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To Bring an End to Global Warming - Make it Rain

By William Van Brunt

Abstract- Over the last 40 years, the average global temperature has risen by 1°C and the catastrophic storm risk has tripled, as the latent heating power of the atmosphere grew, driven by the 15% increase in the average global concentration of the primary greenhouse gas, water vapor. Global warming and the catastrophic storm risk only worsen as the average global concentration of water vapor continues to increase at 0.4% $yr.^{-1}$ driving the average global temperature up at 0.2°C per decade. As the latent heating power of the atmosphere rose, the annual number of catastrophic, weather-related events increased to over 750, by 2019, 525 above the 1980 baseline of 225 annual events. Since 1980, these weather-related catastrophic events have taken tens of thousands of lives, wiped out whole communities while wreaking 4.6 trillion dollars in cumulative worldwide weather-related destruction, of which 2.4 trillion dollars is the result of global warming driven increasing atmospheric latent heating power, as shown by the close correlation of major weather-related events with the average global temperature record (correlation coefficient 0.84).

Keywords: climate change, global warming, carbon dioxide, water vapor, water vapor primary greenhouse gas, relationship of concentration of water vapor to average global temperature, latent heating, increasing latent heating power, global warming driven, major, weather-related, catastrophic events, limiting and reversing global warming, concentration of co_2 *cannot be reduced, precipitation, evaporation, reducing concentra-tion of water vapor, water vapor heating, crisis, existential threat, catastrophic damages, destruction, billion, trillion.*

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To Bring an End to Global Warming - Make it Rain

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Keywords: *climate change, global warming, carbon dioxide, water vapor, water vapor primary greenhouse gas, relationship of concentration of water vapor to average global temperature, latent heating, increasing latent heating power, global warming driven, major, weather-related, catastrophic events, limiting and reversing global warming, concentration of co_2 cannot be reduced, precipitation, evaporation, reducing concentration of water vapor, water vapor heating, crisis, existential threat, catastrophic damages, destruction, billion, trillion.*

I. Introduction

Increasing precipitation to reduce the average global concentration of water vapor, can:

A. Reduce the rate of increase of and, if sufficient, reverse greenhouse heating; and,
B. Reduce the annual occurrence of massive weather-related disasters, lives lost and weather-related economic losses.

II. Background

- Earth is heated by the sun and the greenhouse gases, GHG. The main greenhouse gases are CO_2 and water vapor, the primary greenhouse gas.
- As the concentration of greenhouse gases grow, greenhouse heating and global warming increase.
- Between 1976 and 2019, as the result of an increasing concentration of greenhouse gases, the heating of the planet increased significantly, by 2.4%, increasing the average global temperature by 1°C, escalating the rates of evaporation, convection, precipitation and the rate of release of the potential energy (the "latent heat") of water vapor.
- Compared to the increase of ~ 0.2°C from 1880 to 1976, a period of 96 years, an increase of 1°C since 1976, in less than half that time, is significant. The average rate of increase in global temperature during this 45-year period is ten times the average rate of increase for the prior 96 years and there is nothing to suggest that it is slowing.
- Since 1976, the concentration of CO_2 increased by 82 ppmv, an increase in the atmospheric concentration, of 0.008%.
- What is generally ignored in the IPCC and related climate change literature is that the atmospheric concentration of water vapor, which accounts for 97% of greenhouse heating,[1] increased by 15%,

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an increase in the atmospheric concentration of water vapor of 0.15%.

- This15%, increase, in parts per million, is 18 times greater than CO_2. When compared on a molecule-to-molecule basis, a molecule of H_2O has a heating efficiency 40 times greater than a molecule of CO_2. [2], Fig. 3(a)] Together, in terms of heating power, this is a water vapor increase at least 700 times greater than that of CO_2.
- This atmospheric concentration of water vapor is driven primarily by changes in sea surface temperatures in the Eastern Equatorial Pacific El Niño-Southern Oscillation, or "ENSO" region (5°N–5°S, 170°–90°W) and autonomous feedback, not by changes in the concertation of CO_2.
- While evaporative and precipitative rates are essentially equal, there are slight differences. When the rate of evaporation exceeds the precipitative rate, the atmospheric concentration of water vapor increases and vice versa.
- The year over year changes in the average global temperature correlate closely with changes in the average global concentration of water vapor. However, it is not the changes in temperature that are the direct near-term concern. It is the indirect effects.
- As the average global temperatures rise, the rate of evaporation increases. As water vapor condenses into droplets, the energy absorbed at evaporation, its "latent heat," is released, heating the surrounding air, causing the moist air to rise. Increases in the evaporative rate drive increasing latent heating power. This release of latent heat plays a major role in the formation of thunderstorms and hurricanes.
- Since precipitation and evaporation are essentially equal, the precipitative rate and therefore the latent heating power also rise, increasing the intensity and number of catastrophic weather events.
- Since 1980, major weather-related loss events have more than tripled, driven by a 10% increase in latent heating power.
- Since 1980, increasing greenhouse warming and resultant latent heating power increases fueled 9,000, additional, catastrophic storms, above the baseline of 8,800 such events. These global warming driven events increased each year at a rate of 11.8yr.$^{-1}$, taken thousands of lives, wiped-out whole communities, wreaking nearly 2.4 trillion dollars in cumulative worldwide destruction by 2019. The number of annual weather related catastrophic events tripled with 525 additional annual events, 130 billion dollarsyr.$^{-1}$over the 1980 baseline.
- The global effort to eliminate carbon dioxide, CO_2 emissions, cannot reduce the concentration of CO_2. CO_2 does not breakdown nor does it react with other atmospheric gases. Reducing CO_2 emissions can only limit the rate of increase in the concentration of CO_2. Today, the concentration of CO_2 continues to increase at 2 ppmv yr^{-1}. If carbon emissions were wholly eliminated, CO_2 will remain at or close to the highest level reached to that date. Any meaningful net, natural reduction in the concentration of CO_2 would take decades to centuries.
- With this realization, a number of novel and massive geo-engineering "concepts," which are briefly summarized in the Appendix, to reduce the concentration of CO_2 and/or solar heating, none of which have been shown to be feasible, much less workable and environmentally sound, but if one were, it is still unclear:

a. How effective it would be;
b. How long would it take to fully implement;
c. Whether it would it be difficult to control and terminate;
d. What investments would be required; and,
e. What the ongoing costs are likely to be.

when multiple ways to increase precipitation are well-known and practiced, suggestions to reduce the concentration of water vapor have not been set out.

- With respect to efforts focused on the reducing the concentration of CO_2:

a. The atmospheric concentration ofcarbon dioxide, CO_2, continues to increase at two parts per million, ppmv, annually. That is an increase of 23 billion metric tons of CO_2 each year.
b. CO_2 is well mixed in the atmosphere, with an average concentration today less than 0.05%. This means that, if removal were possible, it would be a slow process because for every ton of CO_2 eliminated, 2,000 metric tons of air, would have to be processed or for 2 ppmv that would be 46 trillion tons.

Thus, any suggestion that a significant reduction in the concentration of CO_2 can be achieved within a reasonable period of time is wholly unrealistic.

- However, as shown below, the concentration of water vapor can be reduced by increasing precipitation and if water vapor reductions are effected, the worsening global problem that is global warming, the immediate catastrophic weather threat and an existential climate change threat to the populations of ever-expanding regions of the globe, can be limited and reversed.

III. Variations in Global Temperature

As noted above, between 1880 and 2019, as the result of an increasing concentration of greenhouse gases, the average global temperature increased by 1ºC as is shown in Figure 1. Also set out in Figure 1 are the yr./yr. changes in the average global temperature.

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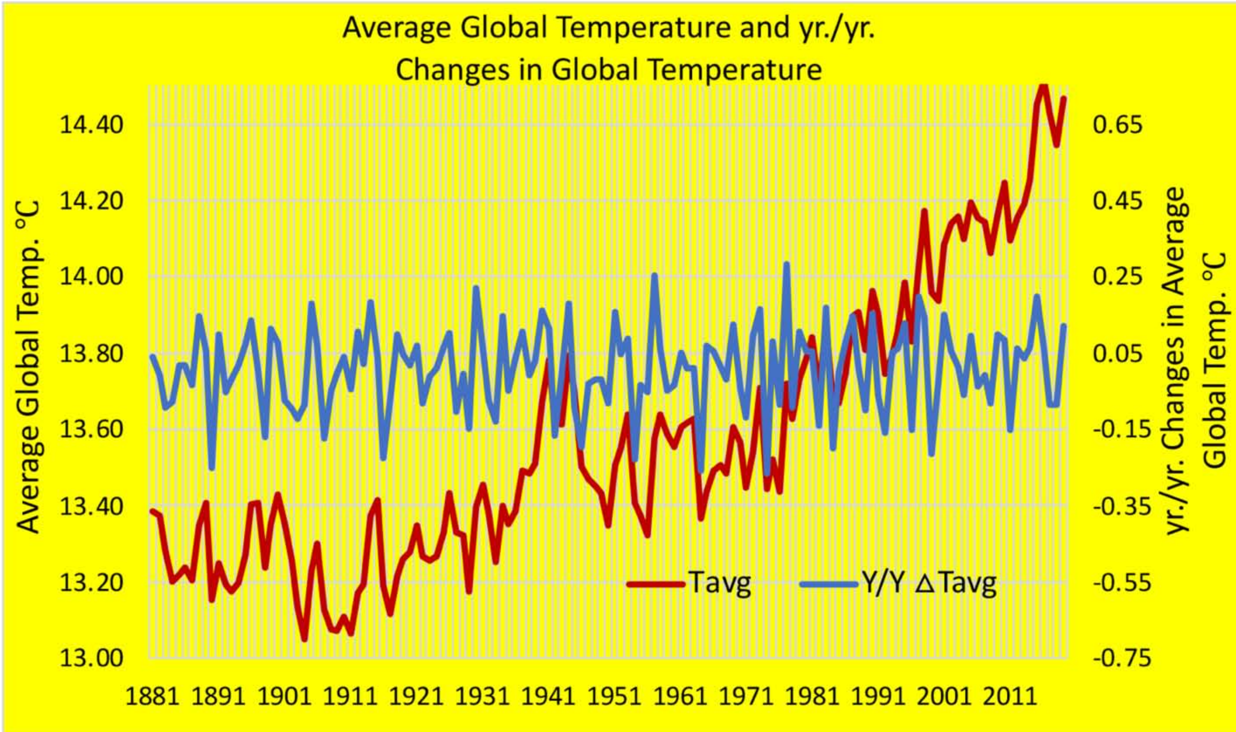

Figure 1: From NOAA Data [3-4] - Average Global Temperature, T_{Avg} plotted against the left vertical axis and yr./yr. changes in the Average Global Temperature plotted against the right vertical axis from1881 to 2019 shown on the Same Scale

While the focus is, as it should be, on the trend in the average global temperature since 1976, the year over year changes in temperature, as much as 0.28 °C in a single year, 28% of the total change in the average global temperature over this period, are significant.

The question is – what drives the year over year changes in the global temperature shown in Figure 1?

IV. Calculating Changes in the Concentration of and Resulting Changes in Average Global Temperature[1]

Current climate change forecast models, based on the assumption that the increasing concentration of CO_2 drive climate change, when applied retroactively, "hind cast", and compared to the historical temperature record do not, cannot, replicate this record. Given that:

- From 1880 to 2019, there are 140 measurements or estimates of the average annual global temperature, the average annual global temperatures of land and the seas and the average global concentration of CO_2;
- While the 1°C increase in the average global temperature since 1976 is a very serious problem, the annual changes in average global temperature are small, reflecting an increase of only 0.02°C ~ 0.008%/yr., on average, (See Figure 2 setting out the average global absolute temperature from Figure 1 for the period 1880 to 2019); and,

[1] Note: The assumptions underlying and the derivations of this and the other two Principles and all of the data underlying this work appear in the Tables and in the Supplementary Materials, which are too lengthy to repeat here and are also all fully set out in [5].

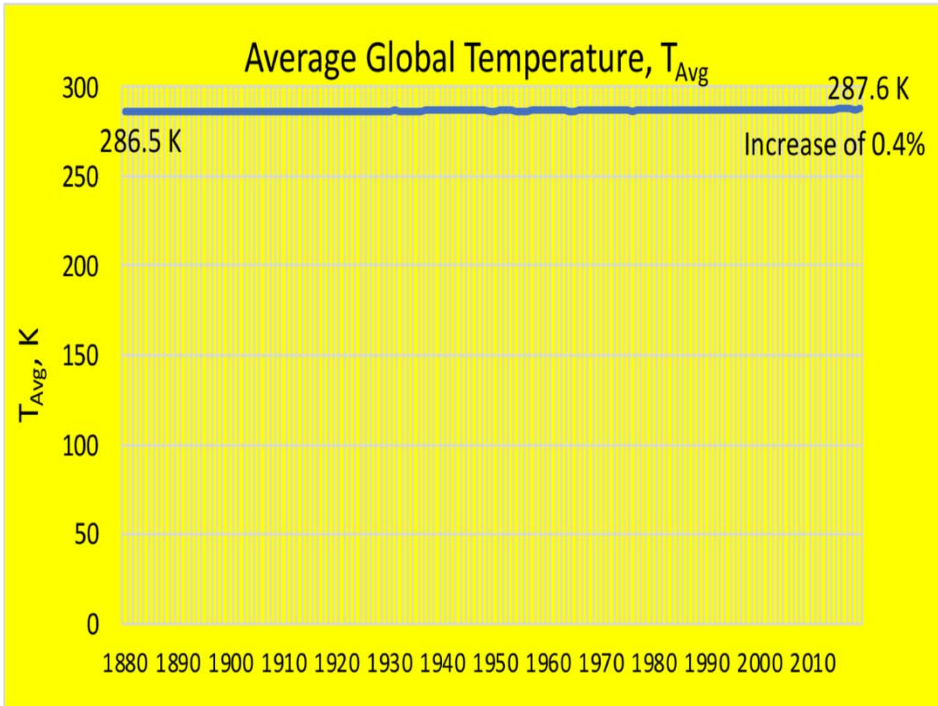

Figure 2: Average Global Absolute Temperature from Figure 1, K

- Changes in the annual average global net absorbed GHG heating, the energy available after the energy absorbed by evaporation and convection, that drove those changes were, therefore, also small, hence, the annual average global temperature determinations clearly represent equilibrium temperatures and calculating the average global net absorbed heating from greenhouse gases at the surface of each of the land and sea, for each year, is straightforward, identifying the key drivers of changes in the average global temperature and precisely determining the annual changes in the average global concentration of water vapor and the effect of these changes on average global temperature can be achieved through the application of the following three basic principles of atmospheric physics.

V. The First Principle – Determining Changes in the Concentration of Water Vapor

As greenhouse heating escalates, sea surface temperatures rise, evaporation increases and the average global concentration of water vapor, TPW, grows.

There are two major factors affecting average global evaporation and changes in the concentration of water vapor:

1. Average global, steady state, sea surface temperature, SST; and,
2. Changes in average global total heating, since for the seas, ~ 64% of the increase in average global total heating is absorbed in driving evaporation.[5]

This is captured by the First Principle- the change in the average global concentration of water vapor, ΔTPW resulting from a change in evaporation in response to a change in a) sea surface temperature, SST and b) total heating, TH, is proportional to the change in total heating,ΔTH and an exponential function of the change in the average global Sea Surface Temperature, ΔSST. [5]

$$\Delta TPW = 0.157\Delta TH + 17.5\{e^{[0.0686\,(SSTo\,+\Delta SST\,)-\,288)]} - e^{[0.0686(SSTo)-\,288)]}\ \mathrm{kgm^{-2}} \quad (1)[5]$$

Where, ΔTH is the change in annual average Global total heating, W m^{-2}

ΔSST is the change in the average Global Sea Surface Temperature, °C

Applying this formulation, percentage changes in the average global concentration of water vapor from 1880 are plotted in Figure 3 against percentage changes in the average global temperature measured in Kelvin.

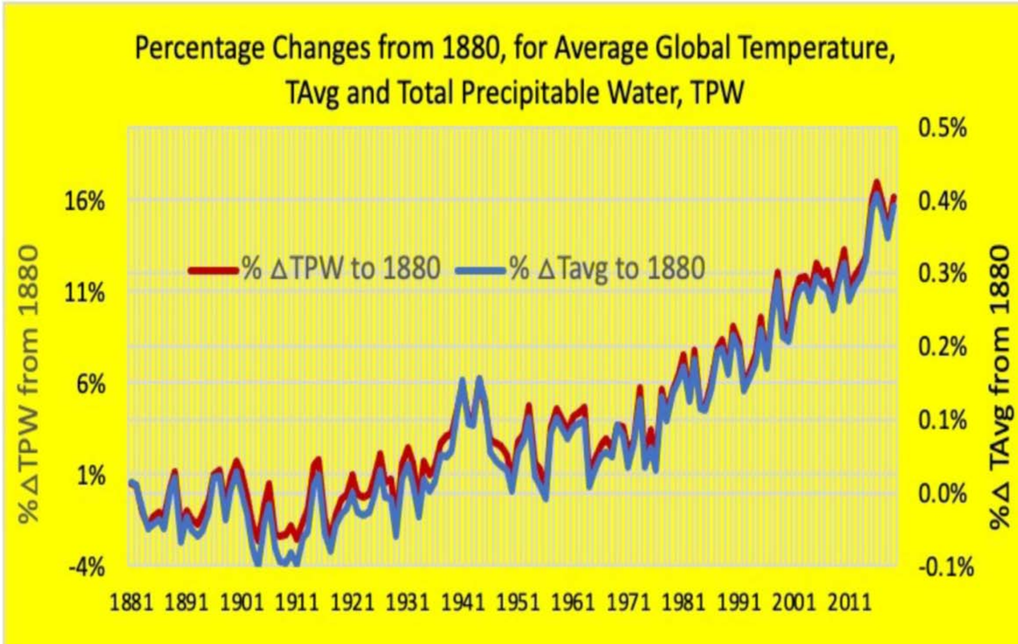

Figure 3: Percentage Changes in the Average Global Temperature, K, % ΔT_{Avg} Compared to Percentage Changes in The Concentration of Water Vapor, %ΔTPW, over 1880

Figure 3 shows the annual percentage changes from 1880 in the absolute average global temperature, ΔT_{Avg} and the calculated concentration of water vapor %ΔTPW. The correlation coefficient is 0.998.

VI. Comparing Calculated Changes in the Concentration of Water Vapor to the Data

From Eqn. 1, the average global concentration of atmospheric water vapor is calculated to have been 18.4 kg/m² in 1880. The results of the application of this Principle to NOAA data for 1996 – 2007, in g cm^{-2} (10 kg m^{-2} = 1 g cm^{-2}) is set out in Table 1.[5]

That this is accurate is shown in Figure 4.

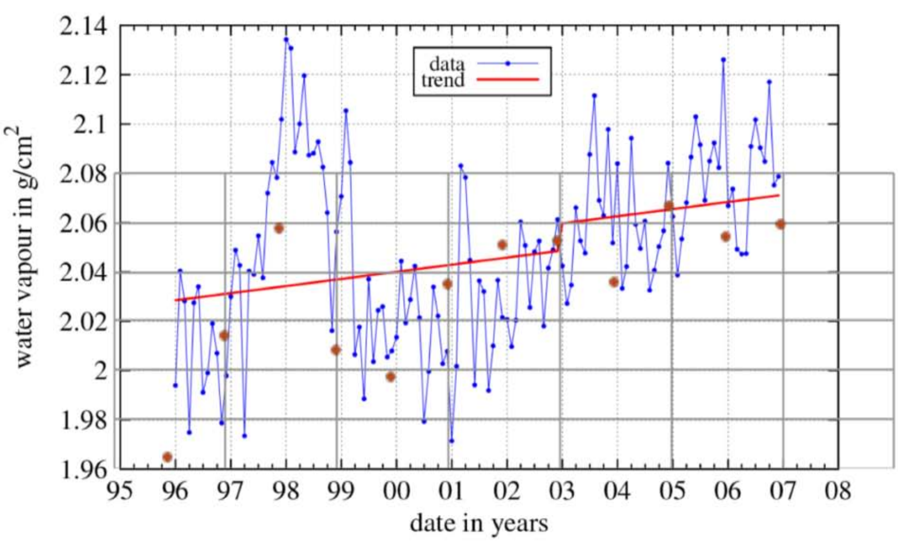

Table 1

Year	TPW gcm-2
1996	1.964
1997	2.013
1998	2.056
1999	2.008
2000	1.997
2001	2.034
2002	2.050
2003	2.052
2004	2.035
2005	2.066
2006	2.053
2007	2.058

Figure 4: Changes in the Concentration of Water Vapor[6]

The calculated average annual results for each year are shown as red dots and can be compared to the monthly global concentration of water vapor concentration data from satellite measurements along with their trendline (red line), in Figure 4. On average this trendline is within 1% of the trendline of the calculated TPW values, thus, demonstrating the validity of the First Principle, Eqn. 1.

These changes in the average global concentration of water vapor, ΔTPW drive changes in water vapor heating, ΔWV.

$$\Delta WV = 73.3 \ln\left(1 + \Delta TPW/TPW_o\right) \quad Wm^{-2.} \qquad [5]$$

How these changes in water vapor heating drive changes in the average global temperature is shown, below.

VII. The Second Principle – The Relationship between Average Global Temperature and the Concentration of Water Vapor

The effect of changes in the average annual concentration of water vapor, from Eqn.1on the annual average global temperature is set out as Figure 5 showing the average global temperature, T_{Avg} and concentration of water vapor, TPW, each for the same year.

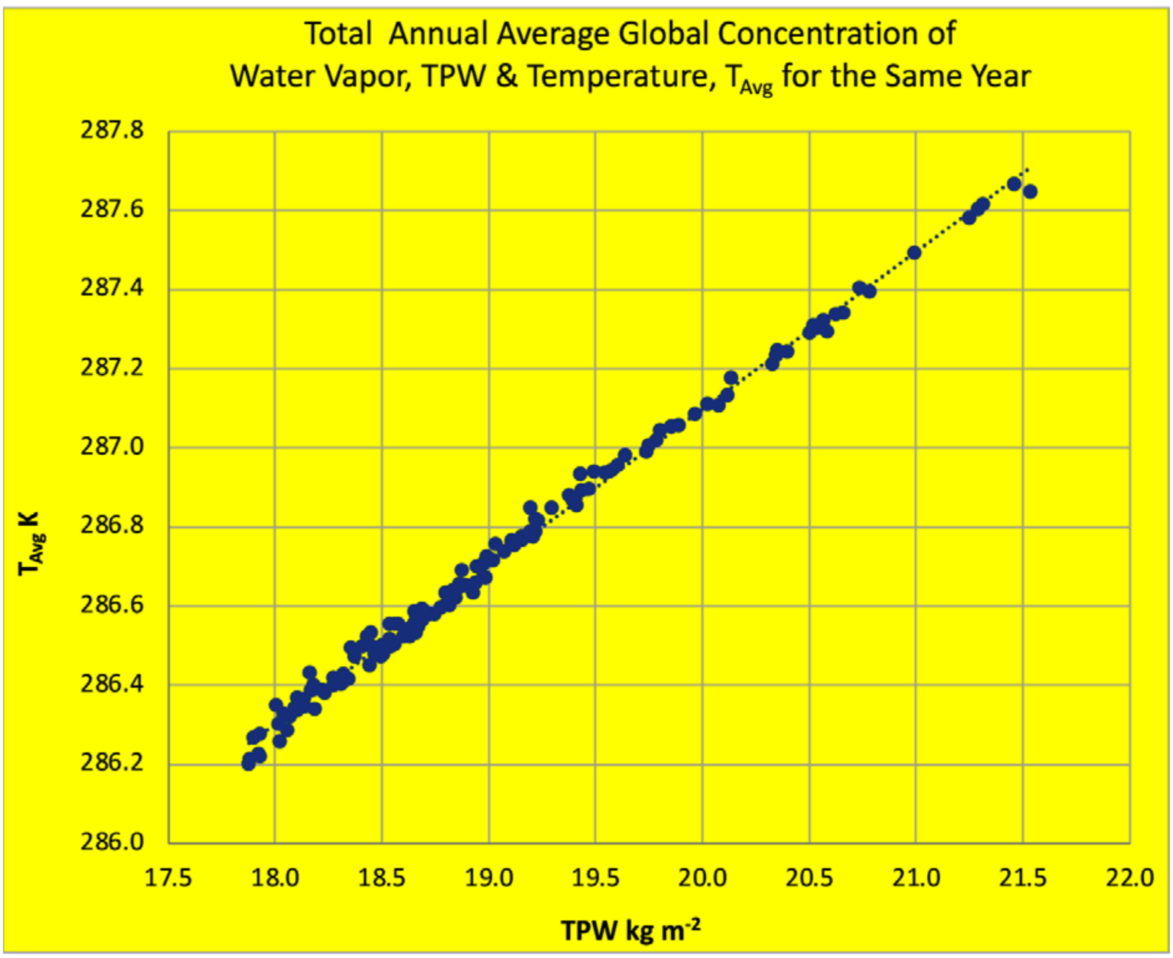

Figure 5: Annual Average Global Temperature, T_{avg} and Concentration of Water Vapor, TPW

The slope of the trendline set out in Figure 5 is 0.39 T_{Avg}/TPW with an R^2 of 0.995. The effect of the concentration of water vapor, TPW in kg m^{-2} on average global temperature, T_{Avg}, K, is therefore:

$$T_{Avg} = 0.39\ TPW + 279.1 \qquad (2)$$

Eqn. 2 is the new Second Principle.

This principle of atmospheric physics is a data-based discovery, the validity of which is demonstrated by the correlation coefficient of average global temperature, T_{Avg}, to the calculated concentration of water vapor, TPW, of 0.998.

Eqn. 2 shows that a reduction in the concentration of water vapor will result in a reduction in average global temperature.

VIII. The Third Principle - Changes in the Concentration of Water Vapor are not Just Responsive To, These Changes Can Initiate and Drive Changes in the Average Global Temperature

From Eqn. 1, the year over year percentage change in the concentration of water vapor, △TPW, along with year over year percentage change in the average global absolute temperature, [1-3] for the period 1880 to 2019, is set out in Figure 6.

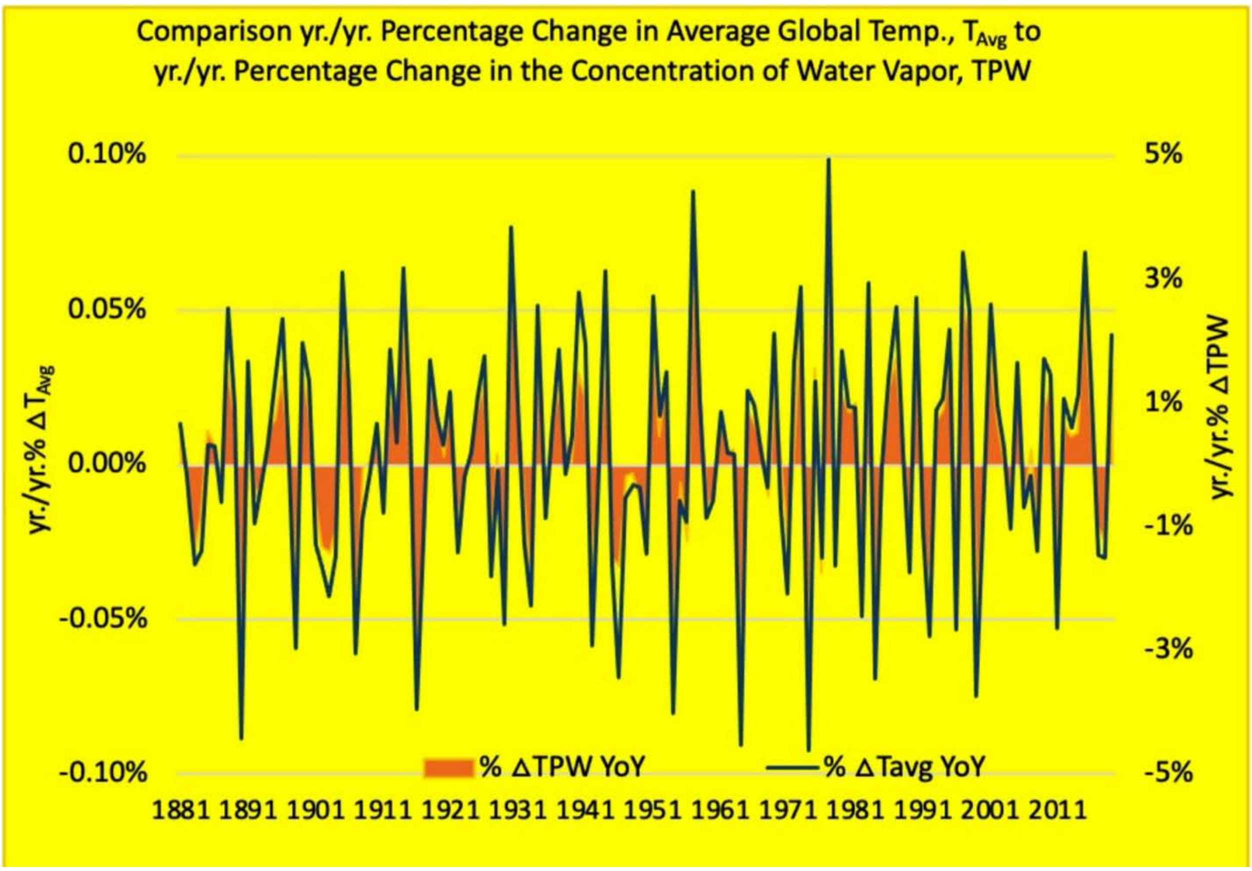

Figure 6: From Eqn. 1 yr./yr. Percentage Changes in the Annual Average Global Temperature, Tavg, Measured in Kelvin, compared to yr./yr. Percentage Changes in the Concentration of Water Vapor, TPW

The correlation coefficient of yr./yr. percentage changes in the average global temperature and yr./yr. percentage changes in the concentration of water vapor is 0.98.

A plot of the change in the Annual Average Global Temperature, ΔT_{Avg}, against the change in the average annual global concentration of water vapor, △TPW, each for the same year. is set out as Figure 7.

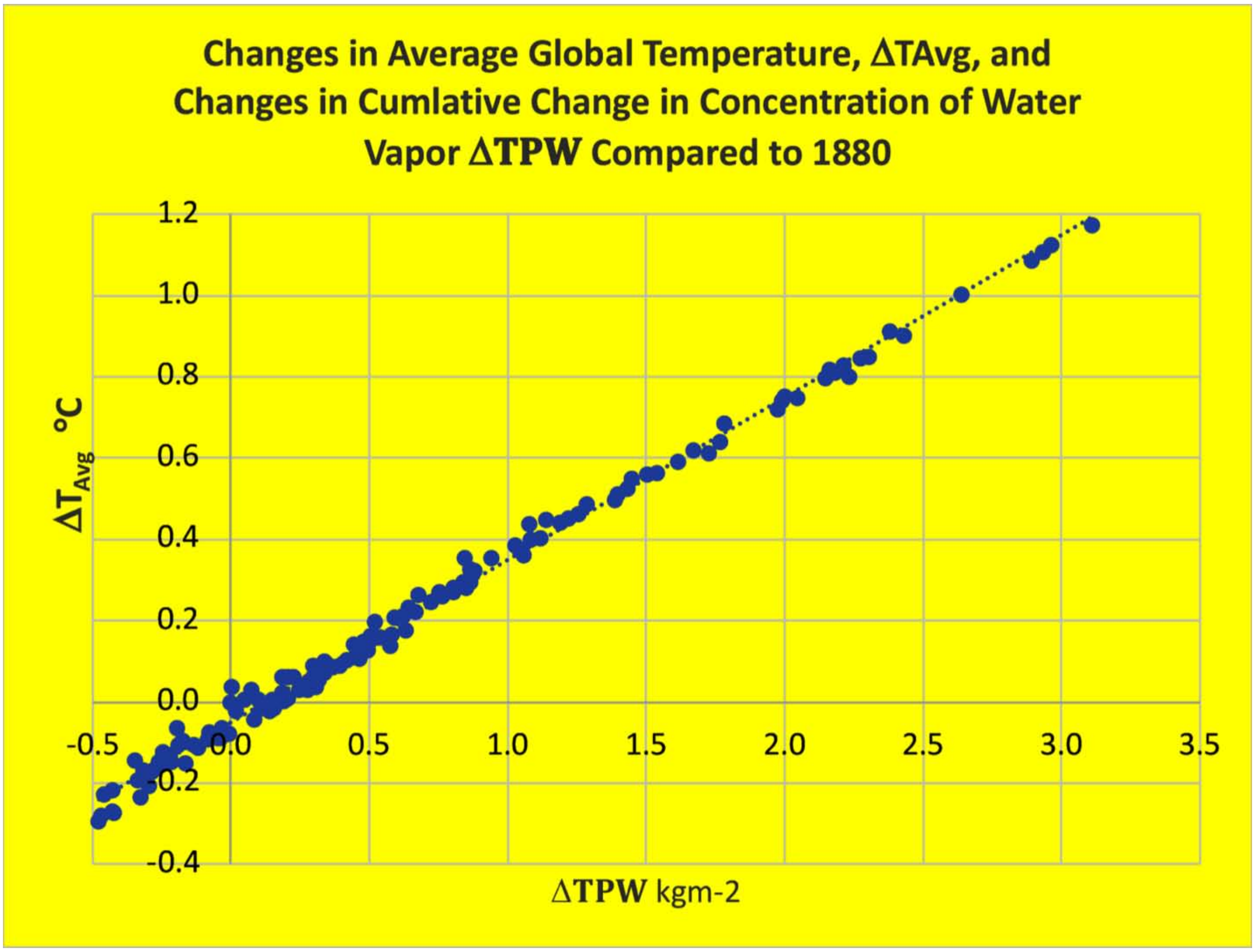

Figure 7: Changes in the Average Global Temperature ΔT_{avg} and in the Average Global Concentration of Water Vapor, ΔTPW Applying Eqn. 1 For Each Year Compared To 1880

The slope of the trend line shown in Figure 7, with an R^2 of 0.9953 and the effect of changes in the concentration of water vapor, ΔTPW in kg m^{-2} on changes in the average global temperature, ΔT_{Avg} in Celsius, is therefore:

$$\Delta T_{Avg} = 0.39\, \Delta TPW\, °C \qquad (3)[5]$$

For these small changes, this is an accurate approximation of the first derivative of Eqn. 2, in Figure 7, with an R^2 of 0.9953 and the effect of changes in the concentration of water vapor, ΔT_{Avg} / in Figure 7, with an R^2 of 0.9953 and the effect of changes in the concentration of water vapor, ΔTPW = 0.39.
Eqn. 3 is the Third Principle.

Because this formulation is a data-based discovery, it takes into account the effects of changes in cloud cover and all other GHG.

The correlation coefficient of the computed ΔT_{Avg} with actual is 0.998. This precise replication of the temperature data validates Principles 1- 3.

IX. Changes in the Average Concentration of Water Vapor are Not Driven by Changes in The Concentration of CO_2

In response to the contention that it is changes in the concentration of water vapor that drive climate change; based on the assumption that CO_2 is the sole driver, the assertion is made that changes in the concentration of water vapor are driven by changes in CO_2 heating, with water vapor heating a feedback effect of the changes in CO_2 heating.

Applying Eqn. 1, changes in the average global concentration of water vapor between 1976 and 2019 are set out in Figure 8.

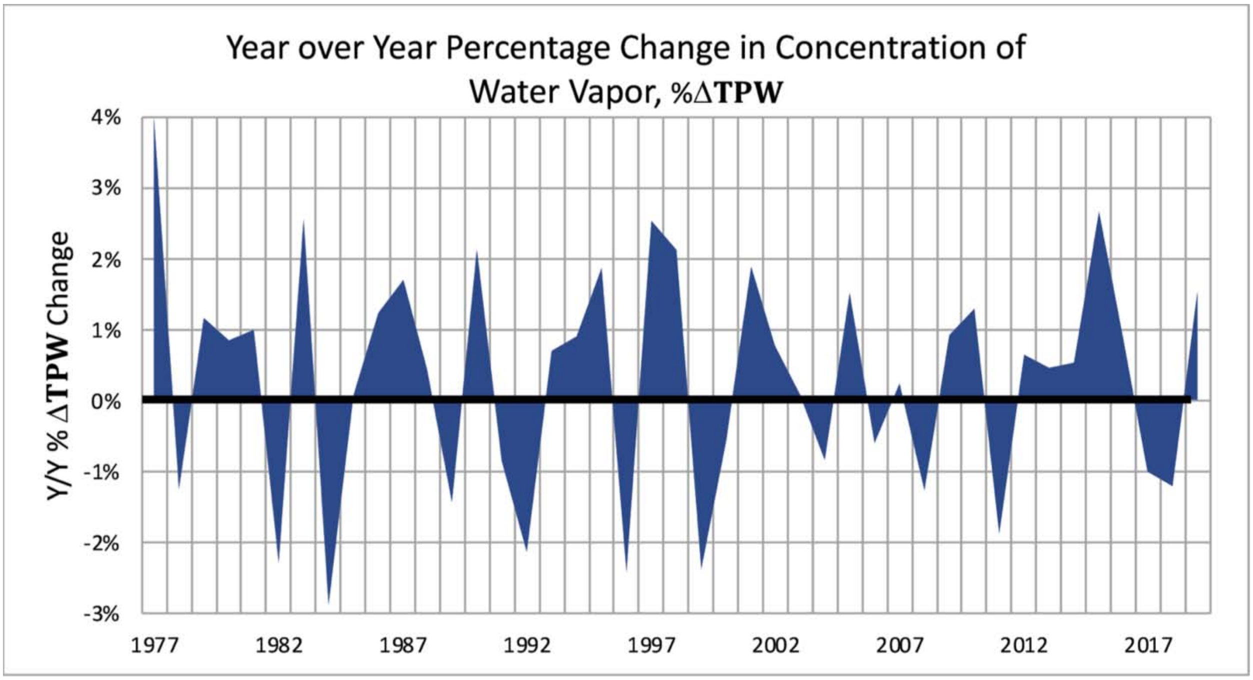

Figure 8: Year over percentage changes in the Global concentration of Water Vapor, % ΔTPW

A change in the concentration of water vapor simply requires a difference between the average change in evaporation, ΔEV and the average change in precipitation ΔPR, for the same time period.

$$\Delta TPW = \Delta EV - \Delta PR \tag{4}$$

Thus, changes in precipitation relative to the changes in evaporation or changes in evaporation stemming from changes in surface temperature unrelated to changes in GHG heating can both drive changes in the concentration of water vapor.

X. Changes in the ENSO Drive Changes in the Concentration of Water Vapor

For example, El Niño driven increases in the Eastern Equatorial Pacific El Niño-Southern Oscillation, or "ENSO" region (5°N–5°S, 170°–90°W) ENSO region Sea Surface Temperatures drive local changes in evaporation and the concentration of water vapor in this region.

These changes in the local concentration of water vapor and water vapor heating disseminateas water vapor and water vapor heating spread outside the ENSO region through large, positive, vertically integrated, water vapor transport anomalies, peaking globally four months later[2]. [7]

[2] It has been found that that the rainfall evolution in the tropical Pacific associated with the ENSO SST anomalies lags one season followed by an atmospheric lag in associated weather events outside the ENSO region of 1–3 months. [13]

Figure 9 is Figure 8 including year over year percentage change in the average Enso region SST for the 12-month period commencing September of prior year.

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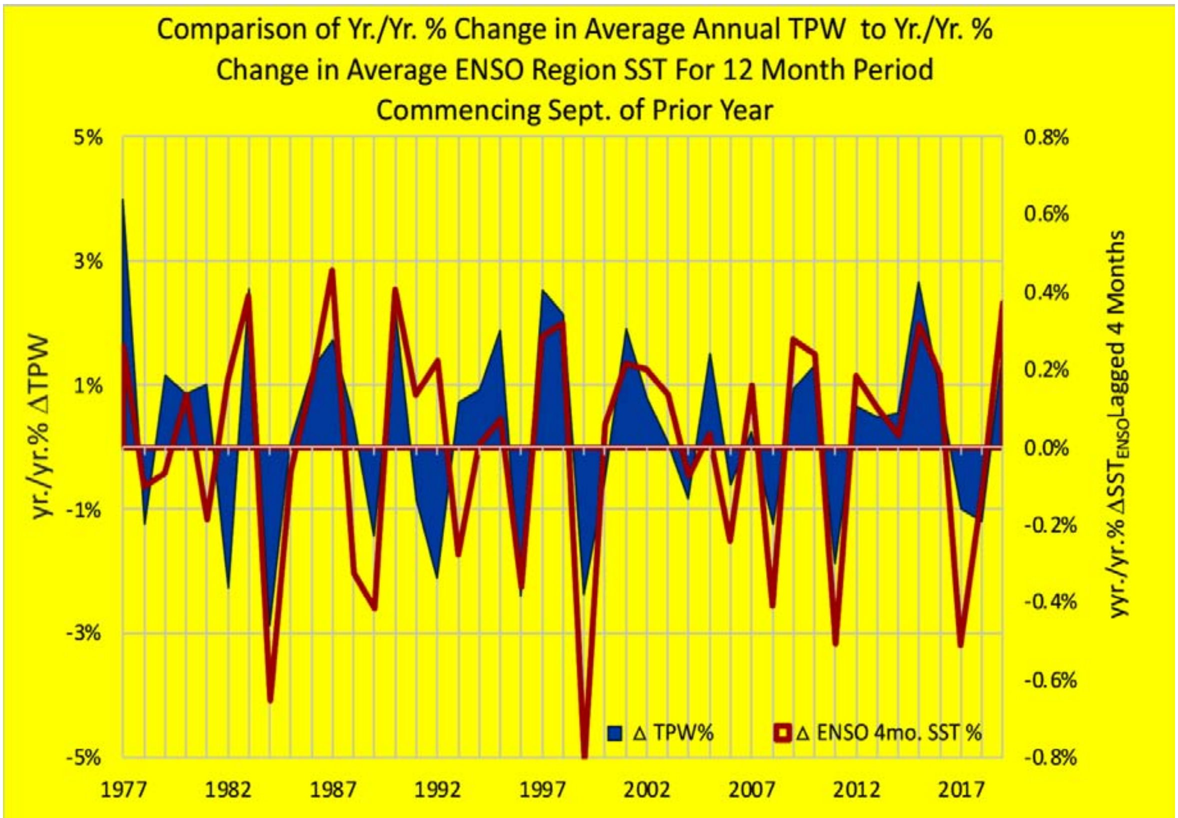


Figure 9: Year Over Year Percentage Change in the average Annual TPW Applying Eqn. 1, Plotted Against the Right Vertical Axis to Year Over Year Percentage Change in the Average ENSO Region SST for the 12 Month Period Commencing September of Prior Year[3] Plotted Against the Right Vertical Axis

As shown in Figure 9, there is a strong correlation between changes in the global concentration of water vapor and changes in Sea Surface Temperatures in the ENSO region lagged four months to capture the effects of water vapor as it rises from and spreads beyond this region. The correlation coefficient is 0.7.

Thus, as shown in Figure 9, it is clear that the year-to-year variations in the average global concentration of water vapor and therefore temperature, are largely the result of ENSO driven changes in the concentration of water vapor.

XI. ENSO SST Changes Arise Independently of Changes in GHG Heating

Changes in the ENSO region SST arise independently of changes in greenhouse heating. See Figure 9.

[3] Note: The changes in the concentration of water vapor, changes in total precipitable water, Δ TPW, shown in Figure 4 are determined solely from the NOAA data. The ENSO SST data comes from the monthly Oceanic Niño Index (ONI). [14]

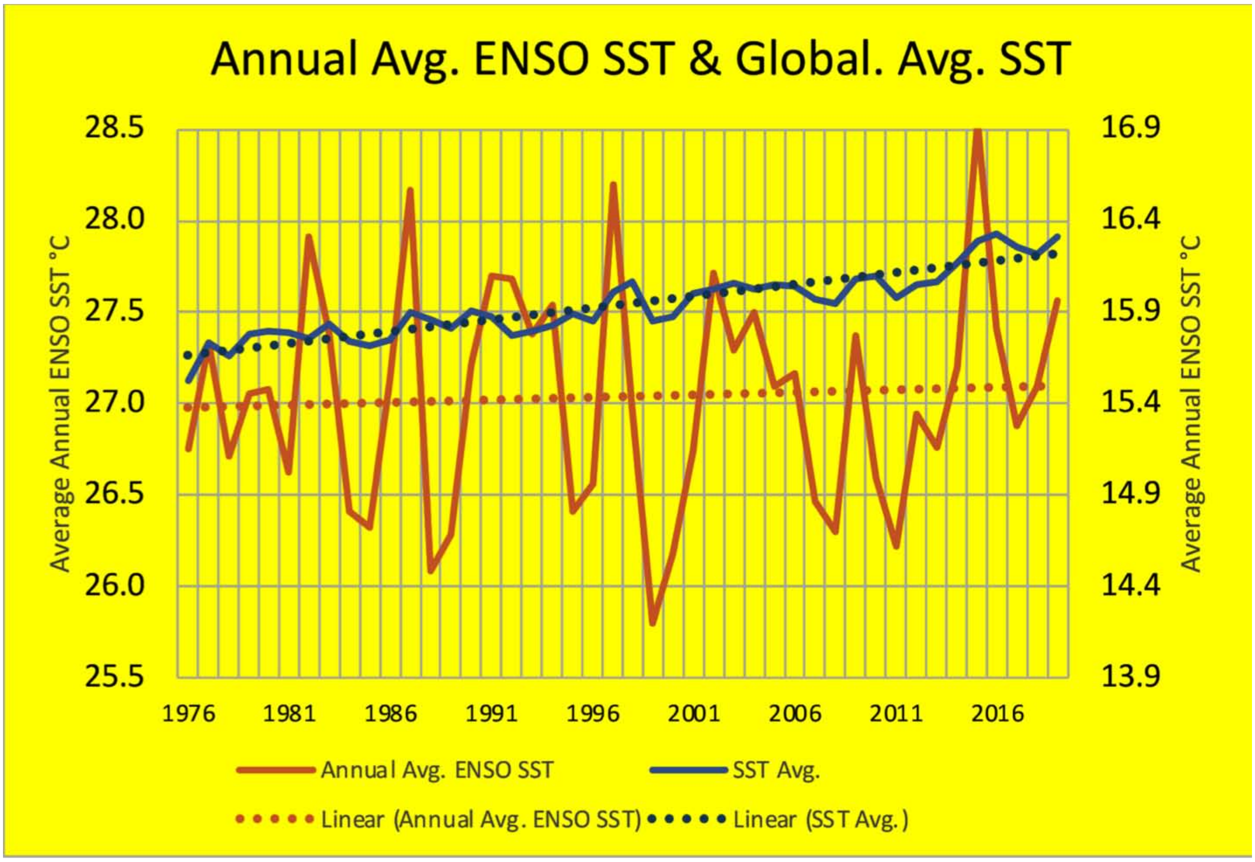


Figure 10: Annual Average Global SST & ENSO SST

There is no correlation between the SST record for the ENSO region shown in orange and the average global SST record, shown in blue, which reflects changes in greenhouse heating. The scales are the same. There is no correlation between changes in the global SST and the ENSO SST.

The trendline for the global SST is 0.13°C yr^{-1} with an R^2 of 0.83. The trendline for the ENSO SST is 0.003°C yr^{-1} with an R^2 of 0.0035, essentially flat. There is no correlation. The correlation coefficient for these two temperatures is 0.28.

Thus, changes in the ENSO region SST arise independently of and are not directly or indirectly driven by or related to changes in the average global temperature.

XII. Other Changes in Water Vapor Heating Can Arise Autonomously, Independently of Changes in the Concentration of CO_2

As a general matter, it is accepted that increases in the concentration of water vapor increase greenhouse warming.

While climate experts agree that increases in the concentration of water vapor require an increase in surface temperature; a position wholly in line with Eqn. 1, the assertion is made that changes in surface temperature are initiated or driven solely or primarily by changes in heating resulting from changes in the concentration of CO_2.

This certainly does not explain reductions in temperature and as to increases, is clearly not the case with El Niño driven changes. To the extent that the position is maintained that the increasing surface temperature is initiated or driven by an increase in the concentration of $CO_2$and the resultant increase in CO_2 heating, it cannot be science based. The relationship between climate change and changes in the concentration of CO_2 and water vapor can be summed up as follows:

The correlation coefficient of yr./yr. percentage changes in the average global temperature and yr./yr. percentage changes in the concentration of water vapor is 0.98.

If increases in the concentration of CO_2 drove the increases in the average global temperature, the year over year changes in the concentration of CO_2 would correlate with the year over year changes in the average global temperature. See Figure 10.

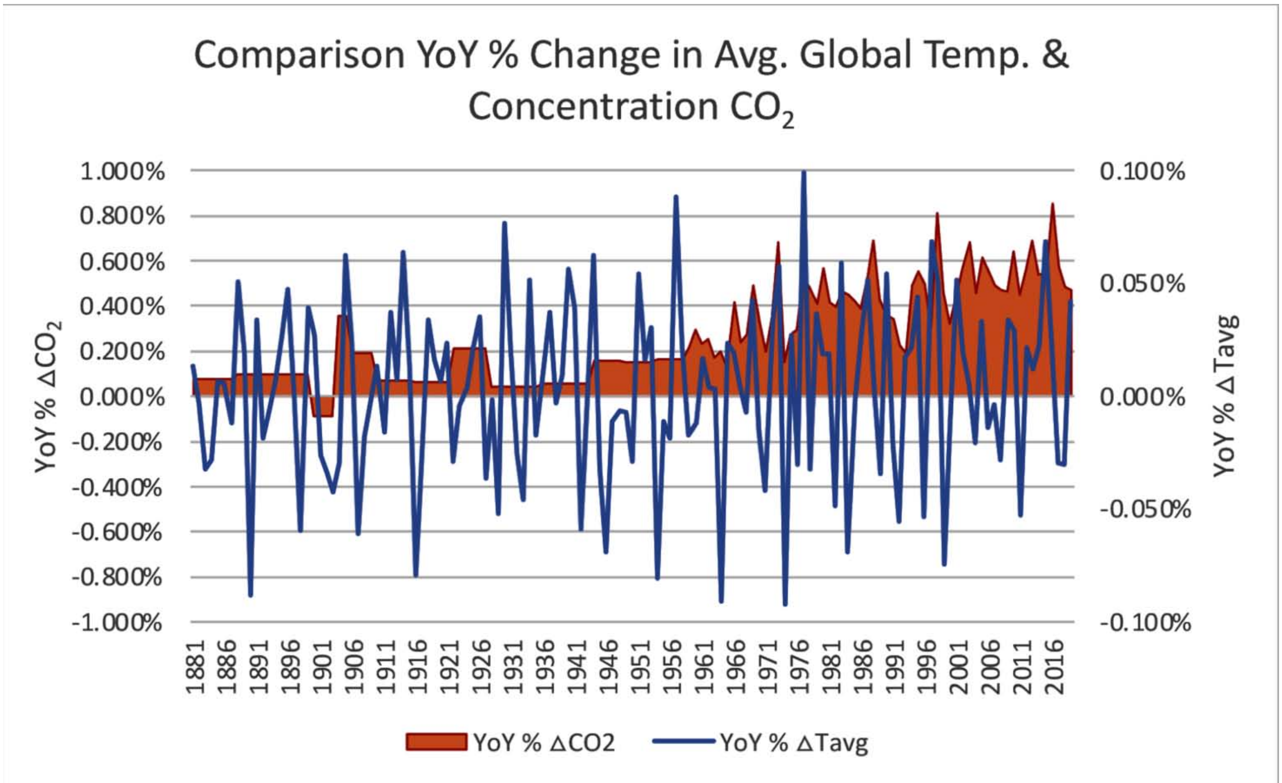


Figure 10: Comparison of yr./yr. percentage changes in concentration of CO_2shown in orange as gauged by the left vertical axis to yr./yr. percentage changes in average global temperature shown in blue and plotted against the right vertical axis

There clearly is no correlation between percentage changes in average global temperature and percentage changes in the concentration of CO_2 as confirmed by the correlation coefficient of 0.16 – no correlation.

Moreover, CO_2 based Climate Change Models [8] cannot accurately replicate the historical temperature record. In many cases, the 95% envelope for calculations of past temperatures from the CO_2 based forecast models is roughly ± 0.3°C, 60% of the increase in the average global temperature since the mid-seventies. Those models to which this confidence level applies do not accurately replicate the data. Therefore, the theories underlying them are invalid.

There is no correlation between changes in the concentration of CO_2 and changes in the average global temperature. Changes in average global temperature arise independently of and not driven by changes in the concentration of CO_2.

Nor, for the same period, is there a correlation between the year over year changes in the global concentration of water vapor and changes in the concentration of CO_2. Changes in the concentration of water vapor, ΔTPW, which some presume to be driven by changes in temperature resulting from changes in the concentration of CO_2 are also wholly unrelated to changes in the concentration of CO_2.

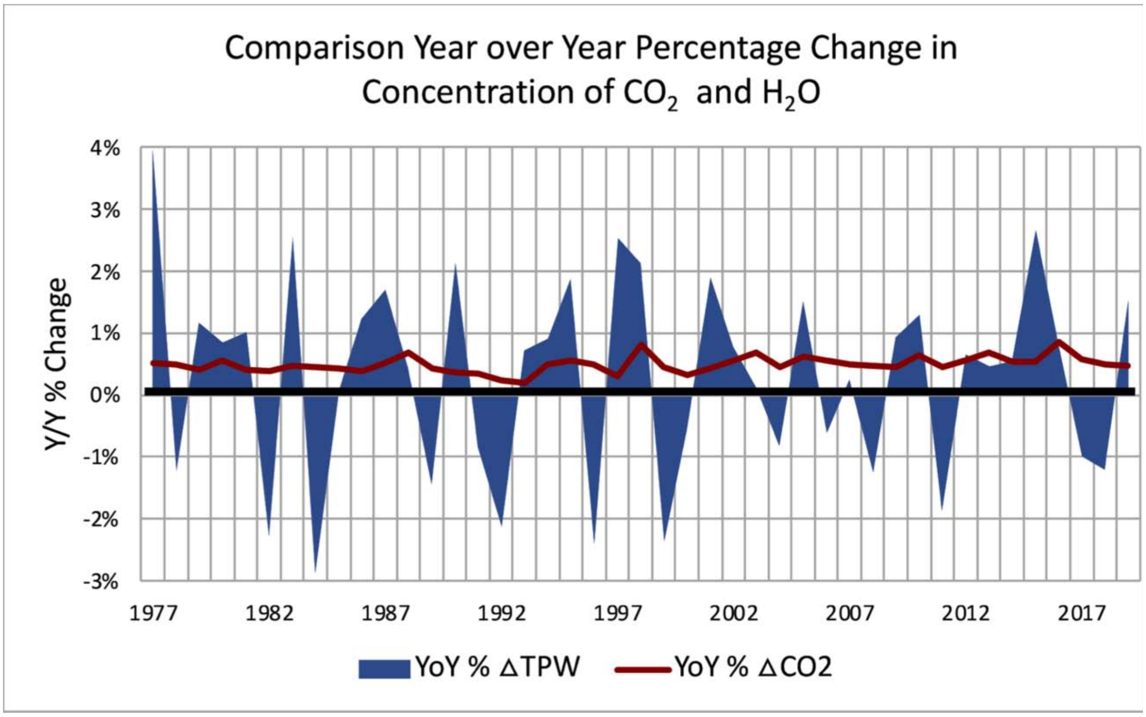


Figure 11: Comparison of year over percentage changes in the global concentration of water vapor, ΔTPW, and carbon dioxide, ΔCO_2

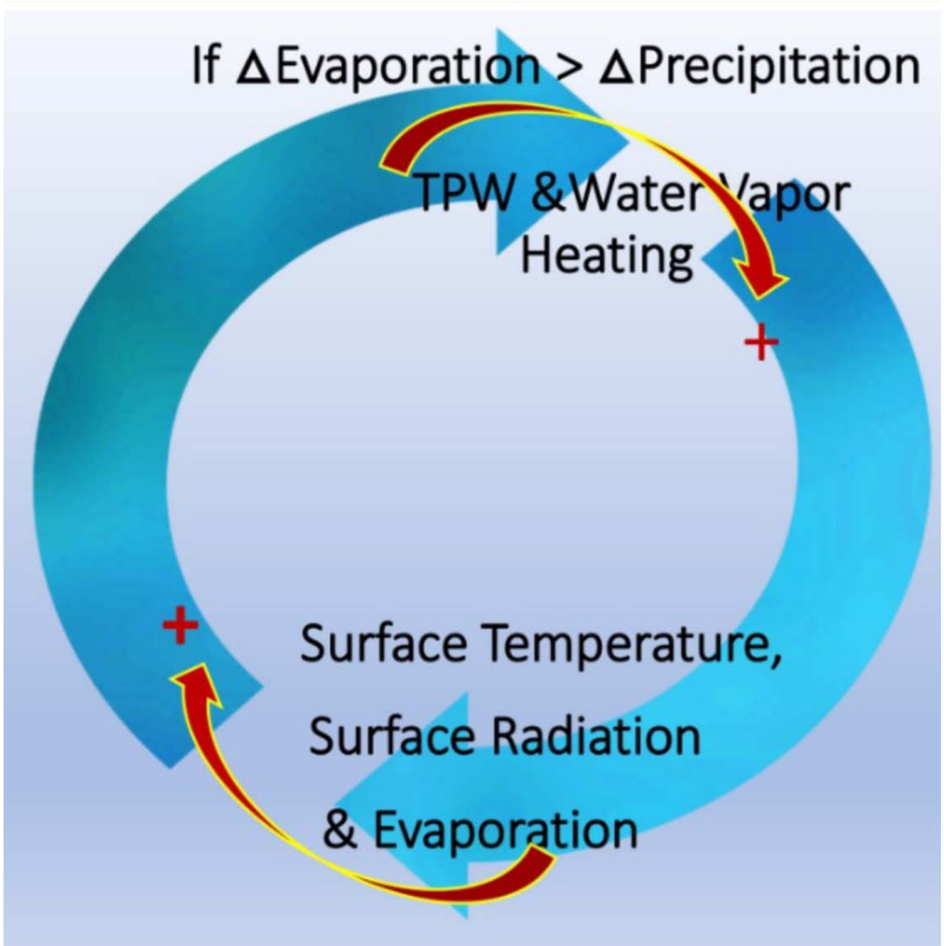
Figure 11 is a comparison of year over percentage changes in changes in the global concentration of CO_2, $\%\Delta CO_2$, shown in red, between 1977 and 2019 and the global concentration of water vapor, $\%\Delta TPW$, shown in blue, calculated in accordance with Eqn.1, as a function of annual changes in average global total heating and average global sea surface temperature. There is no correlation. The correlation coefficient is 0.21.

In terms of the physics, since 1977, 20% of the yr./yr. changes in the concentration of water vapor were negative while the changes in the concentration of CO_2 were all positive. Increases in the concentration of CO_2 cannot drive reductions in the concentration of water vapor.

On the other hand, when compared to the to the historical temperature record, as shown in Figure 3, the average global temperature determined using Eqns. 1 & 2 has a correlation coefficient of 0.998 with the greatest temperature difference being 0.11°C.

Proof of a theory lies in the data. Here, the match is nearly perfect.

In addition to there being no correlation between changes in the concentration of CO_2 and ENSO effects, changes in the average global concentration of water vapor, changes in the average global concentration of water vapor can arise independently of and not be driven by changes in the concentration of CO_2.



Self-Sustaining Increase in Heating

As shown in this illustration, evaporation and water vapor heating can be in an autonomous, positive feedback loop. As the concentration of water vapor increases, water vapor heating and evaporation increase. If the rate of evaporation exceeds precipitation, the concentration of water vapor increases; on and on.

A characteristic of positive feedback loops is that absent external intervention, they continue. Therefore, to the extent evaporation exceeds precipitation, this continues. Only increases in precipitation, which occur, break this wholly autonomous cycle.

XIII. The Need to Increase Precipitation

In any event and regardless of the cause of the continuing increase in the concentration of water vapor, Eqn. 3 is correct; reductions in the global concentration of water vapor will reduce the rate of increase in the average global temperature and can reverse the increase. A sufficient increase in precipitation will do just that.

But while the above shows the role played by, effects of and the underlying causes in the annual variability in the concentration of water vapor, this has likely gone on for centuries without driving the global warming currently being experienced since 1976. The question is – what is driving this?

The average increases in precipitation are less than the average increases in evaporation, since 1976. Why?

To go from water vapor to the formation of raindrops necessary for precipitation generally requires a catalyst in the form of microscopic aerosol particles or molecules of air ionized by cosmic rays.

When present at an altitude at which the atmospheric temperature is below the dew point, water vapor condenses on these particles/molecules which are referred to as cloud condensing nuclei, CCNs, to form raindrops.

Between 1911 and 1941 the average global temperature increased at a slightly greater rate. This warming trend ceased in 1944, when in 1945, precipitation exceeded evaporation.

Then why wouldn't this repeat?

It might, but there is likely a significant difference between 1944 and the years since 1976 - a diminished concentration of aerosols and a resulting increase in the concentration of water vapor.

Possible causes:

- Clean Air Act - Since the advent of the Clean Air Act in the 70's and similar efforts in Europe, the average concentration of aerosols over land has declined; between 2003 and 2012, by more than 7%, while over the oceans, there was only a slight increase. The result a slight net decline, globally, during this period;[9]
- The incidence of atmospheric penetration of ionizing cosmic rays and resulting cloud condensing ionized air molecules may have also declined.[10]

But whatever the cause of the average global evaporation >average precipitation imbalance since 1976, what should occur is the testing of practical and controllable mechanisms to appropriately increase the atmospheric concentration of iWilliam Van Brunt Page 15 3/17/22) ionized air molecules and ii) environmentally safe aerosol particles, such as ice crystals at the right times in the right locations.

If this is successful, and the average global precipitative rate can be maintained in balance with the average global evaporative rate, increases in the average global temperature will be halted.

Moreover, by driving just a slight increase in annual global precipitation relative to evaporation, the rate of increase in global warming cannot only be reduced, it can be reversed, even to the point of returning the planet to the average global temperatures last seen in the mid-seventies.

If this can be shown to be feasible, the economics would have to be examined, but one advantage is that the location and the periods of operation can be selected. Therefore, the effects can be monitored and controlled.

Between 1976 and 2019, the average global temperature rose by 1.03 °C. To effect this reduction the average global concentration of water vapor would have to be reduced by:

$$\Delta \text{TPW} = 2.5 \text{ x } 1.03 = 2.64 \text{ kg m}^{-2} \text{ or mm m}^{-2}$$

The physics, Eqn. 3, shows that if the average global precipitation can be increased, just slightly, from 985 to 988 mm, which is only 0.3% more than average annual precipitation, or an average increase of 0.008 mm/day, for one year, the concentration of water vapor, thus water vapor heating, will be reduced to the point that the average global temperature will revert to the average global temperature for 1976, 13.5°C. This temperature reduction will be maintained, if, thereafter, the rate of precipitation compared to the rate of evaporation remain or can be kept substantially in balance.

In terms of timing and geography one region that could be considered for increasing precipitation is the ENSO region during El Niño events, which as shown in Figure 9, are the primary drivers of yr./yr. increases in the average global temperature. This has the added benefit of reducing the likelihood of flooding. A global average of 2.9 mm yr.-1,is the equivalent 0.4 m yr.-1 increase in precipitation, for the Enso region, which isroughly equivalent to quarterly precipitation anomalies for major areas within the ENSO region.[11]

XIV. Latent Heating & Major Weather Events

Every year the insurance industry publishes data on losses from natural disasters, worldwide, including major meteorological, climatological and hydrological losses, weather-related losses.

Set out in Figure 13 are the annual numbers of major, natural, catastrophic events.

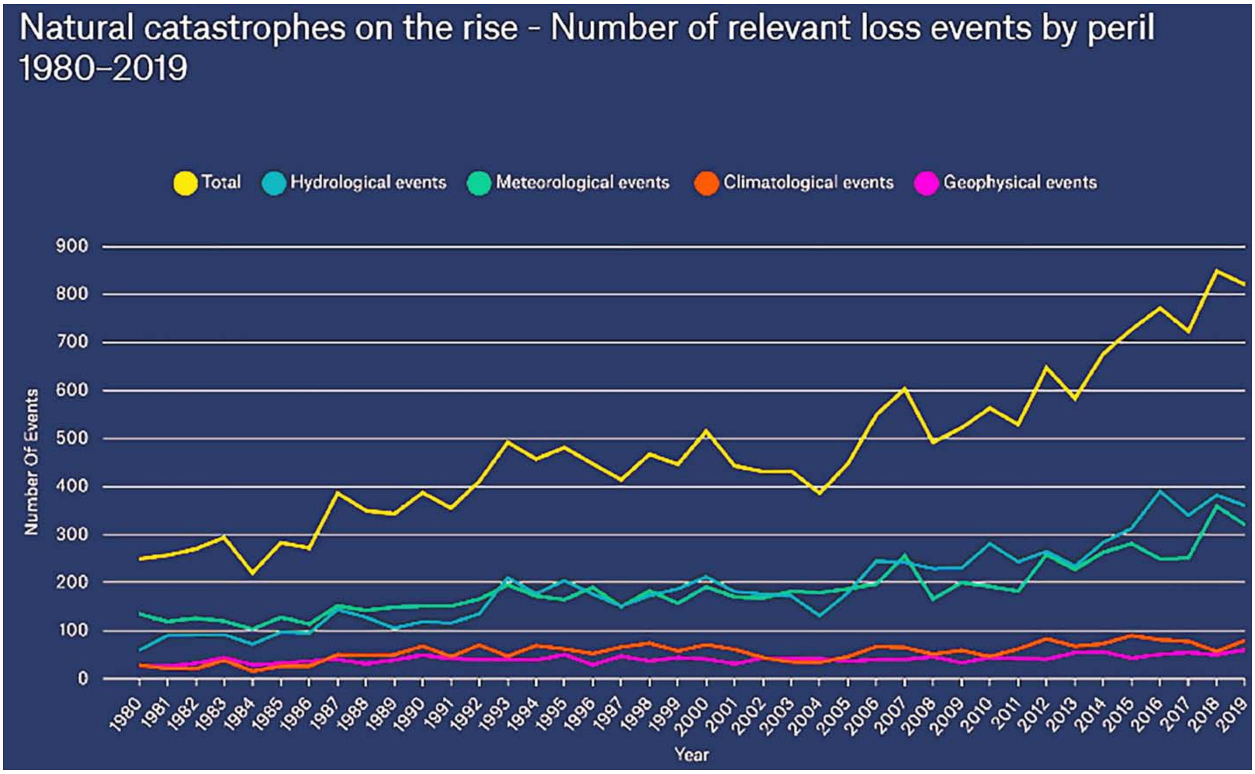


Figure 13: Annual Number and Type of Natural Catastrophes by year 1980 – 2019 [12]

Figure 13, deducting the geophysical events, the annual major weather-related loss event are set out in Table 1A and Figure 14.

Table 1A

Year	No. Major Weather-Related Events
1980	225
1981	250
1982	260
1983	250
1984	180
1985	250
1986	230
1987	250
1988	300
1989	300
1990	340
1991	300
1992	350
1993	450
1994	400
1995	440
1996	450
1997	350
1998	410
1999	390
2000	460
2001	400
2002	370
2003	360
2004	350
2005	400
2006	450

2007	550
2008	450
2009	450
2010	500
2011	520
2012	550
2013	600
2014	550
2015	600
2016	670
2017	725
2018	790
2019	750

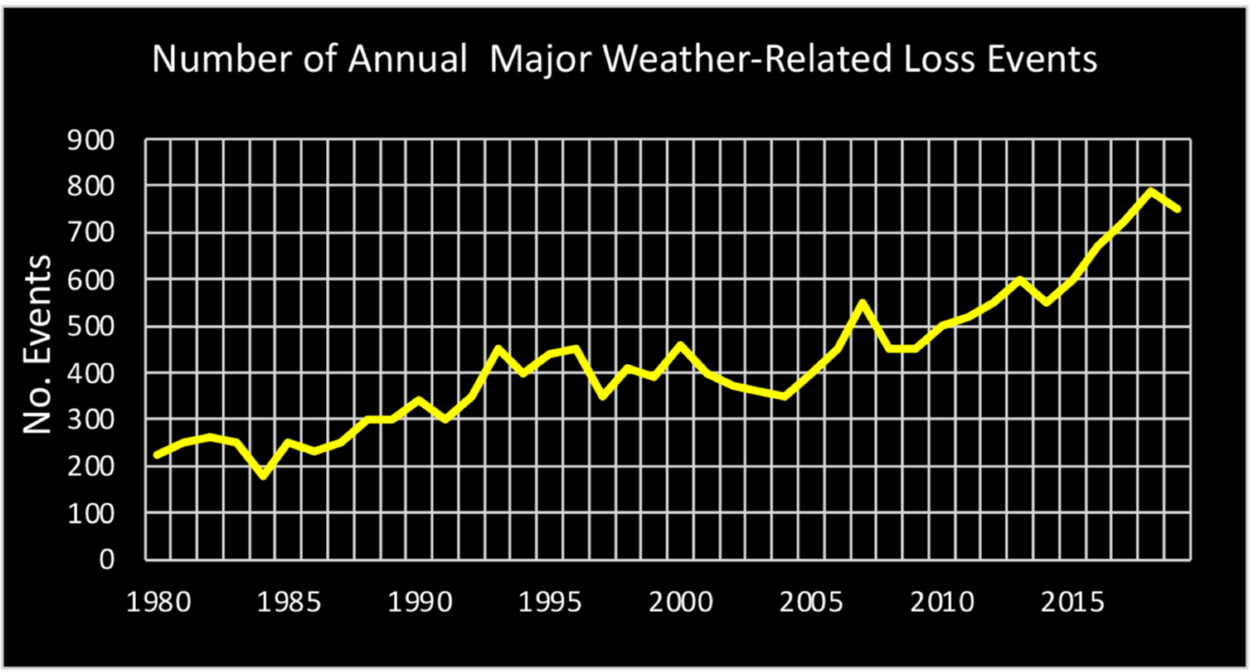


Figure 14: Number of Major Weather-Related Loss Events each Year

In terms of major weather-related losses, global warming is already a calamity, a calamity which continues to increase.

By 2019 major weather-related loss events had more than tripled. That year, there were 575 major weather-related disasters, above the1980, 225 event baseline.

XV. The Data Shows - Global Warming Drives these Catastrophic Storms

While some deny it, much is made, at least anecdotally, about, worsening weather and global warming. This is real and it is driven by the increasing global temperature.

- When water vapor condenses, the energy absorbed as it evaporated is released, heating the surrounding air which causes the moist air to rise and plays a major role in the formation of thunderstorms and cyclonic storms. This energy is termed "latent heat".
- Because it is released upon condensation, the latent heating power of water vapor is proportional to the rate of precipitation. Given that the average global evaporative and precipitative rates are the same and changes in the evaporative rate are proportional to changes in the average global temperature, changes in the average global temperature are used as a proxy for the latent heating rate in Figure 15.

The relationship of changes in average global temperature to major weather-related loss events is shown in Figure 15.

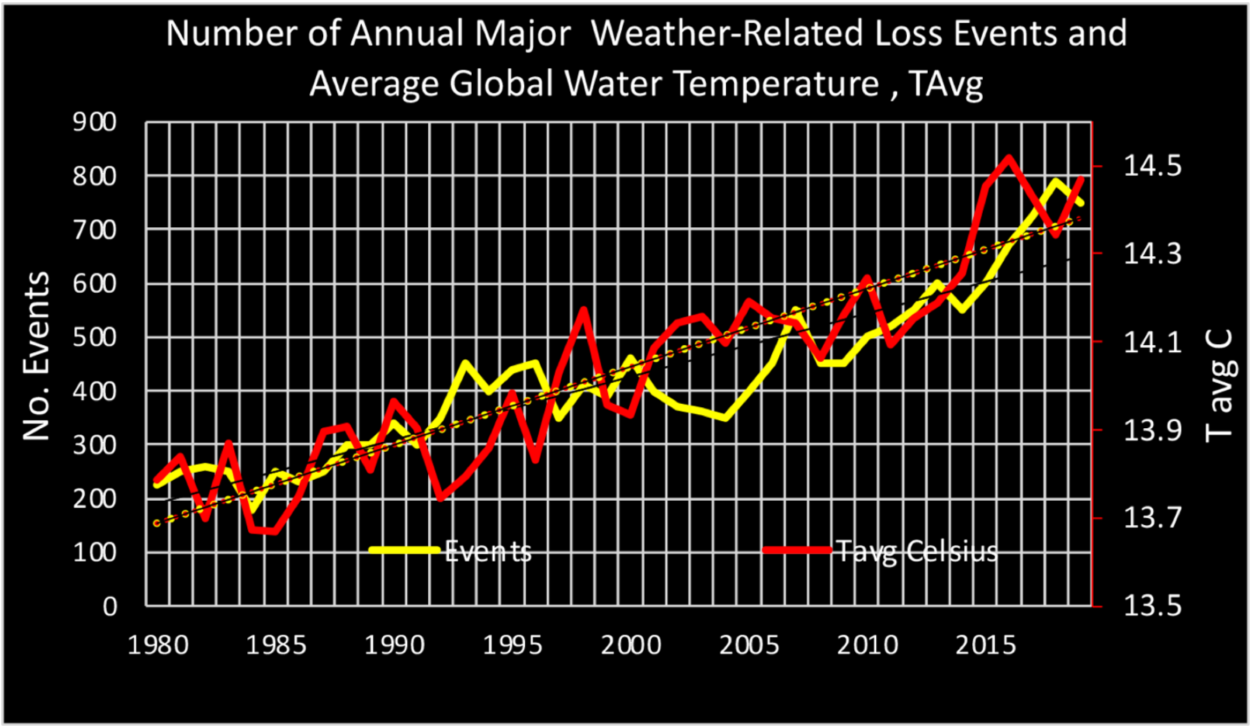


Figure 15: This is Figure 14 with annual loss events shown in yellow and the average global temperature from Figure 1, in red

That the increasing latent heating power is the cause of the growth in catastrophic weather-related events, is shown by the clear correlation between changes in average global temperature in red, and major weather-related loss events in yellow. The correlation coefficient is 0.84.

These increasing major loss events were clearly driven by global warming.

Assuming the loss events in 1980 were not impacted by increases in global warming and taking that as a base, this data shows that for every 0.1°C increase in average global temperature there were roughly an additional 67weather-related loss events.

While the individual events are not global, the damage these major events wreak in a single year has significant and widespread economic impact.

The Munich Re natural disaster loss report [12] shows that from 1980 through 2019, total cumulative economic loss from natural disasters was 5.2 trillion dollars. Averaging this over the estimated total number of events, 17,700 and, subtracting the 2,000 geophysical events, roughly 4.6 trillion of these losses were weather-related. This breaks down to 15,700 weather-related events of which 6,700 were in excess of the 225 event 1980 baseline.

Since 1980, as latent heating increased by 10%, weather-related losses grew at an average rate of \$3.1 billionyr.$^{-1}$. By 2019 the cumulative economic loss from global warming driven catastrophic events above baseline totaled 2.4 trillion dollars.

Not only is the rate of major weather-related loss events increasing, due to the increasing atmospheric latent heating power, the weather can be more severe.

Today, global warming, alone, accounts for loss of lives in the thousands, annually and well over \$100billion dollars in annual economic loss. This crisis is immediate.

Global warming must be reduced, now.

XVI. Solution

- There is no question that greenhouse heating, which continues to increase has already accounted for loss of life in the tens of thousands and damages in the Trillions.
- Knowing the desired reduction in the average global temperature, the goal for the reduction in the global concentration of water vapor can be determined from Eqn. 3.
- This reduction must be monitored and can be achieved by increasing the global precipitative rate to slightly exceed the average global evaporative rate.
- Because changes in latent heating power follow changes in evaporation, reducing the rate of evaporation by reducing the concentration of water vapor and water vapor heating, also reduces the risk of extreme changes in local climate and catastrophic weather.
- Eqn. 3, shows that an increase in the average global rate of precipitation to slightly exceed the average

global evaporative rate, by an average of 0.003 mm d-1 for a year or 1 mm yr-1 will reduce the average global temperature by 0.4 °C, or through an average reduction of 0.0081 mm d^{-1} for a year or 2.9 mm yr^{-1}, the average global temperature will return to the temperatures of the mid-seventies.

- This is the only practicable means of limiting and reversing global warming and reducing the atmospheric latent heating power.

Reducing the atmospheric concentration of the primary greenhouse gas, water vapor, through increasing precipitation to slow the rate of and reverse the increase in the average global temperature must be undertaken.

In Sum: The Solution to Global Warming is Simple make it Rain

Abbreviations and Definition of Terms

Nomenclature

Conv - heating flux that drives thermal convection, Wm^{-2}
ΔT - change in temperature, °C
Eff - heating efficiency - the fraction of total heating remaining after the deduction of evaporative and convective losses, and for the seas, subsurface warming

$$\mathrm{Eff} = 1 - (\mathrm{Evap} + \mathrm{Conv}) / \mathrm{TH}$$

Evap - heating flux absorbed by evaporation, Wm^{-2}
GHG - Greenhouse Gases
IR - Infrared Radiation
NaH - net absorbed heating flux, that fraction of total radiative heating remaining, after deducting the power driving evaporation and convection, Wm^{-2}

$$\mathrm{NaH} = \mathrm{TH} - \mathrm{Evap} - \mathrm{Conv} = \mathrm{Eff} \cdot \mathrm{TH}$$

OLR - Outgoing Long wave Radiation
Power - heating flux per square meter, Wm^{-2}
Ppmv - parts per million, volume
Rad_U - Radiant Emittance, Wm^{-2}
ΔTH_{CO2} - Back-radiation flux solely from CO_2, Wm^{-2}
σ - Stefan–Boltzmann constant, 5.67 x10^{-8} Wm^{-2} K^{-4}
Sol - Heating flux from solar radiation, Wm^{-2}
SST - Sea Surface Temperature
T - absolute temperature, K
TH - total radiative heating flux, including WV, Wm^{-2}
WV - total heating flux from water vapor feedback effect, Wm^{-2}

Subscripts
Avg - average global
CO_2 - indicates a factor driven solely by CO_2
ENSO - Eastern Equatorial Pacific El Niño-Southern Oscillation, "ENSO" region (5°N–5°S, 170°–90°W)
L - land
N - new
o - original or initial
O - ocean
Tot - total
U - up
WV - water vapor

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Appendix

Geo-Engineering Concepts Put Forward to Reduce Global Warming

These are some of the geo-engineering concepts that have been put forward to address this problem:

- Albedo enhancement. *Increase the reflectiveness of clouds or the land surface so that more of the Sun's heat is reflected into space.*
- Space reflectors. *Block a fraction of sunlight before it reaches the Earth, such as by using trillions of tiny spacecrafts to form a sunshade a million miles from Earth in perfect solar orbit.*
- Stratospheric aerosols. *Introduce small, reflective particles into the upper atmosphere such as sulfur dioxide into the stratosphere to reflect a fraction of the sun's rays back into space.*
- Forestation. *Engage in a global-scale tree planting effort.*
- Biochar. *Instead of burning it, "Char" biomass and bury it so that its carbon is locked up in the soil.*
- Ambient Air Capture. *Build large machines that can remove carbon dioxide directly from ambient air and store it elsewhere.*
- Ocean Fertilization. *Fertilize the oceans, with iron for example, to encourage the growth of marine phytoplankton that would pull carbon out of the atmosphere.*
- Enhanced Weathering. *Expose large quantities of minerals that will react with carbon dioxide in the atmosphere and store the resulting compound in the ocean or soil.*
- Ocean Alkalinity Enhancement. *Grind up, disperse, and dissolve rocks such as limestone, silicates, or calcium hydroxide in the ocean to increase its ability to store carbon.*

If workable, to be effective in the near term, these projects would likely have to be massive, difficult of control and not easily terminated.