Optimum Solution to Global Warming In the Control of CO_2, Hotspots, & Hydro-Hotspots Forcing Due to the GHG-Albedo Interaction

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

Key Words: Albedo Solution, Hotspot Forcing, Hydro-Hotspots Forcing, Re-Radiation Model, Albedo-GHG Theorem

Abstract

In this paper we consider the GHG-albedo interactions and show that the albedo solution is the optimum way to mitigate climate change when considering three types of forcing and current trends in climate change. These considerations also indicates that CO_2 solutions have many associated risks compared with albedo solutions. The GHG-albedo interaction strength is also modeled.

1. Introduction

In this introduction, we consider three types of forcing due to

- CO_2 (ignoring other GHGs)
- Hotspots (such as Urban Heat Islands and Roads)
- Hydro-hotspots

Here a hydro-hotspot is a solar hot surface that creates atmospheric moisture in the presence of precipitation. Urban Heat Islands (UHI) and other impermeable surfaces create hydro-hotspots [1] which can contribute to global warming. Such surfaces then create rapid evaporation and excess moisture in the atmosphere promoting a local greenhouse effect. This mechanism includes warmer air-surface temperatures due to the initial hotspot, and then during precipitation, evaporation increases the local atmosphere humidity GHG (as warm air holds more water vapor). The level of hydro-hotspot significance in climate change is currently unknown.

- However observations of this effect are reasonably well established. For example, Zhao et al. [2] observed that UHI temperatures increase in daytime ΔT by 3.0^{o}C in humid climates but decrease ΔT by 1.5^{o}C in dry climates. They found a strong correlation between ΔT increase and daytime precipitation. Their results concluded that albedo management would be a viable means of reducing ΔT on large scales.

Since GHGs need long wavelength radiation to work, changing a hotspot surface's albedo is associated with the greenhouse gas mechanism. Therefore, we know the following ***Interactive GHG-albedo Statements to be true***:

1. *Increasing the reflectivity of a hotspot surface reduces its greenhouse gas effect*
2. *Decreasing the reflectivity of a hotspot surface increases its greenhouse gas effect*
3. *The Global Warming (GW) change associated with a reflectivity hotspot change is given by the albedo-GHG radiation factor having an approximate inherent value of 1.6.*

Interactive Statements 1 and 2 provide the basis for the fact that the albedo solution [3-7] is proficient, having strong interactions with all three types of forcing mechanisms. ***Statement 3*** (see Sec. 2) details the strength of the GHG-albedo interaction. From Statements 1 and 2, we can deduce:

- CO_2 mitigation primarily only reduces its forcing effect
- CO_2 mitigation has weak interactions with hotspot forcing (compared with tropospheric hotspot-water vapor GHG interactions)
- CO_2 mitigation has no direct interaction with hydro-hotspots forcing
- The albedo solution has strong mitigation interactions with hotspots, hydro-hotspots and CO_2 forcing
- Enhanced albedo mitigation can also compensate for increases in CO_2

We also note from Statement 3 that because of the hotspot-albedo interaction, hotspot forcing has an increased GHG additional heat. For example, based on our modeling (see Equations 20 and 21)

- a change in hotspot forcing would require approximately 1.6 times as much GHG forcing to have the same GW effect

We see from these simple arguments, that the albedo solution is optimum way to mitigate global warming. Many climatologists assume that hotspot forcing is negligible and since little is known about hydro-hotspot forcing, these have not been reasonably considered in forcing assessments [8,9].

The assumption that hotspot forcing does not contribute significantly to global warming has been contested by many authors as it relates to UHIs. This is described by these authors' measurements [10-20] and more recently in modeling [6, 21]. One key paper often referred to is by McKitrick and Michaels [10, 11] who found that the net warming bias at the global level may explain as much as half the observed land-based warming. This study was criticized by Schmidt [22] and defended by Mckitrick [11] over many years.

Little is understood about hydro-hotspot forcing. We do know that since the industrial revolution, impermeable surfaces have increased at an alarming rate correlated to population growth [21]. Furthermore, there has been a lack of hotspot controls in terms of solar considerations in their construction of UHIs and roads. More studies on its amplification effect of hydro-hotspots similar to Zhao [2] would be helpful. In terms of amplification effects, it is likely that hydro-hotspots would have both local water-vapor GHG interactions and the additional 1.6 warming influence on GW and UHI heat capacities would also play a large role. Therefore, hydro-hotspots may be more dominant than climatologists realize.

- Therefore, there is a reasonable probability that focusing on CO_2 solutions creates significant associated risks in climate change mitigation as governments are now solely depending on such methods

Furthermore, there are growing concerns regarding

- slow progress reported in CO_2 reduction and this solution's ability to prevent the tipping point
- the yearly increases in reports on large desertification and deforestation occurring [23]
- lack of hotspot and hydro-hotspot controls [1]

Therefore, the only way to reduce these risks are by adopting, at least in parallel, ***albedo solutions since according to interactive albedo-GHG statements 1-3, it would guarantee success in mitigating all three types of forcing*** and offset the slow progress in CO_2 mitigation.

Currently, there remains little educational effort on albedo solutions [3-7] and they have not received any worldwide support compared to the CO_2 effort. This oversight is unfortunate as it hurts the potential business and governmental support of reflectivity solutions.

- Uneducated politicians are now totally invested in CO_2 solutions which puts our planet at great risk given the uncertainty existing in CO_2 mitigation.

Regarding ***Interactive Statement 3***, it is our interest to demonstrate the albedo-GHG re-radiation 1.6 factor [6, 21] strength and its change since the pre-industrial revolution. Such values relate to the effective emissivity constant of the planetary system. Because of its importance as it relates to the albedo-GHG interactive mechanism, it is a primary focus in the rest of this paper as it supports potential albedo geoengineering solutions.

2. Method: 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

$$P_{Pre-Industrial} = P_\alpha + P_{GHG} = P_\alpha + f_1 P_\alpha = P_\alpha\left(1+f_1\right) = \sigma T_S^4 \text{ where } P_\alpha = \frac{S_o}{4}(1-\alpha) \quad (1)$$

and T_s is the surface temperature, $P_{pre\text{-}industrial}$, P_α, and P_{GHG} are the total pre-industrial warming, albedo warming and GHG warming in W/m^2, respectively. 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 $1+f_1=1.618034$ (see Section 2.1) as the pre-industrial albedo-GHG radiation factor (Table 1).

We identify the re-radiation 2019 having a value of $1+f_2=1.6276$ (Table 1). That is, in 2019, due to increases in GHGs, an increase in the re-radiation fraction occurs

$$f_2 = f_{2019} = f_1 + \Delta f = \beta_1^4 + \Delta f \approx \beta_2^4 + \Delta f \quad (2)$$

In this way $f_{2019} = f_2$ is a function of f_1. The RHS of Eq. 2 indicates that $\beta_1 \approx \beta_2$ (see verification results in Eq. 18 and 19). We find that $\Delta f=0.0096$ is relatively small compared to $(1+f_1)$ which we show can fairly accurately be assessed in geoengineering.

2.1 Estimating the Pre-industrial Value f_1

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

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

The definitions of $T_\alpha=T_e$, T_S and β are the emission temperature, surface temperature and typically $\beta\approx0.887$, 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

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

To be consistent with $T_\alpha=T_e$, since typically $T_\alpha\approx255^oK$ and $T_s\approx288^oK$, 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

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

Note that when $\beta^4=1$, 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

$$P_{GHG} = f_1\, P_\alpha = f_1\, \sigma\, T_\alpha^4 \tag{6}$$

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

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

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 3.1. 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.

2.2 Balancing Pout and Pin in 1950

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

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

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.

2.3 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

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

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 [9]. Although this value does not include hydro-hotspot forcing assessment described in the introduction, it possibly may be effectively included since forcing estimates also relate to accurate GW temperature changes. Then the feedback amplification factor, is calibrated so that T_S=T_{2019} (see Table 1) yielding A_F =2.022 [also see ref. 24]. 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 [21] and their coverage. We note that unlike f_1, f_2 is not a strict measure of the emissivity due the increase in GHGs.

3. 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 and reasonable close to 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 (see also Eq. 1). This requires an albedo value of 0.3008 (see Table 1) to obtain the T_{1950}.=287.04^{o}K. This albedo number is reasonable and similar to values cited in the literature [25].

In 2019, the average temperature of the Earth is T_{2019}=14.84^{o}C (287.99^{o}K) given in Eq. 15. We have assumed a small change in the Earth's albedo due to UHIs [21]. The f_2 parameter is adjusted to 0.6276 to obtain the GHG forcing shown in Column 7 of 2.38W/m^2 [9]. Therefore the next to last row in Table 1 is a summary without feedback, and the last row incorporates the A_F=2.022 feedback amplification factor.

Table 1 Model Results

Year	T_S(^{o}K)	T_α(^{o}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

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

and

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

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.

3.1 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 [26]

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

and

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

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

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

and

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

3.2 Hotspot Versus GHG Forcing Equivalency

From Equation 1 and 12 we can estimate the effect in a change in hotspot forcing as

$$\left(\frac{dP_{Total}}{dP_\alpha}\right)_{1950} = \left(1+f_1\right) = 1.618 \ \text{and} \ \left(\frac{dP_{Total}}{dP_\alpha}\right)_{2019} = \left(1+f_2\right) = 1.6276 \tag{20}$$

However, we note a change in GHGs is only a factor of 1 by comparison

$$\frac{dP_{Total}}{dP_{GHG}} = \frac{d\left(P_\alpha + P_{GHG}\right)}{dP_{GHG}} = 1 \tag{21}$$

This indicates that hotspot forcing has a larger effect due to GHG amplification. Alternately, 1 W/m^2 of albedo forcing generally would require 1.628 W/m^2 of GHG forcing to have the same global warming effect. This is an important result and should be factored into albedo forcing estimates.

4 Summary

In this paper we have initially argued the importance of the albedo solution using the fundamental concepts of GHG-albedo interactions. From the basic concept of the GHG-albedo interaction and the reality of today's challenges, it appears to indicate that the albedo solution would be the safest and fastest way to mitigate climate change. It is also logically the only way to fully mitigate global warming when three types of forcing are considered. As well we know CO_2 solutions may be too slow to prevent a tipping point (especially with desertification and deforestation occurring).

The GHG-albedo interaction strength due to the re-radiation factor has been fully described in application to two time periods. Results show that the re-radiation factor for 1950 when taken as a pre-industrial value is 1.6181 which is directly given by β^4 (the emissivity constant of the planetary system). However in present day, this factor has increase to 1.6276 due to the increase in GHGs. In order to make the present day assessment, we assumed a small planetary albedo decrease from 1950 of 0.15% and GHG forcing of about 2.38 W/m^2 (in accordance with IPCC estimates). In terms of geoengineering albedo modification estimates, the interactive value of 1.62 should to be a good approximation [6].

References

1. Feinberg A (2020) Review of Global Warming Urban Heat Island Forcing Issues Unaddressed by IPCC Suggestions Including CO2 Doubling Estimates, viXra:2001.0415
2. 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
3. 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
4. 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
5. 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
6. 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 (Currently in Peer Review in the J. Mitigation and Adaptation Strategies for Global Change)
7. Feinberg A., The Reflectivity (Albedo) Solution Urgently Needed to Stop Climate Change, Youtube, August 2020
8. Hartmann DL, Klein AMG, Tank M, Rusticucci LV, Alexander S, Brönnimann Y, Charabi FJ, Dentener EJ, Dlugokencky D, Easterling DR, Kaplan A, Soden BJ, Thorne PW, Wild M, and Zhai PM (2013) Observations: Atmosphere and Surface. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the *Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. *Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA*
9. 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
10. McKitrick R. and Michaels J. (2004) A Test of Corrections for Extraneous Signals in Gridded Surface Temperature Data, Climate Research
11. McKitrick R., Michaels P. (2007) Quantifying the influence of anthropogenic surface processes and inhomogeneities on gridded global climate data, J. of Geophysical Research-Atmospheres. Also see McKitrick Website Describing controversy: https://www.rossmckitrick.com/temperature-data-quality.html
12. Zhao ZC (1991) Temperature change in China for the last 39 years and urban effects. Meteorological Monthly (in Chinese), 17(4), 14-17.
13. 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
14. 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.
15. Ren, GY, Chu ZY, and Zhou JX (2008) Urbanization effects on observed surface air temperature in North China. J. Climate, 21, 1333-1348
16. 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.
17. Stone B (2009) Land use as climate change mitigation, Environ. Sci. Technol., 43(24), 9052– 9056, doi:10.1021/es902150g
18. 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%
19. 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.
20. 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%)
21. 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 (Currently under peer review in the journal SN Applied Science)
22. Schmidt GA, (2009) Spurious correlations between recent warming and indices of local economic activity, *Int. J. of Climatology*
23. Deforestation, Wikipedia, https://en.wikipedia.org/wiki/Deforestation
24. 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
25. Stephens G, O'Brien D, Webster P, Pilewski P, Kato S, Li J, (2015) The albedo of Earth, *Rev. of Geophysics*, https://doi.org/10.1002/2014RG000449
26. Kimoto K (2006) On the Confusion of Planck Feedback Parameters, Energy & Environment (2009)