Optimum Solution to Global Warming due to a Greenhouse Gas-Albedo Hotspot Theorem

Alec Feinberg
DfRSoft Research, email: dfrsoft@gmail.com

Key Words: Albedo Solution, Global Warming Solution, Global Warming Re-radiation Model,, Hotspot Mitigation, UHI Global Warming Estimates

Abstract

In this paper we suggest that a fundamental GHG-albedo hotspot surface theorem, when applied to the reality of today's climate challenges, appears to indicate that the albedo solution would be the optimum and safest way to mitigate climate change. The theorem also indicates that CO2 solutions has an associated risk in stopping climate change. We also detail the albedo-GHG factor is detailed.

1. Introduction

Since GHGs need long wavelength radiation to work, then changing a hotspot surfaces albedo is associated with the greenhouse gas mechanism. Therefore, we can devise *a greenhouse gas (GHG) albedo hotspot surface theorem* stating*:*

- *Increasing the reflectivity of a hotspot surface has the same effect as reducing greenhouse gases*
- *Decreasing the reflectivity of a hotspot surface has the same effect as increasing greenhouse gases*
- *The global warming change associated with the reflectivity hotspot change is given by the albedo-GHG radiation factor having an approximate value of 1.6.*

This fundamental theorem is important because it leads one to the reality that conservatively, the albedo solution is our fastest and safest method to stop climate change. There have been a number of geoengineering resolutions proposed [1-3] that are either atmospheric of surface-based.

The reflectivity solution is safest because of

- the slow progress reported in GHG reduction
- the yearly increases in reports on large desertification and deforestation occurring [4]
- UHI hotspot contested issues
- Lack of hotspot and hydro-hotspot control [5]
- CO2 solutions are not guaranteed to be optimum
- this theorem indicates the albedo solution has minimal risk [6]

To clarify the last items, many authors have contested that a significant portion of global warming is due to UHIs. This is now confirmed both with measurements [7-18] and more recently assessed in modeling [5,19]. Furthermore, humankind has a lack of hotspot controls in the construction of UHIs and impermeable surfaces which are increasing with population [5, 19] growth. We have two key forcing issues, hotspots and greenhouse gas issues. Hydro-hotspots [5, 20] also increase local atmospheric water vapor GHG in the presence of precipitation. This is not well understood in its contribution to global warming. However, we do know that cities in humid environments are hotter [21]. Therefore, CO_2 solutions themselves are not guarantee to mitigating global warming and puts our planet at risk. ***Yet, the albedo solution must according to this theorem, guarantee success with little if any risk.*** The albedo solution would also promote hotspot controls reducing the inherent global warming. Guaranteeing success is not only important for real-world implementing solutions but also for optimum financial success.

One aspect of that is of interest is to demonstrate the albedo-GHG radiation 1.6 factor [5] and its change since the pre-industrial revolution. Such values relates to the effective emissivity constant of the planetary system β^4. Because of its importance as it relates to the albedo-GHG mechanism, it is a primary focus in the rest of this paper.

2. Albedo-GHG Radiation Global Warming Pre-Industrial Factor

When initial solar absorption occurs, part of the long wavelength radiation given off is re-radiated back to Earth. In the absence of forcing we denote this fraction as f_1. This presents a simplistic but effective model

$$P_{\mathrm{Pr}e-Industrial} = P_\alpha + P_{GHG} = P_\alpha + f_1 P_\alpha = P_\alpha\left(1+f_1\right) = 1.618034\,P_\alpha = \sigma T_S^4 \qquad (1)$$

where

$$P_\alpha = \frac{S_o}{4}(1-\alpha) \qquad (2)$$

and T_s is the surface temperature. As one might suspect, f_1 turns out to be exactly β^4 in the absence of forcing, so that f_1 is a redefined variable taken from the effective emissivity constant of the planetary system. We identify this as 0.618034 [5] in the next section.

2.1 Basic Re-radiation Model and Estimating f_1

In geoengineering, we are working with absorption and re-radiation, we define

$$P_{Total} = \sigma T_S^4 = \sigma\left(\frac{T_e}{\beta}\right)^4 \text{ and } P_\alpha = \sigma T_\alpha^4 = \sigma\left(\beta T_S\right)^4 \qquad (3)$$

The definitions of T_α=T_e, T_S and β are the emission temperature, surface temperature and typically $\beta \approx 0.887$, respectively. Consider a time when there is ***no forcing issues*** causing warming trends. Then by conservation of energy, the equivalent power re-radiated from GHGs in this model is dependent on P_α with

$$P_{GHG} = P_{Total} - P_\alpha = \sigma T_S^4 - \sigma T_\alpha^4 \qquad (4)$$

To be consistent with T_α=T_e, since typically $T_\alpha \approx 255^oK$ and $T_s \approx 288^oK$, then in keeping with a common definition of the global beta (the proportionality between surface temperature and emission temperature) for the moment $\beta = T_\alpha/T_s = T_e/T_S$.

This allows us to write the dependence

$$P_{GHG} = \sigma T_S^4 - \sigma T_\alpha^4 = \frac{\sigma T_\alpha^4}{\beta^4} - \sigma T_\alpha^4 = \sigma T_\alpha^4\left(\frac{1}{\beta^4} - 1\right) = \sigma T_\alpha^4\left(\frac{1}{f} - 1\right) \qquad (5)$$

Note that when β^4=1, there are no GHG contributions. We note that f, the re-radiation parameter equals β^4 in the absence of forcing.

We can also define the blackbody re-radiated by GHGs given by some fraction f_1 such that

$$P_{GHG} = f_1\,P_\alpha = f_1\,\sigma\,T_\alpha^4 \qquad (6)$$

Consider $f=f_1$, in this case according to Equations 5 and 6, it requires

$$P_{GHG} = \sigma T_\alpha^4 \left(\frac{1}{f_1} - 1 \right) = f_1 \sigma T_\alpha^4 \tag{7}$$

This dependence leads us to the solution of the quadratic expression

$$f_1^2 + f_1 - 1 = 0 \text{ yielding } f_1 = 0.618034 = \beta^4 \text{, } \beta = \left(0.618034\right)^{1/4} = 0.886652 \tag{8}$$

This is very close to the common value estimated for β and this has been obtained through energy balance in the planetary system providing a self-determining assessment. In geoengineering we can view the re-radiation as part of the albedo effect. Consistency with the Planck parameter is shown in Section 6. We note that the assumption $f=f_1$ only works if planetary energy is in balance without forcing. In the next section, we double check this model in another way by balancing energy in and out of our global system.

3. Balancing P_{out} and P_{in} in 1950

In equilibrium the radiation that leaves must balance P_α, the energy absorbed, so that

$$\begin{aligned} Energy_{Out} &= (1-f_1)P_\alpha + (1-f_1)P_{Total} = (1-f_1)P_\alpha + (1-f_1)\left\{P_\alpha + f_1 P_\alpha\right\} \\ &= 2P_\alpha - f_1 P_\alpha - f_1^2 P_\alpha = Energy_{In} = P_\alpha \end{aligned} \tag{9}$$

This is consistent, so that in 1950, Eq. 9 requires the same quadratic solution as Eq. 8. It is also apparent that

$$P_\alpha = f_1 P_{Total\_1950} = \beta_1^4 P_{Total\_1950} \tag{10}$$

since

$$P_\alpha = f_1(P_\alpha + f_1 P_\alpha) \;\; or \;\; 1 = f_1(1+f_1) \tag{11}$$

The RHS of Eq. 11 is Eq. 8. This illustrates f_1 from another perspective as the fractional amount of total radiation in equilibrium. As a final check, the application in the next Section in Table 1, illustrate that f_1 provides reasonable results.

4. Re-radiation Model Applied to 2019

In 2019 due to global warming trends, to apply the model we assume that feedback can be applied as a separate term and we make use of some IPCC estimates for GHG forcing as a way to calibrate our model. In the traditional sense of forcing, we assume some small change to the albedo and most of the forcing due to IPCC estimates for GHGs where

$$P_{Total\,2019} = P_{\alpha'} + P_{GHG'} = P_{\alpha'}(1+f_2) \tag{12}$$

Then we introduce feedback through an amplification factor A_F as follows

$$P_{Total\,2019\,\&\,Feedback} = P_{1950} + \left(\Delta P\right) A_F = P_{1950} + \left(P_{2019} - P_{1950}\right) A_F = \sigma T_S^4 \tag{13}$$

Here, we assume a small change in the albedo denoted as P_α' and f_2 is adjusted to the IPCC GHG forcing value estimated between 1950 and 2019 of 2.38W/m^2 [39]. Then the feedback amplification factor, is calibrated so that $T_S=T_{2019}$ (see Table 1) yielding A_F =2.022 [also see ref. 22]. The main difference in our model is that the forcing is about 6% higher than the IPCC for this period. Here, we take into account a small albedo decline of 0.15% that the author has estimated in another study due to likely issues from UHIs [20] and their coverage. We note that unlike f_1, f_2 is not a strict measure of the emissivity due the increase in GHGs.

5. Results Applied to 1950 and 2019 with an Estimate for f_2

In 1950 we will simplify estimates by assuming the re-radiation parameter is fixed at the pre-industrial level of f_1=0.618034. Then, to obtain the average surface temperature T_{1950}=13.89^{o}C (287.04^{o}K), the only adjustable parameter left in our basic model is the global albedo. This requires an albedo value of 0.3008 (see Table 1) to obtain T_{1950}.=287.04°K. This albedo number is reasonable and similar to values cited in the literature [31].

In 2019, the average temperature of the Earth is T_{2019}=14.84°C (287.99°K) given in Eq. 15. We have assumed a small change in the Earth's albedo due to UHIs [20]. The f_2 parameter is adjusted to 0.6276 to obtain the GHG forcing shown in Column 7 of 2.38W/m^2 [23]. Therefore the next to last row in Table 1 is a summary without feedback, and the last row incorporated the A_F=2.022 feedback amplification factor.

Table 1 Model results

Year	T_S(°K)	T_α(°K)	f_1, f_2	α, α'	Power Absorbed W/m^2	$P_{GHG'}$, P_{GHG}	P_{Total} W/m^2
2019	287.5107	254.55	0.6276	30.03488	238.056	149.4041	387.4605
1950	287.04	254.51	0.6180	30.08	237.9028	147.024	384.9267
Δ2019-1950	0.471	0.041	0.0096	(0.15%)	0.15352	2.38	2.53
$\Delta_{Feedback}$ A_F=2.022	0.95	0.083	-	-	0.3104	4.81	5.12

From Table 1 we now have identified the reverse forcing at the surface needed since

$$P_{Total2019\_Feedback\,Amp} = P_{1950} + \left(P_{2019} - P_{1950}\right) A_F = 384.927W/m^2 + (2.5337W/m^2)2.022 = 390.05W/m^2 \quad (14)$$

and

$$\Delta T_S = T_{2019} - T_{1950} = \left(390.05/\sigma\right)^{1/4} - 287.04°K = 287.9899°K - 287.04°K = 0.95°K \quad (15)$$

as modeled. We also note an estimate has now been obtained in Table 1 for f_2=0.6276, A_F=2.022, and $\Delta P_{Total\_Feedback\_amp}$=5.12W/m^2.

6. Model Consistency with the Planck Parameter

As a measure of model consistency, the forcing change with feedback, and resulting temperatures T_{1950} and T_{2019}, should be in agreement with expected results using the Planck feedback parameter. From the definition of the Planck parameter λ_o and results in Table 1, we estimate [24]

$$\lambda_o = -4\frac{\Delta R_{OLW}}{T_S} = -4\left(\frac{237.9028W/m^2}{287.041°K}\right)_{1950} = -3.31524W/m^2/°K \quad (16)$$

and

$$\lambda_o = -4\frac{\Delta R_{OLW}}{T_S} = -4\left(\frac{238.056W/m^2}{287.99°K}\right)_{2019} = -3.306W/m^2/°K \quad (17)$$

Here ΔR_{OLW} is the outgoing long wave radiation change. We note these are very close in value showing miner error and consistency with Planck parameter value, often taken as 3.3W/m^2/°K.

Also note the Betas are very consistent with Eq. 8 for the two different time periods since from Table 1

$$\beta_{1950} = \frac{T_\alpha}{T_S} = \frac{T_e}{T_S} = \frac{254.51}{287.041} = 0.88667 \textit{ and } \beta_{1950}^4 = 0.6180785 \quad (18)$$

and

$$\beta_{2019} = \frac{T_\alpha}{T_S} = \frac{T_e}{T_S} = \frac{254.55}{287.5107} = 0.88526 \textit{ and } \beta_{2019}^4 = 0.6144 \quad (19)$$

7. Summary

In this paper we have devised a greenhouse gas albedo surface theorem. The theorem includes a re-radiation factor which has been fully described and applied to two time periods. Results show that the re-radiation factor for 1950 is taken as a pre-industrial value of 1.6181 while in present day the factor has increase to 1.6276 due to the increase in GHGs.

We suggest the theorem, when applied to the reality of today's challenges, appears to indicate that the albedo solution would be the safest and fastest way to mitigate climate change. Furthermore, focusing solely on the CO2 solution is unrealistic and puts our planet at risk.

References

1. Dunne D, (2018) Six ideas to limit global warming with solar geoengineering, CarbonBrief, https://www.carbonbrief.org/explainer-six-ideas-to-limit-global-warming-with-solar-geoengineering
2. Cho A, (2016) To fight global warming, Senate calls for study of making Earth reflect more light, Science, https://www.sciencemag.org/news/2016/04/fight-global-warming-senate-calls-study-making-earth-reflect-more-light
3. Levinson, R., Akbari, H. (2010) Potential benefits of cool roofs on commercial buildings: conserving energy, saving money, and reducing emission of greenhouse gases and air pollutants. *Energy Efficiency* 3, 53–109. https://doi.org/10.1007/s12053-008-9038-2
4. Deforestation, Wikipedia, https://en.wikipedia.org/wiki/Deforestation
5. Feinberg A., On Geoengineering and Implementing an Albedo Solution with UHI GW and Cooling Estimates vixra 2006.0198, DOI: 10.13140/RG.2.2.26006.37444/6
6. Feinberg A., The Reflectivity (Albedo) Solution Urgently Needed to Stop Climate Change, Youtube, August 2020
7. McKitrick R. and Michaels J. (2004) A Test of Corrections for Extraneous Signals in Gridded Surface Temperature Data, Climate Research
8. McKitrick R., Michaels P. (2007) Quantifying the influence of anthropogenic surface processes and inhomogeneities on gridded global climate data, J. of Geophysical Research-Atmospheres.
9. Schmidt GA, (2009) Spurious correlations between recent warming and indices of local economic activity, *Int. J. of Climatology*
10. Zhao ZC (1991) Temperature change in China for the last 39 years and urban effects. Meteorological Monthly (in Chinese), 17(4), 14-17.
11. Feddema JJ, Oleson KW, Bonan GB, Mearns LO, Buja LE, Meehl GA, and Washington WM (2005) The importance of land-cover change in simulating future climates, *Science*, 310, 1674– 1678, doi:10.1126/science.1118160
12. Ren G, Chu Z, Chen Z, Ren Y (2007) Implications of temporal change in urban heat island intensity observed at Beijing and Wuhan stations. *Geophys. Res. Lett.* , *34,* L05711,doi:10.1029/2006GL027927.
13. Ren, GY, Chu ZY, and Zhou JX (2008) Urbanization effects on observed surface air temperature in North China. J. Climate, 21, 1333-1348
14. Jones PD, Lister DH, and Li QX, (2008) Urbanization effects in large-scale temperature records, with an emphasis on China. J. Geophys. Res., 113, D16122, doi: 10.1029/2008JD009916.
15. Stone B (2009) Land use as climate change mitigation, Environ. Sci. Technol., 43(24), 9052– 9056, doi:10.1021/es902150g
16. Zhao, ZC (2011) Impacts of urbanization on climate change. in: 10,000 Scientific Difficult Problems: Earth Science, 10,000 scientific difficult problems Earth Science Committee Eds., Science Press, 843-846. 30%
17. Yang X, Hou Y, Chen B (2011) Observed surface warming induced by urbanization in east China. *J. Geophys. Res. Atmos*, 116, doi:10.1029/2010JD015452.
18. Huang Q, Lu Y (2015) Effect of Urban Heat Island on Climate Warming in the Yangtze River Delta Urban Agglomeration in China, *Intern. J. of Environmental Research and Public Health* 12 (8): 8773 (30%)
19. Feinberg A, (2020) Urban Heat Island Amplification Estimates on Global Warming Using an Albedo Model, Vixra 2003.0088, DOI: 10.13140/RG.2.2.32758.14402/15
20. Feinberg A (2020) Review of Global Warming Urban Heat Island Forcing Issues Unaddressed by IPCC Suggestions Including CO2 Doubling Estimates, viXra:2001.0415
21. Zhao L, Lee X, Smith RB, Oleson K (2014) Strong, contributions of local background climate to urban heat islands, Nature. 10;511(7508):216-9. doi: 10.1038/nature13462
22. Dessler AE, Zhang Z, Yang P (2008) Water-vapor climate feedback inferred from climate fluctuations, 2003–2008, *Geophysical Research Letters*, https://doi.org/10.1029/2008GL035333
23. Butler JH, Montzka SA, (2020) The NOAA Annual Greenhouse Gas Index, Earth System Researh Lab. Global Monitoring Laboratory, https://www.esrl.noaa.gov/gmd/aggi/aggi.html
24. Kimoto K (2006) On the Confusion of Planck Feedback Parameters, Energy & Environment (2009)