Hydro-Hotspots Global Warming

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Abstract

Understanding root causes is always needed to find proper solutions. In climate change, we must ask, what has historically changed? Besides CO_2*, we have a change in the specific and relative humidity, slight decrease in land albedo, and yearly growth of Hydro-HotSpots (HHS) and its effect on humidity change. We denote hydro-hotspot as water evaporation and bulk heating from low albedo manmade type roads and cities surfaces, including cars and engine hoods. This includes both Highly Evaporating Surfaces (HES) and bulk warm Rain Water Management (RWM). Most significant is land albedo change. An Earth albedo change from 0.29 to 0.288, corresponds to a* $0.32^{o}F$ *rise, due to growth in cities and roads. This feeds most of the HHS' which are concentrated hot areas (not include hot combustive areas).*

We show in this article that such surfaces, while covering less than 2% of the Earth, can have very large effective areas, many times the size of the HES and RWM area itself compared with higher albedo absorbing vegetative areas that also include transpiration. This is significant since water vapor is the most potent greenhouse gas. City surfaces can prove to be enormous when tall buildings are considered. In addition, Hydro-hotspots generate high kinetic energy molecules in the troposphere which can decrease relative humidity while increasing specific humidity. It is thought that global warming ocean evaporation-CO_2 *feedback is the key contributor, but in this paper other issues are considered. For example, we find that it is nontrivial to look at changing the albedo of cities and roads as a partial solution to global warming.*

Also alarming is warm rain water management. For example, New York City dumps an estimated 27 billion gallons of waste water into the ocean each year. This pattern is followed by cities all over the world. This water is often warmed by hot city streets and buildings having high heat capacities. This is also lost land water storage as urban impermeable surfaces increase. Numerous concerns are pointed out: 1) warmer runoff to streams/ocean water, 2) loss of wetland storage in vegetative areas, 3) loss of land evaporation and precipitation, 4) increase in ocean precipitation creating higher land temperatures, and 5) dryer drought-prone regions. This is key as change in global warming goes as the change in specific and relative humidity which are functions of CO_2*, other GHGs, and as described here, HHS.*

1. Introduction - Highly Evaporation Surface and Rain Water Management Feedback

In this paper we look at the effect of Hydro-HotSpots (HHS) from Highly Evaporating Surfaces (HES) feedback (Figure 1) and Rain Water Management feedback (Figure 2) contributions to global warming.

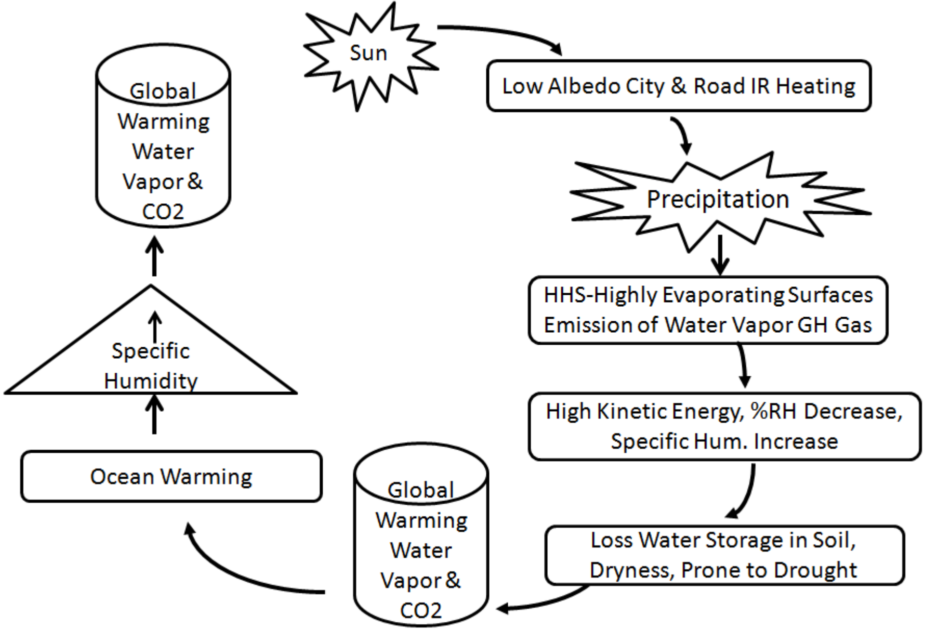


Figure 1A HHS- HES feedback view of contribution to global warming

Figure 1A HES feedback may be summarized as follows:

- Low albedo cities and roads absorbing sun light and emitting infrared radiation (IR)
    - Appendix D & E shows that if the Earth's albedo goes from 29 to 28.8, this equates to a 0.32^{o}F Rise in temperature. If this is focused on cities and roads, the affect is concentrated on HHS.
    - Appendix E shows that such a change can occur form low albedo city and road growth
- Precipitation occurs, followed by evaporation of HES moisture often with high Kinetic Energy (KE) water molecules from hydro-hotspots (wet hot surfaces)
- High KE water molecules decrease %RH and a higher increase in the specific humidity
- Loss of water storage due to replacement of vegetative areas with cities and roads
- Increase in local dryness and some correlation to the potential for drought
- Global warming increase due to higher specific humidity GH gas and the known CO_2 increase including ocean temperature rise creating more evaporation and higher specific humidity
- More greenhouse gas in the form of moisture and eventual further warming.

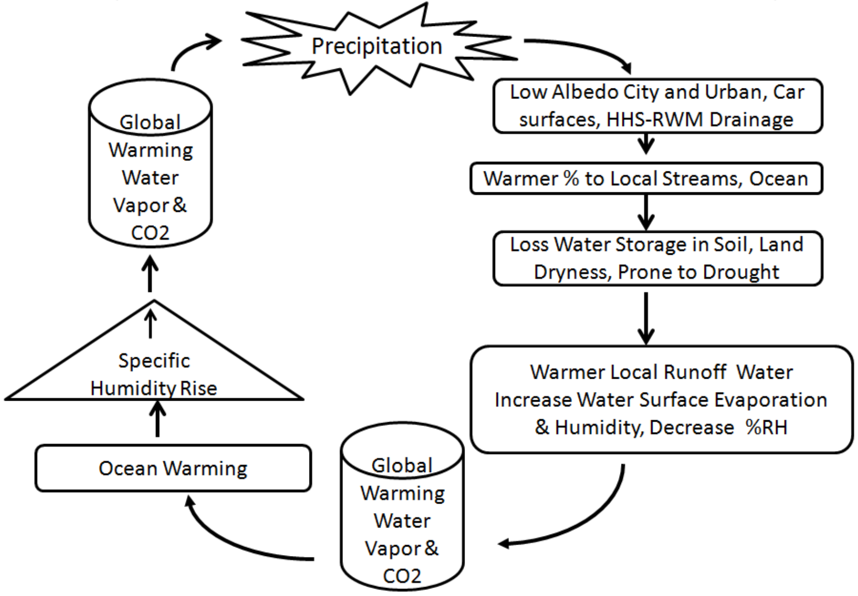


Figure 1B HHS Rain Water Management (RWM) feedback in Climate Change

Figure 1B HHS-RWM feedback may be summarized as follows:

- Precipitation is collected off of HHS buildings, streets and hot cars
- A large percentage is drained to ocean or nearby rivers that may end up in the ocean
- The impermeable city building and roads have replaced vegetative land creating lost area that would have stored cooler water in soil keeping the land moist.
- This increases land dryness and can mean less land evaporation and more ocean rain.
- The RWM is often warmer from HHS than streams and ocean water and may contribute to local surface water temperature increase depending on location. Possibly warmer environment may runoff more water to the ocean due to population trends. This requires some studies.
- This above effects would contribute to a global warming feedback cycle and rising specific humidity and drought prone areas due to runoff distances.

In Section 2 we discuss different theories on CO_2 feedback mechanism creating a rise in specific humidity compared to how HHS-HES and HHS-RWM may be a significant contributor as well. Furthermore, in Section 6 we argue why CO_2 feedback mechanism is likely not be fully responsible for the specific humidity rise. This leads to the conclusion that HHS-HES and HHS-RWM are likely major contributors to global warming. In Section 3 we overview relevant data. In Section 4 we describe a simplified expression for the HHS-HES evaporation rates and its effective area. In Section 5 we discuss details of HHS-RWM, including how lost land water storage is correlated to dryness, heat, and drought, and in Section 6 we provide a brief summary, conclusion and suggestions.

2. Specific Humidity Sources – HHS-HES & HHS-RWM

The key question about specific humidity is, “Where has the increased humidity come from, and how do we account for the global warming trends?” Its source is important as water vapor is the most potent of all the greenhouse gases. It is thought that CO_2 initially increases the planet’s temperature including ocean temperature which increases ocean evaporation and thus specific humidity followed by higher temperature rise from the new greenhouse ocean moisture entering the atmosphere observed via the increase in atmospheric specific humidity. It is this feedback mechanism that climatologist claim is entirely responsible for the increase in specific humidity and subsequent justified full temperature increase. Yet we know two things, part of the CO_2 must emit away from the Earth, furthermore, there is a high probability that any CO_2 emission gets reabsorbed by other CO_2 molecules and moisture, then re-admits 50% towards Earth, this diminishes the effect of CO2 as hypothesized in more detail in Section 6.

One could certainly argue that this feedback mechanism increases global warming. Such a correlation has been described [1,2,3]. However, such assessments view the correlation with CO_2 creating warming to the ocean as the cause rather than looking at other sources to specific humidity that have increased with time. They look at yearly CO_2 trends, which have a similar trend to global warming’s yearly increase. As well they look at complex data sets and have not reviewed observed effective loss of land related to soil moisture, land albedo decrease, and increase in highways and city area HHS effects, and city and urban HHS-RWM water drainage increase away from land. All these play a role in specific humidity, relative humidity and precipitation effects.

- Here we are concerned with a likely correlation of global warming and increase to Asphalt and building material usage!

What is hidden in manmade impermeable surfaces is the effective global area. Since the area of roads and cities is small (<2% of the Earth surface), possibly, some may have thought that these areas do not impact climate change. This assumption may be incorrect. We show that HHS-HES have a very high effective evaporation area. Many times the size of the area itself as it is related to the evaporation rate differences between adjacent soil and say asphalt. We discuss that HHS-RWM can markedly affect relative humidity.

With this understanding, we consider the possibility that loss of soil moisture storage and HHS high evaporation rates in cities, streets and highways, and HHS-RWM can contribute significantly to greenhouse water vapor gasses and global warming. Water vapor is known to dominate greenhouse temperatures effects [3, 4]. Such an inference would then create a strong feedback mechanism as illustrated in Figures 1 above.

2.1 Basic Global Warming Relationships Over Land – CO_2 Versus HHS Effects

Numerous authors have illustrated that global warming is dominated by moisture content in the atmosphere [see Byrne et. al. and references therein]. This can be expressed with relationships of specific humidity h, and relative humidity r. For example, Byrne et al. [1] observe GW_L temperature over land increase of $0.17\pm0.04^{o}K$ per decade, a specific humidity (h_L) increase over land of ($0.08\pm0.04 g\cdot kg^{-1}$per decade), and a relative humidity (r_L) linear decrease trend of −0.22±0.20% per decade. Using these observations, we can formulate some functional relationships to understand global warming change with specific humidity in the atmosphere as

$$\frac{dGW_L}{dh_L}=\frac{dGW_L}{dt}\frac{dt_2}{dh_L}=\frac{0.17}{0.08}=2.13 \tag{1}$$

As well this provides an opportunity to write the time rate of change of Global warming with the time rate of change in specific humidity increase in the atmosphere

$$\frac{dGW_L}{dt}=2.13\frac{dh_L}{dt} \tag{2}$$

Similar to (1) we can write the change in global warming over land with the change in relative humidity r over land

$$\frac{dGW_L}{dr_L}=\frac{dGW_L}{dt}\frac{dt_2}{dr_L}=-\frac{0.17}{0.22}=-0.77 \tag{3}$$

This also provides an opportunity to write the time rate of change of global warming with the time rate of change in relative humidity decrease in the atmosphere as

$$\frac{dGW_L}{dt} = -0.77\frac{dr_L}{dt} \tag{4}$$

From our conjecture of the sources of these changes in the atmosphere related to greenhouse gasses and our new assertion related to HHS, then the change in r_L and h_L in the atmosphere is some function of $CO_2(T_{rad},O_f)$, HHS(Albedo,p) and other GreenHouse Gasses ($GHG_{other}(T_{rad})$), that is

$$\frac{dr_L}{dt} \sim \frac{dh_L}{dt} \sim f\{CO_2(T_{rad},Oc), HHS(Albedo,p), GHG_{other}(T_{rad})\} \tag{5}$$

Here p is the precipitation, T_{rad} is the increase in temperature due to re-radiation of CO_2 IR back to Earth, O_r is the ocean feedback that creates an increase GH moisture gas evaporation due to rising temperature of the CO_2 re-radiation. We can summarize these general relationships on global warming change over time having the form

$$\frac{dGW_L}{dt} = -k_r\frac{dr_L}{dt} = k_h\frac{dh_L}{dt} \sim f\{CO_2(T_{rad},Oc), HHS(Albedo,p), GHG_{other}(T_{rad})\} \tag{6}$$

where each k is a constant that varies with measurement accuracy. It is important to note that CO_2 in general goes into the atmosphere primarily from land. Therefore, for this feedback to occur, the CO_2 must spread into the atmosphere across the ocean sky area, and then eventually, the ocean gets warmer, which in turn creates ocean evaporation. This is in contrast to the more direct effect of HHS which occurs only over land. On the other hand, we note that HHS is also a function of precipitation. HHS requires a combination of sun absorption and timely precipitation which reduces its influence.

3. HHS-HES Supporting Related Data Trends

The following data and analysis are summarized that supports HHS-HES feedback:

- **HHS-HES Areas on Average are Hotter:** When evaporation occurs from cities and roads, the albedo is on average lower by comparison to vegetative areas that are replaced. Often evaporation is then from hotter surfaces, molecules then have higher kinetic energy, this expands air and increase relative humidity. Even when surfaces are not hotter, the evaporation rate increase is associated with higher entropy, higher specific humidity and lower relative humidity. This is discussed in Section 4.

- **HHS-HES area effect**: A simplified analysis is presented in Section 4 illustrating when all things are equal, the area lost from soil water storage due to roads and cities, for example is given primarily by the differences in evaporation times between the would be vegetative area and the city or road replacement area. For example if it takes a road 2 hours to evaporate a volume of water from a road, while it takes soil 48 hours to evaporate the same amount of water in soil, then the effective soil land lost is a factor of 24 times, contributing to the HHS evaporation rate, specific humidity and global warming emitted moisture greenhouse gas. Although we have not formulated this rate related to transpiration, the rate should still apply.

- **HHS-HES city area effects**: These effects are hard to estimate. As a rough estimate let's assume each building sides equate to 10x the bottom surface area due to having 4 sides and their height. Assume now that buildings take up 50% of a cities area. Now it is estimated that 1.2% of the Earth surface are cities. Then we have 1.2%x50%x10=6% of the Earth's surface area increase having HES area from buildings worldwide. Of course not all sides of the building are in sunlight, but the heat capacity of the building in general can be even warmer on the shady side.

- **Specific Humidity Rising:** Figure 2A shows the increase in specific humidity not just to warming oceans but also over land mass. Overall, water vapor in the surface atmosphere has increased over land and ocean since the 1970s (specific humidity is rising) [5], while the atmosphere over land is becoming less saturated (relative humidity is dropping) [5].

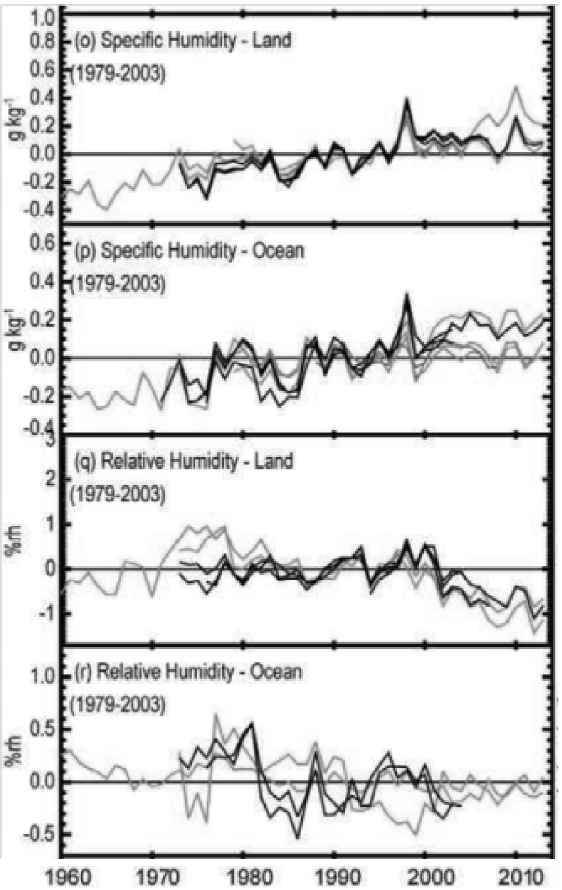


Figure 2A Top two figures shows the specific humidity over land and water both increase while the third figure showing the relative humidity decreasing trend primarily over land while the ocean is more stable but likely harder to measure [5].

- **Precipitation:** Figure 2B illustrates that precipitation has remained constant [5] even though the specific humidity has increased. However in Fig. 7 and 8 we see that in later years it is actually increasing.

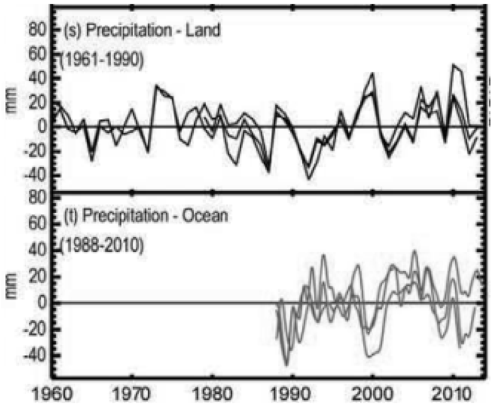


Figure 2B A fairly constant precipitation rate in view of the fact that the specific humidity is increasing [5]. In later years Fig. 7, shows precipitation eventually increasing.

- **Soil Moisture:** Figure 3 shows a decrease in soil moisture [5] likely suggesting a correlation to global warming. This increase in dryness is made worse from HES areas in cities and roads increasing over time.

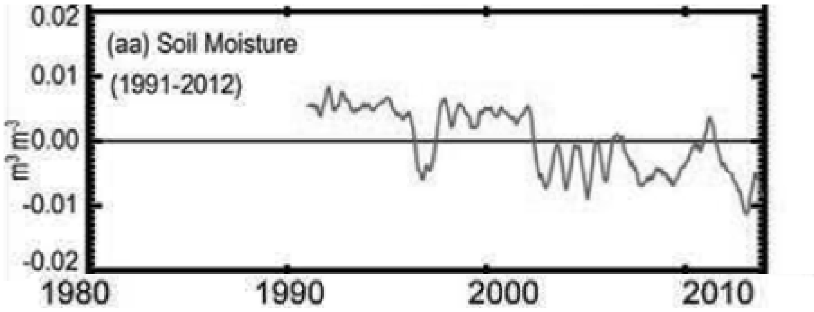


Figure 3 Loss of soil moisture likely due to global warming over land [5]

- **Albedo decline:** In Figure 4, a decline in land albedo [5] is found. One would expect this decrease over land due to the increase in roads and city areas having a much lower albedo value than natural vegetative areas. Global albedo loss has been blamed on glacier loss but here it is illustrated just for land.

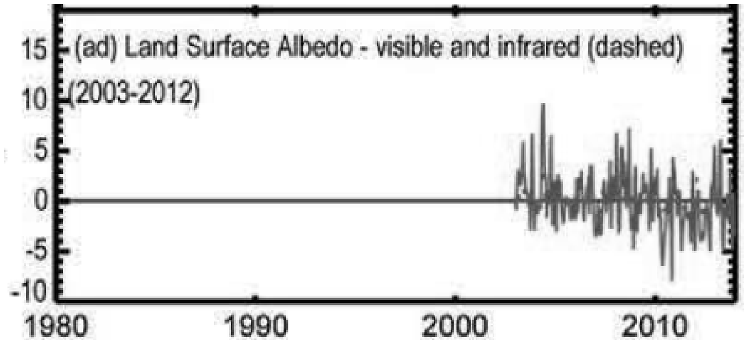


Figure 4 Loss of albedo over land likely due to increase in cities and highways [5]

- **Increase in Asphalt use:** Figures 5 and 6 show an increase in asphalt use (2009-2012) and increase in highway miles (1923-2009), respectively [6,7]. Although the data is limited on asphalt and highway growth, the trend is clear. Climatologists correlate the rising CO_2 greenhouse gases to global warming. Here one could just as well correlate the rising use of asphalt to global warming via contributions from the HES effect and emission of greenhouse water vapor gas**.**

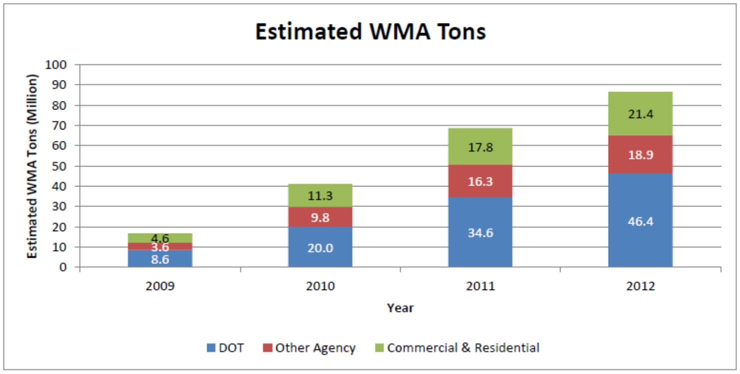


Figure 5 Growth of Warm Mixed Asphalt Usage per year (2009-2012) in USA [6]

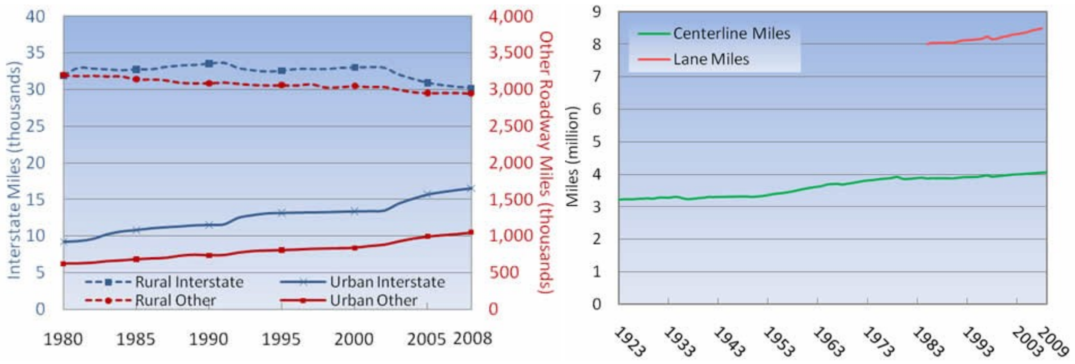


Figure 6 Interstate Miles versus yearly increase in US [7]

- **Specific Humidity Trends and Correlation to Global Warming:** Figure 7 shows specific humidity trends and Figure 8 illustrates the correlation through 2017 from various sources [8]. Here the author does not differentiate between specific humidity and precipitation.

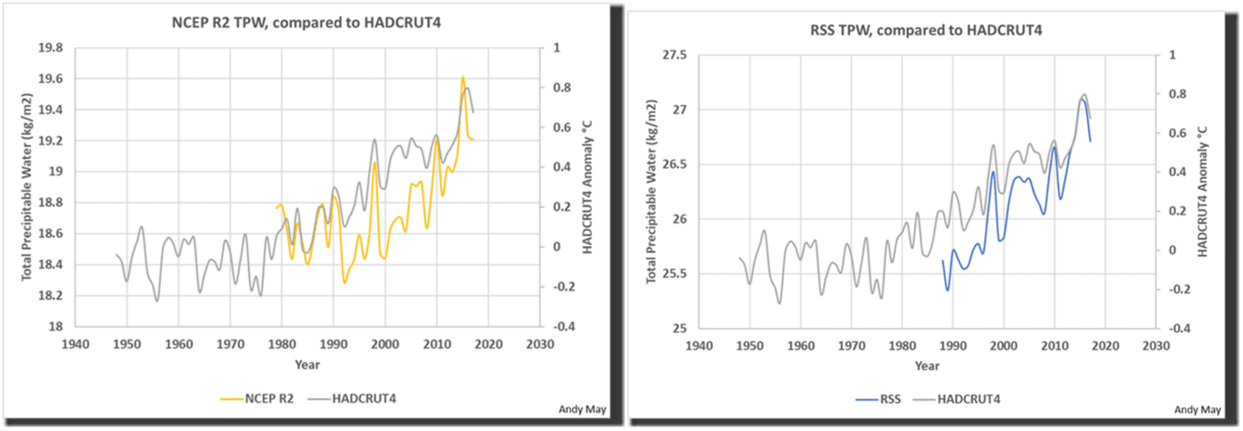


Figure 7 Specific humidity and global warming trends from two different agencies [8]. Here the author does not differentiate between specific humidity and atmospheric precipitation.

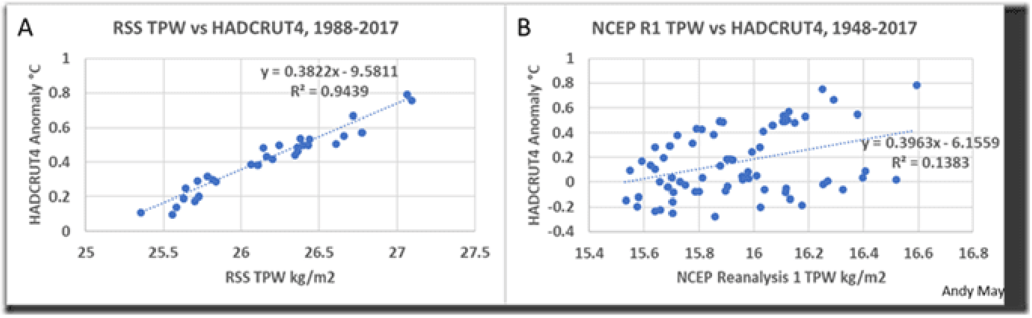


Figure 8 Correlation of specific humidity - Total Precipitation Water (TPW) for different data with global warming [8]. Here the author does not differentiate between specific humidity and atm. precipitation.

The primary effect that we are looking at with respect to data is a possible contribution to the evaporation rate and its effect on the rising specific humidity in the troposphere (lower 10 miles of atmosphere). Other related effects are likely dry conditions that are a necessary but not sufficient condition for drought. Hot roads and city walls also expand air and not only drive up specific humidity during precipitation but lower %RH. One other critical effect that is hard to calculate is loss of plant water storage and transpiration. When impermeable surfaces replace vegetation, the rate of evaporation is exceedingly high compared to transpiration which is said to account for 10% of all evaporation [9]. Climate change is then hard to predict. Lost wet lands can lead to dry condition with less increase in specific humidity.

4. HHS-HES Effective Area of Evaporation and Temperatures

HHS-HES areas are increasing with growth of cities and roads. This feedback mechanism related to new moisture greenhouse gasses is shown in Figure 1A. Below is a list of Albedo average values and associated temperatures in strong sunlight.

When precipitation falls on roads after being exposed to sun, the rapid evaporation initially 20°C hotter than grass lands in similar sunlight of 1000W/m^2 for 1 m^2 area emits energetic water molecules. Often we have more energetic molecules evaporated into the air from such surfaces. This not only increase the specific humidity but decrease the relative humidity. (Air is expanded at higher temperatures, that is warm air can hold more moisture greenhouse gas). Higher evaporation rates even for the same temperature surfaces also increase entropy which may somewhat also increase specific humidity and lower relative humidity.

Table 1 Albedo of different surfaces and temperatures at 1000 W/m^2 for 1m^2 area

Surface	Albedo (0-1)	Temperature For 1M^2 at 1000 W/M^2
Water		
Snow	0.8	-29.5 C
Ice	0.6	16.7 C
Open Ocean	0.06	85.7 C
Land		
Roads (0.04)	0.04	87.6 C
Urban Cov (0.12)	0.12	79.8 C
Forest (0.17)	0.17	74.7 C
Grass lands (0.26)	0.26	64.8 C
Desert (0.4)	0.4	47.6 C

A simplified expression for the equivalent HHS-HES area found in Appendices A, B, and C roughly given by

$$A_{EfHES} = (\frac{t_{Soil}}{t_{HES}})A_{Soil} = (\frac{t_{Soil}}{t_{HES}})(A_{HES} - A_{HES-\%IG}) \tag{7}$$

Where

A_{EfHES}=Effective HHS-HES area,

A_{Soil}=soil area, this is set equal to an equivalent to A_{HES} area, subtracte from

$A_{HES-\%IG}$ any % run off of irrigated water falling on the roads or city surface areas to vegetation areas

t_{Soil} is the evaporation time of the soil

t_{HES} is the evaporation time of the asphalt or city surface after precipitation occurs.

As we mentioned above, if it takes a road 2 hours to evaporate a volume of water from a road, while it take soil 48 hours to evaporate the same amount of water in soil, than the effective soil land lost is a factor of 24 times contributing to the evaporation rate and specific humidity. This example is for roads with zero percent irrigation-equivalent area running off water to adjacent land.

The factor $(\frac{t_{Soil}}{t_{HES}}) = \Delta R$ provides an evaporation rate related to the time rate of change. In the above example we see that the rate would be 24 times faster than if roads were not constructed. In the appendix this rate is shown as a function of

- $\Delta R\{(Exp-(E_a/k_B\ T))$, average soil vs asphalt specific heat Cv, dCv/dt, dm/dt, average Δalbedo, soil diffusion rate, evapotranspiration, windspeed}
- **HHS-HES city area effects**: These effects are hard to estimate. As a rough estimate let's assume each building sides equate to 10x the bottom surface area due to having 4 sides and their height. Assume now that buildings take up 45% of a cities area. Now it is estimated that 1.2% of the Earth surface are cities. Then we have 1.2%x55%+1.2%x45%x10=6% of the Earth's surface increases having HES areas from buildings worldwide, this is also new area for solar heating. That is cities increase the solar surface area of the earth as we mine materials to build them.
- **HHS-HES from cars:** This effect may be significant as car surface area temperatures vary with color and hood temperatures. As well, unlike cities that cool-off at night, hood temperature in the rain still create HHS'. This also causes hot runoffs. As well there are likely other combustive areas. (see solutions).

4.1 An Albedo Change in Cities would be Non-Trivial for a Global Warming Partial Solution

Above we did a crude estimate of the increase in surface area that a cities actually occupy which is significant in terms of HHS-HES. As well it is significant for the Earths energy budget. Not having knowledge of the models that Climatologist use it is hard to know what effective area that have put in for cities. However, there is no real discussion on changing city Albedo's as a partial solution. The focus has been only on CO2. Yet in Appendix F we show a market change in the 2020 Albedo estimate form cities surface area alone. This in addition to the HHS-HES. The renormalized surface increase from 1.2% to 6.79% for Urban coverage. Although the model does not take into account what portion of the surfaces are approximately illuminated, the results shows a drop in 2020 albedo from 28.8% to 28.4%. We see that with the HHS-HES issues and this albedo change, that it non trivial to start consider requiring cities world wide to be more reflective. With the infrared technology today, it is easy to pinpoint urban island buildings that are problematic and mandate changes.

5. Data on Rain Water Management (RWM), Drought, Global Warming Trends

Rainwater management may be an important factor. It can also impact where it rains! Rain follows local evapotranspiration. Apart from precipitation, evapotranspiration is the major component in the hydrologic budget. Evapotranspiration involves the process of evaporation from open bodies of water, wetlands, snow cover, and bare soil and the process of transpiration from vegetation. If ocean precipitation increases, then land precipitation can decrease.

When it rains in a city, much of the land in urban areas is covered by pavement or asphalt. Because rain can't soak into the soil underneath, these covered areas are impermeable surfaces. As the amount of impermeable surface increases with urbanization, so too does the amount of runoff. As an example, in urban cities 30% is often estimated for evapotranspiration, 10% shallow soil infiltration, 5% deep soil infiltration, and RWM takes 55% into runoff.

- The New York Environment Report, in 2014 reported [10], "Every year, old sewers flooded by storm water release more than 27 billion gallons of untreated sewage into the New York Harbor alone."

- Fry et al [11] reported that in February of 2019 California estimated that 18 trillion gallons of rain in February alone had most of the water going to the Pacific Ocean. The article goes on to point out the LA dept. of water captured 22 billion gallons of water during recent storm.

As roads and cities have increased, so too has the albedo decreased, in cities like LA, HHS-RWM runoff can have major impact on local ocean temperature increase and evaporation from its surface. Land can also becomes dryer as there is less water storage in wetlands as shown in Figure 1B. As the water storage is shifted from the land to the ocean, local precipitation can be affected. The precipitation could change to more over the ocean and less over the land. This makes the local area prone to drought and higher average temperatures. When it does rain over drought areas, the runoff is warmer warming the local ocean areas and increasing surface evaporation and moisture greenhouse gas. This could create a feedback cycle of higher temperature on land and again warmer runoff see Fig. 1B.

As an example of the importance in losing wet land (water storage), Cao et. al. [12] did a study on wet land reduction in China and correlation to drought with the following conclusion

- "The wetland distributions and areas of the five provinces of southwestern China in the 1970s, 1990, 2000 and 2008 show that the total reduction of wetland area was 3553.21 km^2 in the five provinces of southwestern China from 1970 to 2008, accounting for about 17% of the ground area, and thus the average annual reduction area is about 88.83 km^2. The reduction rate was comparatively fast from 2000 to 2008 with an average annual reduction of 329.31 km^2. The changes to the wetland area show a negative correlation with temperature (i.e. wetland decrease, increase in temperature), and a positive correlation with precipitation (i.e. wetland decrease, precipitation decrease).” [12]

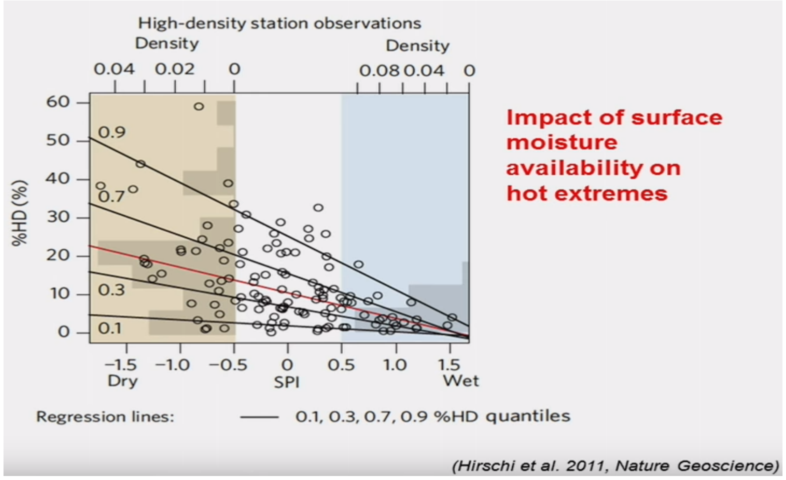
Hirshi et al. [13] did the following study

- “We analyzed observational indices based on measurements at 275 meteorological stations in central and southeastern Europe, and on publicly available gridded observations. We find a relationship between soil-moisture deficit, as expressed by the standardized precipitation index, and summer hot extremes in southeastern Europe. This relationship is stronger for the high end of the distribution of temperature extremes. We compare our results with simulations of current climate models and find that the models correctly represent the soil-moisture impacts on temperature extremes in southeastern Europe, but overestimate them in central Europe.”

Below is the graph from their study [13]. It shows a negative linear relationship between wet land decrease and dry day increase

$$\%HD = -k\ WL(\text{Water Runoff and/or Loss of Wet Land}) + b \tag{9}$$

where k is the slope related to the dryness. Here we have taken some liberties and generalized it to include water runoff.



(Hirschi et al. 2011, Nature Geoscience)

Figure 9 Percent Hot Days (HD) correlated to dry vs wet areas [13]

As another example, it is found that in large areas of the Southwest, evapotranspiration is virtually equal to 100 percent of the precipitation, which is only about 10 inches per year [9].

By contrast, in the conterminous United States, the estimated mean annual evapotranspiration is greatest in the Southeast (about 35 inches per year or about 70 percent of the precipitation), which is an area of abundant precipitation, permeable soils, and substantial solar radiation; it is least in the semiarid region of the Southwest where precipitation is limited. The ratio of estimated mean annual evapotranspiration to precipitation is least in the mountains of the Pacific Northwest and New England where evapotranspiration is about 40 percent of the precipitation [9].

Some efforts have been made to improve storm water innovation in RWM. The effort is called LID [14], “Low Impact Development (LID) is a planning and design approach that aims to mimic naturalized water balances. It combines infiltration, evaporation and transpiration while limiting runoff. The goal of LID is to restore processes that are lost in a built-up urban environment. LID includes several types of low-level new and innovative stormwater technologies that together let water infiltrate the ground and evapotranspire into the air. However, no efforts have been made to cooling HHS.

5.1 RWM Effect on Oceans

Rising oceans’ levels are anticipated with global warming due to the fact that the ocean expands as it warms. Its levels also will increase due to glacier melting. However, it doesn’t help to have RWM also contributing from cities all over the world with water runoffs into the ocean. Prior to the industrial revolution, much of this water went to natural vegetation, streams and lakes. Urban and city are typically few degrees hotter and HHS-RWM may be instrumental in local water temperatures. RWM runoff into the ocean's of course also created a reduction of wet lands. Shifting precipitation from land to over oceans is a large concern. Most climate models do not agree on precipitation and drought areas as climate is hard to predict [15].

"The average of the models shows large increases in precipitation near the equator, particularly in the Pacific Ocean[15]"

It would be close to impossible to tell if RWM has a direct bearing on precipitation in certain areas. However, we have illustrated a number of studies that suggest logically that HHS-RWM is very important.

6. The Contention Against CO_2 Feedback Being Solely Responsible for Specific Humidity Increase

Here we provide some contention that an increase in specific humidity cannot be solely due to CO_2 feedback. We can do a rough thought experiment. The reason it is hard to blame this increase on CO_2 emissions is the following possible low percentages:

1) Ocean area for heating is about 68.7%
2) CO_2 IR radiation back towards Earth are 50%
3) The CO_2 radiation is narrow band 15 um with some spectral width.
   Only a portion of this radiation is likely re-absorbed by other CO_2, 25% for example
4) Then a portion is absorbed by water vapor in the atmosphere, 60% for example
5) A portion of 3) and 4) above are re-radiated away from Earth 50%

This leaves 0.687 x 0.5 x 0.75 x 0.4 x 0.5 = 5.2% re-radiates back to Earth for global warming. These are numbers pulled out of a hat. But the point is, we see there are likely other contributions from HHS-RWM and HHS-HES that are likely contributing to global warming trends besides CO_2.

6. Summary - Solutions

From data and analysis, we do not anticipate that solving the CO_2 problem will fully stop global warming form occurring. We find that it is highly likely that HHS-HES areas and HHS-RWM are contributing to global warming, and that more studies are needed to assess the impact and how much it is contributing compared to the CO_2 feedback mechanism.

HHS-HES and HHS-RWM Reduction Suggested Solutions

- Further studies are required in this area to understand the effect and contribution to GW
- Change Albedo of roads and cities will reducing HHS and the area effect dramatically, i.e. paint roads and building with reflective colors (minimally higher than albedo of 0.25)
- Engineering roads to be more HHS eco-friendly
- Reduce driving speeds during rain to reduce evaporation rates can also reduce KE molecules
- Change to electric cars with HHS - cooler hoods
- Paint all cars metallic or white (high reflective colors)
- Move car engines to the back of the car with as little rain surface area as possible
- Improve HHS-HES irrigation to soil
- Improve vegetation in run off areas by planting millions of trees in HHS-HES areas
- Require negative population growth to reduce increase HHS-HES surfaces
- Adopt Low Impact Development (LID) in city planning and improvements for design approach aiming to mimic naturalized water balances
- Cool rain water runoff with green electricity prior to dumping it in the ocean

- Severe HHS-RWM changes are required to stop runoff into the ocean worldwide

Appendix A HES Effective Area Thought Experiment 1:

We take two identical pieces of asphalt having different albedos and areas. One is measuring 1 meter^2 while the second area is to be determined such that they both have the same evaporation rate when water is on the surface. The first asphalt piece is black and has an albedo of 0.05 while the second is painted white and has an albedo of 0.8. Then looking at the temperature profiles with about 1000 W/M^2 of sunlight falling on them, the temperature is approximated as

$$T_i(albedo) = \left(\frac{(1 - Albedo_i)Eo}{\sigma} \right)^{0.25} \qquad \text{(A1)}$$

Taking E_o=1000W/m^2, then T(0.05)=360°K=87°C, and T(0.8)=340°K=67°C. This shows that we have 20°C difference.

Consider now the general case with a piece of asphalt at temperature T, area A, material constant R_o in an environment with air pressure P, relative humidity RH, and wind speed is r. Now consider a mass m of water spread uniformly on the surface. We then take the evaporation rate E for the non soluble surface approximated as

$$E = \frac{dm}{dt} = R_o A_i \exp\{-\frac{E_a}{K_b}(\frac{1}{T_i})\} f(P, RH, r) \qquad \text{(A2)}$$

Here *f* is some function of the variables *P, RH,* and *r*. We take a second surface of the same material but at different temperature T and area A and look at the ratio of the evaporation rates yielding

$$E(2,1) = \frac{dm_2 / dt}{dm_1 / dt} = \frac{A_2}{A_1} \exp\{\frac{E_a}{K_b}(\frac{1}{T_{1Lower}} - \frac{1}{T_{2Upper}})\} \qquad \text{(A3)}$$

Here we have held variable *P, RH, r,* and R_o left unchanged so they cancel. We allow T_2>T_1. We then find that for A_1 to have the same evaporation rate as A_2 will occur when E(2,1)=1, so that A_1 is found just from the temperature rate as

$$A_1 = A_2 \exp\{\frac{E_a}{K_b}(\frac{1}{T_{1Lower}} - \frac{1}{T_{2Upper}})\} \qquad \text{(A4)}$$

As an example, for typical water evaporation from a surface at temperature T, a common value for E_a=40.8KJ/Mole=0.423eV. Using the values found above for different albedo temperatures we had T(0.05)=360°K=87°C, T(0.8)=340°K=67°C, and inserting these values into the above equation gives

$$A_1 = 2.3\,A_2 \qquad \text{(A5)}$$

Another way of saying this is that if we paint the asphalt a different color with an albedo of 0.8 compared with the typical value of black asphalt of 0.05, we actually make the area 2.3 times smaller in terms of evaporation rate which also impacts the time due to a cooler material with large specific heat. This also allows more time for water to run off and be stored in the land.

We can simplify this result and make a generalization from the above equation related to the effective area for evaporation between two surfaces, and this is

$$A_1 = (\tau_2 / \tau_1)\,A_2 \qquad \text{(A6)}$$

Where τ_i is the evaporation time since the rate goes as the Arrhenius function, for the ith surface at different temperatures all other evaporation factors being the same.

This is an important relation for road design, if we can slow down the evaporation rate from a road, we can decrease its effective evaporation area. Besides albedo change, other design factors can be thought of such a water runoff to land, road irrigation, road water storage similar to soil, transpiration, material changes with lower specific heat capacity. Engineering roads to be more eco-friendly is one conclusion in this paper.

Appendix B- HES Area Effect Thought Experiment 2:

We take two surfaces, one with heat capacity C_{v1} and Area A1, and the second with C_{v2} and Area A2. Both surfaces are evaporating water and start at the same temperature, however we let $C_{v2}=2C_{v1}$. What is the equivalent area if they both are required to evaporate equally for the same time period.

Time to change Q is

$$t=\frac{Q}{P}=\frac{C_v m\Delta T}{P}=\frac{C_v m\Delta T}{pA} \tag{B1}$$

where Q is the change in heat occurring from ΔT change, m is the mass, P is the power in Watts, p is the sunlight power in W/m^2, A=Area. For example for asphalt C_v = 900 J/kg K, if m=1000Kg and ΔT=20K, then ΔQ=900 J/kg K x 1000Kg x 20K=18 E6 Joules. If 1000 W/m^2 falls on a 1 m^2 surface area then the time for this temperature change is

$$t=\frac{18E6J}{1000J/\sec}=300\min \tag{B2}$$

given that both areas have the same mass and same p, and both change by an amount ΔT then general

$$\frac{t_1}{t_2}=\frac{C_{v1}A_2}{C_{v2}A_1} \tag{B3}$$

if $C_{v2}=2C_{v1}$ then for $t_1=t_2$ we must have

$$A_1(C_{v1})=2A_2(2C_{v1}) \tag{B4}$$

Here we see that if Area A2 has a larger C_v, that evaporation times are only equivalent if A1 is larger proportionately. This can again be summarized by their evaporation times such that

$$A_1=(\frac{t_1C_{v2}}{t_2C_{v2}})A_2=(\frac{t_{1Cv}}{t_{2Cv}})A_2 \tag{B5}$$

Appendix C: HES Area Effect Thought Experiment 3

Consider now the complex case of a vegetative area being replaced by an asphalt highway. The specific heat of soil and mass can vary as water evaporates. This is untrue of asphalt. The specific heat of water is 4186 J/kg K compared to asphalt =900 J/kg K. We see that soil holds heat actually 4 times larger than asphalt. However, soil heat capacity varies with precipitation (soil dry=800, soil wet=1480 J/kg K). When it rains, the asphalt cools while it evaporates water. On the other hand, the rain cools the Earth at a faster pace since soil has a lower Cv and it is less conductive below the surface where th temperature is cooler. In order to evaporate from the soil in sunlight after it rains it takes time to heat the surface area. We see that the change in heat is a complex function of time as the soils mass and Cv changes with time.

$$\frac{d\Delta Q}{dt}=(dm/dt\,C_v+m\frac{dC_v}{dt})\Delta T \tag{C1}$$

To simplify the complex problem we take an average

$$\overline{\Delta Q}=\overline{m}\overline{C_v}\Delta T \tag{C2}$$

Furthermore as water evaporates at the surface of the soil the stored water below diffuses to the top surface. Therefore the time is further lengthening by the diffusivity of water in the soil. So the equation is modified and simplified again so it is just a function of time to estimate the area ratios

$$A_1=(\frac{t_1\overline{D}\overline{m}\overline{C}_{v2}\overline{\Delta T}_2}{t_2mC_{v2}\overline{\Delta T}_1})A_2=(\frac{t_{1\overline{m}\overline{D}\overline{C}v\Delta T}}{t_{2mCv\Delta T}})A_2 \tag{C3}$$

The result demonstrates that the area effect can be simplified to the evaporation time. For example if water evaporates from a highway in 5 hours and on land the same amount of water evaporation takes 50 hours, then lost area is a factor of 10.

Appendix D – Earth's Energy Budget 2020 & 1950 Due to Slight Albedo Change

Earth's energy budget estimates when the albedo decrease from 0.29 to 0.288 we get a 0.32°F temperature increase. This feeds the HHS across the globe from roads and cities.

<u>1950 Albedo=0.29</u>

Power Absorbed = 0.71 x 0.25x 1361 W/m2 =241.58 Watts/m^2

E=σT^4=241.58 W/m2 , T=255.5°K=0.2°F

2020 Albedo=0.288

Power Absorbed = 0.712 x 0.25 x 1361 W/m2 =242.26 Watts/m^2

E=sT^4=242.26 W/m2, T=255.66K=0.52°F

ΔT=0.32 °F increase in 2020

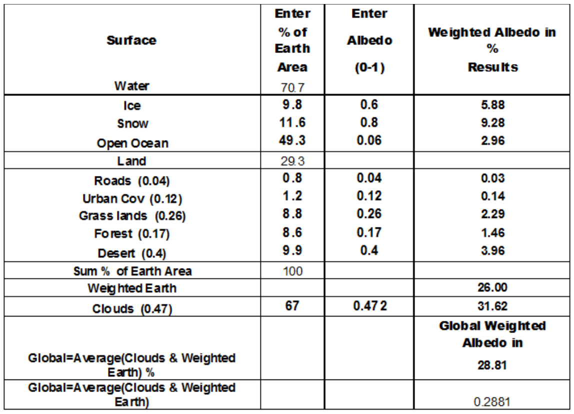
Appendix E Simplified Weighted Albedo Model 1950 & 2020

Below is a simplified Albedo model to estimate the Earth's total albedo decrease with increase in city and road areas and a decrease in grass lands where the albedo decrease from 0.29 to 0.288, estimated between 2020 and 1950 respectively. Results of the simplified weighted model are given in Tables E1 and E2. Equation E1 is the weighted albedo by area, E2 is the weighted albedo with clouds.

$$Earth\ Weighted\ \ Albedo = \sum\nolimits_i (\%\,Earth\ Area_i\ x\,Surface\,Item\ Albedo_i) \tag{E1}$$

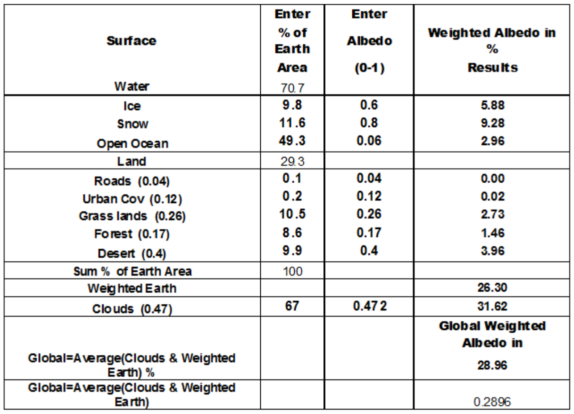
$$Global\,Weighted\ Albedo = Average\{(Clouds\ Albedo\,x\,\%\ Coverage) + (Earth\ Weighted\ Albedo)\} \tag{E2}$$

Table E1: Albedo of 0.288 Year=2020



Surface	Enter % of Earth Area	Enter Albedo (0-1)	Weighted Albedo in % Results
Water	70.7		
Ice	9.8	0.6	5.88
Snow	11.6	0.8	9.28
Open Ocean	49.3	0.06	2.96
Land	29.3		
Roads (0.04)	0.8	0.04	0.03
Urban Cov (0.12)	1.2	0.12	0.14
Grass lands (0.26)	8.8	0.26	2.29
Forest (0.17)	8.6	0.17	1.46
Desert (0.4)	9.9	0.4	3.96
Sum % of Earth Area	100		
Weighted Earth			26.00
Clouds (0.47)	67	0.472	31.62
Global=Average(Clouds & Weighted Earth) %			Global Weighted Albedo in 28.81
Global=Average(Clouds & Weighted Earth)			0.2881

Table E2: Albedo of 0.29, Year=1950

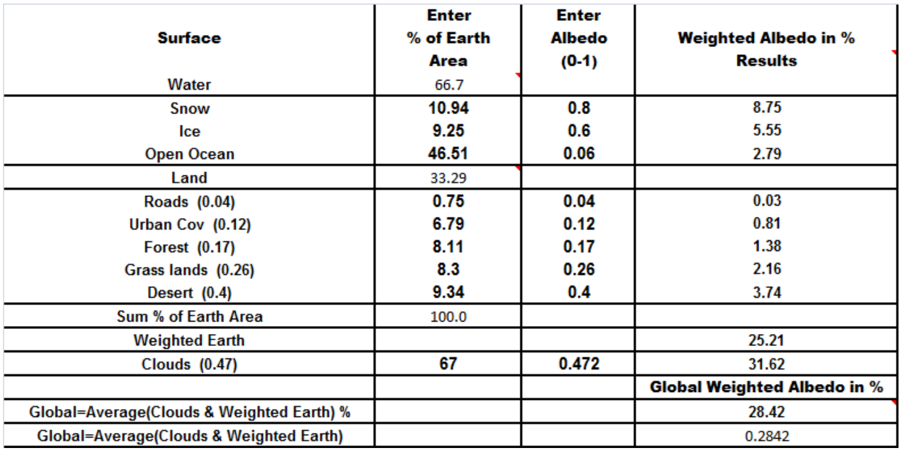


Surface	Enter % of Earth Area	Enter Albedo (0-1)	Weighted Albedo in % Results
Water	70.7		
Ice	9.8	0.6	5.88
Snow	11.6	0.8	9.28
Open Ocean	49.3	0.06	2.96
Land	29.3		
Roads (0.04)	0.1	0.04	0.00
Urban Cov (0.12)	0.2	0.12	0.02
Grass lands (0.26)	10.5	0.26	2.73
Forest (0.17)	8.6	0.17	1.46
Desert (0.4)	9.9	0.4	3.96
Sum % of Earth Area	100		
Weighted Earth			26.30
Clouds (0.47)	67	0.472	31.62
Global=Average(Clouds & Weighted Earth) %			Global Weighted Albedo in 28.96
Global=Average(Clouds & Weighted Earth)			0.2896

Appendix F: Re-normalizing the Earth's Surface Albedo Area with Cities

We have asserted in Section 4 that the Earth's surface area has increase as we build cities. Esentially we have mined materials like steel underground and built the Earth surface up. We provided a crude estimate in Section 4 that cities now occupy a factor of 6 times larger than the current estimated surface area. The original surface area was 1.2% of the earth surface, multiplying by 6 this is 7.2%. This would yield 106% in the 2020 Albedo Table E1 so we would have to renormalize the Earth's surface area to re-estimate the 2020 Albedo table E1 as an example. Table F1showe the new surface area renormalized from 106% the effective area of Urban coverage is now 6.69% and the albedo as a result has fallen to 28.42% from the first estimate of 28.8% in Table E1. This yields to major things. First it seriously impacts the Earths energy budget. Furthermore it shows the HHS-HES area increase. On the positive side, it shows that it would be non trivial to require that cities be mandated to improve their reflectivity requiring all buildings to has a higher Albedo.

Table F1: Albedo of 0.288 Year=2020



Surface	Enter % of Earth Area	Enter Albedo (0-1)	Weighted Albedo in % Results
Water	66.7		
Snow	10.94	0.8	8.75
Ice	9.25	0.6	5.55
Open Ocean	46.51	0.06	2.79
Land	33.29		
Roads (0.04)	0.75	0.04	0.03
Urban Cov (0.12)	6.79	0.12	0.81
Forest (0.17)	8.11	0.17	1.38
Grass lands (0.26)	8.3	0.26	2.16
Desert (0.4)	9.34	0.4	3.74
Sum % of Earth Area	100.0		
Weighted Earth			25.21
Clouds (0.47)	67	0.472	31.62
			Global Weighted Albedo in %
Global=Average(Clouds & Weighted Earth) %			28.42
Global=Average(Clouds & Weighted Earth)			0.2842

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