CO2 Plant Transpiration Reduction Is a 9.1 factor Larger Global Warming Driver than CO2 GHG. Solution: Increase Ocean Evaporation (<4% of CO2 Reduction Cost)

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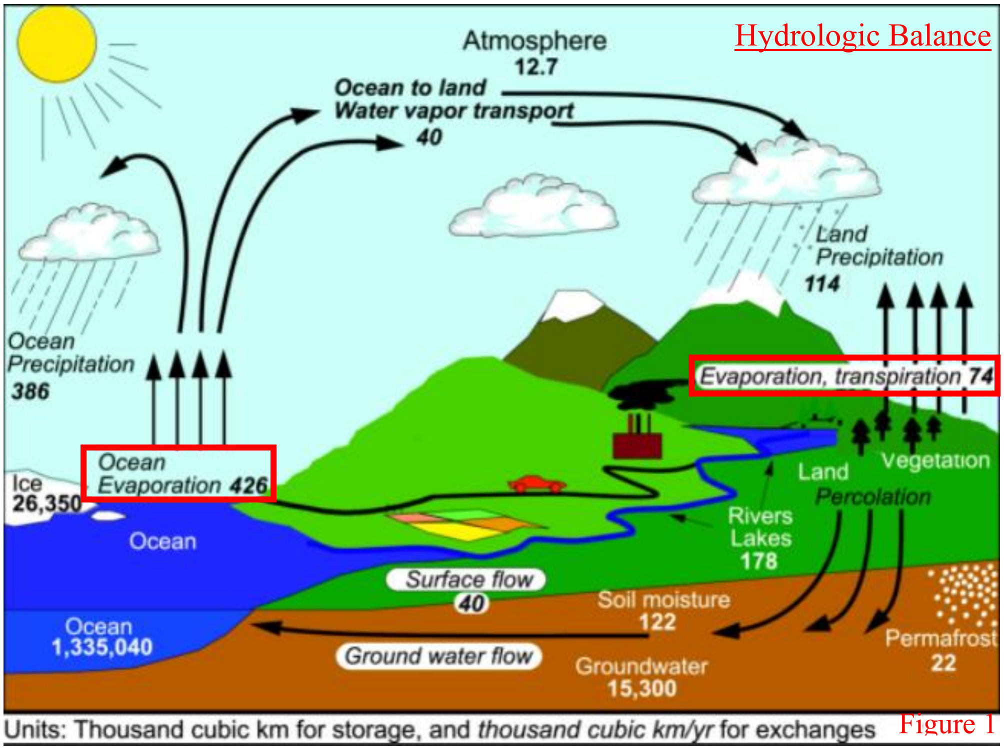


Figure 1

Abstract- Anthropogenic Global Warming (AGW) is real, is anthropogenic (man-made), and is caused by increasing CO2. However, it is not driven by the prevailing CO2 Greenhouse Gas (GHG) theory, but rather by a much larger CO2 induced Plant Transpiration Reduction (PTR). This PTR is caused by increased plant Water Use Efficiency (WUE, consensus science), is driven by increased atmospheric CO2 concentrations, and is a 9.1 factor larger AGW driver than the CO2 GHG theory. In summary, "**CO2 PTR drives AGW, not CO2 GHG**". The ocean evaporation solution proposed below costs <4% of the prevailing Carbon Capture & Storage (CCS) solutions and is only ~2% of the US federal budget and may be the paper's best contribution. This paper uses only consensus scientific data, facts, and diagrams from CO2 GHG proponent sites such as the IPCC (Intergovernmental Panel on Climate Change), NASA, NOAA (National Oceanic and Atmospheric Agency), and the IEA (International Energy Agency) to make all the calculations presented. Our paper is solely calculations and explanations, with no new data or theory (including WUE). Our calculations dictate our conclusions. Our quantitative evidence that PTR drives AGW vs CO2 GHG follows:

1. Using the NOAA solar energy balance (Figure 3, page 7), the CO2 PTR radiative energy imbalance (watts/m^2) is a 9.1 factor larger than the IPCC CO2 GHG theory energy imbalance (per Section 2 calculations). These calculations prove that CO2 PTR is a larger AGW driver than CO2 GHG. This quantitative comparison between PTR science and CO2 GHG theory is this engineering paper's most compelling calculation. Explaining this large PTR impact on surface temperatures- The energy balance on Figure 3 quantifies that 51% of the sun energy reaching the earth is removed by evaporation (Latent Heat) or reflected / absorbed by clouds (produced by that same evaporation), thus transporting that 51% sun energy back to the troposphere for subsequent radiation to space.
2. The prevailing CO2 GHG theory that a small 131 ppm CO2 increase caused a 1.1 °C temperature rise (since 1880) is not quantifiable. The Stefan–Boltzmann law of thermal radiation (assuming no feedbacks) calculates only <u>0.47°C</u> AGW vs an actual of <u>1.1°C</u> AGW

(by CO_2 increasing from 290 ppm in 1880 to 421 ppm in 2023), per page 8, calculation #3. The GHG theory needs >doubling from feedbacks (contradicts equilibrium science) to generate the temperature rise. However, that same 45% CO_2 increase (1880 to 2023) increased photosynthesis, plant WUE, and PTR which quantitatively drove the measured 1.1 °C increase per Section 2 calculations.

3. Using the published IPCC Climate Sensitivity Factor, PTR generates a temperature rise 7 times the actual measured temperature rise per Section 2, #2, page 7 calculations. In explanation, the IPCC tries to force a large temperature increase from a small GHG energy imbalance.
4. The above PTR explains the surprising global relative humidity decline (published in 2020) and particularly the more severe land relative humidity decline. Both declines were more than predicted by IPCC Global Circulation Models (GCMs) per Section 3.
5. Solar elliptical cycles drove the 800k year geologic correlation between CO_2 and temperature, not CO_2 GHG. As calculated in Section 4, the solar elliptical cycles increased temperatures by 10°C, which caused a 35% ocean CO_2 solubility decrease, which resulted in the measured atmospheric CO_2 increase from 180 to 280ppm. Conversely, using the IPCC's max factor, CO_2 GHG contributed only 17% of that 10°C temperature rise.
6. The PTR / WUE impact on global warming is measured in real life at many locations such as city centers proven 1-3 °C warmer than the surrounding suburbs or countryside. Additionally, the air is 4-5 °C cooler in a forest vs under a shed over a concrete parking lot. Conversely, the CO_2 GHG theory uses empirically based GHG modelling (without using the actual GHG parameters) and the temperature impact cannot be replicated in a lab. Additionally, the net effect on air temperature cannot be quantified on a small 1 km^2 block of atmosphere, much less on a global scale. Although CO_2 GHG theory contributes to AGW, it is not the primary driver.

This novel PTR science provides a quantitative explanation for the AGW since 1880 that fits all the scientific data: the 2 different temperature / CO_2 historic correlations of Section 5, relative humidity decreases of Section 3, carbon source for CO_2 of Section 6, energy balances, hydrologic balances, carbon mass balances, thermodynamics, chemical reaction kinetics for the photosynthesis reaction, etc. All the engineering calculations presented are **quantified facts** based on IPCC data and science. Conversely, the CO_2 GHG **theory** does not fit the 2 distinctly different CO_2 / temperature correlations (geological and more recent 143 years, per Section 5). CO_2 GHG theory is proven science and contributes to AGW, just not as big an AGW driver as PTR, the main driver.

Our paper is a quantitative determination of the primary cause of AGW. The paper focuses on engineering calculations, versus the hereto date presentation of GHG data and theories. The authors calculated the energy imbalance and surface temperature impacts using only peer-reviewed IPCC scientific data, and summarized these facts into a logical, step by step, quantified explanation. This fresh chemical engineering perspective from a high-altitude sheds new quantified insights on the old global warming debate. These engineering calculations identify a new root cause of AGW, revealing a much more cost-effective and greener solution (a potential paradigm shift).

Burning fossil fuels creates CO_2 which causes AGW but also significantly enhances plant growth. This paper details a new, practical, and green solution versus the prevailing plans to reduce fossil fuel consumption or sequestrate CO_2. Per Section 4, the implementation advantages of ocean evaporation over the prevailing, impractical CO_2 emission reduction plans follow:

1. Ocean evaporation uses commercially proven, reliable, green technology that is substantially more cost effective and practical: <4% of the current CO_2 GHG solutions and only ~2% of the US federal budget.

2. Other advantages- Higher implementation success probability, simpler, practical, uses existing technology, more environmentally friendly, and probably reduces extreme weather events.
3. The proposed CO_2 fossil fuel emission reduction plans primarily focuses on reducing the current 8% CO_2 emissions driver, while completely ignoring the 92% plant biomass CO_2 driver. Conversely, our Section 4, "increased ocean evaporation solution" increases that 92%, green photosynthesis driver.

Prior to implementing any solutions to the current AGW problem, we must identify, quantify, and confirm the root causes, their magnitudes, and costs. Then, practical solutions become clearer and more cost effective.

Table of Contents:

1. The CO_2 Plant WUE / PTR Generates a 0.11%/year Evaporation Reduction (ER)

Figure 2

Photosynthesis and Transpiration Background

Plants are the source of life: generating O_2 to breathe, increasing evaporation (cooling the earth), consuming atmospheric CO_2, and transforming sunlight into food. Plants made Earth habitable vs other planets by converting CO_2 to O_2. All our existing O_2 is attributable to plants. Without plants, the Earth's atmosphere would be dryer, hotter, and with more extremes (between night / day and between seasons). Photosynthesis is how plants grow, reproduce, generate O_2, and reduce CO_2 in our atmosphere.

Photosynthesis Defined- The photosynthesis chemical reaction is commonly written as:

$$6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

This means that the reactants, six carbon dioxide molecules and six water molecules, are converted by light energy captured by chlorophyll (implied by the arrow) into a sugar molecule and six oxygen molecules, the products. In summary, green leaves convert sunlight to sugars thus providing food, fiber, and fuel, while replacing carbon dioxide in the air with oxygen. Take-away- CO_2 is one of the reactants and carbon uptake is one of the products.

Plant transpiration converts sun energy to water vaporization. Plant transpiration is the uptake of water at the roots, transport of water through plant tissues, and release of water vapor into the air by leaf stomata. Transpiration is the plant "blood system" bringing nutrients up from the soil and "sweating" out water vapor. Almost all water evaporation over land is from plant evapotranspiration. A large oak tree will transpire 40,000 gallons per year.

Evapotranspiration & WUE Definitions

Plant Evapotranspiration (E) defined- Per Wikipedia and Cheng et al, Total Plant Evapotranspiration (E) is the sum of plant transpiration (Et) + evaporation from soil surface (Es) + evaporation from canopy interception (Ei). Transpiration (Et) is the only productive photosynthesis usage.

$$E = E_t + E_s + E_i$$

Plant Water Use Efficiency (WUE) defined- WUE is the terrestrial carbon uptake (vegetative organic mass) produced by the plant divided by the total plant water use (plant evapotranspiration, E above).

WUE = carbon uptake mass / E

Typical units are: mg Carbon / millimeter water rainfall / year, abbreviated as mg C / mm / year.

Scientific consensus (including the IPCC) is that WUE has increased significantly due to higher atmospheric CO2 (ppm) and is very beneficial to both plants and humans. CO2Science.org, Subject Index, Water Use Efficiency summarizes 139 scientific studies documenting WUE increases: 17- global, 43- agricultural species, 4- desert species, 122- grassland species and 63- trees. By consensus, botanical science confirms increasing CO2 increases WUE and decreases plant evapotranspiration.

WUE increases are driven by CO2 increases per chemical reaction kinetics. Photosynthesis chemical reaction kinetics follow: CO2 (a reactant) concentration steadily increased by a factor of 1.35 (1958 = 312 ppm to 2023 = 421 ppm per Figure 12 on page 19) pushing the above photosynthesis chemical reaction to the right. Consequently, less water (the other reactant) is needed for the same photosynthesis reaction rate. (For more reaction kinetics details, rate equations due to concentration changes are documented at: Libre Texts, Chemistry, Chemical Reaction Kinetics, 14.3: Effect of Concentration on Reaction Rates, Rate Law.) Physically inside the plant leaves, the stomata close with higher CO2, reducing water transpiration to the atmosphere (PTR).

WUE Calculations

1. Cheng measured global plant WUE increases generated a 0.70%/year* plant transpiration reduction from 1982 to 2011. Per Cheng et al. (2017) from CO2science.org, (full article in Nature journal), WUE "increased at a mean rate of 0.7% per year from 1982 to 2011", or 21% over 30 years. Ten researchers used a combination of ground-based and remotely sensed land and atmospheric observations (229 site-years) to then calculate changes in water use efficiency (WUE), evapotranspiration (E), and Gross Primary Production (GPP or carbon uptake) over the period 1982 to 2011. (Per the Carbon Mass Balance, Figure 13, page 21, Deforestation and Land Use Change, plant biomass is actually decreasing globally by 1.0 GtC/year, not increasing, a less green planet. Also, per a 2011 biomass census compiled by Vaclav Smil, human activity has reduced global biomass.) Similarly, Li *et al.* (2017), utilized globally-distributed databases to calculate a 21.5 percent WUE increase over 50 years. Cheng WUE increase was chosen over >100 other WUE articles due to the largest site-years of data and greater plant diversity- basically more measurements over a longer period.

Optional Reading Notations-

*Equation: Measured 21% WUE increase / 30 years = 0.70%/year WUE increase.

2. Above 0.70%/year plant evapotranspiration reduction generates a 0.11%/year* ER.

*Inputs- 1. Per an article in American Society for Horticultural Science, 2020, 15% of evaporation is from plant evapotranspiration with 85% evaporation from oceans and surface water. 2. That 15% is further confirmed by the

Hydrologic Balance on page 1: 74 terrestrial evaporation and transpiration / (426 ocean evaporation plus 74 terrestrial evaporation) = 15% from plant evapotranspiration.
Equation: 0.0070/year WUE increase * 0.15 evaporation from evapotranspiration * 100% = **0.11%/year ER**.

WUE & CO2 benefits are scientific consensus per IPCC climatologists and botanists. - Higher atmospheric CO2 promotes plant growth by increasing WUE and promoting the photosynthesis chemical reaction above. Global "greening" from higher CO2 concentrations has been quantified per >60 peer-reviewed botany studies including the below list. However, the smaller plant WUE increase (greening) is globally overridden by the larger deforestation and land use changes, yielding a less green planet per Figure 13, page 21.

1. CO2 Science.org lists 42 peer-reviewed scientific studies on CO2 benefits- 20 on local biomass increases, 19 on photosynthesis increases, and 15 on WUE.
2. 2016 Nature journal article- A positive trend in vegetation greenness over global dry lands is probably caused by higher CO2 which reduces water consumption, yielding soil water increases.
3. 2017 Nature journal article- Plants have been growing at a rate far faster than at any other time in the last 54,000 years. Plants are converting 31 percent more carbon dioxide into organic matter than they were before the Industrial Revolution.
4. 2014 IPCC article- A United Nations IPCC climate scientist, Dr Indur Goklany admits that the rising atmospheric CO2 concentration is currently net beneficial for both humanity and the biosphere by fertilizing plants and increasing crop yields by 10 – 15%.
5. 2019 article- Researchers from the Oak Ridge National Laboratory and the University of California, Irvine admit that the rising CO2 emissions creates a greener world and prevents the worst parts of global warming.
6. 2018 French study- Shows the land greening by vegetation type over the 1999-2015 period: The largest global trend is for coniferous forests (primarily cone bearing evergreen trees) at 4.2%/year, followed by summer crops at 3.9%/year.
7. Per a wryheat.wordpress.com summary and Greenpeace co-founder, Dr. Patrick Moore in a 24 page article, plants die at 80-120 ppm, little growth occurs up to ~180 ppm, struggle at <280 ppm, and optimum is 1000 - 3000 ppm. The current 421 ppm CO2 is geologically low and plants benefit from increasing CO2 at much higher levels.

Further, US Navy submarines typically operate 300 – 11,000 ppm CO2, average 4,100 ppm (compared to only 421 ppm atmospheric CO2 currently). Human breath exhaled contains ~38,000 ppm CO2. Chemically, CO2 is considered almost an inert gas. Increased CO2 "greens" the planet which we all desire. **Conclusion - CO2 is a harmless inert plant food, not a pollutant to be regulated and removed. CO2 is a net benefit to plants and probably humans.**

The effectiveness of plant transpiration reducing local warming is scientifically quantified at many locations around the world:
1. City centers have less plant life and are 1-3°C warmer per Weather.com than the surrounding suburb and rural country areas. The plant life cools the atmosphere by absorbing energy, whereas concrete, buildings, and asphalt are all heat sinks: absorbing sunlight, retaining heat, and eventually releasing that heat to the atmosphere.
2. The air is 4-5 °C cooler in a forest vs under a shed over a concrete parking lot per theconversation.com.
3. The hottest regions on earth are deserts with limited rain and plant life to reduce temperatures through evaporation and transpiration. In conclusion, plant transpiration cooling is readily observed, measured, quantified, and understood.

Summary- This Section calculated that CO2 induced plant Water Use Efficiency (WUE) generated a 0.11%/year ER. CO2 induced plant Water Use Efficiency is consensus IPCC science per the references above. We simply converted WUE into PTR and then into ER.

Next, we will convert the above 0.11%/year ER to an energy imbalance and compare it directly to the CO2 GHG theoretical energy imbalance (watts/m^2).

2. The Above PTR is a 9.1 factor Larger AGW Driver than CO2 GHG

To convert the above 0.11%/year evaporation reduction to temperature rise, we used the IPCC Transient Climate Sensitivity Factor = 0.97 °C/(W/m^2). Wikipedia, Climate Sensitivity (pulling from the most recent IPCC reports) is the best reference from which the following data was derived. The IPCC Climate Sensitivity is defined as a measure of how much the Earth's climate will warm from a doubling in CO2 concentration. In technical terms, climate sensitivity is the average change in the Earth's surface temperature (units of °C) in response to changes in radiative forcing energy, the difference between incoming and outgoing earth energy. The most recent IPCC Sixth Assessment Report estimates: Equilibrium Climate Sensitivity (ECS, requires centuries to see the full impact) is 2.5 – 4.0 °C, best estimate of 3.0 °C. This paper uses the shorter, lower Transient Climate Response (TCR, averaged over a 20-year impact), 1.0 – 2.5 °C, median 1.8 °C. The deep ocean heat sink causes the TCR to be lower than the ECS. Both sensitivities include exacerbating and suppressing climate feedbacks. The large range in climate sensitivity estimates is due entirely to modeling of feedbacks in the climate system, including water vapor, clouds, ice–albedo (light reflection), and lapse rate (temperature decrease with increasing elevation).

Radiative forcing is defined as the imbalance between incoming and outgoing radiation at the top of the atmosphere. Per the latest IPCC Sixth Assessment Report: The radiative forcing caused by a doubling of atmospheric CO2 levels (from the pre-industrial 280 ppm to 560 ppm (year ~2095 at the current rate of fossil fuel emissions) is ~3.7 watts per square meter (W/m2). In the absence of feedbacks, the energy imbalance would eventually result in ~1°C of global warming (projected actual instead of 2.6°C). This undisputed figure is a straightforward calculation using the Stefan–Boltzmann law of thermal radiation. Since centuries are required to see the full impact and our comparison will be only 50 years, we will conservatively* use 3.7 / 2 = **1.85 W/m^2 radiative imbalance** in calculation #1 below. Radiative forcing can be caused by any energy imbalance: increased greenhouse effect per the IPCC GHG hypothesis, water evaporation reduction (PTR, our theory), solar radiation due to planetary orbit changes, solar irradiance changes, effects of aerosols, albedo (fraction of light reflected by a surface), energy reflected due to cloud cover, loss of reflective ice cover, changes in land use and deforestation, etc. Dividing the **Transient Climate Response (TCR)** median of 1.8 ^{O}C by the 1.85 W/m^2 radiative forcing yields our **TCR = 0.97 °C/(W/m^2)**. This IPCC TCR factor is the only scientifically accepted method to convert energy watts/m^2 to ^{o}C temperature rise that includes all feedbacks.

In conclusion, this lengthy discussion has 2 take-aways: 1. The 1.85 W/m^2 radiative imbalance from CO2 GHG doubling is compared to our PTR W/m^2 in calculation #1. 2. The TCR = 0.97 °C/(W/m^2) is used to calculate the below IPCC temperature rise as a result of our Section 1 PTR in calculation #2. The 1.85 W/m2 energy imbalance is an undisputed calculation, which will be our direct comparison. However, the Temperature Response is empirical and thus has a wide, changing range and is not our primary comparison.

The Radiative Imbalance (RI) and Transient Climate Response (TCR) are extremely technical terms with books written on the subject. The GHG effect on RI translates to watts/m^2 (energy per surface area). TCR translates to ^{o}C temperature increase from that given RI energy. In simpler terms, the GHG effect increases the energy retained (imbalance) which then increases atmospheric temperatures.

*Conservative Selection- Since centuries are required to see the full impact and our comparison will be only 50 years, one could argue that the reduction should be a 4 factor, rather than the conservatively selected 2 factor reduction.

Feedbacks- Both CO2 GHG and PTR science have positive and negative feedbacks. Per the IPCC latest report summarized in Wikipedia: "In the absence of feedbacks, the energy imbalance would eventually result in roughly 1 °C of global warming", rather than the TCR above of 1.8 °C. Consequently, feedbacks are assumed by the IPCC to increase the TCR by a 1.8 factor. Conversely, the primary PTR feedback is cloud cover reduction, hugely positive since 27% of the sun energy is reflected or absorbed by clouds, while 24% is absorbed by evaporation (Figure 3, page7). To be consistent, feedbacks are not included in either of the following calculations comparing W/m^2 for PTR or CO2 GHG.

NOAA Energy Balance- The 2010 energy balance in Figure 3 below from the National Oceanic & Atmospheric Administration is the most complete and updated balance between incoming energy from the sun and outgoing energy leaving earth. The chart uses 100 units of energy from the sun as the baseline (100 units = 341.3 watts / m^2) transmitted as shortwave light and ultraviolet energy. When energy reaches the Earth, some energy is reflected back to space by clouds, some is absorbed by the atmosphere, and some is absorbed at the Earth's surface. To balance, an equal 100 units of energy must also be emitted to space to maintain our relatively stable temperature and climate. Energy absorption by the atmosphere stores more energy near its surface than it would if there was no atmosphere. For example, the average surface temperature of the moon (which has no atmosphere) is -18°C. By contrast, the average surface temperature of the Earth is 13.9°C. This heat absorption is called the "greenhouse effect" and is beneficial and necessary for biologic life. Radiant heat (thermal radiation) is emitted by all materials (solids, liquids, and gases) above absolute zero.

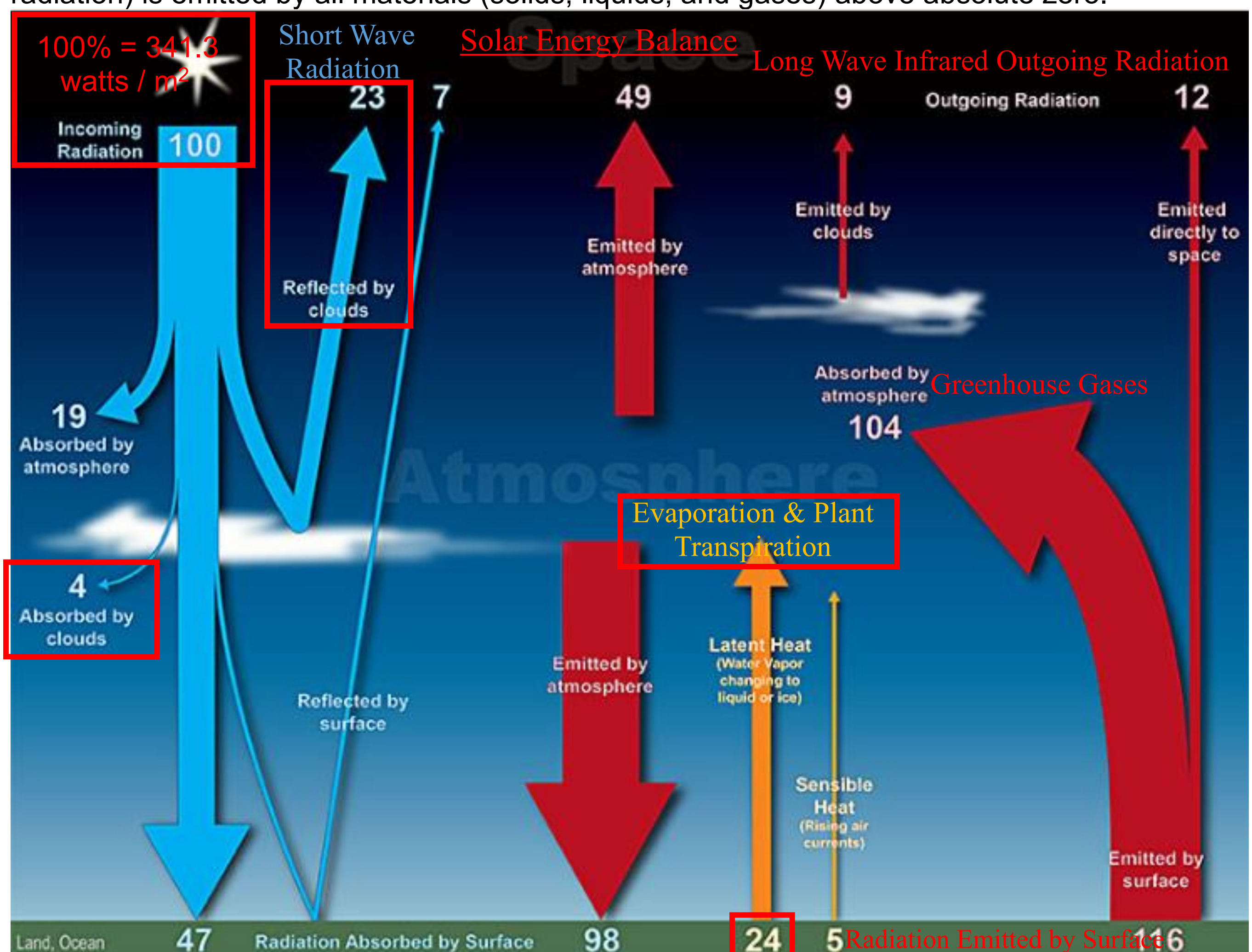


Figure 3

Evaporation Reduction (ER) Calculations:

1. The above 0.11%/year ER is a 9.1 factor* larger AGW driver (W/m^2) than CO_2 GHG theory. Conclusion- Using only IPCC GHG proponent data, this 9.1 factor comparison means PTR drives AGW, not CO_2 GHG.

***Inputs-** Per the energy balance chart above, evaporation and plant transpiration account for 24% of that 100 units of sun energy (100% = [341.3 watts/m^2]). Per above from the IPCC, the radiative forcing caused by a doubling of atmospheric CO_2 levels is conservatively 1.85 watts per square meter (W/m^2) for our 50-year period. Over the same 50-year period as our WUE / PTR data, using Figure 12 on page 19, the CO_2 ppm only increased from 325ppm in 1970 to 412ppm in 2020 (not doubled).

Equation: 0.0011 ER/year * 50 years * 0.24 evaporation * 341.3 watts/m^2 sun energy / (1.85 W/m^2) from CO_2 doubling / (412-325 ppm) * 325 ppm = **9.1 factor** larger AGW driver than CO_2 GHG theory.

2. The above 0.11%/year ER generates a calculated temperature rise 6.5 times* the actual measured temperature rise, using the IPCC Transient Climate Response factor. The above measured 0.11%/year ER since 1970 generates a 0.054 °C / year temperature increase, a 6.5 factor** larger than the measured temperature rise. The similar 6.5 factor high compared to above #1, 9.1 factor further corroborates calculations #1 and #2.

***Inputs-** In a similar calculation to #1 above, use the IPCC Transient Climate Response (TCR) = 0.97 °C/(W/m^2) from the prior page. Per Figure 12 on page 19, the measured temperature rise since 1958 is only 0.88 °C over 65 years = 0.0135 °C / year.

Equation: 0.0011 ER/year * 0.24 evaporation * 341.3 watts/m^2 sun energy * 0.97 °C/(W/m^2) = 0.087 °C/year from ER / 0.0135 °C/year measured = **6.5 factor**.

**Explaining the above 6.5 factor high, clearly the IPCC Transient Climate Response factor is a 6.5 factor too large because the IPCC tried to force a large temperature response from a relatively small CO_2 GHG energy imbalance (rather than the larger PTR energy). The IPCC Transient Climate Response factor should be lowered by a 6.5 factor from 0.51 to 0.08°C/(W/m2). Per Warwick Hughes and Douglas Hoyt (climatologist and solar physicist) empirical determinations using only atmospheric gas properties estimate climate sensitivity to be 0.07 to 0.26, right at our above 0.08°C/(W/m2).

3. **The Stefan–Boltzmann law of thermal radiation (assuming no feedbacks) calculates only <u>0.47°C</u> AGW vs an actual of <u>1.1°C</u> AGW (by CO_2 increasing from 290ppm in 1880 to 421ppm in 2023).** The GHG theory needs >doubling from feedbacks to generate the temperature rise, unlike PTR. That >doubling of positive feedbacks contradicts the laws of equilibrium. Mother Nature and science generally produces net negative (decelerating) feedbacks.

*Inputs- Per the Stefan–Boltzmann law (page 6 reference), the radiative forcing caused by a doubling of CO_2 from 280 ppm to 560 ppm generates **1.0°C** warming, in the absence of feedbacks. The following °C and ppm deltas were generated by combining Figures 11 & 12 on pages 18 and 19: 1880: 290 ppm, -0.5°C and 2023: 421 ppm, +0.6°C.

Equation: (421 -290) ppm / (560 – 280) ppm * 1.0°C = **0.47°C**. Actual rise = 0.6°C – (-0.5°C) = **1.1°C**.

Plant WUE is not included in GCM climate models, but should be. From a literature review, IPCC Global Circulation Models (GCMs) do not include the impact of plant WUE on transpiration. The only "plant WUE and transpiration" references in IPCC documents discusses the impact WUE has on droughts, land cover changes, biomass, and crop yields. The most relevant IPCC discussion of WUE and plant transpiration is a 2001 Working Group, but again focuses on the WUE impact possibly being offset by biomass increase: "increased plant growth, compensating for increased WUE". Per the Carbon Mass Balance, Figure 13, page 21, Deforestation and Land Use Change, plant biomass is actually decreasing globally by 1.0 GtC/year (IPCC and scientific consensus). Also, per a 2011 biomass census compiled by Vaclav Smil, human activity has reduced global biomass. The WUE increase results in global PTR and warming. The IPCC limited WUE discussions are accurate, but the **IPCC does not recognize or calculate the impact WUE has on transpiration and global warming** as done in our Sections 1 and 2. The authors do not have access to any GCM, but would work with any climatologist willing to model the WUE impact. Including our WUE data into GCM models will be relatively straight forward and will significantly improve the model accuracy of all parameters including humidity and evaporation.

IPCC researchers are coming to the same conclusion: Per a 2010 Long Cao journal article: "Our study points to an emerging consensus that the physiological effects of increasing atmospheric CO2 on land plants will increase global warming beyond that caused by the radiative effects of CO2." Cao derived such from a modified NCAR model, ours from the above calculations. However, both reach the same conclusion. No literature exists arguing against our emerging consensus that: CO2 PTR drives AGW, not CO2 GHG.

Summary- The above calculations show the PTR energy imbalance (watts/m^2) is a 9.1 factor higher than calculated for the IPCC CO2 GHG theory. Meaning **PTR** directly and quantitatively drove the measured surface air temperature rise since 1970, not CO2 GHG.

Next, we will show that our Section 1, 0.11%/year ER calculation explains the measured 0.005%/year global relative humidity reduction below.

3. The Above PTR Explains the Global Relative Humidity Decline Below, more than GCM Predictions

Figure 4 relative humidity chart below is from the Met Office, London (Great Britain's equivalent of our NOAA) showing land, ocean, and a blended global relative humidity, all at the surface (1.0 bars), from 1971 to 2020, plotting % difference from a 1981 – 2010 average. **Conclusion-** The chart shows a decreasing surface blended relative humidity from 1971 to 2020 of 0.25%, calculating 0.25% / 50 years = 0.005%/year relative humidity reduction.

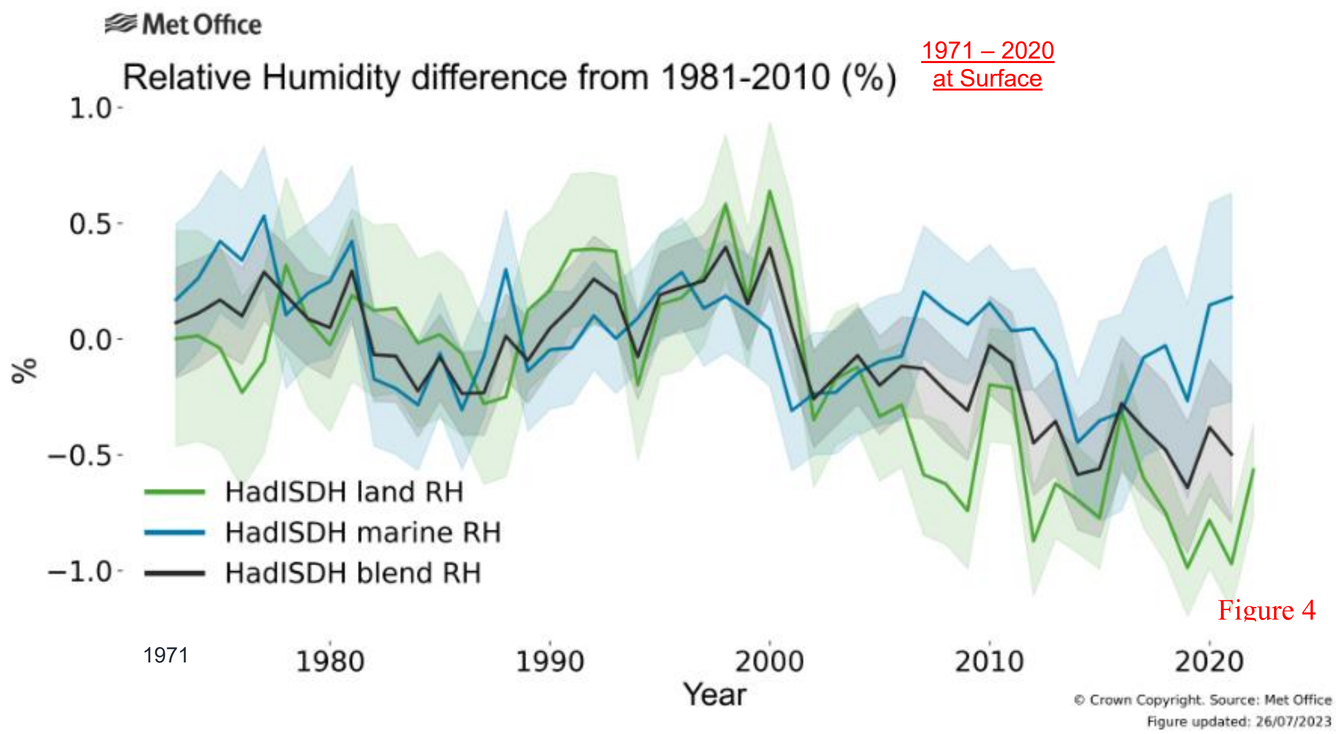


Figure 4

Annual mean relative humidity anomalies (relative to 1981-2010) from 70°S-70°N.

The above global relative humidity decline is more than previously predicted by climate models:

1. Proceedings of the National Academy of Sciences (PNAS)- April, 2018. "Climate models predict that… relative humidity will decline over land but remain approximately constant over oceans". Also, from vapor pressure science, ocean surface relative humidity should

remain approximately constant with increasing temperatures, given the vast ocean surface and unlimited water evaporation capacity. The above measured ocean humidity (data published August, 2020) actually declined.

2. Carbon Brief- December, 2020. "The decrease in relative humidity over land is really interesting. We do not see the same decrease in historical reconstructions from climate models." In other words, the decrease in land RH is more than expected from climate models, probably due to WUE / PTR (not included in climate models).
3. Theoretically, as global temperatures increase, global surface relative humidity should stay flat or increase very slightly*, not decrease per above.

*Consider the extremes: The warm tropics tend to have the highest relative humidity with the cold Antarctic the lowest. Per the globe map at WeatherSpark.com, the highest relative humidity locations are closer to the tropics (warmer) and the lowest relative humidity locations are closer to the poles, particularly the South Pole. The highest relative humidity is Patna, northwest India, land locked, with a median of 99.2% humidity. Alternatively, per Discoveringantarctica.org, the South pole has the lowest relative humidity reaching as low 0.03%, a polar desert. Annual precipitation is <50mm rain equivalent. Also, relative humidity theoretically approaches 100% at boiling temperatures, considering the vast oceans.

Conclusion- The greater than modeled relative humidity decline is best explained by plant transpiration reduction (not included in the GCM climate models). Also, the above larger-than-expected land relative humidity decline (per #2 above) is also explained by PTR

Global Precipitation Increase Does Not Contradict PTR- A 2022 US Environmental Protection Agency (EPA) study determined that global precipitation is increasing slightly over the past century, calculated below at 0.010% increase per year*. Per the Hydrologic Balance on page 1, precipitation = evaporation. The ocean evaporation increase over rode our Section 1 land transpiration decrease, since 85% of evaporation is from the oceans. However, the small precipitation increase is lower than theoretically expected from the temperature rise, based on the above global relative humidity decrease.

*A 2022 EPA Study showed a worldwide precipitation increase of "0.04 inches per decade" from 1901 - 2022. The data source was the National Oceanic and Atmospheric Administration's (NOAA's), National Centers for Environmental Information. This EPA precipitation increase does not contradict the relative humidity decrease because surface relative humidity is an independent measurement from precipitation. Per Wikipedia, Earth rainfall, the global average annual precipitation is 39 inches per year, yielding an increase of 0.04" / 10 years / 39" per year median = **0.010% /year increase,** very slight. Our Section 1, **0.11%/year ER from plant transpiration is a factor 11 higher**. Increased ocean evaporation over rode the decreased land evaporation (PTR) yielding an overall evaporation / precipitation slight increase. However, global temperatures still increased due to more radiant heat to atmosphere from the hotter land surface temperatures.

Our paper agrees that global precipitation / evaporation increased slightly over the last century per the EPA study above. However, plant transpiration over land has declined, causing an energy imbalance, yielding global warming over the land where humans reside. Specifically, the surface temperature impact from plant transpiration reduction over land (factor 11 higher* than the global evaporation increase) more than offsets the slight global evaporation / precipitation increases, resulting in overall global warming at the surface (even though overall evaporation increased).

Said quantitatively below*, large surface temperature increases over land (from transpiration reduction) over rode the much smaller ocean temperature decrease impact (due to increased ocean evaporation). This math is possible because 29% of the global surface is land, whereas only 15% of evaporation is from land. The footnote below calculates that temperature increase factor.

*****Inputs- Per the United States Geological Survey (USGS), 71% of the earth's surface is water-covered, with 29% land. Per the Hydrologic Balance on page 1, evaporation is 85% from ocean evaporation, with 15% from plant transpiration. Per page 7, calculation #1, transpiration decrease over land from WUE is 0.70%/year. Per footnote above, the evaporation / precipitation increase globally is 0.010%/year

2 Equations: 1. Required ocean evaporation increase: (0.010%/year, global evaporation increase + 0.70%/year, transpiration decrease over land * 0.15 land evaporation portion) / (0.85 ocean evaporation portion) = 0.135%/year ocean evaporation increase.

2. Resulting Global temperature increase net factor: (0.70%/year, transpiration decrease over land * 0.29 land surface portion) - (0.135%/year, evaporation increase over ocean * 0.71 ocean surface portion) = 0.11%/year global temperature increase net factor from global evaporation. (Coincidentally the same as our Section 1, 0.11%/year evaporation reduction from PTR).

Per another 9-1-2020 article in Carbon Brief, land is warming faster than the oceans. Our Section 1 **land transpiration reduction also explains this land faster warming**. Ocean surface temperatures do not warm as fast due to cooling from the evaporation increase. The article postulated that lapse rate differences (temperature decrease rate with elevation) between land and water explained the difference dynamically. Their explanation is basically that higher land surface temperature yields more vertical convection over land. Per the above calculations, the smaller temperature decrease rate with elevation over land (versus over oceans) “resulted” from the land warming faster, but did not “cause” the faster warming. Land is warming faster than oceans due to PTR.

The above, small 0.010%/year Evaporation Increase is considered a negative Feedback of PTR (per Section 2, page 6) in comparing the radiative energy balance between CO2 PTR vs GHG. The larger positive clouds Feedback (27% from clouds vs 24% from evaporation per page 11, first paragraph of Section 4) over rides this smaller negative Evaporation Increase feedback. Both PTR and GHG theory have both positive and negative Feedbacks.

This Section 3 charted relative humidity rather than absolute humidity* because relative humidity drives the Hydrologic Balance of Figure 1: precipitation equals evaporation.

***** Surface relative humidity was charted above over absolute humidity (grams of water per cubic meter of air) because relative humidity drives precipitation which drives evaporation and the hydrologic cycle of Figure 1. Absolute humidity admittedly **increased ~3%** due to increased temperature per Climate.gov NOAA chart from 1971 -2012. Conversely, our surface blended relative humidity above **decreased 0.25%** from 1971 to 2020, increasing surface temperatures.

Summary- Our PTR completely explains the unexpected global relative humidity decline, which was more than GCM predictions. The above relative humidity decline further supports our PTR concept.

Next, rather than pursuing the technically and politically challenging and highly expensive CO2 emission reduction plans, we propose researching a significantly less expensive, technically and commercially proven, and greener ocean evaporation solution.

4. Solution: Increase Ocean Evaporation (<4% of Current Solutions Cost)

Figure 5

Water evaporation is a highly concentrated energy storage that is carried from the earth surface to the troposphere and released for radiation to space. The atmospheric water cycle acts similar to a “refrigerant cycle”, carrying energy from the surface to the troposphere: Water absorbs heat (via evaporation) at the warm earth surface, transported (via convection) to the cooler troposphere, releases its energy (via condensation), falls as rain or snow back to the surface (via gravity), and repeats the cycle. The energy balance on Figure 3, page 7 quantifies the energy concentration: Evaporation (Latent Heat) transports 24% of the sun energy to the troposphere for subsequent radiation to space while another 23% is reflected by clouds (resulting from same evaporation) plus 4% absorbed by those same clouds, totaling 51% removal from the surface via the water evaporation cycle. Illustrating the energy density: **The evaporation of 1m^3 of water will cool 2.68 x 10^6 m^3 of air by 1°C***. Evaporation is definitely more energy efficient than any CO2 GHG emission reduction as quantified in Section 2 above. In summary, evaporation (and resultant clouds) is the largest earth surface cooler and should be the focus of any practical AGW solution, not CO2 GHG reduction.

***Inputs for calculation for 1 m^3 water evaporation heating 2.68 x 10^6 m^3 air by 1°C: latent heat of steam = 2257kj/kg, heat capacity of air = 0.700 kj/kg°C, density of water = 999 kg/m^3, density of air = 1.2 kg/m^3. All 4 of these properties are at 0 barG and average global temperature = 13.9°C.

Equation: 1 m^3 water x 999 kg/m^3 x 2257 kj/kg / 0.700 kj/kg°C / 2.68x$10^6$$m^3$ air / 1.2 kg/m^3 = 1°C rise on 2.68 x 10^6 m^3 of air.

Commercial evaporative coolers (swamp coolers) demonstrate this massive evaporative cooling effect. Industrial evaporative coolers have been used for centuries. Reference the below Hydrologic Balance on the next page from the Royal Meteorological Society (originally from our American Meteorological Society, Figure 9). Ocean evaporation at 85% of total evaporation {426 / (426 + 74) = 85%} should be our focus. Ocean evaporation is limited by mass transfer between undersaturated air and liquid water (not by temperature or air saturation). Valuable fresh water should not be evaporated for climate cooling purposes. Alternatively, just planting more trees* is not practical compared to increasing ocean evaporation. Although, planting more trees will certainly help a little.

*Alternative- Planting more trees (to increase evapotranspiration) is not as practical as ocean evaporation. We cannot reasonably plant enough trees to counteract current anthropogenic global warming per quantifications in several studies. Nevertheless, ocean evaporation will help green the planet by producing more precipitation which will increase biomass and further "green" the planet.

Floating ocean evaporators currently do not exist. - The below RWI Resource West Inc. Apex down draft evaporator is used for evaporation of industrial waste water, not oceans. For example, a similar down draft unit could be optimized for ocean applications powered by a solar panel and batteries, rather than the external power shown below. The ocean fogger in the second photo is much less energy efficient than the first photo of the down draft evaporator, but is the same evaporator concept. Thousands should be distributed along dry coastlines, preferably globally. Our purpose is not to design or develop this potential equipment, but to identify a practical, viable alternative global warming solution.

Figure 6

Figure 7

The Section 1, 0.11%/year evaporation reduction is offset by only a 0.13%* ocean evaporation increase and only 14% of worldwide human fresh water consumption. Conclusion- readily achievable.** The hydrologic balance below is from the American Meteorological Society Journal, Figure 8 (including complicating additions) and also from the Royal

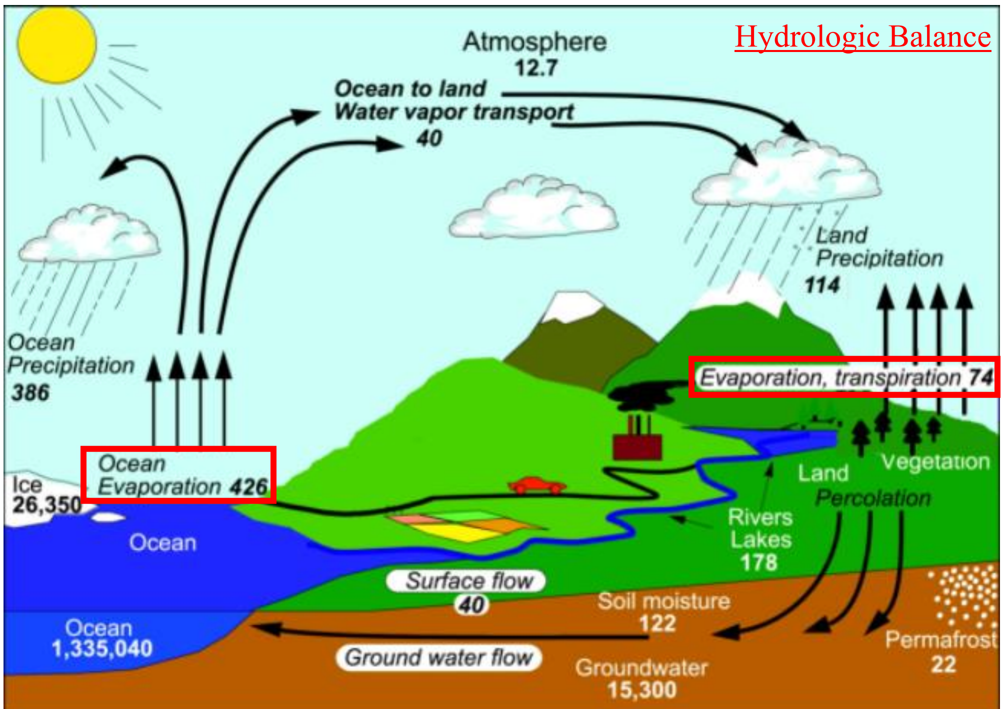
[Meteorological Society](#) (simpler, without the complicating data). The 2 calculations show the recommendation is readily achievable with existing, proven, greener technology.

*Inputs- Ocean evaporation and land evaporation / transpiration are 426 and 74 thousand km3/year per the balance below.

Equation: (426 +74) x 1000 km3/year evaporation * 0.0011/year evaporation decline / 426 x 1000 km3/year ocean evaporation *100%/1 = **0.13%** ocean evaporation increase.

**Inputs- Per [TheWorldCounts.com](#), global human consumption is 4 trillion cubic meters of fresh water per year = 4 thousand km3/yr.

Equation: (426 +74) x 1000 km3/year evaporation * 0.0011/year evaporation decline / 4.0 x 1000 km3/year human consumption *100%/1 = **13.8%** of consumption.



Units: Thousand cubic km for storage, and *thousand cubic km/yr* for exchanges Figure 8

Estimates of the current global water budget and its annual flow using observations from 2002-2008 (1000 km3 for storage and 1000 km3 yr−1 for exchanges). Based on K.E. Trenberth, J. Fasullo, and J Mackaro, 2011: Atmospheric Moisture Transports from Ocean to Land and Global Energy Flows in Re-analyses. J. Climate, 24, 4907–4924. doi: **http://dx.doi.org/10.1175/2011JCLI4171.1**

Ocean Evaporation Is <4% of Current Solutions Cost:

Global Carbon Capture and Storage (or Sequestration) (CCS) has a broad range of costs depending on CO2 concentration, temperature, pressure, location, and process. Below are 3 references with costs in $ per tonne (t) of CO2 for global carbon capture applications necessary to reverse increasing CO2 ppm. These estimated costs are probably low since this complex technology has never been designed, built, or implemented on a commercial scale.

1. 135 – 340 $ / tonne of CO2, [iea.org](#), reference the first chart, direct air capture.
2. 94 – 232 $ / tonne of CO2, [joule.com](#), latest technology, for a 1 Mt-CO2/year direct air capture plant.
3. 60 – 200 $ / tonne of CO2, [global CCS institute.com](#), reference their Figure 2 on page 8.
4. Take-away- Use a conservative low side, 100 $ / tonne of CO2. Explanation- the costs are expected to fall by applying expanding technology on larger applications. The storage costs are not included above.

Conclusion- The below calculates a CCS cost to eliminate 2021 CO2 emissions = 4.08 e^{12} $/year = 4.08 trillion $/year*.

*Inputs- The iea.org estimates 40.8 Gt of CO2 equivalent emissions in 2021, reference the chart labeled "Energy related greenhouse gas emissions, 2000-2021".
Equation: 100 \$/tonne CO2 * 40.8 Gt CO2/ year * $1e^9$ / Giga = **4.08 e^{12} \$/year**.

Ocean Evaporation Costs- The below calculates an ocean evaporation cost = 0.139 \$ e^{12} /year = 139 billion \$/year which is <4%***** of the above CCS cost and only 2%** of the US federal budget. Other countries contributing ocean evaporators will reduce this 2% for the US. In conclusion, ocean evaporation costs to reverse global warming are much simpler, cheaper, and greener than CCS.

*Inputs- We will use the published costs of wastewater evaporators such as the down draft evaporator in the first photo above. Cornerstoneh2o.com study pdf quotes 0.006 \$/B using the latest Resource West Inc. Apex down draft technology. Competitor evaporationworks.com quotes 0.04 \$/B. We conservatively use the higher 0.04 \$/B waste water evaporator cost.
Equation: (426 +74) x 1000 km3/year evaporation * 0.0011/year evaporation decline * 0.04 \$/B evaporation cost * 2.64 e^{11} gal/km3 / 42gal/B = **0.139 e^{12}** \$/year for evaporation / 4.08 e^{12} \$/year for CCS = **3.4%** of CCS cost.
**Inputs- The federal budget for the 2021 fiscal year per the US treasury was \$6.82 trillion.
Equation: 0.139 e^{12} \$/year for ocean evaporation / 6.82 e^{12} \$/year federal budget **= 2.0%** of US federal budget.
Qualifier- Our purpose is not to summarize the costs of CCS or ocean evaporation. Books are written on the CCS subject with much research on going. Instead, we are simply and roughly illustrating the obvious substantially lower costs of ocean evaporation versus CO2 emission reduction plans to reverse global warming.
***Conservative Selection- Reversing the full 0.11%/year PTR above is probably not necessary given the positive feed backs from increasing evaporation: The energy balance on Figure 3, page 7 above, shows: Evaporation (Latent Heat) is how a significant 24% of the sun energy is transferred to the troposphere for subsequent radiation to space + 23% is reflected by clouds (resulting from same evaporation). + 4% absorbed by those same clouds. The 2 cloud feed backs (23% + 4% = 27%) are not included in the above reversal calculation.

Advantages of the "Ocean Evaporation" solution vs prevailing CO2 GHG emission reduction plans beyond the above 96% cost reduction:

1. **Higher success probability, existing technology, proven effective, much simpler, and more environmentally friendly-** Ocean Evaporation reduces global temperatures with existing, simple technology, unlike CO2 emission reduction or carbon capture plans. Increasing evaporation will increase precipitation, decrease surface temperatures, increase biomass, "greening" the planet. Effectively, the proposal is to add small ocean cooling towers globally. Cooling towers have been used industrially for centuries for primary cooling and remain the most efficient / effective mass cooling process. Ocean evaporation will undoubtably be effective and we know how to implement it. Conversely, no reasonable plan exists to drastically reduce (much less eliminate) CO2 emissions globally and cost effectively. The new CCS technologies under development are completely unproven, highly challenging and expensive. Until fossil fuels can be reasonably replaced, ocean evaporation appears to be the best and most cost-effective choice.
2. **CO2 is a net benefit by increasing biomass-** Any plan to reverse the CO2 increases and its documented benefits should be avoided given the above greener option. Eliminating CO2 emissions would reduce plant WUE, which would increase plant transpiration, which would reduce global temperatures, probably even to pre-industrial levels. However, the higher CO2 WUE is a bigger benefit by increasing plant mass (more food and materials). CO2 reduction would devastate man's current food and plant production. Higher CO2 is needed to help offset man's detrimental effects on plant life.
3. **Increasing ocean evaporation "greens" the planet**- Per the Hydrologic Balance of Figure 1, evaporation = precipitation. Water and precipitation are the source of plant and animal life. Increasing ocean evaporation increases plant biomass which helps plants, animals, and humans.
4. **Probably reduces extreme weather events-** Extreme weather events include droughts and wildfires, blizzards and floods, hurricanes, tornadoes, and cyclones. Droughts and

wildfires are reduced with more evaporation = more precipitation. Flooding will not increase significantly with only a 0.11% increase in global evaporation. In explanation, precipitation will be less localized and sporadic. "Rotating" extreme weather events (such as hurricanes, tornadoes, cyclones, etc.) will be reduced by reducing the atmospheric temperature differentials (what creates the hurricane spin). Increased evaporation reduces the range of temperatures between night / day and between winter / summer and between ocean / land. As an example of water vapor temperature reduction of extremes, we have all observed how much wider temperature ranges between night and day in dry vs humid conditions (desert vs tropics). The hydrologic cycle is one of the primary reasons the earth's temperature and weather is more stable than other planets. In summary, extreme weather events are probably reduced globally with an evaporation increase.

5. **Increases freshwater-** Increasing the ocean evaporation has a side benefit of increasing freshwater which is definitely needed due to increasing human population. Much of the evaporation will yield precipitation over land, particularly when strategically placed in low relative humidity coastline locations.

The slight temperature increase from increased absolute humidity GHG effect is overridden by PTR. This proposed solution will reduce surface temperatures by increasing evaporation, but also increases absolute humidity (contributes to warming by increasing the GHG effect). The Section 1 and 2 calculations prove that the evaporation increase is a bigger surface temperature driver than the GHG effect of increased absolute humidity. In an interesting admission, per YaleClimateConnections.org 2008: "Water vapor and clouds account for 66 – 85% of the greenhouse effect, compared to 9 – 26% for CO2 with the balance from methane, and nitrogen oxides". In summary, the IPCC admits that water vapor is a 4.3 factor stronger GHG than CO2. However, AGW is quantitatively driven by PTR, not GHG.

Summary- Evaporation of ocean water using upgraded waste water evaporators is simpler and less costly than the expensive, complicated CCS processes. Unfortunately, energy corporations are prematurely setting up business units to monetize carbon capture. Reversing this financial momentum will be onerous, but is obviously more practical. This ocean evaporation solution is possible regardless of accepting the conclusions of Sections 1-3. Ocean evaporation should reduce global temperatures at orders of magnitude less cost and time than will carbon capture.

Next, we will calculate that atmospheric CO2 did not "cause" an increase in geologic temperature pre-1800, but actually "resulted" from a temperature increase caused by geologic solar cycles.

5. Solar Elliptical Cycles Drove the Pre-1800 Geologic Correlation between CO2 & Temperature, not CO2 GHG.

Figure 9 below is available from Wikipedia, bottom graph on right, (previously available from the National Oceanic and Atmospheric Administration) with a time scale 800,000 years ago **until only ~1800**. (Unfortunately, the NOAA pulled Figure 9 below in 2022 due to demonstrated conflicts with the correlation since 1800 per this Section 5). Nevertheless, the graph shows a clear correlation between CO2 & global temperatures which was the original basis for the current CO2 GHG theory.

Figure 10 below from The Conversation.com uses the same data except the graph is extended from 1800 to 2021. The CO2 spike since 1800 from 280 ppm to 421 ppm increased the temperature at a 6.1 factor lower relative scale than the prior 800k year correlation. The question then becomes why? Our main point for this Section 5 is that 2 different correlations now exist: 1. Prior 800k year geologic correlation, per Figure 9. and 2. Recent 1800+ correlation of the fossil fuel burning industrial age (anthropogenic), per Figures 11 and 12. Prior Sections 1 and 2 quantified that CO2 WUE / PTR drove the recent 1800+ AGW, not CO2 GHG.

2. This Section 5 will quantify that orbital solar elliptical cycles drove the pre-1800 geologic correlation between CO2 & temperature, not CO2 GHG. The 2 different CO2 sources explain the 6.1 relative scale factor decrease for the recent temperature / CO2 correlation since 1800. CO2 from fossil fuels does not cause as big a temperature change as geologic solar cycles which drove the below geologic correlation.

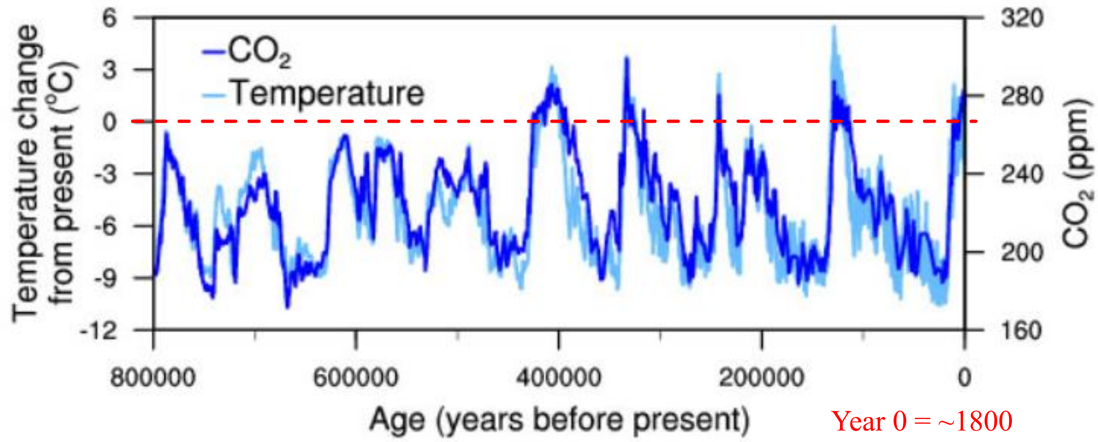


Figure 9

Temperature change (light blue) and carbon dioxide change (dark blue) measured from the EPICA Dome C ice core in Antarctica (Jouzel et al. 2007; Lüthi et al. 2008).

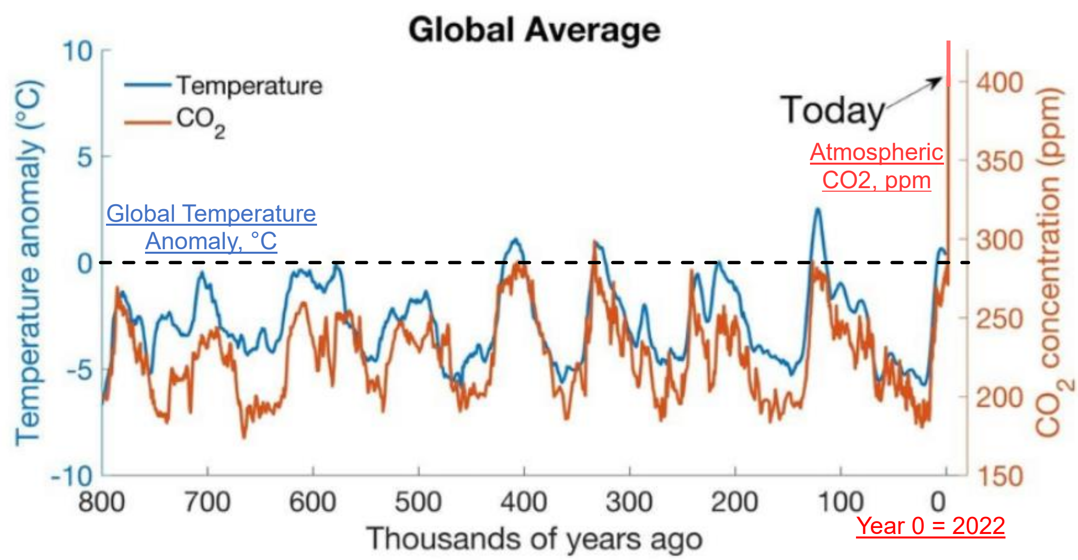


Figure 10

Global average CO2 levels in atmosphere. Data from Parrenin et al. 2013; Snyder et al. 2016; Bereiter et al. 2015. Image: Ben Henley and Nerilie Abram/The Conversation

Problem 1- 1800+ CO2 spike has no correlated temperature spike.

As charted, the recent CO2 spike from 280 ppm to 421 ppm did not create an associated temperature spike. Per the right half of the chart above, the current CO2 ppm is the highest seen for the past 800k years, yet the temperature remains lower than 3 prior peaks. Applying the above geologic correlation, the GHG effect should have caused a 13.6°C rise* since 1800 versus an actual rise of 1.5°C. Why? CO2 GHG theory proponents have no explanation for this problem so they now just prefer to disregard the above 800k year correlation and use a current correlation ~6 factor lower (Problem 2). Hence, the above 800k year CO2 and temperature correlation contradicts the prevailing CO2 GHG theory.

*Inputs for 13.6°C rise- Per Figure 9 above, the typical CO2 range was 180 – 280 ppm with corresponding temperature range of -8 - +2 °C. Combining Figures 11 and 12 on pages 18 and 19, the increase since 1800 was from 280 to 421 ppm with an actual temperature rise of 1.1 °C.

Equation- (8 +2) °C / (280 -180) ppm * (421 – 280) ppm = **13.6 °C theoretical rise vs actual rise of 1.5 °C** since 1800.

Explanation for Geologic Correlation between CO_2 and Temperature: Orbital solar cycles increased geologic temperature by ~10°C, which decreased ocean CO_2 solubility by 35%, which could reasonably increase atmospheric CO_2 from the measured 180 to 280 ppm. Solar cycles increased temperatures, not CO_2 GHG. Per NASA, Milankovitch (Orbital Solar Elliptical) Cycles primarily drive earth's climate changes on 100k year cycles per Figures 9 and 10 above, not man's actions. Per the 800k year temperature graph above, there have actually been 3 other periods warmer than present day, all of which are prior to mankind, all with correlated CO_2 increases, and all unexplained by the prevailing CO_2 GHG theory. The higher CO_2 was a "result" of the orbital solar cycle temperature increases, but did not "cause" the higher temperatures.

Geologic Calculations:

1. The measured 10 °C ocean temperature rise caused a 35% CO_2 solubility decrease which then generated the measured 100ppm atmospheric carbon increase - The Oceanography Journal, 2001 article, page 5 confirms the oceans on average are ~98% CO_2 saturated. The solubility of CO_2 decreases with temperature. Per the 2 charts above, the full range geologic atmospheric CO_2 increased from 180 – 280 ppm with a corresponding 10 °C temperature rise. Numerically, the solubility of CO_2 decreased 35% due to the 10 °C rise while only a 25%* solubility decrease was necessary to generate the CO_2 increase from 180 to 280ppm. The 10% CO_2 difference between the available and actual atmospheric increase was probably CO_2 stored in the "Deep Ocean", per Figure 13, page 21 below.

*Inputs for calculation of 10°C impact to ocean CO_2 saturation: Per Figure 9 of the 800-thousand-year graph of CO_2 and temperature above: geologic temperature ranged -8 to +2°C = 10 °C range while CO_2 ranged from 180 – 280 ppm. 17°C average ocean temperature. Use Engineering Toolbox, 4th chart, Solubility of CO_2 in Water: At 12°C = 2.3 g CO_2/ kg water, decreasing at 22°C = 1.5 g CO_2/ kg water, which equates to a **35% decrease** for a 10°C increase. CO_2 solubility is ~50% lower in seawater than the linked fresh water chart, but acceptable since we only use the 35% decrease. Per the Carbon Mass Balance on page 21, atmospheric CO_2 mass = 776 GtC in 2022 at 421ppm CO_2, with 725 GtC in Surface Ocean.

Equation: 776 GtC in atmosphere current / 421ppm CO_2 current * 100ppm decrease / 725 GtC in surface ocean = **25% decrease required vs above 35% actual ocean solubility decrease.**

2. Using the IPCC TCR, the CO_2 GHG effect contributed only 17%* of the actual measured geologic temperature rise. Even using the highest IPCC theoretical, empirical factor, the geologic CO_2 GHG effect contributed only 17% of the measured temperature rise. In conclusion, solar cycles caused the temperature changes, definitely not CO_2 GHG.

*Inputs- From Section 2, page 6, the IPCC Equilibrium Climate Sensitivity (requires centuries to see the full impact) = 3.0 °C for a doubling of CO_2. Per Figure 9 of the 800-thousand-year graph of CO_2 and temperature above: geologic temperature ranged -8 to +2°C = 10 °C range while CO_2 ranged from 180 – 280 ppm (not doubling).

Equation: 3.0 °C/doubling * (280-180)/180 = 1.7 °C from the GHG CO_2 increase / 10 °C measured range = **17%** of measured temperature range.

PTR science resolution- The 800-thousand-year geologic correlation between CO_2 and temperature was primarily driven by Milankovitch orbital solar cycles (not CO_2 GHG theory). Solar cycles increased temperatures, decreasing ocean CO_2 solubility, causing increased atmospheric CO_2 concentrations. Oppositely, solar cycles decreased temperature, increasing ocean CO_2 solubility, decreasing atmospheric CO_2 concentration. Numerically, orbital solar cycles increased geologic temperature by 10°C, which decreased ocean CO_2 solubility by 35%, which could reasonably increase atmospheric CO_2 from the measured 180 to 280 ppm. CO2 Science.org, Solar Influence lists 24 scientific articles on "Solar Irradiance

Influence on Climate". In conclusion, Milankovitch cycles are fact and increased geologic temperatures

Conversely, calculation #2 above shows that the CO2 GHG increase contributed <u>at most 17%</u> of the temperature rise per the IPCC empirical factors. CO2 GHG definitely did not cause the geologic temperature rise. These 2 different response factors contradict current CO2 GHG theory.

Problem 1 Conclusion- Milankovitch cycles caused the geologic temperature cycles, not CO2 GHG. 1. Ocean desorption was the carbon source for the 180 – 280 ppm CO2 range over the prior 800k years. The higher geologic CO2 was a "result**"** of temperature increases, but did not "cause" the higher temperatures. 2. Anthropogenic emissions were the carbon source for the most recent 140+ years, with a much lower relative scale factor. The 2 different CO2 sources explain the 6.1 scale factor decrease for the recent temperature / CO2 correlation since 1800. In summary, CO2 from fossil fuels does not cause as big a temperature change as geologic solar cycles, which drove the above geologic correlation.

Problem 2- Relative scale above must be decreased by a 5.7 factor for 1880+ and by a 6.1 factor for 1958+ to show a correlation.

The first graph below from Zfacts.com shows the same global temperatures and CO2 as the above 800k year graph with a much shorter time scale from 1880 through 2008 and with 5.7 factor lower relative scales for CO2 and temperature. The relative scales (°C / ppm) were decreased to show the proposed theoretical correlation between CO2 ppm and °C. However, the GHG theory requires that temperature rise be proportional to the CO2 increase, not the observed hugely variable factor between CO2 and temperature. The 2 negative correlations from 1880 – 1915 and from 1936 – 1977 are also inconsistent with GHG theory.

The second graph below is from Climate4you.com. from Jan.,1958 through March, 2023. (To locate the graph, click the far left dark blue "Greenhouse Gases" link, then the third light blue right bullet "Temperature records versus atmospheric CO2"). The multi colors are measured temperatures from 5 academic sources. This graph has a similar 6.1 factor lower relative scale for CO2 and temperature. The graph shows a negative correlation from 1958 to 1978, but a positive correlation from 1979 to 2005, with a weaker correlation from 2006 to 2023.

Although CO2 and temperature have both increased over the last 140 years, the proposed new correlation does not mean that CO2 "caused" the corresponding temperature increase. Further, these 2 hugely lower correlation factors between CO2 and temperature (versus the prior geologic graph) contradicts the scientific basis for GHG theory.

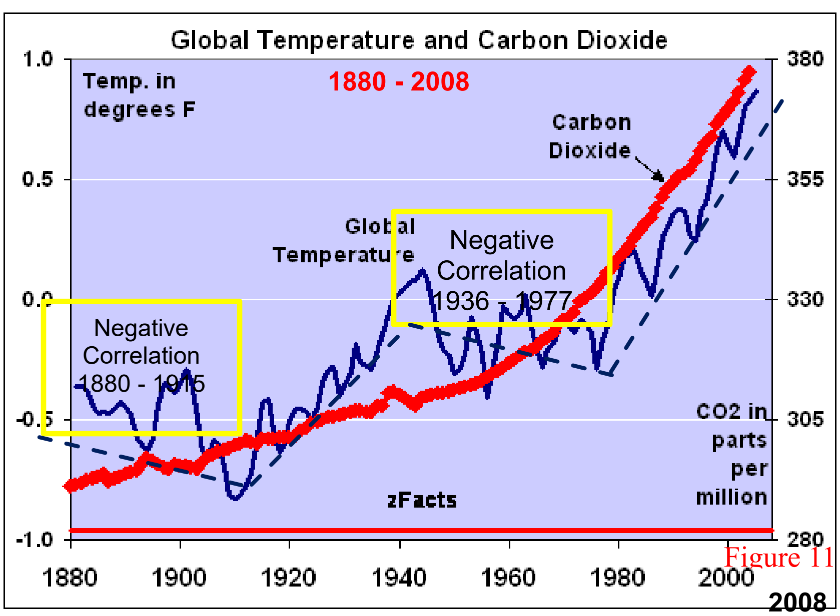


Figure 11

Climate4you.com temperature records versus atmospheric CO2:

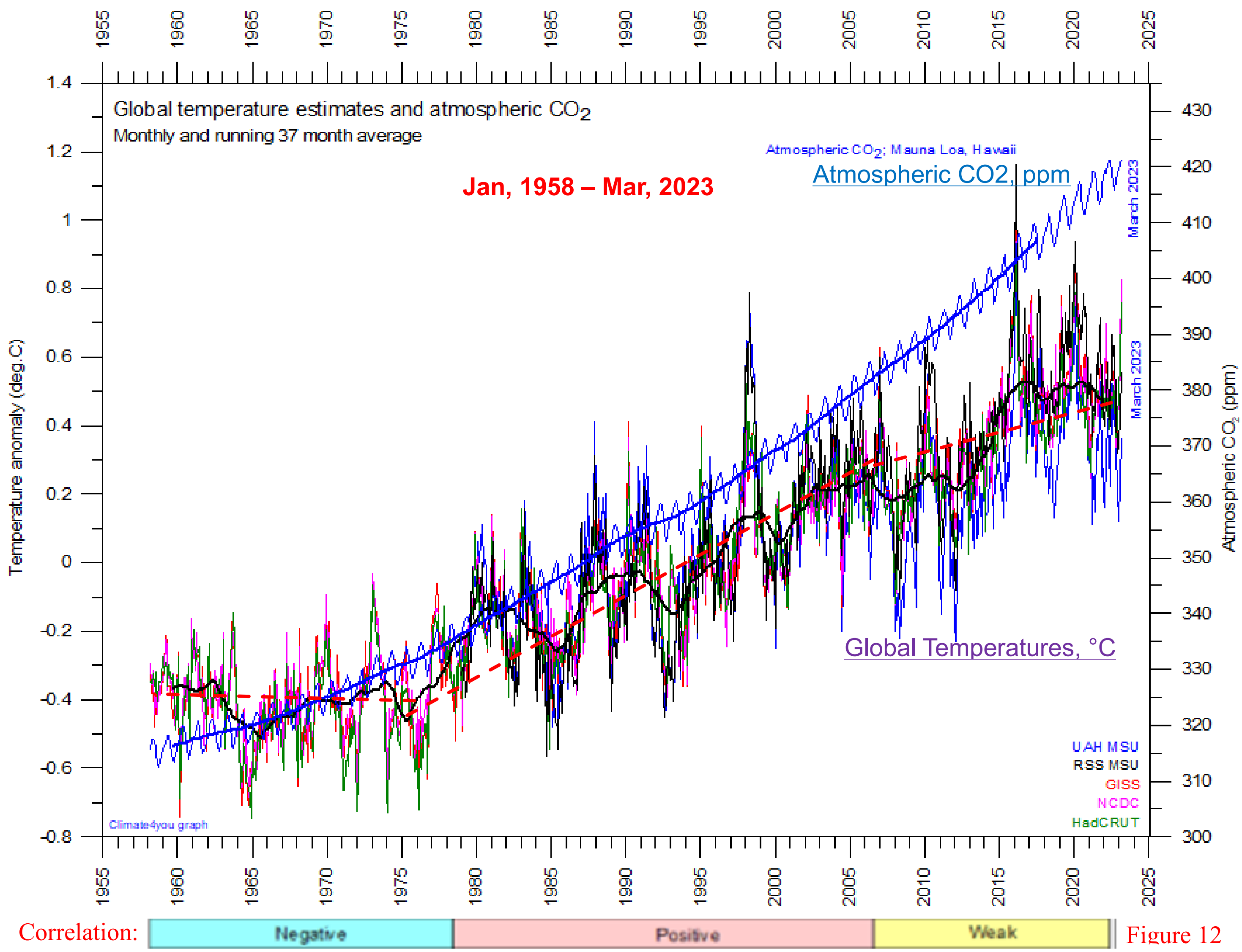


Figure 12

Superimposed plot of five different global monthly temperature estimates shown individually elsewhere. As the base period differs for these estimates, they have all been normalised by comparing to the average of their initial 120 months (10 years) from January 1979 to December 1988. Click here to go to the associated comparison of these five temperature records. The heavy black line represents the simple running 37 month (c. 3 year) mean of the average of all temperature estimates (before 1979 only the three surface records). The blue graph shows the amount of atmospheric CO_2 (Mauna Loa station, Hawaii, see also above). The heavy blue line represents the simple running 37 month (c. 3 year) mean of the monthly CO_2-values. The scale for atmospheric CO_2 (right) is adjusted to display the CO_2-graph roughly parallel to the 1975-2000 temperature increase. Last month shown: March 2023. Last diagram update: 12 May 2023.

Two different correlations exist: 1. Recent 140 years of fossil fuel burning and 2. Prior 800k year geologic correlation. For the last 140 years, relative scales were decreased by a by a 6.1 factor to show a correlation.

PTR science resolution- Prior Sections 1 and 2 quantified that CO2 driven PTR drove the recent AGW, not CO2 GHG. This Section 6 quantified that orbital solar elliptical cycles drove the pre-1800 geologic correlation between CO2 & temperature. The 2 different CO2 sources explain the 6.1 relative scale factor decrease for the recent temperature / CO_2 correlation of the last 140 years.

Problem 2 Conclusion- Recent CO_2 from fossil fuels does not cause as big a temperature change as prior geologic solar orbital cycles, which increased temperatures, desorbing CO_2 from the ocean. These hugely varying correlation factors between CO_2 and temperature contradict the scientific basis for GHG theory.

6. Carbon Mass Balance Calculations Quantify Concerns with the Prevailing CO2 Emission Reduction Plan

Carbon Mass Balance- The below Figure 13, 2017 carbon balance is from NASA's GLOBE Carbon Cycle Project. Units are giga-tonnes (metric tons) of carbon, Gt = Pg (Peta-grams). 1.0 Metric tonne = 1.10 US tons. Values in blue are stocks of carbon while values in red are annual flows. This author updated 2017 data to 2022*

*This author updated 2017 data to 2022: 1. Atmospheric CO_2 increased from 750 to **776 GtC***. 2. Fossil fuel CO_2 emissions increased from 9.3 to **10.0 GtC/year****, using the International Energy Agency (IEA) March, 2023 Report.

1. Inputs- Per statistica.com, the average annual atmospheric CO_2 ppm levels: 2017 = 406.8 ppm increasing to 2022 = 421 ppm. Per the Carbon Mass Balance below, atmospheric carbon mass = 750 GtC in 2017.

Equation: 421ppm in 2021 / 406.8ppm in 2017 * 750 GtC02 in 2017 = **776 GtC** in 2021.

2. Inputs- 36.8 GtCO2/year in 2021 per IEA report linked above. Molar weights: 12 = carbon and 44 = CO_2.

Equation: 36.8 GtCO2/year * 12 GtC / 44 GtC02 = **10.0 GtC/year**.

1. CO2 emissions generate 115%* of the measured atmospheric CO2 ppm increase.

*Inputs- Imbalance Summation: Using the Carbon Mass Balance below, add the 6 "up" pointed values to atmosphere less the 2 "down" pointed values from atmosphere: 9.9 + 58 + 59 + 0.1 + 1.0 + 90 – 120 - 92 = 6.0 GtC/year imbalance. Effectively, all the 6.0 GtC/year imbalance was from the 9.9 GtC/year fossil fuel emissions. Per the Carbon Mass Balance below, atmospheric CO_2 mass = 776 GtC in 2022 at 421ppm CO_2. Per statistica.com, the average annual atmospheric CO_2 ppm measured levels: 2017 = 406.8 ppm increasing to 2022 = 421 ppm over 5 years.

Equation: 6.0 GtC/year imbalance * 421 ppm / 776 GtC = 3.26ppm/year increase / ((421 – 406.8) ppm / 5 years) = **115%** of the CO_2 ppm measured increase was from the emissions imbalance.

2. This 0.15 factor high is eliminated by a small Photosynthesis increase from 120 to 120.8 GtC/year*. This 1% increased Photosynthesis consumption over 4 years was probably driven by increased WUE and CO_2 Fertilization (per Section 1), driven by man's beneficial CO_2 emissions. In explanation, Mother Nature (through chemical reaction kinetics) generally attempts to offset man's alterations (emissions) to reach a balance.

*Inputs- Use the above 6.0 GtC/year imbalance. 0.15 factor high versus 1.15 factor total. 120 GtC/year from photosynthesis in 2017.

Equation: (6.0 GtC/year imbalance * 0.15 factor high / 1.15 factor total) + 120 GtC/year current = **120.8 GtC/year** from photosynthesis updated.

3. The CO2 increase from anthropogenic CO2 emissions is a 10 factor* larger than the "Deforestation and Land Use Change"*.

*The 1.0 GtC/year from "Deforestation and Land Use Change" per the Carbon Mass Balance diagram below is probably low, but still < the 10.0 GtC/year CO_2 from fossil fuel emissions.

4. Annual man-made CO2 emissions are only 1.3%/year* of existing atmospheric CO2.

*Calculation: 10.0 GtC/year from fossil fuels in 2023 / 776 GtC in atmosphere = **1.3%/year** contribution.

5. The 2023 fossil fuel emissions equate to only 8.3%* photosynthesis reduction.

*Calculation: 10.0 GtC/year from fossil fuels / 120.8 GtC/year from photosynthesis = 8.3**%** from fossil fuel emissions.

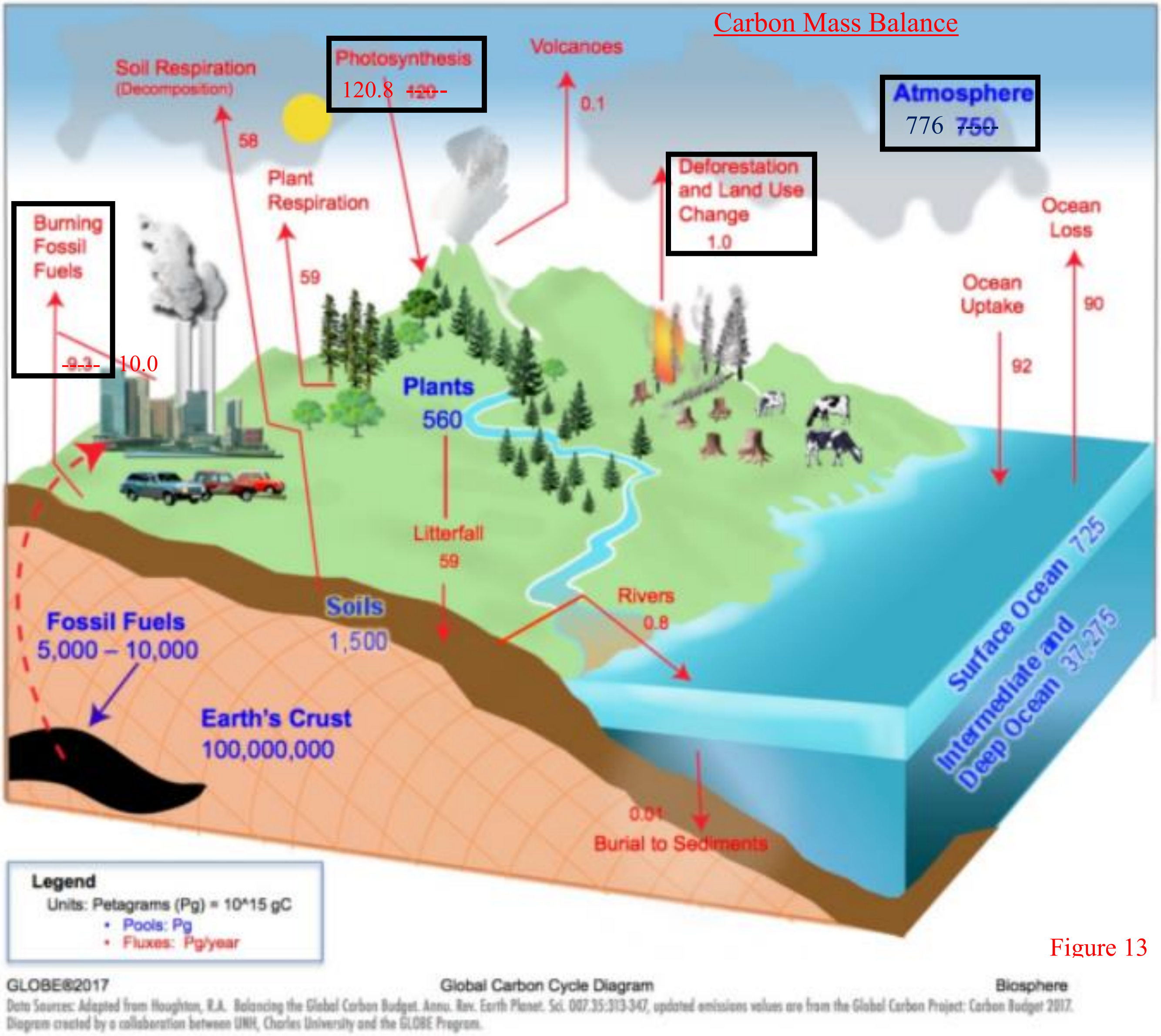


Figure 13

Conclusions-

1. The atmospheric CO2 ppm increase was definitely from anthropogenic CO2 emissions. The anthropogenic "Deforestation and Land Use Change" is a 10 factor smaller per the above NASA generated Carbon Mass Balance.
2. The proposed CO2 fossil fuel emission reduction plans only focus on the 1%/year contributing source while completely ignoring the 99% existing atmospheric CO2.
3. The proposed CO2 fossil fuel emission reduction plans focus on reducing the 8% CO2 emissions driver, while completely ignoring the 92% plant biomass CO2 driver. Conversely, our Section 4, "increased ocean evaporation solution" focuses on the larger (92%), green photosynthesis driver.

Next, the authors characterize each of the observations by Section, make suggestions for follow up studies, and summarize conclusions.

7. Study Characterization & Conclusions

Why these authors? This paper is the first to calculate and convert plant WUE to a PTR energy imbalance and directly compare it to the CO2 GHG energy imbalance (watts/m^2), Sections 1 and 2. This comparison showed that PTR was a 9.1 factor larger AGW driver than

CO2 GHG. Although CO2 GHG theory is proven science and does contribute to AGW, it is a 9.1 factor smaller driver than PTR. This paper is engineering quantifications and explanations with no new data or theory.

This study focused primarily on engineering quantifications versus the prevailing climate data, theories, and models. The calculated energy imbalances and temperature impacts used only consensus data published by the IPCC and other pro-CO2 GHG sites. The main conclusions of each Section are summarized below:

1. Sections 1 and 2- **Quantified Fact- The CO2 plant transpiration reduction (PTR) is a 9.1 factor larger AGW driver than CO2 GHG theory.** WUE increase definitely caused plant transpiration reduction, which definitely increased global temperatures more than CO2 GHG. The calculations are simply engineering conversions of the respective W/m^2 from plant transpiration and GHG. Admittedly, CO2 PTR is conceivably not the AGW driver, but CO2 GHG theory is absolutely not (too small an energy imbalance).
2. Section 3- The above PTR explains the unexpected but measured global relative humidity decrease, particularly the more severe land decrease.
3. Section 4- That ocean evaporation is a **valid, practical solution that is <4% of current CO2 emission reduction costs.** Ocean evaporation is a simpler, more cost effective, greener solution to global warming than CO2 emission reduction. However, it does require more engineering study prior to implementation.
4. Section 5- **"Orbital solar elliptical cycles drove the 800k year correlation between CO2 and temperature, not CO2 GHG.** Although not a scientifically proven fact, it is quantitatively sound. Reason- The geologic ocean CO2 concentration data needed for quantified proof is not available. However, the orbital solar cycle explanation is quantifiably reasonable, whereas the prevailing CO2 GHG theory is quantifiably inaccurate.
5. Section 6- Just some interesting calculation results using the Carbon Mass Balance.

Recommendation– More PTR research. Our paper is primarily calculations and analysis of existing data comparing CO2 GHG versus PTR energy imbalances. This paper proposes more evaporation research be conducted: 1. Model (GCM) the temperature impact of the detailed WUE and PTR per Section 2. 2. Further research any adverse weather events that could result from increased ocean evaporation. 3. Evaluate alternative and various ocean evaporation increase designs. For example, this research could possibly be a chemical engineering or meteorological graduate theses. This alternative science should be researched further rather than focusing solely on CO2 emission reduction or sequestration. The complex GCMs should be updated to further quantify the significant PTR impact on global temperatures.

Complex problem, multiple causes, many mitigations, novel PTR science- Global Warming is a difficult, complex, and challenging problem with many variables, contributory factors, and limited global data. There is no single cause nor a simple solution to solve this growing critical problem (such as simply eliminating fossil fuel CO2 emissions). Addressing the fact that CO2 climate change has been studied for decades by hundreds of skilled scientists: Hopefully, this fresh chemical engineering approach from a high-altitude will shed new, quantified insights on this old global warming debate (leading to a possible paradigm shift). To our knowledge, the above energy balance, hydrologic balance, carbon balance, surface relative humidity decline, ocean solubility, photosynthesis chemical reaction kinetics, and other calculations detailed in this paper have not previously been quantified and summarized as presented.

Even though prevailing CO2 GHG theory is proven science, these calculations show that CO2 PTR is a larger AGW than CO2 GHG. As with all science, numbers should identify the root cause, not data and a theory. Surprisingly to the authors, no climate scientist has identified and quantified WUE as a potential cause of AGW.

Next Action- Further PTR and ocean evaporation research as discussed above.

Conclusion- Ultimately**,** Mother Nature and science will eventually find a global warming solution with a new CO_2 equilibrium. However, simply reducing fossil fuel CO_2 emissions is currently not practical due to political and technical challenges along with exorbitantly high costs. Instead, we should research ocean evaporation increases to reverse AGW as a more cost-effective, simpler, and greener solution. Our publishing objective is to disseminate this science, data, and calculations for further analysis and research by climate professionals.

8. Wider Publication Needed, Acknowledgments, About the Author, Educational Links, Acronyms, & Definitions

1. Second Author for Peer Review Support- The authors are always interested in wider publication of this paper or the 4-page introduction. Feel free to forward. Our ultimate objective is publication in a peer-reviewed scientific journal. We are open to a second author in exchange for support in the peer review process. The authors will do the work, just need the peer review experience and connections. The authors will even fund a graduate student fellowship. Make my year by sending an email with your peer-review support offer to: davidmotes7@gmail“DOT”com.
2. About the Author: David Motes is a 46-year professional chemical engineer residing in Houston, TX. After 40 years with ExxonMobil, he is semi-retired developing patents in multiple disciplines. David has a BS in ChE from Auburn University in 1977 and an MBA from the University of New Orleans in 1983. Online profile: David Motes LinkedIn. David may be contacted at davidmotes7@gmail“DOT”com. David initiated his investigation into AGW because AGW is the largest ChE problem in today’s world. David is a working engineer with no experience in peer-reviewed publications.
3. Acknowledgments- Tom Crosier- Editor and Chief Consultant, Dr Ray Mentzer, Dr Mark T. Holtzapple, Dr Craig Idso, Dr. Douglas V. Hoyt, Dr Hans Haarman, and Gene Thomas. Contributors include climatologists, chemical engineers, solar physicists, geologists, geophysicists, reservoir engineers & simulators, and heat transfer experts. The paper required >3 years to develop and is periodically updated on docdroid.
4. Educational Links: 1. The Chemical Composition of Air 2. Carbon dioxide description 3. The Carbon Cycle and Balance 4. The Hydrologic Water Cycle 5. Libre Texts, Chemistry, Chemical Reaction Kinetic, Effect of Concentration Changes, Rate Law.
5. Acronyms List:
    1. AGW- Anthropogenic Global Warming
    2. CCS- Carbon Capture and Storage (or Sequestration)
    3. GCM- Global Circulation Model
    4. ER- Evaporation Reduction.
    5. GHG- Green House Gas, primarily CO_2
    6. IEA- International Energy Agency
    7. IPCC- Intergovernmental Panel on Climate Change, United Nations sponsored.
    8. NASA- National Aeronautics and Space Administration
    9. NOAA- National Oceanic and Atmospheric Administration
    10. PTR- Plant Transpiration Reduction
    11. WUE- plant Water Use Efficiency
6. Definitions:
    1. Plant Evapotranspiration- The sum of all 3 plant water vaporizations: transpiration from the stomata (productive water use including photosynthesis) + evaporation from soil surface + evaporation from canopy interception with air.
    2. Plant Water Use Efficiency (WUE)- The terrestrial carbon uptake (vegetative organic mass) produced by the plant divided by the total plant water use (plant evapotranspiration mass).
    3. Relative Humidity- A ratio, expressed in %, of the amount of atmospheric moisture present relative to the amount that would be present if the air were saturated.
    4. Troposphere- The lowest layer of Earth's atmosphere. Contains 75-80% of the atmospheric mass. Almost all weather occurs within this layer and contains most of the clouds. Above the troposphere is the stratosphere and exosphere radiating heat to space.