Urban Heat Island Amplification Estimates on Global Warming Using an Albedo Model

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Abstract

In this paper we provide nominal and worst case estimates of global warming due to UHI effect (including urban areas) using a Weighted Amplification Albedo Solar Urbanization (WAASU) Model. This is done with the aid of related studies on UHI footprint surface coverage yielding effective amplification factors. Using this method, we find conservatively between 4% and 22% of global warming may be due to the UHI effect (with urban areas).We also provide more aggressive estimates. Results provides insight into the UHI area effects from a new perspective and illustrates that one needs to take into account effective amplification factors when assessing UHI's to include their footprint on a global scale. Lastly, such effects likely show a more persuasive argument for the need of world-wide UHI albedo goals.

1. Introduction

It is concerning that there are so few UHI publications recently on their possible influences to global warming. Part of the motivation for this paper is to illustrate the continual need for more up-to-date related studies including UHI amplification effects (that include their urban areas) as will be discussed in this paper. The subject of UHI effect having significant contributions to global warming is very important and should remain so. The topic has a controversial history. One such paper was from McKitrick and Michaels, in 2007, 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 (Schmidt 2009) and defended for a period of about 10 years by Mckitrick (see McKitrick Website). Other authors have also found significance (Feddema et al. 2005, Ren et al. 2007, Stone 2009, Yang et al. 2011, and Haung et al. 2015). These studies used land-based temperature station data to make assessments. Although the studies have all found global warming UHI significance with different assessments, they have yet to influence the IPCC enough to necessitate albedo goals in their many reports and meetings like the CO_2 effort. This is important because, we feel it really is the IPCC's responsibility to inform the global community of such needs in the form of goals. Although they have provided reports on UHIs including health related issues, the response to their reports does not appear to be effective on the global scale compared with the on-going CO_2 effort. Surely promoting UHI albedo goals would make a large impact.

The contention that UHI effects are basically only of local significance is most likely related to urban area estimates. For example, IPCC (Satterthwaite et. al. 2014) AR5 report references Schneider et al. 2009 study that resulted in urban coverage of 0.148% of the Earth (Table 1). This seemingly small area tends to dismiss the contention that UHI effect can play a large scale role in global warming. Furthermore, estimates of how much of land has been urbanized vary widely in the literature and this is in part due to the definition of what is urban and the datasets used. Despite the growing importance of urban land in regional to global scale environmental studies, it remains extremely difficult to map urban areas at coarse scales due to the mix of land cover types in urban environments, the small area of urban land relative to the total land surface area, and the significant differences in how different groups and disciplines define the term 'urban'.

Furthermore, global warming UHI amplification effects are not quantified to a large degree related to area estimates. Because of this, the average solar heating area itself has not been quantified as part of such area estimates on land size effect and typically unrelated to important building solar heating areas.

Table 1 Summarizing Literature Urbanization Area Estimates

Percent of Land	Percent of Earth	References
2.7	0.783	GRUMP 2005, From NASA Satellite Light study based on 2004 data supplemented with census data
1%	0.29	NASA 2000 Satellite data, Galka 2016
0.5	0.148	(Schneider et al. 2009) based on 2000-2001 data from Satterthwaite IPCC 2014 reference
0.5%	0.145	(Zhou 2015) based on a 2000 data set [60]

Surface area land approximations vary widely and most are obtained with satellite measurements sometimes supplemented in some way with census data. Table 1 captures some papers that are of interest.

One key paper listed in the table that we study here is due to Schneider et al. (2009) since it is cited by the AR5 2014 IPCC report (Satterthwaite et al. 2014). In Schneider paper, the larger area found in the GRUMP 2005 study in Table 1 is criticized. These area estimates are important in our paper as we are using a *Weighted Amplification Albedo Solar Urbanization (WAASU) Model*. Amplification factors that we will use are related to such urban coverage. Therefore, we decided to use both the Schneider et al. and GRUMP studies as the nominal and worst cases urbanization area estimates respectively. Furthermore they were both done using data set from around 2000 which is a convenient time to extrapolate down to 1950 and up to 2019 (see Sec. 3).

In our study, where we introduce the WAASU model, we will see that it has some advantages over the ground-based temperature studies like McKitricks and Michaels. The model is non probabilistic, in line with the way typical energy budgets are calculated, it uses only two key parameters (urban coverage, and average albedo). Because it is simplistic, it has transparency compared with the complex land-based studies.

2. UHI Amplification Effects

The table below lists the global warming causes and amplification effects. In this section we will summarize only the UHI amplification effects listed in the table since the root causes and the main global warming amplification effects are fairly well known.

Table 2 Global Warming Cause and Effects

Global Warming Causes →	Population → Expanding Urban Heat Islands (UHI), Roads & Increases in Greenhouse gas
Global Warming Amplification Effects →	Increase in Specific Humidity, Decrease in Relative Humidity, Decrease in land albedo due to cities & roads, Decrease in water type areas from loss of albedo (reflectivity) due to Ice and snow melting
Urban Heat Island Amplification Effects →	UHI solar heating area (building areas), UHI building heat capacities, humidity effects and hydro-hotspots, reduced wind cooling, solar canyons

The UHI amplification effects that we consider to dominate listed in the Table are as follows:

- ***The humidity amplification effect:*** This has been observed. For example, Zhao et al. (2014) noted that UHI temperature increases in daytime ΔT by 3.0^oC in humid climates but decreasing ΔT by 1.5^oC in dry climates. They noted that such relationships imply that UHIs will exacerbate heat wave stress on human health in wet UHI climates. One explanation for this is how heat dissipates through convection which is more difficult in humid climates. Another explanation is that warmer air holds more water vapor. This can increase local specific humidity so that there could be local greenhouse effects.

- ***The heat capacity and solar heating area amplification effect:*** This contributes to the day-night UHI cycle. Here in most cities, it is observed that daytime atmospheric temperatures are actually cooler compared to night. For example, in a study by Basara et al. (2008) in Oklahoma city UHI it was found that at just 9-m height, the UHI was consistently 0.5–1.75°C greater in the urban core than the surrounding rural locations at night. Further, in general UHI impact was strongest during the overnight hours and weakest during the day. This inversion effect can be the results of massive UHI buildings acting like heat sinks with large solar area and heat capacities, absorb radiation via convection in the day, and actually reducing the UHI effect, but at night, buildings cools down, giving off their stored heat that increases local temperatures to the surrounding atmosphere. This effect increases with city growth as buildings have gotten substantially taller (Barr 2019) since 1950.

- ***The Hydro-hotspot amplification effect:*** This effect is not well addressed. Here atmospheric moisture source is a complex issue due to Hydro HotSpots (HHS). Hydro hotspots occur when buildings are hot due to sun exposure. Then during precipitation periods, the hot highly evaporation surfaces increase localized water vapor in the air via the effect that warm air holds more moisture. This increase in local greenhouse gas, could blanket city heat and increase infrared radiation during these periods. This, as discussed above, is another possible UHI humidity amplification.

- ***Reduced Wind Cooling and Solar Canyons:*** In UHIs reduced wind is a known effect due to building wind friction. As well, tall buildings create solar canyons and trap sunlight reducing the average albedo although some benefits occurs from shading. In general, both have the effect of amplifying the temperature profile of UHIs.

2.1 Urbanization Surface Area Amplification Factors

We see from the previous section that estimating climate change impact just based on the UHI and Urban area coverage as in Table 1, cannot take into account solar heating building sidewall areas, massive heat capacities, the humidity effects, wind reduction and the solar canyon effect which amplify UHI effects beyond its own climate area. In order to estimate the UHI amplification effects, it is logical to look at UHI footprint studies. Zhang et al. (2004) found the ecological footprint of urban land cover extends beyond the perimeter of urban areas, and the footprint of urban climates on vegetation phenology they found was 2.4 times the size of the actual urban land cover. In a more recent study by Zhou et al. (2015), they looked at day-night cycles using temperature difference measurements. In this study they found UHI effect decayed exponentially toward rural areas for majority of the 32 Chinese cities. Their study was very thorough and extended over the period from 2003 to 2012. They describe China as an ideal area to study since it has experienced the rapidest urbanization in the world in the decade they evaluated. They found that the "footprint" of UHI effect, including urban areas, was 2.3 and 3.9 times of urban size for the day and night, respectively. These factors are summarized in the table below. Our study uses the average day-night amplification footprint coverage factor of 3.1 as a conservative value in our WAASU model.

In this study we consider these as urban area coverage amplification factors. That is, because buildings have a larger solar area, greater than its ground area, one can think of this as essentially making up for the building surface sides by increasing the ground "footprint" surface urban coverage area by a factor of 3.1. As buildings do increase the solar heating area of the Earth, this is a reasonable way to account for the UHI effect through the footprint amplification. This is the "footprint" concept. Essentially the UHI climate coverage has an average area 3.1 times larger than its own which is how the parameter is treated in the WAASU model. This also increases the solar surface area of the Earth that is accounted for in our model through renormalization discussed in Section 4 and Appendix B.

Table 3 Urban Climate Amplification Factors

Urban Climate Amplification	Footprint Amplification Factor	Day-Night Average Factor
Area Coverage Amplification	2.3-3.9	3.1 Conservative
Spherical Area Coverage	4.6-7.8	6.2 Aggressive

Although the 3.1 amplification factor may seem high, it is likely conservative. For example, two effects that would be hard to quantify are loss of wetlands and rainwater management due to urbanization. Here we note,

- 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)." Cao et. al. (2011) Hirshi et al. (2011)
- Impermeable surface creates annual evapotranspiration unknown amplification issues with natural cooling
- As well many coastal cities like Sydney, dump (132 billion gallons, Cormack 2015) frequently elevating temperatures from storm water runoff from hot buildings and streets into rivers, lakes and the sea raising local and costal temperatures in the vicinity also extending the UHI footprint.

These effects in some areas may be responsible for added draught, deforestation due to urbanization and draught related fires. We note that such amplification effects are hard to quantify.

Furthermore the 3.1 factor from the Zhou et al. (2015) study does not provide for altitude atmospheric dissipative effects that also may contribute to global warming. We might envision altitude area effects as part of a spherical area footprint about the UHI and its coverage. In this way, we might aggressively extend this with a half sphere over the UHI with urban coverage in order to include some vertical radiation effects for global extent. UHI have been modeled with exponential decay as described (Zhou et al.), this can more easily be approximated by a half sphere roll off to simplify for an aggressive case. A half sphere model may be more appropriate as well. The area of a half sphere would then add another factor of 2 $\{(4\pi r^2/2)/\pi r^2\}$. Therefore, this extrapolated amplification footprint factor ranges of 4.6-7.8 for the day-night cycle respectively yielding an average of 6.2 shown in the table.

3.0 Area Extrapolated Rates to 1950 and 2019

In order to apply the area amplification factors, we first need to project the Schneider and GRUMP area estimates down to 1950 and up to 2019. Both use datasets from around 2000 so this is a convenient somewhat middle time frame. Here we decided to use the world population growth rate (World bank 2018) which varies by year as shown in Appendix A in Figure A1. We used the average growth rate per ½ decade for iterative projections (that averaged between 1.3% and 1.6% per year).

To justify this we see that Figure A2a illustrates that building material aggregates (USGS 1900-2006) used to build cities and roads correlates well to population growth (US Population Growth 1900-2006).

It is also interesting to note that building materials for cities and roads also correlates well to global warming trends (NASA 1900-2006) shown in Figure A2b.

Column 2 in Table 4 show the projections with the actual year (~2000) data point tabulated value also listed in the table (also see Table 1). Since 1950 is taken as the reference year, we did not use any amplification factor for this period. Next we assumed the amplification factor of 3.1 (conservative) and 6.2 (aggressive) applied to the percent of the Earth values (see Table 1) shown in the Schneider and GRUMP studies. Therefore, under these assumptions, the urban effective amplification coverage used in the WAASU model is shown in Column 4.

Table 4 Values used to estimate the Solar Surface area in cities

Year	Urban coverage Percent of Earth	Urban Coverage Amplification Factor Effect	Effective Amplification Coverage Area Effect
IPCC Schneider Study			
1950	0.059*	1	0.059%**
2000-2001	0.0051x29%=0.148		
2019	0.188*	3.1 footprint***	**0.583%**
2019	0.188*	6.2 half-sphere****	**1.166%**
Worst Case GRUMP Study			
1950	0.316%	1	**0.316%****
2000	0.027x29%=0.783%		
2019	0.952%*	3.1 footprint***	**2.95%**
2019	0.952%*	6.2 half-sphere****	**5.9%**

*Growth rate of cities using world population yearly growth rate in Fig A1, study,**amplification factors not used, considered reference year,*** conservative, ****aggressive amplification.

4. Weighted Amplification Albedo Solar Urbanization (WAASU) Model Overview *1950 & 2019*

The WAASU model is very straightforward; it is based on a global weighted albedo model. The weighted Earth constituents are

$$EWA = \sum_i \{\% \, Earth \; Area_i \; x \; Surface \; Item \; Albedo_i\} \quad (1)$$

Here EWA is the Earth's Weighted Albedo value. The model allows us to hold all values from 1950 to 2019 constant except for the urban coverage value. The effect of cloud coverage is also weighted and is averaged in with Equation 1 as

$$Global \, Weighted \; Albedo = Average\{(Clouds \; Albedo) \, x \, \% \; Coverage) + (Earth \; Weighted \; Albedo)\} \quad (2)$$

The components of our model are flexible and only need to have reasonableness in known values and maintain relative consistency from 1950 to 2019 as they are held fixed. The important values are the variables of interest, urban coverage. In this way the WAASU model has been adjusted to the most commonly used global albedo 1950 value of ~30% (30.024%) shown in Table 5a. Then in 2019, using the extrapolated area coverage (see Sec.3.0) the area is amplified, the resulting model change to the global albedo is found as 29.982% for the Schneider nominal case (shown in Table 5b) and for the GRUMP worst case the albedo was similarly obtained as 29.794% for the conservative amplification factor. Other examples provided in Appendix B.

Although factors are held constant, since urban coverage increases in 2019, this increases the surface area of the Earth which realistically does occur with city growth of tall buildings having large solar heating areas as accounted for by the amplification in the model. This new area, however small, requires some renormalization in the model of the Earth components in the WAASU model (see Appendix B). Renormalization then may introduce some slight error in the model (estimated below to be about ±1.2%). However, the model is sensitive to urban coverage changes but works well with renormalization and shows consistency with proportionality to the coverage as described in the next section.

Table 5a: Albedo=30.024%, 1950

Surface	Enter % of Earth Area	Enter Albedo (0-1)	Weighted Albedo in % Results
Water	71.0		
Sea Ice	15	**0.66**	9.900
Open Ocean	56	**0.06**	3.360
Land	29.0		
Roads (0.04)	0.051	**0.04**	0.002
Urban Cov (0.12)	0.059	**0.12**	0.007
Forest (0.17)	3.5	**0.17**	0.595
Forest (Snow)	4.9	**0.81**	3.969
Grass lands (0.26)	3.79	**0.26**	0.985
Grass Lands Snow	7	**0.81**	5.670
Desert (0.4)	9.7	**0.4**	3.880
Sum % of Earth Area	100.000		
Weighted Earth			28.37
Clouds (0.47)	**66.6**	**0.476**	31.68
			Global Weighted Albedo in
Global=Average(Clouds & Weighted Earth) %			30.024

Table 5b : Albedo=29.982%, 2019

Surface	Enter % of Earth Area	Enter Albedo (0-1)	Weighted Albedo in % Results
Water	70.6		
Sea Ice	14.922	**0.66**	9.848
Open Ocean	55.708	**0.06**	3.342
Land	**29.4**		
Roads (0.04)	0.051	**0.04**	0.002
Urban Cov (0.12)	0.580	**0.12**	0.070
Forest (0.17)	3.482	**0.17**	0.592
Forest (Snow)	4.874	**0.81**	3.948
Grass lands (0.26)	3.770	**0.26**	0.980
Grass Lands Snow	6.964	**0.81**	5.640
Desert (0.4)	9.649	**0.4**	3.860
Sum % of Earth Area	100.000		
Weighted Earth			28.28
Clouds (0.47)	**66.6**	**0.476**	31.68
			Global Weighted Albedo in
Global=Average(Clouds & Weighted Earth) %			29.982

4.1 WAASU Model Global Warming Estimates

From the above global WAASU model the estimates of the Earth's power absorption and temperature are then straightforward using the fundamental equation

$$P_{Total}= 1361W/m2 \{0.25 \text{ x } (1\text{-Albedo})\} =\sigma T^4 \tag{3}$$

Table 5 Results of GW Temperature Budget Change With City Surface Areas and Albedos

Year	Urban Extent Global Area %	UHI Effective Global Surface Area %	Albedo Roads	Albedo Cities	Global Weighted Albedo	Temperature (no GH gases)*	UHI Radiative Forcing W/m^2	UHI Radiative Solar Area Sensitivity W/m^2 ^{o}K	Percent Of Global Warming
				Nominal Case IPCC Schneider 2009 Study					
1950	0.059	0.059	0.04	0.12	30.024	-18.594	0	0	Par
2019	.188	0.583	0.04	0.12	29.982	-18.555	0.143	3.76	**4.02%**
2019	.188	1.166	0.04	0.12	29.935	-18.513	0.303	3.70	**8.52%**
What if	0.188	0.583	0.04	0.5	30.092	-18.655°C	-0.231	-3.79	-6.51% (Cooler)
				Worst Case GRUMP 2005 Study					
1950	0.316%	0.316	0.04	0.12	30.03	-18.599°C	0	0	Par
2019	0.952%	2.95	0.04	0.12	29.794	-18.385°C	0.783	3.74	**22%**
2019	0.952%	5.9	0.04	0.12	29.573	-18.184	1.53	3.74	**43%**
What if	0.952%	2.95%	0.04	0.5	30.339	-18.881°C	-1.07	-3.79	-30.2% (Cooler)

Results are compiled in Table 5. The table also includes "what if" estimates, if we could change urbanization to be more reflective with cool roofs. The values here are relative to the conservative footprint amplification values. The general results are summarized:

Conservative Area Coverage:

- Nominal Schneider case from 1950 to 2019 is 0.038C (-0.18.555-(-18.594) due to urban amplification coverage. This represents 4.02% (0.038C/0.95C) contribution to global warming
- Worst GRUMP case from 1950 to 2019 is 0.209C (-0.18.385-(-18.594) due to urban amplification coverage. This represents 22% (0.209C/0.95C) contribution to global warming
- "What if" corrective action results using cool roofs shows that changing city albedos range from 6.51% to 30.2% cooler for reducing global warming

Aggressive half-sphere dome area coverage:

- Nominal Schneider case from 1950 to 2019 is 0.081C (-0.18.513-(-18.594) due to urban amplification coverage. This represents 8.52% (0.081C/0.95C) contribution to global warming
- Worst GRUMP case from 1950 to 2019 is 0.409C (-18.184-(-0.18.594) due to urban amplification coverage. This represents 43% (0.409C/0.95C) contribution to global warming

We note that the global warming goes as the UHI footprint coverage as one might expect showing model consistency. For example, the Schneider nominal case, when the UHI effective surface area doubles, the percent of global warming approximately doubled. This shows the strength of the model and the ability of it to adapt with renormalization (see Appendix B). As well we see the solar area sensitivity (Table 5), defined here as the forcing per ΔT resulting from area change is very consistent in the model and averages about 3.76 W/M^{2o}K, also indicating renormalization is consistently accurate with a variability of only 0.09 W/M^{2o}K or about 2.4% (0.091/3.76). This implies that model consistency is about ±1.2%.

5. Conclusions and Suggestions

In this paper we were able to estimate using UHI effect (with urban area) amplification coverage estimates with the aid of a Zhou et al. (2015) footprint study. These estimates inserted into our WAASU model found that between 4.0 and 22% of global warming is related to UHI effect. The model found that the effect on global warming was proportional to the UHI footprint coverage. This was noted since the amplification factors doubled using a half spherical coverage in the aggressive assessment; the model then found global warming results roughly also doubled from 8.52% to 43%. As area estimates and amplification factors are very sensitive to the final results, it is clear refined estimates are needed.

Only UHI amplification effects were considered, global amplification effects in Table 2 were not speculated on to factor in. It is known that such feedback factors are positive (van Nes, 2015). For example, water-vapor feedback alone, which is one of the most important in our climate system, has the capacity to about double the direct warming (Manabe and Wetherald, 1967; Randall et al., 2007, Dessler et. al, 2008). Other global amplification factors have not been quantified such as albedo decrease due to loss of ice and snow. However, using just water-vapor feedback, it suggests values could then range 8% to 86% of global warming due to the UHI effect. This result, obtained now from a totally different perspective using a WASSU model, provides some credence to the McKitrick and Michaels 2007 contention that UHI effect's net warming bias at the global level may explain as much as half the observed land-based warming.

However, given even our conservative results, the study still points to the need for albedo enhancements like cool roofs in cities and urban areas to help stop related global warming anomalies.

Below we provide suggestions and corrective actions which include:

- Creating IPCC goals to include the need for albedo enhancements in existing UHIs and roads
- A directive for future albedo design requirements of city and roads
- Recommend an agency like NASA be tasked with finding applicable solutions to cool down UHIs.
- Recommendation for cars to be more reflective. Here although world-wide cars likely do not embody much of the Earth's area, recommending that all new manufactured cars be higher in reflectivity (e.g., silver or white) would help raise awareness of this issue similar to electric cars that help improve CO2 emissions

We stress again that the IPCC is the main governing force and the only agency capable of promoting such albedo changes for cities and roads. Therefore, whether it is just for UHI known health reasons or due to studies similar to ours, we strongly urge the IPCC to set albedo goals and include such goals in their global meetings.

Appendix A Growth Rates and Natural Aggregates Information

Below is a plot of the world population growth rate that varies from about 2.1 to 1.1. This is used to make growth rate estimate of urban coverage. We note that natural aggregate used to build cities and roads are reasonably correlated to population growth in Figure A2a. Also of interest (Fig. A2b) is the fact that one can see some correlation to global warming with the use of natural aggregates.

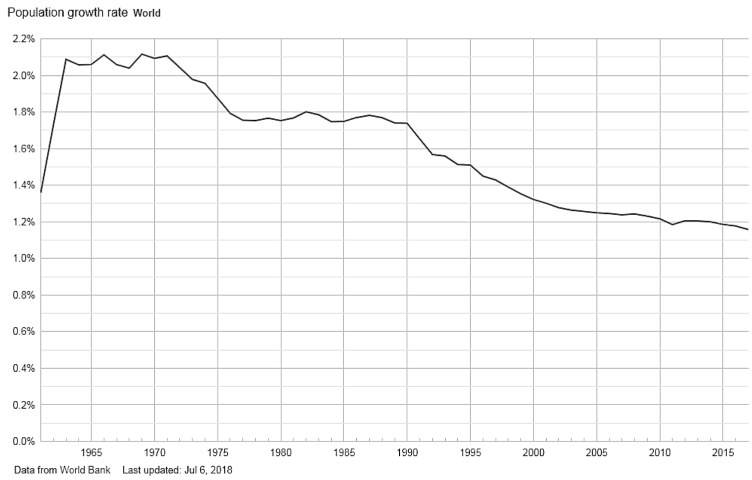

Figure A1 Population growth rate by year from 1960 to 2018, World Bank, 2018

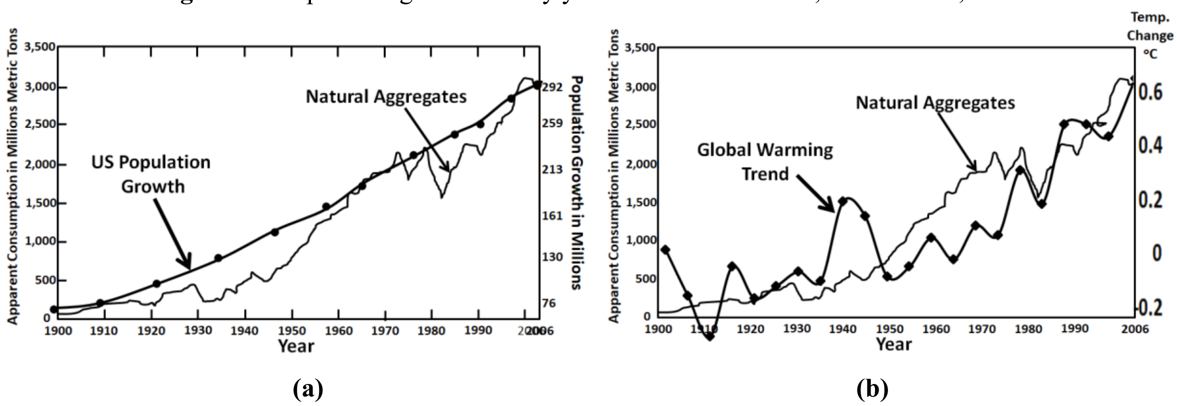

Figure A2 a) Natural aggregates correlated to U.S. Population Growth (USGS 1900-2006) **b)** Natural aggregates correlated to global warming (NASA 2020)

Appendix B: Albedo Model Examples Similar to Section 4 & Renormalization Information

Table B1 shows Albedo Model with Albedo of 29.935% results with Urban Cov of 1.166% (Schneider case) renormalized to 1.153 along with other renormalized results. Table B2 showing Albedo results of 29.794% with Urban Cov. 2.95% (GRUMP case) renormalized to 2.867% along with renormalized results. We see in Table 5 there is good agreement with the albedo model's ability to adapt with renormalization as global warming due to UHI effect is proportional to urban coverage as one might expect. That is, the albedo model is relative to global solar normalized area.

Table B1 Albedo results 29.935%

Surface	Enter % of Earth Area	Enter Albedo (0-1)	Weighted Albedo in % Results
Water	70.2		
Sea Ice	14.836	**0.66**	9.792
Open Ocean	55.387	**0.06**	3.323
Land	29.8		
Roads (0.04)	0.050	**0.04**	0.002
Urban Cov (0.12)	1.153	**0.12**	0.138
Forest (0.17)	3.462	**0.17**	0.588
Forest (Snow)	4.846	**0.81**	3.926
Grass lands (0.26)	3.749	**0.26**	0.975
Grass Lands Snow	6.923	**0.81**	5.608
Desert (0.4)	9.594	**0.4**	3.838
Sum % of Earth Area	100.000		
Weighted Earth			28.19
Clouds (0.47)	**66.6**	**0.476**	31.68
			Global Weighted Albedo in
Global=Average(Clouds & Weighted Earth) %			29.935

Table B2 Albedo Results 29.794%

Surface	Enter % of Earth Area	Enter Albedo (0-1)	Weighted Albedo in % Results
Water	69.0		
Sea Ice	14.579	**0.66**	9.622
Open Ocean	54.427	**0.06**	3.266
Land	31.0		
Roads (0.04)	0.050	**0.04**	0.002
Urban Cov (0.12)	2.867	**0.12**	0.344
Forest (0.17)	3.402	**0.17**	0.578
Forest (Snow)	4.762	**0.81**	3.857
Grass lands (0.26)	3.684	**0.26**	0.958
Grass Lands Snow	6.803	**0.81**	5.511
Desert (0.4)	9.427	**0.4**	3.771
Sum % of Earth Area	100.000		
Weighted Earth			27.91
Clouds (0.47)	**66.6**	**0.476**	31.68
			Global Weighted Albedo in
Global=Average(Clouds & Weighted Earth) %			29.794

Renormalization is done as follows:

1. Model starts with 1950 Table 5a albedo 30.024%, then 2019 Urban Coverage area is entered
2. For example, in Table B1, if the new Urban area is 1.166% larger, now the "Sum of % of Earth Area" will be 101.116% in 2019
3. All areas are renormalized to 101.107% (1.107=1.166-0.059 where 0.059 original area Table 5a) For example, Sea Ice at 15% in 1950 becomes 15%x(100.000/101.107)=14.836% and the Urban Cov becomes 1.166%x(100/101.11)=1.153%.

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