figure 3). We have many other areas of rain differences which give similar results. In almost all rain and cloud areas we find that albedo energy flux rises at a greater rate than IR energy flux is reduced.

   As the space resolving ability of the satellite albedo measurements is coarser than the individual rain-cloud elements it is likely that the real albedo is slightly greater than the measured albedo of the ISCCP data. For enhanced rainfall differences of 2 percent and 4 percent between our two long-period data sets we believe we are under-measuring the magnitude of albedo by about 1 percent. We estimate that changes of tropical and/or global albedo associated with rainfall variations does not, in the net, bring significant change to global albedo. The greater enhanced albedo of the rain-cloud areas is closely compensated by the reduced albedo which occurs in the surrounding subsidence areas where cloud amounts are being reduced from enhanced sinking and drying.

Table 1. Monthly differences of albedo, IR and (IR + albedo) for the 10 highest minus 10 lowest rainfall days per month at 15^{o}S; 160^{o}E for a year period.

15^{o}S; 160^{o}E

10 Highest – 10 Lowest Rainfall Days Per Month

	Δ Rain 10^{-1} mm/d	Δ Albedo Wm^{-2}	Δ IR Wm^{-2}	Δ IR+Alb Wm^{-2}
January	23.54	23.59	-15.31	8.28
February	36.86	89.60	-54.97	34.63
March	32.77	27.44	-26.88	0.56
April	46.58	97.10	-84.75	12.35
May	19.55	45.65	-59.79	-14.14
June	23.88	-8.61	-2.02	-10.63
July	2.16	23.61	-14.46	9.15
August	3.99	41.07	-31.95	9.12
September	7.28	18.83	-10.98	7.85
October	12.23	54.44	-46.34	8.10
November	40.69	73.92	-45.50	28.42
December	15.66	14.86	-13.18	1.68
AVERAGE	**22.10**	**41.79**	**-33.84**	**7.95**

Table 2. Same as Table 1 but for the area of 20^{o}N-25^{o}N; 170^{o}E-175^{o}E.

20^{o}N-25^{o}N; 170^{o}E-175^{o}E

10 Highest – 10 Lowest Rainfall Days Per Month

	Δ Rain 10^{-1} mm/d	Δ Albedo Wm^{-2}	Δ IR Wm^{-2}	Δ IR+Alb Wm^{-2}
January	5.37	29.89	-25.40	4.49
February	2.90	9.40	-5.74	3.66
March	4.34	34.59	-18.56	16.03
April	6.16	30.69	-15.24	15.45
May	7.33	38.47	-30.47	8.00
June	4.29	13.38	-9.28	4.10
July	9.75	40.20	-31.46	8.74
August	6.38	31.22	-14.02	17.20
September	13.39	52.79	-39.65	13.14
October	6.13	7.52	-17.12	-9.60
November	4.63	7.93	-5.78	2.15
December	4.75	23.24	-19.50	3.74
AVERAGE	**6.29**	**26.61**	**-19.35**	**7.26**

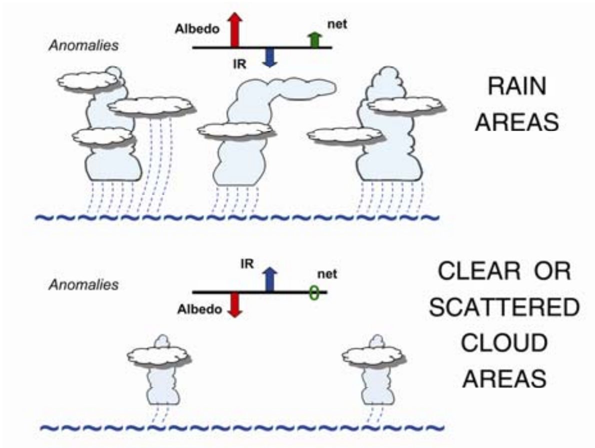


Figure 3. Idealized deviational changes of IR and albedo for rainy and cloudy areas (top) versus clear and scattered cloud areas (bottom).

b) Enhanced rates of net tropical (30°N-30°S; 0-360°) and net global precipitation cause a slightly higher net tropical and global IR increase to space. IR and albedo usually change in opposite directions. But there are places and times where they change together to either enhance outgoing radiation flux or suppress it during periods of greater or less rates of precipitation. For higher rates of net tropical and net global rainfall there is, in general, a larger net global IR energy loss to space.

The typical enhancement of rainfall and updraft motion in the cumulus and cumulonimbus clouds within meso-scale disturbance areas acts to increase the return flow subsidence in the surrounding broader clear and partly cloudy regions. Global rainfall increases cause an overall reduction of specific (q) and relative humidity (RH) in the upper and middle tropospheric levels of the broad scale subsidence regions and in the net causes an enhancement of IR loss to space (Figure 4). Albedo typically changes in an opposite manner to IR. Albedo is decreased when IR is increased in the broad scale clear and partly cloudy areas.

Tables 3 and 4 portray the 12-month averages of the amount of rain in each of six 60° areas along with IR, albedo and (IR + albedo) difference values for the tropics (30°N-30°S; 0-360°). Note that for the mean of the sum of the six areas shows that with enhanced rainfall there is, in general, slightly more (IR + albedo) radiation flux to space.

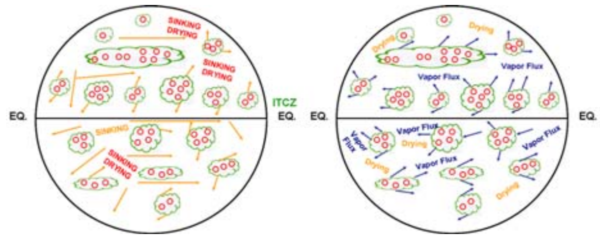


Figure 4. Idealized portrayal of global deep cumulus rain areas. The left diagram illustrates the sinking mass coming from the deep rain clouds which acts to dry and slightly warm the upper and middle troposphere. The right diagram shows the water vapor emanating from the same rain areas. Observations indicate that, in general, the sinking-drying in the middle and upper troposphere is greater than the vapor replacement and evaporation cooling.

Table 3. Rainfall difference in the tropics (30°N-30°S) for our 10 high – 10 low monthly rainfall values and associated IR, albedo, and IR + albedo differences (in Wm^{-2}). The final three rows give the regional product of rainfall difference rate times IR, albedo, and IR + albedo. Note that the outflow energy values change sign when they are multiplied by the rain difference. Negative values are in red. Rainfall differences are given in 10^{-1} mm/d.

(10 High) - (10 Low) ANNUAL	1 0-60E	2 60-120E	3 120E-180	4 180-120W	5 120-60W	6 60W-0	Total/6
Rain	0.50	1.46	5.20	0.07	1.00	1.04	1.54
IR	1.46	0.32	(0.96)	2.16	1.24	1.22	0.91
Albedo	(0.98)	1.18	2.30	(1.71)	(1.95)	(1.50)	(0.44)
IR+Albedo	0.47	1.51	1.34	0.45	(0.71)	(0.27)	0.47
Rain X IR	(0.90)	(1.49)	(6.75)	(1.39)	0.95	0.65	(1.49)
Rain X Albedo	(0.07)	3.83	15.10	1.97	(2.24)	(0.98)	2.94
Rain X (IR+Albedo)	(0.98)	2.34	8.36	0.58	(1.29)	(0.32)	1.45

Table 4. Same as Table 3 but for our (1995-2004) – (1984-1994) data set. Negative values are in red.

(95-04) - (84-94) ANNUAL	1 0-60E	2 60-120E	3 120E-180	4 180-120W	5 120-60W	6 60W-0	Total/6
Rain	0.08	1.28	2.92	(1.88)	1.96	0.30	0.77
IR	2.57	1.95	2.20	2.91	1.18	2.56	2.23
Albedo	(2.54)	0.49	0.27	(3.29)	(4.83)	(4.18)	(2.35)
IR+Albedo	0.02	2.45	2.47	(0.38)	(3.67)	(1.61)	(0.12)
Rain X IR	(0.62)	2.79	5.87	(5.72)	2.03	0.95	0.88
Rain X Albedo	0.02	1.10	1.83	6.04	(9.06)	(0.94)	(0.17)
Rain X (IR+Albedo)	(0.60)	3.91	7.71	0.32	(7.06)	0.02	0.72

Table 5. Changes in 300 mb temperature, 300 mb specific humidity (q), and 300 mb relative humidity (RH) by area between our two rainfall difference data sets for the tropics (30°N-30°S). Rain differences average 3.9 percent for the 10 high – 10 low monthly differences and 1.9 percent for the (95-04)-(84-94) data set differences. Negative values are in red.

(10 High) - (10 Low) ANNUAL	0 0-360	1 0-60E	2 60-120E	3 120E-180	4 180-120W	5 120-60W	6 60W-0
300 mb Temp. (°C)	0.02	0.13	0.27	0.23	(0.34)	(0.21)	0.02
Specific Humidity (q)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
Relative Humidity (RH)	(1.66)	(1.34)	(2.33)	(1.73)	(0.41)	(1.20)	(2.69)

(95-04) - (84-94) ANNUAL	0 0-360	1 0-60E	2 60-120E	3 120E-180	4 180-120W	5 120-60W	6 60W-0
300 mb Temp. (°C)	0.16	0.26	0.24	0.11	(0.05)	0.13	0.25
Specific Humidity (q)	(0.03)	(0.02)	(0.03)	(0.05)	(0.04)	(0.02)	(0.04)
Relative Humidity (RH)	(3.92)	(2.84)	(3.53)	(4.84)	(3.83)	(3.24)	(5.23)

c) We observe that upper level RH and moisture content (q) at 300 mb (~10 km) and 400 mb (~8 km – not shown) are reduced for increasing amounts of net tropical rainfall (Table 5). This is a direct consequence of the slightly greater return flow mass subsidence coming from the smaller areas of strong and concentrated updrafts of the rainfall areas. This lowering of water vapor increases the optical depth (τ) and slightly lowers the emission level to a warmer layer where more IR energy is radiated to space.

d) We observe that troposphere temperature at 250, 300 and 400 mb increases only slightly with precipitation increases of 2-4 percent (Table 6). The NCEP reanalysis data shows that there has been a steady decrease in upper tropospheric RH over the last 40 years as global temperatures have risen (Figure 5). If global warming is occurring it certainly is not occurring in the mode envisioned by the modelers.

Table 6. Change in upper tropospheric temperature (°C) between the 10 high minus 10 low monthly rainfall difference data set.

	10 High – 10 Low (70°N-70°S; 0-360°)
250 mb	– .01
300 mb	.06
400 mb	.04

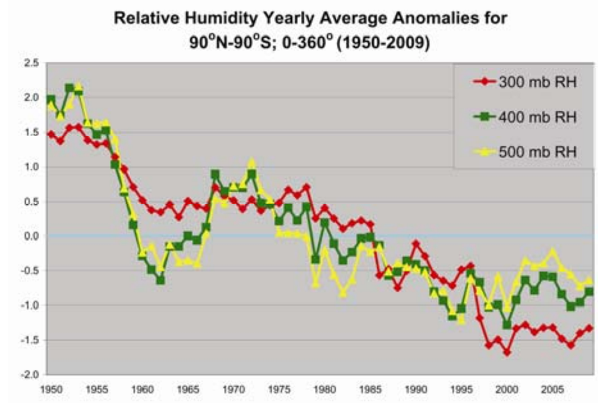


Figure 5. Global tropospheric water vapor trends over the period from 1950-2009.

3. IMPLICATIONS OF THESE OBSERVATIONS

The above measurements are at odds with the Global Climate Model (GCM)l simulations of precipitation increase associated with rising CO_2 amounts. Models show large tropical upper tropospheric temperature and water vapor increases to be associated with increased rates of precipitation (due to CO_2 increases) that are similar to increased rates of precipitation that this study measures. We do not observe such upper tropospheric temperature and moisture increases for rainfall enhancements as do the modelers. The GCM simulations assume that as CO_2's blockage of IR increases, it stimulates an enhancement of extra rainfall which causes yet larger increased upper level IR blockage. This requires an extra large upper level temperature gain to compensate. Such temperature rises are not observed.

The basic question is – what is the mechanism to bring about the needed increase of IR flux to space in order to balance the CO_2–forced IR blockage? This can occur by lowering the radiation emission level to a warmer temperature and thereby increasing the outward IR radiation flux to space. This entails reducing upper-level water vapor as seen in Figures 6 and 7. Or, the CO_2-induced blockage could be compensated for rising CO_2 and water vapor by having upper tropospheric temperature rise by amounts of 3-4°C or more. This is the way the GCM models make their balance.

It is necessary that any enhanced flux of outward radiation energy to space from the upper atmosphere be matched by a similar upward flux of energy (radiation, evaporation, and sensible heat) from the surface. The troposphere cannot store energy. The primary question of compensation for increased CO_2 blockage of IR energy to space is how it will produce the required compensating upward energy response from both the surface and aloof. Excess upward surface energy flux to the atmosphere will have to be passed on to space.

The climate modelers have assumed that as CO_2 increases it will cause a progressive blockage of IR energy to space and, in addition, a further blockage of IR energy to space will occur from the original increase in upper-level water vapor. Increased IR blockage brings about a gradual increase in global temperature. They then make the crucial, but faulty, assumption that as temperature rises it will do so in a way that keeps RH constant. This requires that CO_2 increases produce additionally large compensating temperature and water vapor increases. This leads to yet higher temperature and yet higher water vapor contents.

Our observations do not agree with these GCM scenarios. Our observations indicate that tropical RH and moisture (q) rather than rising with enhanced precipitation do the opposite and actually go down as precipitation rates increase. Also, upper tropospheric temperature in the tropics and around the globe rise very little for increased rates of precipitation of 2-4 percent, similar to the precipitation rise rates obtained by the climate modelers for a doubling of CO_2.

We find that there is not a positive water vapor feedback as the modelers have assumed. In fact we see the opposite. As rainfall increases upper-level water vapor contents are weakly reduced.

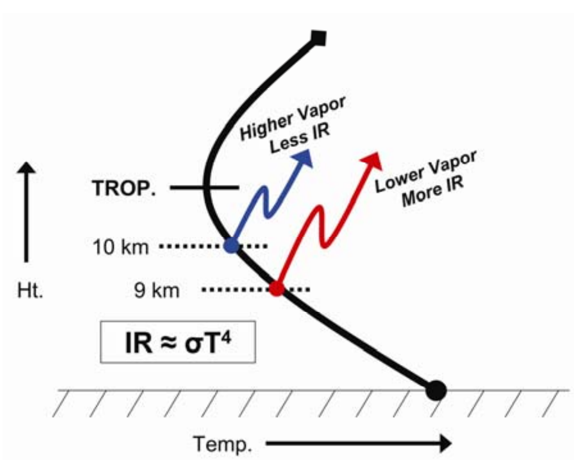


Figure 6. Idealized portrayal of atmospheric vertical temperature lapse rates which has an optical depth (τ) or a radiation emission level at 10 km (blue) with a temperature of 243°K. This is colder than that of an optical depth and emission level at 9 km (red) where the temperature is 262°K. The Stefan-Boltzmann equation specifies IR emission energy to space at 10 km height is 198 Wm^{-2}, while IR emission energy at 9 km height is 229 Wm^{-2} or 16 percent higher. For these optical depths and emission levels to vary in this way it is necessary that the lower level (red) value have reduced relative humidity above it.

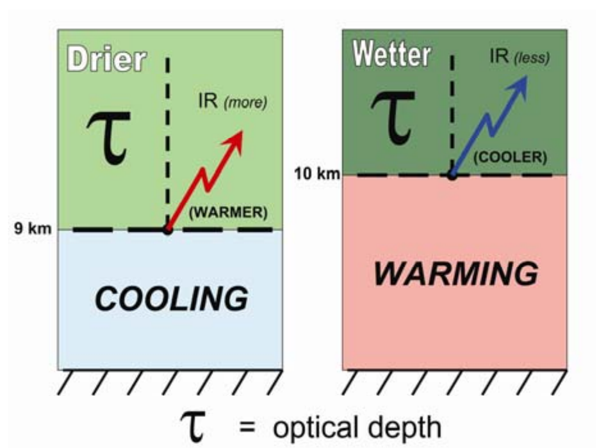


Figure 7. Idealized portrayal of the atmospheric response to the varying optical depth (τ) and emission levels of Figure 6. The 10 km emission level (right) gives off less IR energy to space due to the higher vapor content (wetter) above 10 km. The opposite happens to the lower emission level (9 km – left) where the water vapor content above this level is lower. More IR is expended to space by the left diagram and (all other things being equal) this atmosphere undergoes cooling compared to the atmosphere on the right.

4. THE NAS OR CHARNEY REPORT OF 1979 – BEGINNING SOURCE OF THE FAULTY AGW SCENARIOS

The basic error of the global climate modelers has been their general belief in the National Academy of Science (NAS) 1979 study – often referred to as *The Charney Report* - which hypothesized that a doubling of atmospheric CO_2 would bring about a general warming of the globe's mean temperature of between 1.5 – 4.5°C (or an average of ~ 3.0°C). This was based on the report's assumption that the relative humidity (RH) of the atmosphere would remain quasi-constant as the globe's temperature increased. This assumption was made without any type of cumulus convective cloud model and was based on the Clausius-Clapeyron (CC) equation which specifies that as atmospheric air temperature rises the ability of the air to hold water vapor goes up exponentially. If relative humidity (RH) were to remain constant as atmospheric temperature rose then the water vapor (q) amount in the atmosphere would accordingly rise (Figures 8 and Figure 9). The water vapor content of the atmosphere rises by about 50 percent if atmospheric temperature were to increase by 5°C and relative humidity remained constant. Atmospheric water vapor increases act to sharply reduce the amount of outgoing IR energy which can escape to space.

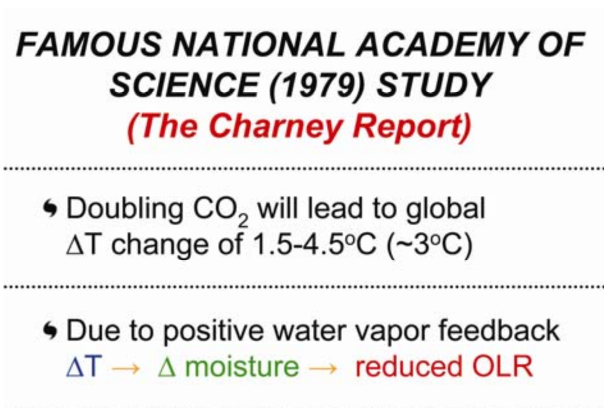


Figure 8. The influential NAS report of 1979 which deduced that any warming of the globe would occur with constant relative humidity (RH). This would assure an increase in atmospheric water vapor (q) with any temperature rise.

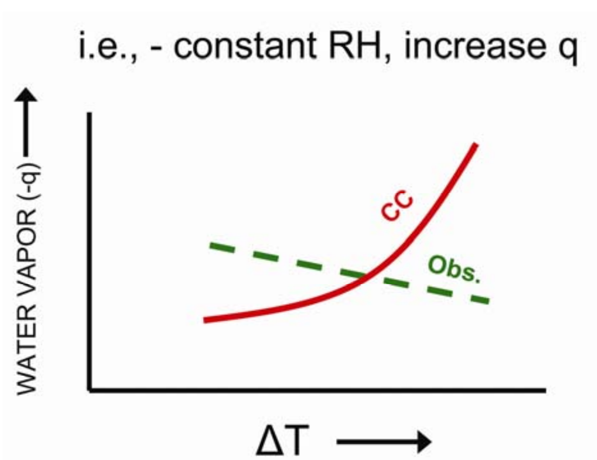


Figure 9. The relationship showing the increase of water vapor as temperature increases at constant relative humidity (RH) based on the Clausius-Clapeyron (CC) equation - red line. The observations of upper and middle tropospheric water vapor show water vapor weakly decreasing as temperature increases – green line.

Some of the climate modelers, such as the early NASA-GISS (Hansen 1988) model, have even gone further than the CC equation would specify for water vapor increasing with temperature. Hansen's early GISS model assumed that for a doubling of CO_2 that upper tropospheric RH would not just stay constant but actually increase. This upper tropospheric water vapor (q) which Hansen assumed for a doubling of CO_2 led to a water vapor increase (Δq) in the upper troposphere of nearly 50 percent. This caused his model to specify a tropical (30°N-30°S) upper tropospheric atmospheric warming for a doubling of CO_2 as much as 7°C (Figure 10 and Figure 11). No wonder Hansen got such high global warming estimates for a doubling of CO_2. It was these excessive warming values that he presented at the famous US Senate Committee hearing in June of 1988.

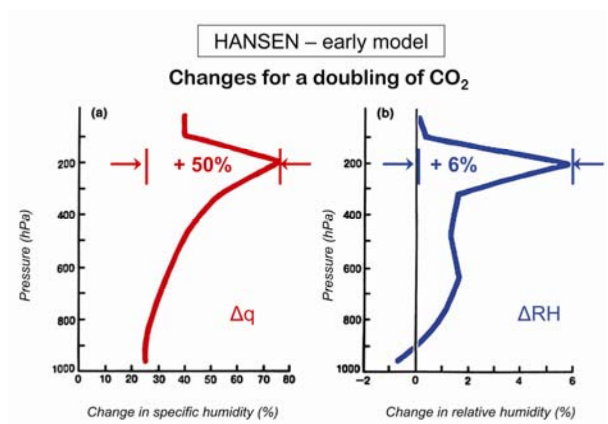


Figure 10. Early GISS' model showing assumed increases in specific humidity (q) and RH for a doubling of CO_2. This model is very unrealistic.

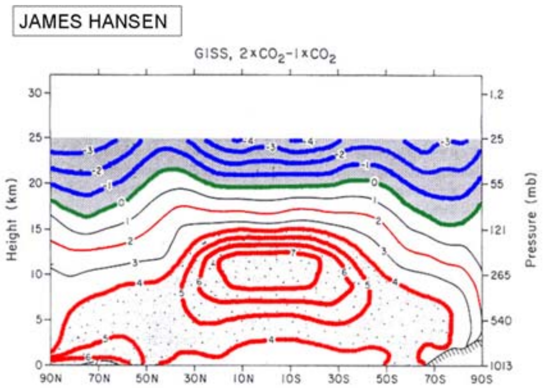


Figure 11. North-South vertical cross-section showing Hansen's early GCM's change in temperature (°C) that would accompany a doubling of CO_2. There is no way an extra 3.7 Wm^{-2} blocking of IR could lead to such extreme upper tropospheric temperature rises.

Not only have Hansen's extreme and unrealistic high values of upper tropospheric moisture and temperature increases (for a doubling of CO_2) not been challenged by his fellow modelers, they were instead closely emulated by most of the other prominent GCM modeling groups of NOAA-GFDL (Figure 12), NCAR (Figure 13) and the UK Met Office (Figure 14). All these early climate model simulations were designed to give unrealisticly high amounts of upper tropospheric water vapor increases and, as a result, additional extra large blockage of IR energy to space with resulting large and unrealistic required upper level temperature rises to compensate.

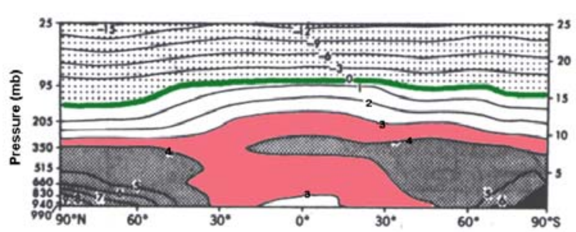


Figure 12. Same as Figure 11 but for NOAA-GFDL GCM temperature rise for a doubling of CO_2.

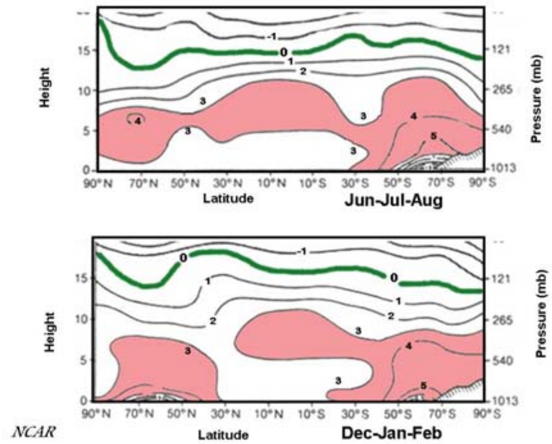


Figure 13. Same as Figure 11 but for NCAR GCM temperature rise for a doubling of CO_2.

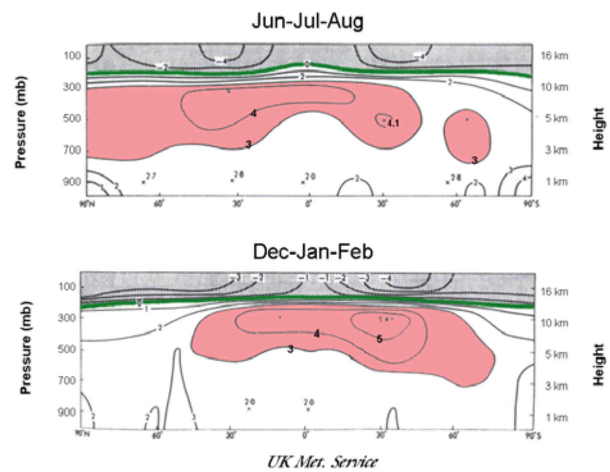


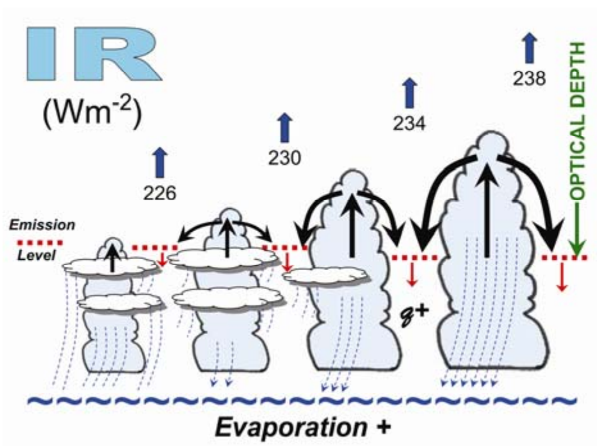
Figure 14. Same as Figure 11 but for the UK Met Office's temperature projections for a doubling of CO_2.

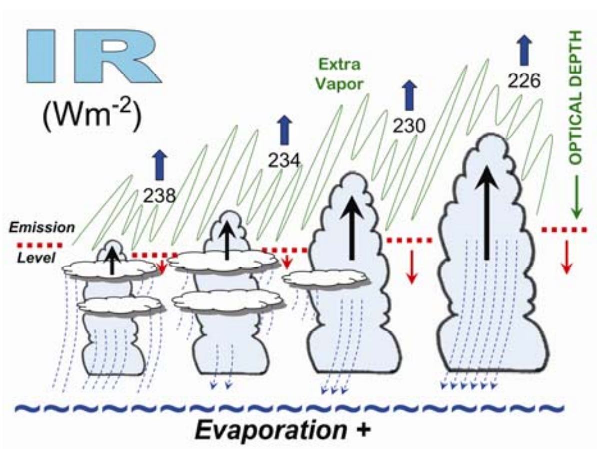
Our analysis did not show significant increases of upper tropospheric temperature and moisture with enhancement of tropical or global rainfall amounts of 2-4 percent that are similar to what would likely occur with a doubling of CO_2 and no assumed feedbacks.

5. CENTRAL PROBLEM OF THE CLIMATE MODELERS

The cloud condensation schemes of the climate models have been flawed from the start. Their heating schemes are not properly mass balanced in the vertical. The updraft mass which goes up in the deep cumulus or cumulonimbus (Cb) clouds must return to lower levels as seen in the top frame of Figure 15. The vertical gradient of water vapor holding capacity in the upper troposphere is especially large. Saturated air from upper tropospheric cumulonimbus (Cb) which sinks 100 mb has its RH greatly reduced by values of 60 to over 90 percent (Table 7). The upper tropospheric rainfall efficiency from Cb clouds is very high. These clouds, in the net, tend to reduce their broad scale surrounding upper level RH. This allows for more IR energy loss to space.

Figure 15. Two contrasting views of the effects of deep cumulus convection. The top diagram emphasizes the return mass flow subsidence and its general drying and lowering of the emission level to let more IR to space. By contrast, the bottom diagram interprets the outflow from the deep cumulus as moistening the upper levels and blocking additional IR to space.





The climate modelers appear not to have been sensitive to implications of strong upper troposphere Cb-induced subsidence drying. They view Cb convection as acting to moisten the upper troposphere as seen by the bottom diagram of Figure 15. This is a crucial flaw in their thinking because it has allowed them to accept the unrealistic view that very large upper level moistening occurs from enhanced deep Cb convection. This is not supported by the observations.

Table 7. Amount of relative humidity (RH) decrease by saturated air sinking 100 mb between various pressure levels (middle). The resulting humidity is given on the right.

Sinking 100 mb Pressure Levels	*RH Percent Decrease*	*Resulting RH at base of sinking*
125 mb to 225 mb	93	07
150 mb to 250 mb	90	10
175 mb to 275 mb	88	12
200 mb to 300 mb	86	14
225 mb to 325 mb	83	17
250 mb to 350 mb	77	23
275 mb to 375 mb	69	31
300 mb to 400 mb	63	37
325 mb to 425 mb	59	41
350 mb to 450 mb	56	44

6. A MORE REALISTIC ANALYSIS OF CO_2's LIKELY INFLUENCE ON GLOBAL TEMPERATURE

We have used the combination of ISCCP and NCEP-NCAR reanalysis data to construct an annual average of the global tropical (30°N-30°S; 0-360°) energy budget (Figure 16) for the years from 1984-2004. Note that the various surface and top of the atmosphere energy fluxes are very large. For the tropical surface, for instance, there are 637 Wm^{-2} units of downward incoming solar and infrared (IR) energy. This downward energy flux is largely balanced by an upward surface energy flux of 615 Wm^{-2} which is due to upward fluxes from IR radiation, evaporation of surface liquid water, and sensible heat. Similar large energy fluxes are present at the top of the atmosphere and within the troposphere.

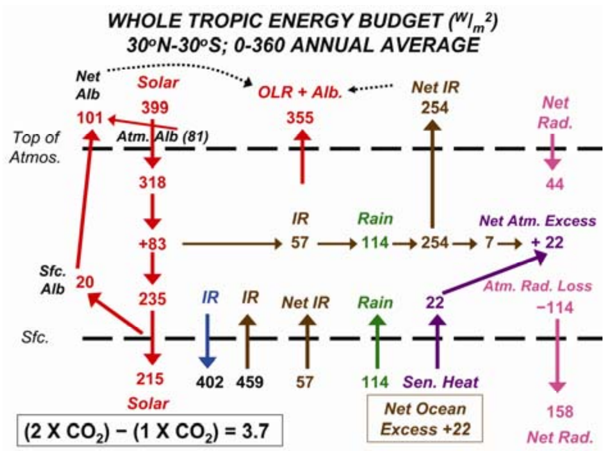


Figure 16. Vertical cross-section of the annual tropical energy budget as determined from a combination of ISCCP and NCEP-NCAR Reanalysis data over the period from 1984-2004. The tropics receive an excess of about 44 Wm^{-2} radiation energy which is convected and exported as sensible heat to latitudes poleward of 30°. Estimates are about half (22 Wm^{-2}) is transported by the atmosphere and the other half is transported by the oceans.

It has been estimated that a doubling of CO_2 (from the pre-industrial period) without any feedback influences would result in a blockage of IR to space of about 3.7 Wm^{-2}. The currently-measured value of CO_2 in the atmosphere is 380 parts per million by volume (ppmv). If we take the background pre-industrial value of CO_2 to be 280 ppmv, then by theory we should currently be having (from CO_2 increases alone) about (100/280)*3.7 = 1.3 Wm^{-2} less IR energy flux to space than was occurring in the mid-19th century.

The 1.3 Wm^{-2} reduction in IR we have experienced since the mid-19th century (about one-third of the way to a doubling of CO_2) is very small compared with the overall 399 Wm^{-2} of solar energy impinging on the top of the tropical atmosphere and the mostly compensating 356 Wm^{-2} of IR and albedo energy going back to space. It is impossible to isolate and to directly attribute changes in global temperature over the last century to such a relatively small CO_2-induced energy gain of 1.3 Wm^{-2}.

Slight changes in any of these other larger tropical energy budget components could easily negate or reverse this small CO_2-induced IR blockage. For instance, an upper tropospheric warming of about 0.4°C with no change in moisture would enhance IR (σT^4) sufficient that it would balance the reduced IR influence that has been experienced up to now. Similarly, if there were a reduction of upper level water vapor such that the optical depth (τ) or emission level were lowered about 2½ mb (~ 50 m), there would be an enhancement of IR (with no change of temperature) sufficient to balance the suppression of IR energy (~ 1.3 Wm^{-2}) that has occurred up to now. These small CO_2-induced energy changes that have occurred up to now are largely in the noise level and are a good deal less than we would expect for natural climate changes such as the potential energy altering influences of deep ocean circulation changes.

7. DIFFERENCES IN RAINFALL BUDGETS

The global energy budget analysis of Trenberth et al. (2007) is shown in Figure 17. Assuming that a doubling of CO_2 reduces IR to space of 3.7 Wm^{-2} it would be necessary that the surface of the earth and the top of the atmosphere give out an increased balancing amount of energy in order to establish equilibrium. As the atmosphere has no capacity to store energy it is necessary that this compensating upward flux at the top of the atmosphere be similar at the surface energy flux. Trenberth and colleagues found that the surface balancing loss of energy to evaporation is half (or 80 Wm^{-2}) of the required upward net surface energy flux of 161 Wm^{-2}. To attribute 50 percent of 3.7 upward flux to balance a doubling of CO_2 would require an additional 1.85 Wm^{-2} of extra evaporation or an increase of 2.3 percent in global rainfall. This is comparable to our long period and monthly differences of 1.9 and 3.9 percent rainfall. The top of the atmosphere could send an extra 3.7 Wm^{-2} of energy to space by increasing its temperature by 1.1°C while having its optical depth and radiation emission level remain the same.

To add an additional upward flux of 3.7 Wm^{-2} to our tropical (30°N-30°S) energy budget (Figure 16) would require an additional increase of tropical precipitation of 1.9 percent. Table 8 compares the necessary precipitation increases of Trenberth's et al.'s and this studies tropical budget in order that an energy balance for a doubling of CO_2 be obtained. These rainfall differences are very similar to our two ISCCP rainfall variations. We find no observed positive rainfall feedback for our two ISCCP rainfall differences. There appear to be no good reason why we should expect to find positive rainfall feedback in global budget analyses which have precipitation differences equivalent to what we measure with our reanalysis-ISCCP data for which there is no feedback.

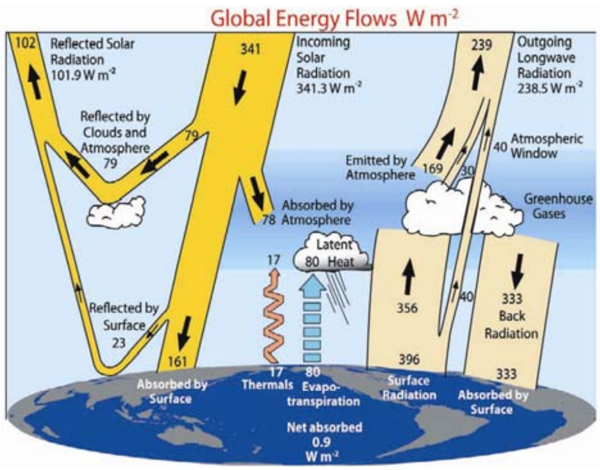


Figure 17. The global annual mean Earth's energy budget for the Mar 2000 to May 2004 period (Wm-2). The broad arrows indicate the schematic flow of energy in proportion to their importance. (Trenberth et al*.* 2009)

Table 8. Required percentage increase in precipitation to balance an upward surface loss of 3.7 Wm^{-2} with no (or negative) assumed water vapor feedback.

DATA SET	PRECIPITATION DIFFERNCE (percent)
Global Energy Budget (Trenberth *et al.* 2009)	2.3
Tropical Energy Budget (this study)	1.9
10 High – 10 Low Monthly Average Precipitation Difference	3.9
(1995-2004) – (1984-1994) Decadal Rainfall Difference	1.9

8. CONCLUSION

We find that as rainfall increases that there is not a reduction of global net radiation to space as most of the climate models have assumed. There is a weak enhancement of radiation to space with increased rainfall. We find no positive water vapor feedback.

The IPCC-IV Report lists 19 global model simulations of the equilibrium climate sensitivity (in ^{o}C) to the influence of a doubling of CO_2. Values range from 2.1^{o}C to 4.4^{o}C with the mean value being 3.2^{o}C. Assuming no moisture change above the emission level (optical depth constant), then for a doubling of CO_2 it would be required that there be a temperature increase of 1.1^{o}C. For a doubling of CO_2 warming of 3.2^{o}C to occur as the current climate models suggest it would be necessary that these models have a required positive moisture feedback of about 2.2^{o}C or about 7 Wm^{-2} of extra enhanced radiation flux to space. This is not realistic and indicates that the new climate models are making the same false assumptions as regards to water vapor feedback that was made by the global modelers of 15-20 years ago.

If the upper level moisture values actually decreased as our analysis indicates (negative water vapor feedback), then the emission level would be lowered to a level to give much less required warming to balance a doubling of CO_2. Were the moisture above the emission level to be decreased about 4 percent, then the optical depth above the emission level would be lower (about 7 mb) to a level that were 1.1^{o}C warmer. In this situation we could have a doubling of CO_2 with no global temperature change but with increased rainfall by about 2 percent.

Figure 18 gives an idealized picture of variation of the optical depth (τ) as related to relative humidity (RH) differences through this depth. The higher the RH, the more shallow is the optical depth and the higher and colder is the emission level. To satisfy a required amount of upward IR energy flux, the higher emission level temperature has to increase. A 1^{o}C rise in upper tropospheric emission level temperature with no change in moisture and optical depth is equivalent to an increased IR flux to space of about 3.4 Wm-2. Relative humidity (RH) increase throughout the full layer of the optical depth of 4 percent is equivalent to a 1.1^{o}C warming from water vapor feedback. Through their convective heating schemes the climate models assume a RH increase over this (τ) layer of about 8% for a doubling of CO_2. This leads to their approximate 2.2^{o}C water vapor feedback warming. This warming, in addition to the need to balance the increase CO_2 doubling warming of 1.1^{o}C, leads to the climate models requiring an upper tropospheric warming for a doubling of CO_2 of about 3.3^{o}C (Figure 19).

If, on the other, the optical depth (τ) were to undergo a RH drying of 2 or 4 percent from upper level return flow subsidence drying (as our measurements indicate) then the extra deep convection from a doubling of CO_2 might lead to a small lowering of the optical depth and emission level (Figure 20). This would cause only a very small global warming from CO_2 doubling of only about half a degree or even less.

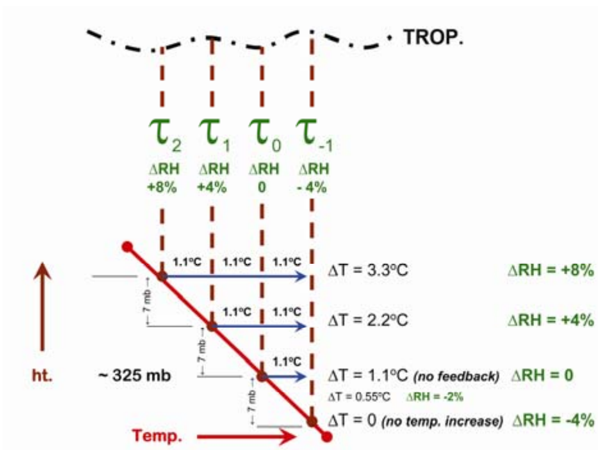


Figure 18. Idealized portrayal of how variation in the optical depth (τ) due to RH differences can lead to changes in the emission level and differences in required upper level warming.

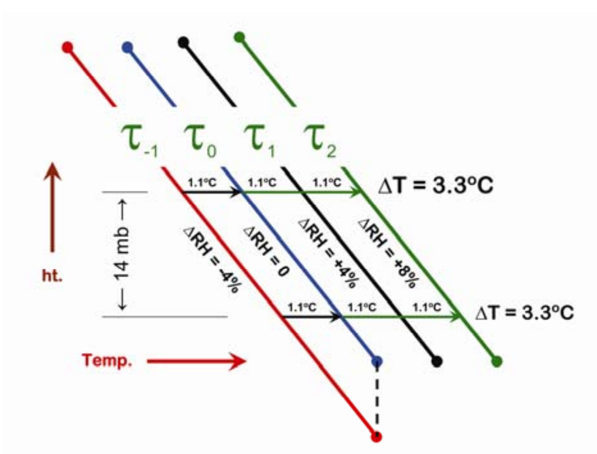


Figure 19. Idealized portrayal how assumed variations in the upper level RH for CO_2 doubling requires different amounts of upper level warming.

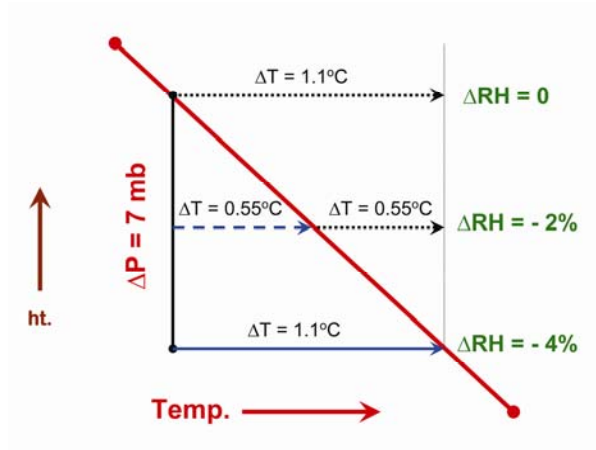


Figure 20. Idealized portrayal how a lowering of RH above the emission level would require even less amounts of upper level warming.

A reduction of upper level RH of about 4 percent to go along with a lowering of the emission level of 7 mb would allow a doubling of CO_2 to proceed with no warming (Figure 20). We estimate the extra precipitation from a doubling of CO_2 to cause a negative (not positive) temperature feedback of about minus 0.6°C. This will involve lowering the emission level about 4 mb. We thus anticipate that a doubling of CO_2 will bring about a net global warming of about 0.5°C (1.1°C warming for CO_2 doubling and a precipitation induced negative feedback of about 0.6°C). This is less than one-sixth of the global warming of over 3°C projected by the GCMs (Figure 21).

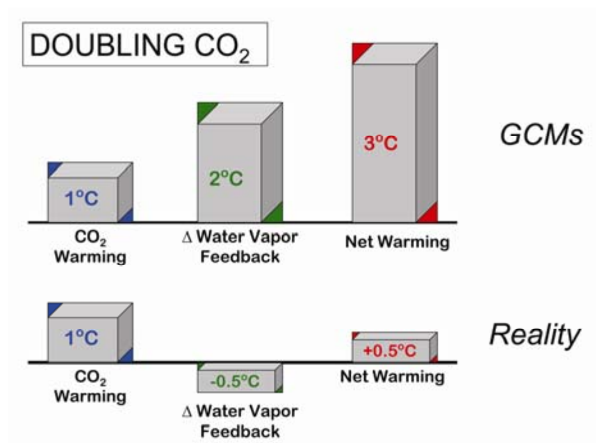


Figure 21. Contrast of what GCMs give versus what our observations imply.

9. REFERENCES

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