How to Heat a Planet? Impact of Anthropogenic Landscapes on Earth's Albedo and Temperature

Mark Healey

Lindfield, Australia
Email: ma1healey@hotmail.com

Abstract

Today anthropogenic climate change is underway and predicted future global temperatures vary significantly. However, the drivers of current climate change and their links to Earth's natural glacial cycle have yet to be fully resolved. Currently, many on a local level understand, and are exposed to, the heat energy generated by what's referred to as the urban heat island effect (UHI), whereby natural flora with higher albedos is replaced by manmade urban areas with lower albedos. This heat effect is not constrained to these regions and all anthropogenic surfaces with lower albedos need to be studied and quantified as the accumulated additional heat energy (infrared energy) is trapped within Earth's atmosphere and could affect the Earth on a planetary level. Deployed satellites have detected critical changes to Earth's albedo to lower levels, however the cause and impact of these changes have yet to be fully understood and incorporated into Global Circulation models (GCMs). Here it's shown that industrialization of anthropogenic landscape practices of the past century has displaced millions of square kilometres of naturally high albedo grasslands with lower albedo agricultural landscapes. Utilising a fundamental Energy Balance Model, (EBM) it's demonstrated these specific changes have generated vast amounts of additional heat energy which is trapped by the atmosphere, transferred and stored within the oceans of the Earth as shown in Figure 1. The total additional heat energy accumulated over the preceding 110 years correlates to that required to warm the Earth to the levels seen to date, altering Earth's overall energy budget. This energy will continue to accumulate and warm the Earth to a predicted 1.60 ± 0.20 Celsius by 2050 over 1910 levels. These findings are independent of anthropogenic Greenhouse Gas (GHG) additions and are further validated by predicting Earth's temperature and albedo at the last glacial maxima, suggesting that an albedo cycle aligned to Gaia theory is the primary driver of Earth's natural climate cycle.

1. Introduction

Anthropogenic landscapes have been around for millennia with mankind domesticating crops in abundant quantities to realize and exploit these new sustainable agricultural methods [1]. These practices have been overwhelmingly beneficial for humanity. Today, Earth's surface is vastly different to that of the early 1900's [2]. Currently anthropogenic landscapes are the largest disruptive development to the planet's ecosystem, with over 52 ± 13 million square kilometres (50%) [3] of habitable land converted to agriculture/urban areas. This equates to 33% of the Earth's land surface. Many first think of deforestation as the major alteration when it comes to land clearing changes in the last century. However, it's been estimated up to 90% [4] of the Worlds Grasslands have suffered the greatest clearing and this has occurred at a faster rate than forests due to grassland's general topography, annual rainfall, rich dark fertile soils [5] and ease of conversion to cropland. As it stands, these areas are one of the least protected regions of the world [5]. The calculated conversion ratio between grassland to cropland and forest to cropland is estimated at (60%:40%) [2]. With the onset of industrialization, today, most grasslands have been converted into agricultural landscapes. The transformation of the World's natural landscapes to agricultural land has increased by 6.7 ± 1.6 million square kilometres within the last 110 years (Figure 2), and now estimated at 15.0 ± 3.5 million square kilometres (1/10 of the Earth's land area) [2]. The juxtapose heat flux or albedo properties of these altered flora surfaces has been overlooked in the causation climate change debate.

Figure 1. Mechanism for anthropogenic landscape heat energy production, trapped by the atmosphere and stored within the oceans.
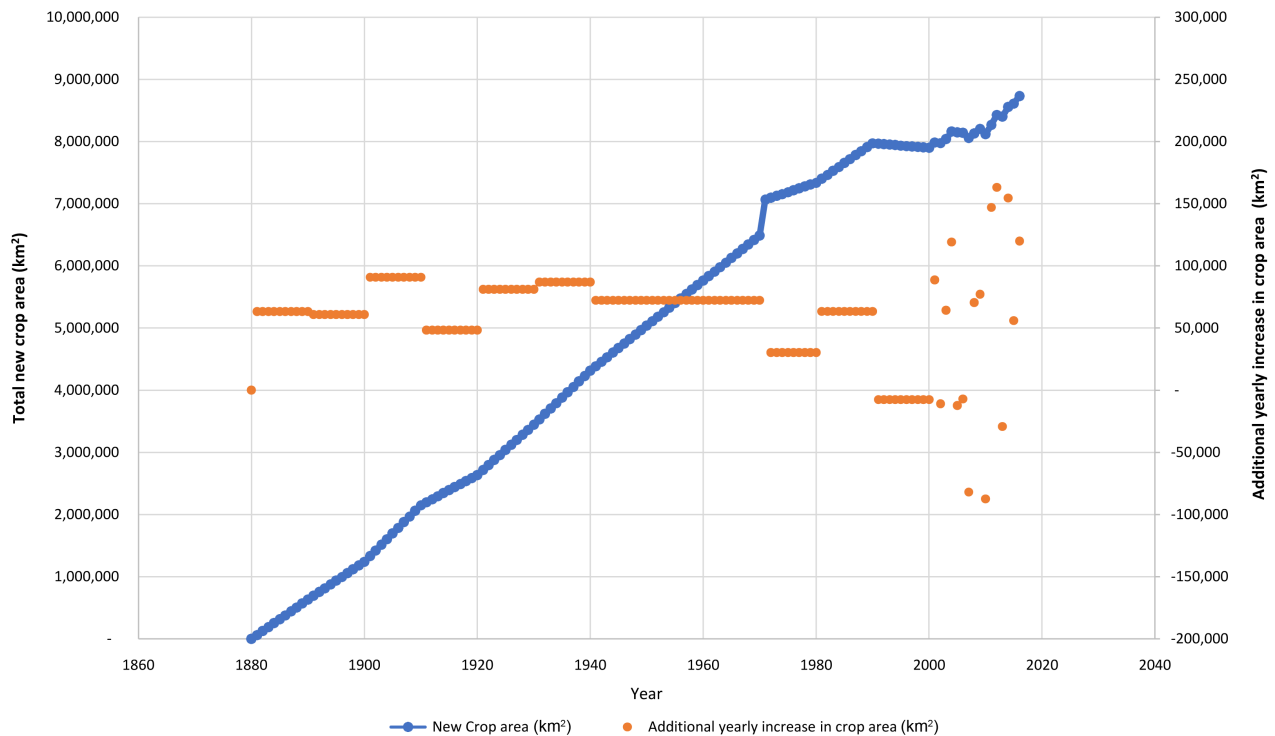
Figure 2. Total new global crop area (square kilometres) as well as additional yearly increase (square kilometres) on the secondary y axis from 1880-2016 [2].

While much attention has been focused on the correlated anthropogenic CO_2, (Greenhouse Gas Emissions (GHG)) increases, these increases have lagged temperature rise and questions remain about the overall causation mechanism [6] and have marred the study of other climate drivers. Without fully accounting for anthropogenic landscape heat effects over the past 110 years, the conclusion drawn to date maybe casuistic. At present there is no alternate, credible theory to readily explain and account for the energy necessary to raise the global temperature by the levels seen. Furthermore, using the fundamental laws of thermodynamics encompassing energy conservation, additional accumulated heat energy generated from the removal & conversion of 4.02 ± 1.6 million square kilometres of natural grasslands with high albedo properties to newly created anthropogenic darker agricultural landscapes with lower albedos, can be identified as the main contributor and causation of climate change [7].

The word Albedo (al-bee-doh) refers to a measure of how much light energy is reflected by a surface, or stays as short-wave energy, while the remaining amount is absorbed and transformed to longwave energy, *i.e.* heat/infrared radiation. Surfaces that appear whiter reflect most of the light energy that is radiated upon the surface and therefore has a high albedo, while darker surfaces absorbs/transforms most of the light energy into longwave, heat energy, indicating a lower albedo. The albedo scale is between 0 for full absorption to 1 for full reflection. This concept and its application are fundamentally important when dealing with climate change and anthropogenic alterations.

While at first thought, it would appear inconceivable that such a simple change in albedo from grasslands to croplands would have the capability or potency to deliver the necessary energy to warm the entire planet within this time frame. However, a 10% - 20% albedo reduction of this extremely large area, resulting in a net heat flux of (4.60 - 9.20 Watts per square meter), [8] can transform the sun's light energy to the heat energy required to increase the Earth's temperature, and lower the Earth's overserved terrestrial surface albedo and overall top of atmosphere (TOA) planetary albedo. While fully-grown crops such as wheat and corn albedos don't differ to that of the natural grasslands at certain growth phases and seasons of the year, the major variance is that at the start of the cropping cycle where bare cultivated soils with low albedos 0.11 ± 0.01 [9] are fully exposed for extended periods of the season. This conditional state is dependent on rainfall/soil moisture for the crops to germinate and change the overall surface to higher albedo settings and associated lower heat fluxes. These areas are carefully ploughed, tilled, sprayed, limed and fertilized to ensure crop success. Furthermore, when dormant brown grasslands albedos of 0.36 [8] and a near-infrared reflectance of 0.58 at certain parts of the season are replaced by croplands with green growth phase albedos (visible leaf reflectance of 0.10 & near-infrared reflectance of 0.58), ultimately changes the heat flux of this area and produces additional heat energy by up to 50% [8]. These changes lower the overall yearly average albedo of this area. The grasslands albedo buffering capabilities are removed and replaced with anthropogenic croplands incapable of displaying the exact albedo/heat flux properties within the yearly cropping cycle. This additional heat energy not only raises the temperature of the surrounding land surfaces, but this heat energy is contained, trapped and distributed within the atmosphere and oceans of the planet. The area of croplands has evolved and increased year on year since 1910 and is only now approaching peak agricultural/cropland area (**Figure 2**) [2]. To date, these changes have not been incorporated into GCMs as it has been assumed that such changes do not play a significant role in Earth's overall heat flux budget [10]. This measured change to heat fluxes and additional build-up of heat energy is correct for short durations, however over decades and centuries the accumulated energy has significant differences. The natural grasslands converted to grafted anthropogenic agricultural croplands have been judged to exhibit the exact same heat flux properties in all GCMs [11]. While deforestation and clearing of the world's forested areas with associated lower albedos 0.142 ± 0.011 to make way for agricultural land with higher albedos of 0.163 ± 0.013 have partially offset the temperature rise in this time frame [10], these areas are less favoured croplands as they are documented to be less fertile with lower productivity to that of grassland/cropland conversions [6]. These cooling changes and heat fluxes have been recognized and accounted for in the GCMs currently used [11].

It's been further recognized that, changes to surface albedos are powerful climate drivers of local, regional land areas and ultimately Earth's climate [12].

These changes are currently responsible for the Urban Heat Island effect (UHI) many already know far too well in our large sprawling cities of the World, sending temperatures to unprecedented high levels for extended periods [13]. This heat effect is not constrained to these man-made alterations and the additional heat energy produced from all anthropogenic landscapes with overall negative albedos, obey the laws of thermodynamics and flows to cooler regions, affecting the entire planet's energy balance, seasonal weather patterns and ultimately the Earths planetary albedo and temperature. This has been labelled here the Anthropogenic Landscape Heat Effect, (ALHE). The anthropogenic surfaces borne from the industrialized development of large parts of natural unaltered grasslands with higher albedos (0.25 ± 0.02) to that of cultivated croplands with lower albedos of (0.20 ± 0.02) or up to a 20% reduction, have not been given the necessary attention such a powerful heat energy source command. To give an example of the additional energy added to Earth's energy budget for every 0.01 albedo units lower than previous, every square kilometre produces an extra 2.94×10^{13} Joules per year.

Moreover, concerns remain for the arctic region as the high albedo (0.60 ±.10) sea ice is slowly transformed to deep ocean low albedo (0.08 ± 0.02) properties due to the shorter winter season caused by the warmer ocean temperatures. Additionally, fires and burnt areas of the world are seemingly increasing in frequency and area and while these are not directly linked to causing global warming, they also contribute to lower albedo terrain. Both alterations will only further exacerbate the warming currently underway due to the positive feedbacks, however, have not been considered in the accumulated heat energy calculations performed herein.

In real terms additional worldwide cropland areas (6.7 ± 1.6 million square kilometres) has roughly increased by 90% of the area of Australia (7.6 million square kilometres) within 110 years. The full impact of these anthropogenic landscape changes has only recently been introduced into some land surface models (LSM) and have been an area of consideration when it comes to the associated net energy flux impacts to the Earth's energy budget [4] [14]. While at the same time other research has touted increased albedo/reflectance changes with lower heat fluxes or new geo-engineering practices to cropland areas as a major way to fully mitigate the current global warming trend currently being experienced [15]. Ultimately, global warming is dictated by the iron-clad laws of thermodynamics. If the additional heat energy is more than the previous year the Earth warms. In reverse, the Earth cools and if the heat energy stays the same, the Earth's temperature remains unchanged.

2. Methodology

In the following calculations the Earth is considered using an Energy Balance Model (EBM). EBMs do not simulate the climate, but instead consider the balance between the energy entering the Earth's atmosphere from the sun and the heat released back out to space and are the foundation and basis upon which

GCMs are built. The Earth is a unique planet in many ways. The existence of an atmosphere with greenhouse gases that's able to trap heat energy (infrared energy) is one such unique system, while allowing to pass shorter frequency energy back into space as the Earth radiates at a (TOA) black body temperature of 254 Kelvin (−19 Celsius) with an albedo of 0.302 and current average observed temperature of 288 Kelvin (15 Celsius). A second is the existence of vast oceans filled with liquid saltwater. Saltwater has rare elementary properties that include a very high heat capacity of 3.89 Joules per gram per kelvin, which enables the oceans to act as a large heat sink that stabilizes the overall temperature of the planet. While the interaction between the atmosphere and oceans are very complex requiring super computers to run GCM models to predict future weather events, the overall energy balance is less so and basic EBMs, Budyko, Rakipova & Sellers [16] [17] [18] utilized in the 1960's can be employed as a good fundamental starting point.

To heat the Planet, you must essentially heat the oceans that stores 93% of the energy [19]. Due to the immense size of the ocean, the epipelagic zone or top 150 ± 50 meters ($5.4 \times 10^7 \pm 1.8 \times 10^7$ cubic kilometres) of the ocean can mix with the atmosphere, with deeper parts taking thousands of years to completely overturn and absorb additional energy and increase in temperature. Furthermore, it's been estimated that the oceans take 2640 years to fully overturn [20]. When considering the energy impacts of the past 110 years, this equates to 4% or (5.4×10^7 cubic kilometres) ocean volume. Eventually, the above-mentioned subtle observation and important interpretation of landscape heat flux changes, make vast differences to the Earth's energy budget and resulting land/ocean mean temperature.

Examining the NOAA global land & ocean mean temperature chart from 1880 to present there is a clear inflection period in 1910-1911 whereby the overall 10-year average temperature, post this year are higher than the previous year with some exceptions in the mid 1940 to the late 1970's. Today's temperature is 1.33 Celsius above 1910, or an additional 0.25 Celsius above the normally quoted 1880 temperature of 1.08 Celsius. Therefore, in this series of calculation, 1910 will be considered the starting year and zero temperature point. All modelled temperature simulations will be compared to this shortened adjusted NOAA 1910 zeroed temperature timeframe shown in Figure 3(i).

A second adjusted baseline temperature chart Figure 3(ii) consists of the standard NOAA global land & ocean mean temperature chart and removes all the years having Atmospheric Atomic testing between 1946-1981, thus, shifting the 1981 temperature reading to 1946. By excluding these years 1946-1981 due to the dawn of atmospheric atomic testing, this completely removes any atmospheric cooling effects that may have been experienced at this time period [21].

The modelled temperature simulations (1910-2050) charts can also be expressed as additional accumulated energy contained within the oceans/atmosphere, and NOAA currently measures this at 1.6×10^{23} Joules above 1990 levels [22].
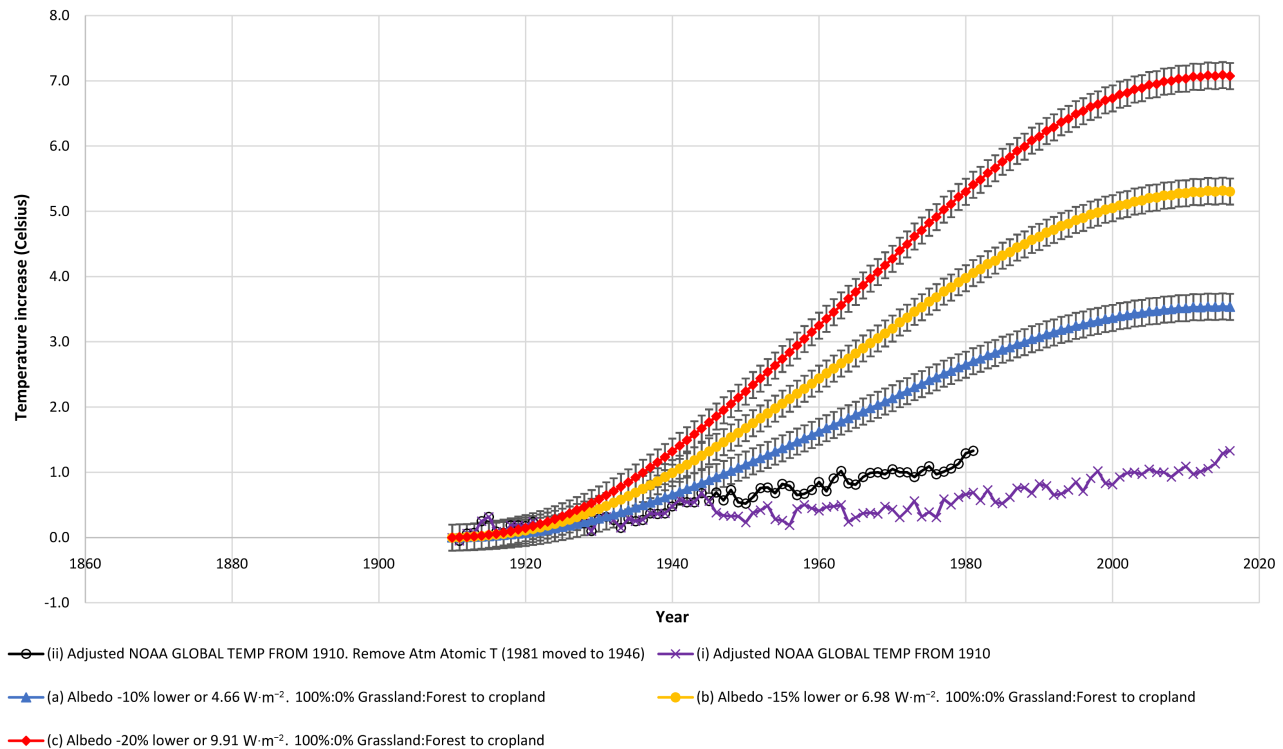
Figure 3. Global temperature increase (Celsius) chart (1910 zero temperature).

To start this series of temperature calculations, an average sea depth of 100 m or 3.6×10^{19} Litres will be set. Utilizing the heat capacity of saltwater (3.89 Joules per gram per Kelvin or 3890 Joules per kilogram per Kelvin), this equates to 1.45×10^{23} Joules per Kelvin. Now applying the laws of thermodynamics, once the amount of accumulated additional heat energy reaches this figure the temperature of the Earth increases by 1-degree Kelvin or Celsius.

To continue the EBM calculations the following 7 assumptions are made:

1) The surface change for the averaged albedo difference of the converted land area (considering the cropping cycles) is constantly maintained year on year due to the same anthropogenic practices.

2) The area of the change is permanent, once the alteration has been initiated.

3) The amount of energy at the surface of the Earth is taken from the average surface energy of the planet obtained from Earth's Global Energy Budget figure, now estimated at 184.0 Watts per square meter [23].

4) Energy reflected by clouds and the Atmosphere is constantly maintained at 79 Watts per square meter [23], throughout this time period This may indeed overestimate the contribution of clouds in the early 1900's.

5) Average sunlight per square meter of terrain is 12 hours per day or (43,200 seconds per day), 365 days per year.

6) The amount of energy required to heat the Earth, 1 Celsius or Kelvin is estimated at 1.45×10^{23} Joules based on 100 m ocean depth (3.6×10^7 cubic kilometres).

7) The remaining of Earth's radiation budget quantities and annual mean

energy budget for the globe are taken from the Trenberth *ET AL.* work. As shown in Supplementary **Table S1(a)** and **Table S1(b)** [23], with 2002 as the benchmark year.

Formulae used to determine additional heat energy from anthropogenic landscape albedo alterations are based from the amount of heat Q required to warm an object of mass m by raising its temperature ΔT and is given by

$$Q = mc\Delta T \tag{1.1}$$

where c is the specific heat of the material from which an object is made.

Equation 1

$$
\begin{aligned}
&\text{Yearly heat Energy (Joules)} \\
&= \text{Total changed area (square meters)} \\
&\quad \times \text{Total daylight time (seconds)} \\
&\quad \times \text{Difference in heat flux (Joules per second)} \\
&\quad - \text{Previous Year Energy (Joules)}
\end{aligned} \tag{1}
$$

Equation 2

$$
\begin{aligned}
&\text{Total accumulated heat energy (Joules)(particular year)} \\
&= \text{Yearly heat Energy (Joules)} + \text{All previous yearly heat Energies (Joules)}
\end{aligned} \tag{2}
$$

Equation 3

$$
\begin{aligned}
&\text{Global temperature increase (Celsius)} \\
&= \text{Total accumulated heat energy (Joules)} / 1.45 \times 10^{23} \text{Joules per Celsius}
\end{aligned} \tag{3}
$$

Earth's planetary albedo can be calculated utilizing the Stefan-Boltzmann law, with T_P equal to average planetary temperature, with S_{ave} equal to the top of atmosphere solar energy, and α the Earth's albedo, σ is the Stefan-Boltzmann constant.

Equation 4

$$
\begin{aligned}
S_{ave}\left(1-\alpha\right) &= \sigma T_P^4 \\
T_P &= \left(S_{ave}\left(1-\alpha\right)/\sigma\right)^{1/4}
\end{aligned} \tag{4}
$$

3. Results

The first series of modelled temperature calculations derived from Equations (1)-(3) are performed using 10%, 15% and 20% reduction on the anthropogenic albedo surface alteration converting from grasslands to croplands for the entire introduced 6.7 million square kilometres anthropogenic area, with no accounting for the forest to cropland conversions resulting in a (100%:0%) ratio. The resulting additional heat flux is 4.60 Watts per square meter, 6.90 Watts per square meter and 9.20 Watts per square meter respectively.

All the temperature results overshot the expected baseline NOAA adjusted temperature and are shown in **Figures 3(a)-(c)**.

A second series of temperature calculations are performed that accounts for forest to cropland conversions. Starting at a lowered 55%:45% (grassland to

cropland):(forest to cropland) ratio. The resulting additional heat flux is 0.82 Watts per square meter, 2.10 Watts per square meter and 3.38 Watts per square meter respectively, totalling 6.7 million square kilometres shown in **Figures 4(a)-(c)**. The resulting temperature chart 4(b) shows a Pearson correlation of 0.97 when compared to the adjusted NOAA temperature chart 4(ii), *i.e.*, removing the atmospheric atomic testing years, and a paired *t* test result of. 1.6×10^{-10}, making these highly probable they are correlated. The total energy (Joules) is plotted on the secondary y axis in **Figure 4(e)**.

An additional temperature chart is constructed, shifting the resulting modelled temperatures from 1946 to 1981 thereby excluding the Atmospheric atomic testing years; resulting in **Figures 5(a)-(c)**. These temperature charts can be used to predict the future global atmospheric/ocean mean temperatures and are compared to the 1910 adjusted NOAA temperature chart 5(i). To date, Earth's global temperature has risen 1.33 Celsius above 1910 levels, (an increase of 0.25 Celsius above the normally quoted 1880 temperature increase of 1.08 Celsius), here it's shown that additional accumulated heat energy generated from darker anthropogenic landscape changes totalling 2.28×10^{23} Joules from 1910, will continue increasing Earth's temperature but not exceeding 1.60 ± 0.20 Celsius by 2050 as shown in **Figure 5(b)**.

Utilising Equation (4), the Earth's TOA planetary albedo can be obtained. These changes have decreased the Earths, top of atmosphere (TOA) planetary albedo from 0.3160 in 1910 to 0.2987 in 2050 and are seen in **Figure 6**, which equates to 5.88 Watts per square meter, global energy flux difference.
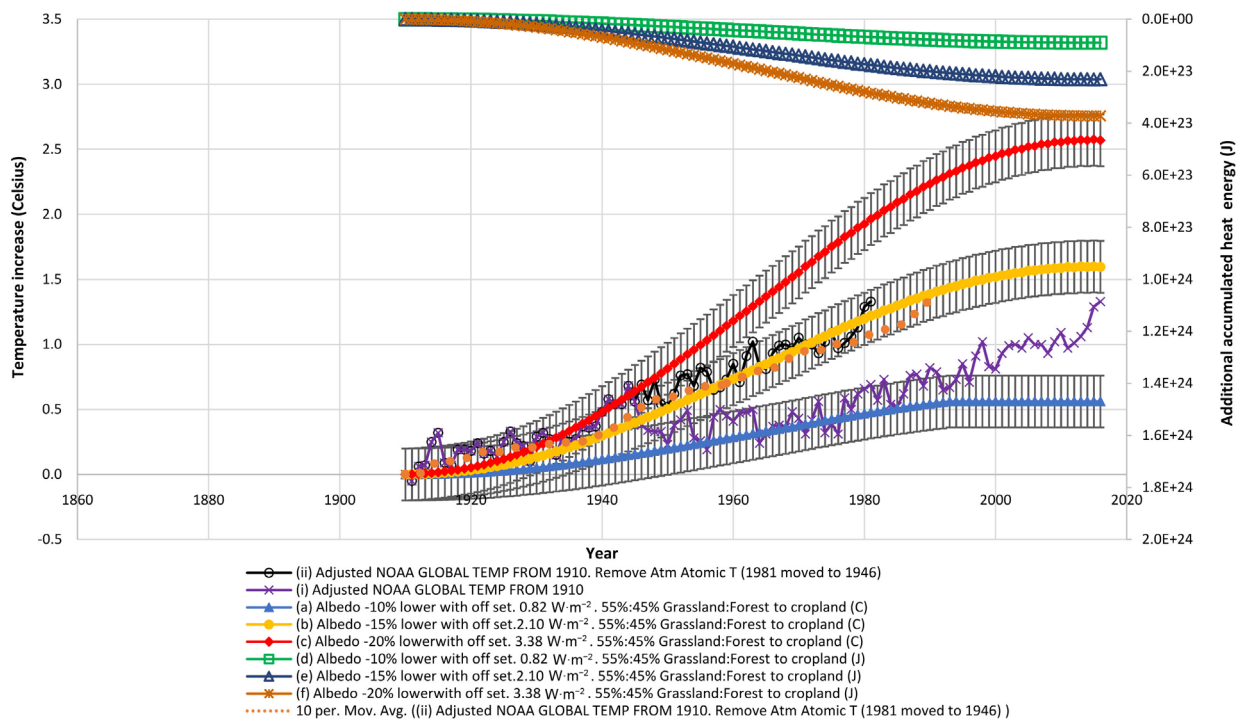
Figure 4. Global temperature increase (Celsius) chart, additional accumulated heat energy (Joules) plotted on the secondary y axis.
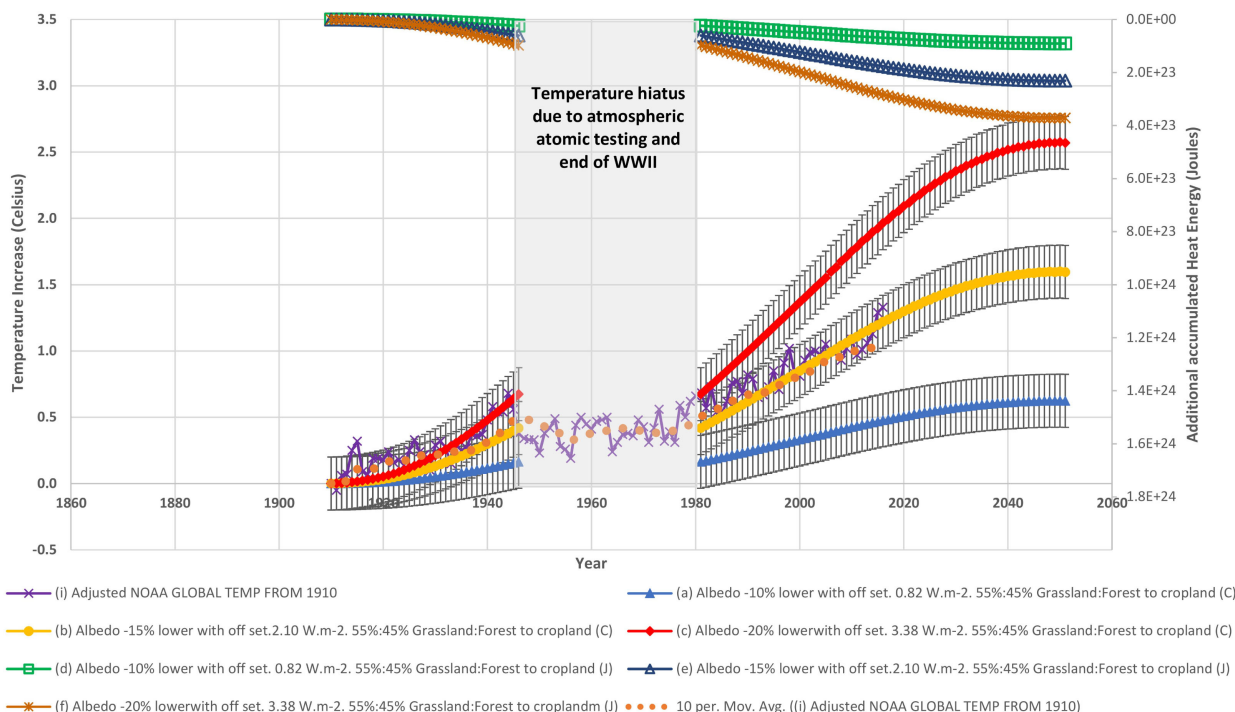
Figure 5. Global temperature increase (Celsius) chart, additional accumulated heat energy (Joules) plotted on the secondary (y) axis (1910 zero temperature). This chart includes the temperature hiatus due to atmospheric atomic testing and end of WWII.
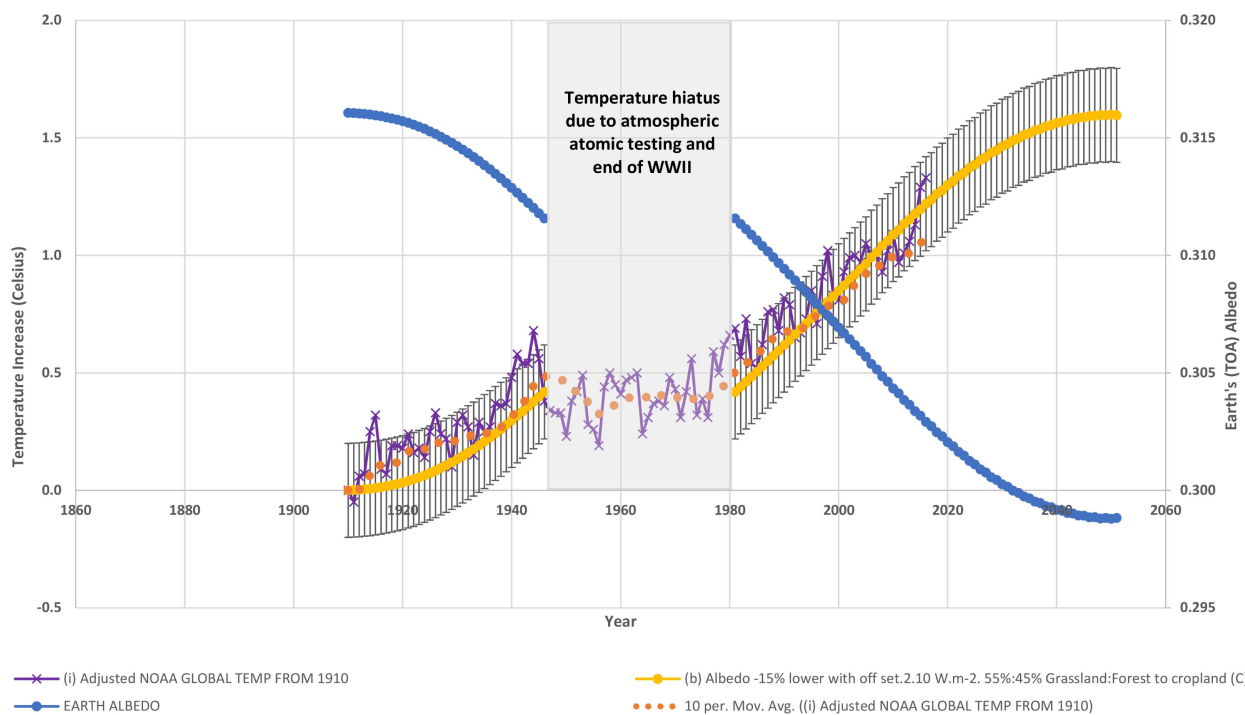
Figure 6. Global temperature increase (Celsius) chart, with Earth's (TOA) albedo plotted on the secondary y axis (1910 zero temperature).

A further chart, **Figure 7** is constructed to compare the predicted Earth's albedo and TOA temperature (Kelvin) again from the results of Equation (4).
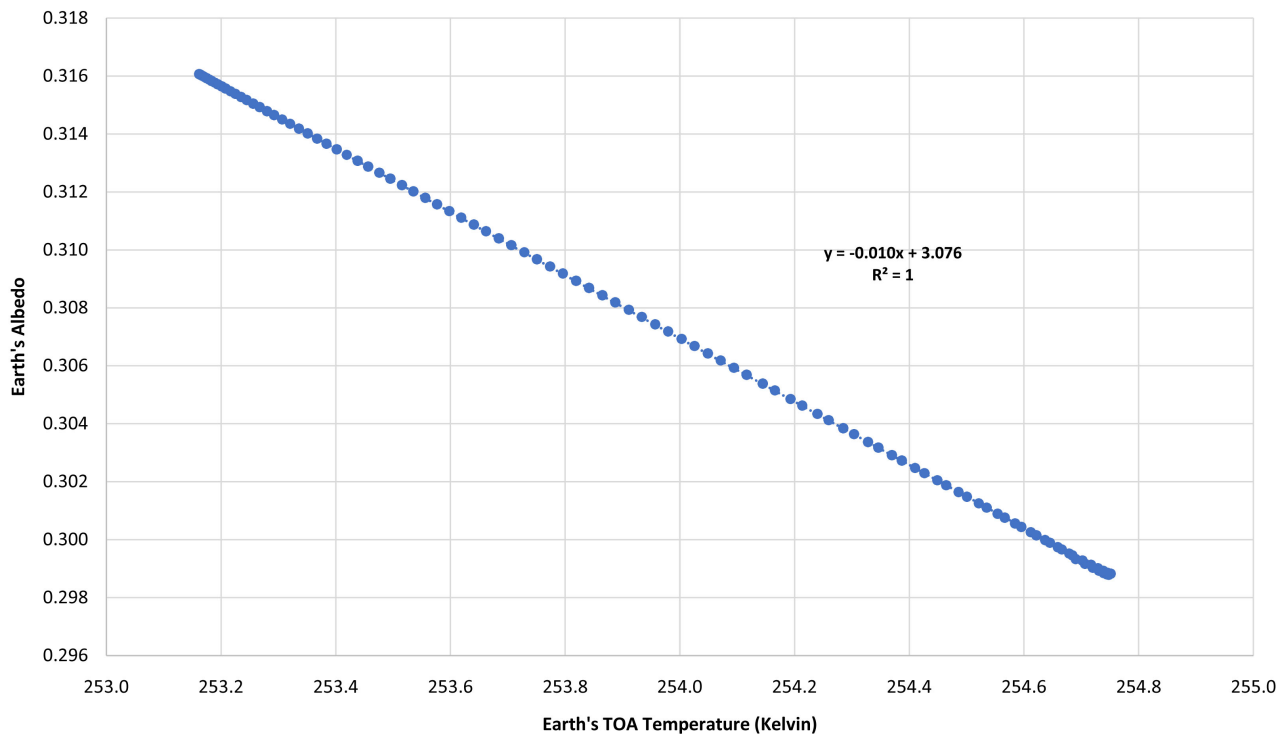
Figure 7. Earth's albedo versus Earth's TOA temperature (Kelvin).

This results in Equation (5) below:

$$y = -0.0109x + 3.0769, \ \ R^2 = 1 \tag{5}$$

All calculations can be seen in supplementary spreadsheet (1) for calculations and summarized in Supplementary Table S2.

Validation

To validate this methodology and calculations, we subject them to the ultimate test by determining the Earth's temperature and albedo at the last glacial maxima some 20,000 years ago. This is the last known undisputed steady state of Earth, whereby 25% (36,760,564 square kilometres) of the Earth's land surface was covered in glacial ice sheets [24] with a high surface albedo (0.6) replacing natural grasslands and forests at an estimated 60%: 40% ratio. This represents a newly calculated heat flux reduction for this area of −73.21 Watts per square meter when compared to the previous 60% grassland: 40% forest surfaces ratio. Following that the entire oceans would completely overturn several times leading into the glacial maxima time frame, the total volume of ocean used in this calculation is 1.35×10^{21} Litres. The total amount of heat energy entering into Earths system would therefore need to be substantially less to drive the Earth's observed temperature down to 281 Kelvin (8 Celsius) seen in the last glacial maxima some 7 Celsius below the current average global temperature 15 Celsius. This would equate to -5.42×10^{24} Joules per Celsius not entering the Earths system as heat energy (long wave infrared energy) and being reflected into space as short wave energy.

These calculations driven by this immense area of high albedo ice area establishes the total energy decrease of -4.49×10^{25} Joules, equating to a -8.29 ± 0.20 Kelvin or Celsius below current temperature or 246.4 Kelvin (-26.6 Celsius) TOA and observed global temperature at 279.4 Kelvin (6.4 Celsius). Furthermore, the Earth's albedo can be calculated using the Stefan-Boltzmann Equation (4), which would increase to 0.385 at this time as seen in supplementary spreadsheet (8).

A revised glacial ice albedo of 0.55 for the entire glacial ice area (-63.16 Watts per square meter) results in a calculated temperature of -7.23 ± 0.20 Celsius below current temperature or 247.45 Kelvin TOA temperature and observed global temperature at 280.45 Kelvin. The Earth's albedo would be revised to 0.373, well within the scope of the actual Earth's temperature recorded in the ice cores at this time.

To further understand and valid the methodology used, the Earth's albedo is calculated from Equation (5) obtained in the first series of calculations:

$$y = -0.0109x + 3.0769, \quad R^2 = 1 \tag{5}$$

The Earth's albedo is calculated for Last Glacial maxima temperature of 247.45 Kelvin, at 0.3784, a very close result to the previous above 0.373 albedo obtained, or 1.84 Watts per square meter difference. All calculations can be seen in supplementary spreadsheet (1) for calculations and summarized in Supplementary Table S2.

4. Discussion

While there are some inherent errors that exist within the calculations performed, from the tessellated grafted anthropogenic surface area changes, associated land and cloud albedos and resulting heat fluxes that culminates in a ±0.2 Celsius estimated error, these are outweighed by the basic, fundamental laws of thermodynamics employed as well as the reasonable, logical assumptions made in the semiempirical calculations performed within the EBM. This combined with the validation calculations predicting Earth's temperature and albedo at the last glacial maxima, shows how large-scale albedo changes can drive the planetary temperatures experienced in Earth's past, and may indeed be aligned to an Earth albedo cycle associated with Gaia theory [25].

Looking closely at the recorded NOAA global temperatures from 1910 to present and comparing them to the modelled temperatures seen in Figure 6(b), the modelled results appear are on the lower side of the actual NOAA global temperatures, and only 10 of the 110 of the NOAA global temperatures yearly results fall outside the predicted error results. This stems from the conservative estimates for the anthropogenic induced heat fluxes and total converted areas utilized. While lower latent heat in the early 1900's may also contribute to additional heat energy entering the system due to reduced cloud formation and therefore less reflected energy resulting in higher transmission of energy reaching Earth's lowered albedo surfaces and ultimately transformed to additional

heat energy. This would result in increased temperatures than otherwise modelled. Current research indicates the latent heat measurements have increased over the century, resulting in greater cloud formation and rainfall [26] [27]. However, from the results obtained by the two separate methods above, the heat fluxes used appear to be maintained and accurate, and within acceptable limits over the 110-year period.

5. Conclusion

In conclusion, this paper shows that utilising an EBM, the unintended additional accumulated heat energy as a consequence of all ALHE alterations, has year on year resulted in increased global average temperatures since 1910, except for the atmospheric atomic testing years (1946-81). A Pearson's correlation of 0.97, as well as a paired t-test result of 1.6×10^{-10} was calculated between these results and NOAA average global temperatures, indicating a strong correlation. Using the Stefan-Boltzmann law the Earth's average absorbed heat flux will increase by 5.88 Watts per square meter from 1910 to 2050, as an indirect result of Earth's TOA albedo decreasing from 0.3160 to 0.2987 over this timeframe. Without any contrary change, or off-setting, this additional accumulated heat energy totalling 2.29×10^{23} Joules, will continue to enter Earth's system, warming the planet to a predicted temperature of 1.60 ± 0.20 Celsius above 1910 levels by 2050 and is independent of anthropogenic GHG increases. These findings should be closely studied and incorporated into more complex GCMs. If all global warming seen to date can be attributed to surface albedo changes, this gives rise to the question of whether surface albedo changes, may, in fact, have been a larger contributor to global temperature fluctuations seen in the distant past and therefore been the primary driver of natural climate change, *i.e.* Ice Ages/interglacial periods, and may indeed be aligned to an Earth albedo cycle associated with Gaia theory.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Supplementary

Table S1. (a) Top of atmosphere (TOA) mean radiation budget quantities clouds and the Earth's radiation energy system from 1910 to 2050. Global. The downward solar (Solar in), reflected solar (Solar reflected), and net (NET down) radiation are given with the ASR and OLR (W·m⁻²), and albedo is given in percentage. The values start with figures from Earth's Global energy budget. Trenberth al et American Meterological society March 2009 [23]; (b) Top of atmosphere (TOA) mean radiation budget quantities clouds and the Earth's radiation energy system from 1910 to 2050. Global. The downward solar (Solar in), reflected solar (Solar reflected), and net (NET down) radiation are given with the ASR and OLR (W·m⁻²), and albedo is given in percentage. The values start with figures from Earth's Global energy budget. Trenberth *et al.* American Meteorological society March 2009 [23]. Removed atmospheric atomic testing years, *i.e.* the 1946 temperature readings are and restart at 1981. The bench mark year is highlighted as 2002.

(a)

Year	Solar in (W·m⁻²)	Solar reflected (W·m⁻²)	Albedo	ASR (W·m⁻²)	OLR (W·m⁻²)	NET down (W·m⁻²)	Temp (K) TOA	Reflected by clouds (W·m⁻²)	Reflected by surface (W·m⁻²)	Absorbed by the surface (W·m⁻²)	absorbed by Atmosphere (W·m⁻²)	Back Radiation (W·m⁻²)	Radiation up (W·m⁻²)	Atmospheric window (W·m⁻²)	Net absorbed (W·m⁻²)	Latent heat (W·m⁻²)	Thermals (W·m⁻²)
1910	341.70	107.66	31.51%	234.04	233.14	0.90	253.16	79.00	28.66	155.08	78.00	333.00	392.71	40.00	0.90	80.00	17.00
1911	341.70	107.66	31.51%	234.04	233.14	0.90	253.16	79.00	28.66	155.08	78.00	333.00	392.71	40.00	0.90	80.00	17.00
1912	341.70	107.65	31.50%	234.05	233.15	0.90	253.16	79.00	28.65	155.09	78.00	333.00	392.72	40.00	0.90	80.00	17.00
1913	341.70	107.64	31.50%	234.06	233.16	0.90	253.17	79.00	28.64	155.09	78.00	333.00	392.73	40.00	0.90	80.00	17.00
1914	341.70	107.64	31.50%	234.06	233.16	0.90	253.17	79.00	28.64	155.10	78.00	333.00	392.73	40.00	0.90	80.00	17.00
1915	341.70	107.62	31.50%	234.08	233.18	0.90	253.17	79.00	28.62	155.12	78.00	333.00	392.75	40.00	0.90	80.00	17.00
1916	341.70	107.61	31.49%	234.09	233.19	0.90	253.18	79.00	28.61	155.13	78.00	333.00	392.76	40.00	0.90	80.00	17.00
1917	341.70	107.60	31.49%	234.10	233.20	0.90	253.18	79.00	28.60	155.14	78.00	333.00	392.77	40.00	0.90	80.00	17.00
1918	341.70	107.58	31.48%	234.12	233.22	0.90	253.18	79.00	28.58	155.16	78.00	333.00	392.79	40.00	0.90	80.00	17.00
1919	341.70	107.56	31.48%	234.14	233.24	0.90	253.19	79.00	28.56	155.18	78.00	333.00	392.81	40.00	0.90	80.00	17.00
1920	341.70	107.54	31.47%	234.16	233.26	0.90	253.19	79.00	28.54	155.20	78.00	333.00	392.83	40.00	0.90	80.00	17.00
1921	341.70	107.52	31.46%	234.18	233.28	0.90	253.20	79.00	28.52	155.22	78.00	333.00	392.85	40.00	0.90	80.00	17.00
1922	341.70	107.49	31.46%	234.21	233.31	0.90	253.21	79.00	28.49	155.25	78.00	333.00	392.88	40.00	0.90	80.00	17.00
1923	341.70	107.46	31.45%	234.24	233.34	0.90	253.22	79.00	28.46	155.28	78.00	333.00	392.91	40.00	0.90	80.00	17.00
1924	341.70	107.43	31.44%	234.27	233.37	0.90	253.22	79.00	28.43	155.31	78.00	333.00	392.94	40.00	0.90	80.00	17.00
1925	341.70	107.39	31.43%	234.31	233.41	0.90	253.23	79.00	28.39	155.35	78.00	333.00	392.98	40.00	0.90	80.00	17.00
1926	341.70	107.36	31.42%	234.34	233.44	0.90	253.24	79.00	28.36	155.38	78.00	333.00	393.01	40.00	0.90	80.00	17.00
1927	341.70	107.31	31.41%	234.39	233.49	0.90	253.26	79.00	28.31	155.43	78.00	333.00	393.06	40.00	0.90	80.00	17.00
1928	341.70	107.27	31.39%	234.43	233.53	0.90	253.27	79.00	28.27	155.47	78.00	333.00	393.10	40.00	0.90	80.00	17.00
1929	341.70	107.22	31.38%	234.48	233.58	0.90	253.28	79.00	28.22	155.51	78.00	333.00	393.15	40.00	0.90	80.00	17.00
1930	341.70	107.18	31.37%	234.52	233.62	0.90	253.29	79.00	28.18	155.56	78.00	333.00	393.19	40.00	0.90	80.00	17.00
1931	341.70	107.13	31.35%	234.57	233.67	0.90	253.31	79.00	28.13	155.61	78.00	333.00	393.24	40.00	0.90	80.00	17.00
1932	341.70	107.07	31.34%	234.63	233.73	0.90	253.32	79.00	28.07	155.66	78.00	333.00	393.29	40.00	0.90	80.00	17.00
1933	341.70	107.02	31.32%	234.68	233.78	0.90	253.34	79.00	28.02	155.72	78.00	333.00	393.35	40.00	0.90	80.00	17.00

Continued

1934	341.70	106.96	31.30%	234.74	233.84	0.90	253.35	79.00	27.96	155.78	78.00	333.00	393.41	40.00	0.90	80.00	17.00
1935	341.70	106.90	31.28%	234.80	233.90	0.90	253.37	79.00	27.90	155.84	78.00	333.00	393.47	40.00	0.90	80.00	17.00
1936	341.70	106.84	31.27%	234.86	233.96	0.90	253.38	79.00	27.84	155.90	78.00	333.00	393.53	40.00	0.90	80.00	17.00
1937	341.70	106.77	31.25%	234.93	234.03	0.90	253.40	79.00	27.77	155.97	78.00	333.00	393.60	40.00	0.90	80.00	17.00
1938	341.70	106.71	31.23%	234.99	234.09	0.90	253.42	79.00	27.71	156.03	78.00	333.00	393.66	40.00	0.90	80.00	17.00
1939	341.70	106.64	31.21%	235.06	234.16	0.90	253.44	79.00	27.64	156.10	78.00	333.00	393.73	40.00	0.90	80.00	17.00
1940	341.70	106.57	31.19%	235.13	234.23	0.90	253.46	79.00	27.57	156.17	78.00	333.00	393.80	40.00	0.90	80.00	17.00
1941	341.70	106.50	31.17%	235.20	234.30	0.90	253.48	79.00	27.50	156.24	78.00	333.00	393.87	40.00	0.90	80.00	17.00
1942	341.70	106.43	31.15%	235.27	234.37	0.90	253.50	79.00	27.43	156.31	78.00	333.00	393.94	40.00	0.90	80.00	17.00
1943	341.70	106.35	31.12%	235.35	234.45	0.90	253.52	79.00	27.35	156.39	78.00	333.00	394.02	40.00	0.90	80.00	17.00
1944	341.70	106.28	31.10%	235.42	234.52	0.90	253.54	79.00	27.28	156.46	78.00	333.00	394.09	40.00	0.90	80.00	17.00
1945	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1946	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.1264	156.6126	78.0000	333.00	394.24	40.00	0.9000	80.00	17.00
1947	341.70	106.05	31.04%	235.65	234.75	0.90	253.60	79.00	27.0468	156.6922	78.0000	333.00	394.32	40.00	0.9000	80.00	17.00
1948	341.70	105.97	31.01%	235.73	234.83	0.90	253.62	79.00	26.9694	156.7696	78.0000	333.00	394.40	40.00	0.9000	80.00	17.00
1949	341.70	105.89	30.99%	235.81	234.91	0.90	253.64	79.00	26.8880	156.8510	78.0000	333.00	394.48	40.00	0.9000	80.00	17.00
1950	341.70	105.81	30.97%	235.89	234.99	0.90	253.66	79.00	26.8089	156.9301	78.0000	333.00	394.56	40.00	0.9000	80.00	17.00
1951	341.70	105.73	30.94%	235.97	235.07	0.90	253.68	79.00	26.7259	157.0131	78.0000	333.00	394.64	40.00	0.9000	80.00	17.00
1952	341.70	105.65	30.92%	236.05	235.15	0.90	253.71	79.00	26.6454	157.0936	78.0000	333.00	394.72	40.00	0.9000	80.00	17.00
1953	341.70	105.56	30.89%	236.14	235.24	0.90	253.73	79.00	26.5610	157.1780	78.0000	333.00	394.81	40.00	0.9000	80.00	17.00
1954	341.70	105.48	30.87%	236.22	235.32	0.90	253.75	79.00	26.4793	157.2597	78.0000	333.00	394.89	40.00	0.9000	80.00	17.00
1955	341.70	105.39	30.84%	236.31	235.41	0.90	253.77	79.00	26.3938	157.3452	78.0000	333.00	394.98	40.00	0.9000	80.00	17.00
1956	341.70	105.31	30.82%	236.39	235.49	0.90	253.80	79.00	26.3111	157.4279	78.0000	333.00	395.06	40.00	0.9000	80.00	17.00
1957	341.70	105.22	30.79%	236.48	235.58	0.90	253.82	79.00	26.2248	157.5142	78.0000	333.00	395.14	40.00	0.9000	80.00	17.00
1958	341.70	105.14	30.77%	236.56	235.66	0.90	253.84	79.00	26.1414	157.5976	78.0000	333.00	395.23	40.00	0.9000	80.00	17.00
1959	341.70	105.05	30.74%	236.65	235.75	0.90	253.87	79.00	26.0545	157.6845	78.0000	333.00	395.32	40.00	0.9000	80.00	17.00
1960	341.70	104.97	30.72%	236.73	235.83	0.90	253.89	79.00	25.9706	157.7684	78.0000	333.00	395.40	40.00	0.9000	80.00	17.00
1961	341.70	104.88	30.69%	236.82	235.92	0.90	253.91	79.00	25.8833	157.8557	78.0000	333.00	395.49	40.00	0.9000	80.00	17.00
1962	341.70	104.80	30.67%	236.90	236.00	0.90	253.93	79.00	25.7992	157.9398	78.0000	333.00	395.57	40.00	0.9000	80.00	17.00
1963	341.70	104.71	30.64%	236.99	236.09	0.90	253.96	79.00	25.7118	158.0272	78.0000	333.00	395.66	40.00	0.9000	80.00	17.00
1964	341.70	104.63	30.62%	237.07	236.17	0.90	253.98	79.00	25.6277	158.1113	78.0000	333.00	395.74	40.00	0.9000	80.00	17.00
1965	341.70	104.54	30.59%	237.16	236.26	0.90	254.00	79.00	25.5404	158.1986	78.0000	333.00	395.83	40.00	0.9000	80.00	17.00
1966	341.70	104.46	30.57%	237.24	236.34	0.90	254.03	79.00	25.4565	158.2825	78.0000	333.00	395.91	40.00	0.9000	80.00	17.00
1967	341.70	104.37	30.54%	237.33	236.43	0.90	254.05	79.00	25.3696	158.3694	78.0000	333.00	396.00	40.00	0.9000	80.00	17.00
1968	341.70	104.29	30.52%	237.41	236.51	0.90	254.07	79.00	25.2863	158.4527	78.0000	333.00	396.08	40.00	0.9000	80.00	17.00
1969	341.70	104.20	30.49%	237.50	236.60	0.90	254.09	79.00	25.2000	158.5390	78.0000	333.00	396.17	40.00	0.9000	80.00	17.00
1970	341.70	104.12	30.47%	237.58	236.68	0.90	254.12	79.00	25.1174	158.6217	78.0000	333.00	396.25	40.00	0.9000	80.00	17.00

Continued

1971	341.70	104.01	30.44%	237.69	236.79	0.90	254.14	79.00	25.0127	158.7263	78.0000	333.00	396.36	40.00	0.9000	80.00	17.00
1972	341.70	103.93	30.42%	237.77	236.87	0.90	254.17	79.00	24.9331	158.8060	78.0000	333.00	396.44	40.00	0.9000	80.00	17.00
1973	341.70	103.83	30.39%	237.87	236.97	0.90	254.19	79.00	24.8314	158.9076	78.0000	333.00	396.54	40.00	0.9000	80.00	17.00
1974	341.70	103.75	30.36%	237.95	237.05	0.90	254.21	79.00	24.7549	158.9841	78.0000	333.00	396.61	40.00	0.9000	80.00	17.00
1975	341.70	103.66	30.34%	238.04	237.14	0.90	254.24	79.00	24.6564	159.0826	78.0000	333.00	396.71	40.00	0.9000	80.00	17.00
1976	341.70	103.58	30.31%	238.12	237.22	0.90	254.26	79.00	24.5831	159.1560	78.0000	333.00	396.79	40.00	0.9000	80.00	17.00
1977	341.70	103.49	30.29%	238.21	237.31	0.90	254.28	79.00	24.4878	159.2512	78.0000	333.00	396.88	40.00	0.9000	80.00	17.00
1978	341.70	103.42	30.27%	238.28	237.38	0.90	254.30	79.00	24.4178	159.3212	78.0000	333.00	396.95	40.00	0.9000	80.00	17.00
1979	341.70	103.33	30.24%	238.37	237.47	0.90	254.33	79.00	24.3259	159.4131	78.0000	333.00	397.04	40.00	0.9000	80.00	17.00
1980	341.70	103.26	30.22%	238.44	237.54	0.90	254.35	79.00	24.2593	159.4798	78.0000	333.00	397.11	40.00	0.9000	80.00	17.00
1981	341.70	103.17	30.19%	238.53	237.63	0.90	254.37	79.00	24.1698	159.5692	78.0000	333.00	397.20	40.00	0.9000	80.00	17.00
1982	341.70	103.11	30.17%	238.59	237.69	0.90	254.39	79.00	24.1058	159.6332	78.0000	333.00	397.26	40.00	0.9000	80.00	17.00
1983	341.70	103.02	30.15%	238.68	237.78	0.90	254.41	79.00	24.0191	159.7199	78.0000	333.00	397.35	40.00	0.9000	80.00	17.00
1984	341.70	102.96	30.13%	238.74	237.84	0.90	254.43	79.00	23.9579	159.7812	78.0000	333.00	397.41	40.00	0.9000	80.00	17.00
1985	341.70	102.87	30.11%	238.83	237.93	0.90	254.45	79.00	23.8740	159.8650	78.0000	333.00	397.50	40.00	0.9000	80.00	17.00
1986	341.70	102.82	30.09%	238.88	237.98	0.90	254.46	79.00	23.8159	159.9232	78.0000	333.00	397.55	40.00	0.9000	80.00	17.00
1987	341.70	102.74	30.07%	238.96	238.06	0.90	254.49	79.00	23.7352	160.0038	78.0000	333.00	397.63	40.00	0.9000	80.00	17.00
1988	341.70	102.68	30.05%	239.02	238.12	0.90	254.50	79.00	23.6802	160.0588	78.0000	333.00	397.69	40.00	0.9000	80.00	17.00
1989	341.70	102.60	30.03%	239.10	238.20	0.90	254.52	79.00	23.6029	160.1361	78.0000	333.00	397.77	40.00	0.9000	80.00	17.00
1990	341.70	102.55	30.01%	239.15	238.25	0.90	254.53	79.00	23.5515	160.1876	78.0000	333.00	397.82	40.00	0.9000	80.00	17.00
1991	341.70	102.48	29.99%	239.22	238.32	0.90	254.55	79.00	23.4792	160.2598	78.0000	333.00	397.89	40.00	0.9000	80.00	17.00
1992	341.70	102.43	29.98%	239.27	238.37	0.90	254.57	79.00	23.4328	160.3062	78.0000	333.00	397.94	40.00	0.9000	80.00	17.00
1993	341.70	102.37	29.96%	239.33	238.43	0.90	254.58	79.00	23.3656	160.3734	78.0000	333.00	398.00	40.00	0.9000	80.00	17.00
1994	341.70	102.32	29.95%	239.38	238.48	0.90	254.60	79.00	23.3243	160.4147	78.0000	333.00	398.05	40.00	0.9000	80.00	17.00
1995	341.70	102.26	29.93%	239.44	238.54	0.90	254.61	79.00	23.2622	160.4768	78.0000	333.00	398.11	40.00	0.9000	80.00	17.00
1996	341.70	102.23	29.92%	239.47	238.57	0.90	254.62	79.00	23.2259	160.5131	78.0000	333.00	398.14	40.00	0.9000	80.00	17.00
1997	341.70	102.17	29.90%	239.53	238.63	0.90	254.64	79.00	23.1688	160.5702	78.0000	333.00	398.20	40.00	0.9000	80.00	17.00
1998	341.70	102.14	29.89%	239.56	238.66	0.90	254.65	79.00	23.1375	160.6015	78.0000	333.00	398.23	40.00	0.9000	80.00	17.00
1999	341.70	102.09	29.88%	239.61	238.71	0.90	254.66	79.00	23.0854	160.6536	78.0000	333.00	398.28	40.00	0.9000	80.00	17.00
2000	341.70	102.06	29.87%	239.64	238.74	0.90	254.67	79.00	23.0592	160.6798	78.0000	333.00	398.31	40.00	0.9000	80.00	17.00
2001	341.70	102.01	29.85%	239.69	238.79	0.90	254.68	79.00	23.0108	160.7282	78.0000	333.00	398.36	40.00	0.9000	80.00	17.00
2002	341.70	101.99	29.85%	239.71	238.81	0.90	254.68	79.00	22.9896	160.7494	78.0000	333.00	398.38	40.00	0.9000	80.00	17.00
2003	341.70	101.97	29.84%	239.73	238.83	0.90	254.69	79.00	22.9685	160.7705	78.0000	333.00	398.40	40.00	0.9000	80.00	17.00
2004	341.70	101.92	29.83%	239.78	238.88	0.90	254.70	79.00	22.9244	160.8146	78.0000	333.00	398.45	40.00	0.9000	80.00	17.00
2005	341.70	101.91	29.82%	239.79	238.89	0.90	254.71	79.00	22.9070	160.8320	78.0000	333.00	398.46	40.00	0.9000	80.00	17.00
2006	341.70	101.87	29.81%	239.83	238.93	0.90	254.72	79.00	22.8681	160.8709	78.0000	333.00	398.50	40.00	0.9000	80.00	17.00
2007	341.70	101.86	29.81%	239.84	238.94	0.90	254.72	79.00	22.8559	160.8831	78.0000	333.00	398.51	40.00	0.9000	80.00	17.00

Continued

2008	341.70	101.82	29.80%	239.88	238.98	0.90	254.73	79.00	22.8228	160.9162	78.0000	333.00	398.55	40.00	0.9000	80.00	17.00
2009	341.70	101.82	29.80%	239.88	238.98	0.90	254.73	79.00	22.8151	160.9239	78.0000	333.00	398.55	40.00	0.9000	80.00	17.00
2010	341.70	101.79	29.79%	239.91	239.01	0.90	254.74	79.00	22.7866	160.9524	78.0000	333.00	398.58	40.00	0.9000	80.00	17.00
2011	341.70	101.78	29.79%	239.92	239.02	0.90	254.74	79.00	22.7846	160.9544	78.0000	333.00	398.59	40.00	0.9000	80.00	17.00
2012	341.70	101.76	29.78%	239.94	239.04	0.90	254.75	79.00	22.7605	160.9785	78.0000	333.00	398.61	40.00	0.9000	80.00	17.00
2013	341.70	101.76	29.78%	239.94	239.04	0.90	254.74	79.00	22.7632	160.9759	78.0000	333.00	398.61	40.00	0.9000	80.00	17.00
2014	341.70	101.74	29.78%	239.96	239.06	0.90	254.75	79.00	22.7445	160.9945	78.0000	333.00	398.63	40.00	0.9000	80.00	17.00
2015	341.70	101.75	29.78%	239.95	239.05	0.90	254.75	79.00	22.7522	160.9868	78.0000	333.00	398.62	40.00	0.9000	80.00	17.00
2016	341.70	101.74	29.77%	239.96	239.06	0.90	254.75	79.00	22.7390	161.0000	78.0000	333.00	398.63	40.00	0.9000	80.00	17.00
2017	341.7																
2018	341.7																
2019	341.7																
2020	341.7																
2021	341.7																
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2049	341.7																
2050	341.7																
2051	341.7																

(b)

Year	Solar in (W·m⁻²)	Solar reflected (W·m⁻²)	Albedo	ASR (W·m⁻²)	OLR (W·m⁻²)	NET down (W·m⁻²)	Temp (K) TOA	Reflected by clouds (W·m⁻²)	Reflected by surface (W·m⁻²)	Absorbed by the surface (W·m⁻²)	absorbed by Atmosphere (W·m⁻²)	Back Radiation (W·m⁻²)	Radiation up (W·m⁻²)	Atmospheric window (W·m⁻²)	Net absorbed (W·m⁻²)	Latent heat (W·m⁻²)	Thermals (W·m⁻²)
1910	341.70	107.66	31.51%	234.04	233.14	0.90	253.16	79.00	28.66	155.08	78.00	333.00	392.71	40.00	0.90	80.00	17.00
1911	341.70	107.66	31.51%	234.04	233.14	0.90	253.16	79.00	28.66	155.08	78.00	333.00	392.71	40.00	0.90	80.00	17.00
1912	341.70	107.65	31.50%	234.05	233.15	0.90	253.16	79.00	28.65	155.09	78.00	333.00	392.72	40.00	0.90	80.00	17.00
1913	341.70	107.64	31.50%	234.06	233.16	0.90	253.17	79.00	28.64	155.09	78.00	333.00	392.73	40.00	0.90	80.00	17.00
1914	341.70	107.64	31.50%	234.06	233.16	0.90	253.17	79.00	28.64	155.10	78.00	333.00	392.73	40.00	0.90	80.00	17.00
1915	341.70	107.62	31.50%	234.08	233.18	0.90	253.17	79.00	28.62	155.12	78.00	333.00	392.75	40.00	0.90	80.00	17.00
1916	341.70	107.61	31.49%	234.09	233.19	0.90	253.18	79.00	28.61	155.13	78.00	333.00	392.76	40.00	0.90	80.00	17.00
1917	341.70	107.60	31.49%	234.10	233.20	0.90	253.18	79.00	28.60	155.14	78.00	333.00	392.77	40.00	0.90	80.00	17.00
1918	341.70	107.58	31.48%	234.12	233.22	0.90	253.18	79.00	28.58	155.16	78.00	333.00	392.79	40.00	0.90	80.00	17.00
1919	341.70	107.56	31.48%	234.14	233.24	0.90	253.19	79.00	28.56	155.18	78.00	333.00	392.81	40.00	0.90	80.00	17.00
1920	341.70	107.54	31.47%	234.16	233.26	0.90	253.19	79.00	28.54	155.20	78.00	333.00	392.83	40.00	0.90	80.00	17.00
1921	341.70	107.52	31.46%	234.18	233.28	0.90	253.20	79.00	28.52	155.22	78.00	333.00	392.85	40.00	0.90	80.00	17.00
1922	341.70	107.49	31.46%	234.21	233.31	0.90	253.21	79.00	28.49	155.25	78.00	333.00	392.88	40.00	0.90	80.00	17.00
1923	341.70	107.46	31.45%	234.24	233.34	0.90	253.22	79.00	28.46	155.28	78.00	333.00	392.91	40.00	0.90	80.00	17.00
1924	341.70	107.43	31.44%	234.27	233.37	0.90	253.22	79.00	28.43	155.31	78.00	333.00	392.94	40.00	0.90	80.00	17.00
1925	341.70	107.39	31.43%	234.31	233.41	0.90	253.23	79.00	28.39	155.35	78.00	333.00	392.98	40.00	0.90	80.00	17.00
1926	341.70	107.36	31.42%	234.34	233.44	0.90	253.24	79.00	28.36	155.38	78.00	333.00	393.01	40.00	0.90	80.00	17.00
1927	341.70	107.31	31.41%	234.39	233.49	0.90	253.26	79.00	28.31	155.43	78.00	333.00	393.06	40.00	0.90	80.00	17.00
1928	341.70	107.27	31.39%	234.43	233.53	0.90	253.27	79.00	28.27	155.47	78.00	333.00	393.10	40.00	0.90	80.00	17.00
1929	341.70	107.22	31.38%	234.48	233.58	0.90	253.28	79.00	28.22	155.51	78.00	333.00	393.15	40.00	0.90	80.00	17.00
1930	341.70	107.18	31.37%	234.52	233.62	0.90	253.29	79.00	28.18	155.56	78.00	333.00	393.19	40.00	0.90	80.00	17.00
1931	341.70	107.13	31.35%	234.57	233.67	0.90	253.31	79.00	28.13	155.61	78.00	333.00	393.24	40.00	0.90	80.00	17.00
1932	341.70	107.07	31.34%	234.63	233.73	0.90	253.32	79.00	28.07	155.66	78.00	333.00	393.29	40.00	0.90	80.00	17.00
1933	341.70	107.02	31.32%	234.68	233.78	0.90	253.34	79.00	28.02	155.72	78.00	333.00	393.35	40.00	0.90	80.00	17.00
1934	341.70	106.96	31.30%	234.74	233.84	0.90	253.35	79.00	27.96	155.78	78.00	333.00	393.41	40.00	0.90	80.00	17.00
1935	341.70	106.90	31.28%	234.80	233.90	0.90	253.37	79.00	27.90	155.84	78.00	333.00	393.47	40.00	0.90	80.00	17.00
1936	341.70	106.84	31.27%	234.86	233.96	0.90	253.38	79.00	27.84	155.90	78.00	333.00	393.53	40.00	0.90	80.00	17.00
1937	341.70	106.77	31.25%	234.93	234.03	0.90	253.40	79.00	27.77	155.97	78.00	333.00	393.60	40.00	0.90	80.00	17.00
1938	341.70	106.71	31.23%	234.99	234.09	0.90	253.42	79.00	27.71	156.03	78.00	333.00	393.66	40.00	0.90	80.00	17.00
1939	341.70	106.64	31.21%	235.06	234.16	0.90	253.44	79.00	27.64	156.10	78.00	333.00	393.73	40.00	0.90	80.00	17.00
1940	341.70	106.57	31.19%	235.13	234.23	0.90	253.46	79.00	27.57	156.17	78.00	333.00	393.80	40.00	0.90	80.00	17.00
1941	341.70	106.50	31.17%	235.20	234.30	0.90	253.48	79.00	27.50	156.24	78.00	333.00	393.87	40.00	0.90	80.00	17.00

Continued

1942	341.70	106.43	31.15%	235.27	234.37	0.90	253.50	79.00	27.43	156.31	78.00	333.00	393.94	40.00	0.90	80.00	17.00
1943	341.70	106.35	31.12%	235.35	234.45	0.90	253.52	79.00	27.35	156.39	78.00	333.00	394.02	40.00	0.90	80.00	17.00
1944	341.70	106.28	31.10%	235.42	234.52	0.90	253.54	79.00	27.28	156.46	78.00	333.00	394.09	40.00	0.90	80.00	17.00
1945	341.70	106.20	31.08%	235.50	234.60	0.90	253.56	79.00	27.20	156.54	78.00	333.00	394.17	40.00	0.90	80.00	17.00
1946	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1947	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1948	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1949	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1950	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1951	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1952	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1953	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1954	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1955	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1956	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1957	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1958	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1959	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1960	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1961	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1962	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1963	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1964	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1965	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1966	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1967	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1968	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1969	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1970	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1971	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1972	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1973	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1974	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1975	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1976	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1977	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1978	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00

Continued

1979	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1980	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.13	156.61	78.00	333.00	394.24	40.00	0.90	80.00	17.00
1981	341.70	106.13	31.06%	235.57	234.67	0.90	253.58	79.00	27.1264	156.6126	78.0000	333.00	394.24	40.00	0.9000	80.00	17.00
1982	341.70	106.05	31.04%	235.65	234.75	0.90	253.60	79.00	27.0468	156.6922	78.0000	333.00	394.32	40.00	0.9000	80.00	17.00
1983	341.70	105.97	31.01%	235.73	234.83	0.90	253.62	79.00	26.9694	156.7696	78.0000	333.00	394.40	40.00	0.9000	80.00	17.00
1984	341.70	105.89	30.99%	235.81	234.91	0.90	253.64	79.00	26.8880	156.8510	78.0000	333.00	394.48	40.00	0.9000	80.00	17.00
1985	341.70	105.81	30.97%	235.89	234.99	0.90	253.66	79.00	26.8089	156.9301	78.0000	333.00	394.56	40.00	0.9000	80.00	17.00
1986	341.70	105.73	30.94%	235.97	235.07	0.90	253.68	79.00	26.7259	157.0131	78.0000	333.00	394.64	40.00	0.9000	80.00	17.00
1987	341.70	105.65	30.92%	236.05	235.15	0.90	253.71	79.00	26.6454	157.0936	78.0000	333.00	394.72	40.00	0.9000	80.00	17.00
1988	341.70	105.56	30.89%	236.14	235.24	0.90	253.73	79.00	26.5610	157.1780	78.0000	333.00	394.81	40.00	0.9000	80.00	17.00
1989	341.70	105.48	30.87%	236.22	235.32	0.90	253.75	79.00	26.4793	157.2597	78.0000	333.00	394.89	40.00	0.9000	80.00	17.00
1990	341.70	105.39	30.84%	236.31	235.41	0.90	253.77	79.00	26.3938	157.3452	78.0000	333.00	394.98	40.00	0.9000	80.00	17.00
1991	341.70	105.31	30.82%	236.39	235.49	0.90	253.80	79.00	26.3111	157.4279	78.0000	333.00	395.06	40.00	0.9000	80.00	17.00
1992	341.70	105.22	30.79%	236.48	235.58	0.90	253.82	79.00	26.2248	157.5142	78.0000	333.00	395.14	40.00	0.9000	80.00	17.00
1993	341.70	105.14	30.77%	236.56	235.66	0.90	253.84	79.00	26.1414	157.5976	78.0000	333.00	395.23	40.00	0.9000	80.00	17.00
1994	341.70	105.05	30.74%	236.65	235.75	0.90	253.87	79.00	26.0545	157.6845	78.0000	333.00	395.32	40.00	0.9000	80.00	17.00
1995	341.70	104.97	30.72%	236.73	235.83	0.90	253.89	79.00	25.9706	157.7684	78.0000	333.00	395.40	40.00	0.9000	80.00	17.00
1996	341.70	104.88	30.69%	236.82	235.92	0.90	253.91	79.00	25.8833	157.8557	78.0000	333.00	395.49	40.00	0.9000	80.00	17.00
1997	341.70	104.80	30.67%	236.90	236.00	0.90	253.93	79.00	25.7992	157.9398	78.0000	333.00	395.57	40.00	0.9000	80.00	17.00
1998	341.70	104.71	30.64%	236.99	236.09	0.90	253.96	79.00	25.7118	158.0272	78.0000	333.00	395.66	40.00	0.9000	80.00	17.00
1999	341.70	104.63	30.62%	237.07	236.17	0.90	253.98	79.00	25.6277	158.1113	78.0000	333.00	395.74	40.00	0.9000	80.00	17.00
2000	341.70	104.54	30.59%	237.16	236.26	0.90	254.00	79.00	25.5404	158.1986	78.0000	333.00	395.83	40.00	0.9000	80.00	17.00
2001	341.70	104.46	30.57%	237.24	236.34	0.90	254.03	79.00	25.4565	158.2825	78.0000	333.00	395.91	40.00	0.9000	80.00	17.00
2002	341.70	104.37	30.54%	237.33	236.43	0.90	254.05	79.00	25.3696	158.3694	78.0000	333.00	396.00	40.00	0.9000	80.00	17.00
2003	341.70	104.29	30.52%	237.41	236.51	0.90	254.07	79.00	25.2863	158.4527	78.0000	333.00	396.08	40.00	0.9000	80.00	17.00
2004	341.70	104.20	30.49%	237.50	236.60	0.90	254.09	79.00	25.2000	158.5390	78.0000	333.00	396.17	40.00	0.9000	80.00	17.00
2005	341.70	104.12	30.47%	237.58	236.68	0.90	254.12	79.00	25.1174	158.6217	78.0000	333.00	396.25	40.00	0.9000	80.00	17.00
2006	341.70	104.01	30.44%	237.69	236.79	0.90	254.14	79.00	25.0127	158.7263	78.0000	333.00	396.36	40.00	0.9000	80.00	17.00
2007	341.70	103.93	30.42%	237.77	236.87	0.90	254.17	79.00	24.9331	158.8060	78.0000	333.00	396.44	40.00	0.9000	80.00	17.00
2008	341.70	103.83	30.39%	237.87	236.97	0.90	254.19	79.00	24.8314	158.9076	78.0000	333.00	396.54	40.00	0.9000	80.00	17.00
2009	341.70	103.75	30.36%	237.95	237.05	0.90	254.21	79.00	24.7549	158.9841	78.0000	333.00	396.61	40.00	0.9000	80.00	17.00
2010	341.70	103.66	30.34%	238.04	237.14	0.90	254.24	79.00	24.6564	159.0826	78.0000	333.00	396.71	40.00	0.9000	80.00	17.00
2011	341.70	103.58	30.31%	238.12	237.22	0.90	254.26	79.00	24.5831	159.1560	78.0000	333.00	396.79	40.00	0.9000	80.00	17.00
2012	341.70	103.49	30.29%	238.21	237.31	0.90	254.28	79.00	24.4878	159.2512	78.0000	333.00	396.88	40.00	0.9000	80.00	17.00
2013	341.70	103.42	30.27%	238.28	237.38	0.90	254.30	79.00	24.4178	159.3212	78.0000	333.00	396.95	40.00	0.9000	80.00	17.00
2014	341.70	103.33	30.24%	238.37	237.47	0.90	254.33	79.00	24.3259	159.4131	78.0000	333.00	397.04	40.00	0.9000	80.00	17.00
2015	341.70	103.26	30.22%	238.44	237.54	0.90	254.35	79.00	24.2593	159.4798	78.0000	333.00	397.11	40.00	0.9000	80.00	17.00
2016	341.70	103.17	30.19%	238.53	237.63	0.90	254.37	79.00	24.1698	159.5692	78.0000	333.00	397.20	40.00	0.9000	80.00	17.00

Continued

2017	341.70	103.11	30.17%	238.59	237.69	0.90	254.39	79.00	24.1058	159.6332	78.0000	333.00	397.26	40.00	0.9000	80.00	17.00
2018	341.70	103.02	30.15%	238.68	237.78	0.90	254.41	79.00	24.0191	159.7199	78.0000	333.00	397.35	40.00	0.9000	80.00	17.00
2019	341.70	102.96	30.13%	238.74	237.84	0.90	254.43	79.00	23.9579	159.7812	78.0000	333.00	397.41	40.00	0.9000	80.00	17.00
2020	341.70	102.87	30.11%	238.83	237.93	0.90	254.45	79.00	23.8740	159.8650	78.0000	333.00	397.50	40.00	0.9000	80.00	17.00
2021	341.70	102.82	30.09%	238.88	237.98	0.90	254.46	79.00	23.8159	159.9232	78.0000	333.00	397.55	40.00	0.9000	80.00	17.00
2022	341.70	102.74	30.07%	238.96	238.06	0.90	254.49	79.00	23.7352	160.0038	78.0000	333.00	397.63	40.00	0.9000	80.00	17.00
2023	341.70	102.68	30.05%	239.02	238.12	0.90	254.50	79.00	23.6802	160.0588	78.0000	333.00	397.69	40.00	0.9000	80.00	17.00
2024	341.70	102.60	30.03%	239.10	238.20	0.90	254.52	79.00	23.6029	160.1361	78.0000	333.00	397.77	40.00	0.9000	80.00	17.00
2025	341.70	102.55	30.01%	239.15	238.25	0.90	254.53	79.00	23.5515	160.1876	78.0000	333.00	397.82	40.00	0.9000	80.00	17.00
2026	341.70	102.48	29.99%	239.22	238.32	0.90	254.55	79.00	23.4792	160.2598	78.0000	333.00	397.89	40.00	0.9000	80.00	17.00
2027	341.70	102.43	29.98%	239.27	238.37	0.90	254.57	79.00	23.4328	160.3062	78.0000	333.00	397.94	40.00	0.9000	80.00	17.00
2028	341.70	102.37	29.96%	239.33	238.43	0.90	254.58	79.00	23.3656	160.3734	78.0000	333.00	398.00	40.00	0.9000	80.00	17.00
2029	341.70	102.32	29.95%	239.38	238.48	0.90	254.60	79.00	23.3243	160.4147	78.0000	333.00	398.05	40.00	0.9000	80.00	17.00
2030	341.70	102.26	29.93%	239.44	238.54	0.90	254.61	79.00	23.2622	160.4768	78.0000	333.00	398.11	40.00	0.9000	80.00	17.00
2031	341.70	102.23	29.92%	239.47	238.57	0.90	254.62	79.00	23.2259	160.5131	78.0000	333.00	398.14	40.00	0.9000	80.00	17.00
2032	341.70	102.17	29.90%	239.53	238.63	0.90	254.64	79.00	23.1688	160.5702	78.0000	333.00	398.20	40.00	0.9000	80.00	17.00
2033	341.70	102.14	29.89%	239.56	238.66	0.90	254.65	79.00	23.1375	160.6015	78.0000	333.00	398.23	40.00	0.9000	80.00	17.00
2034	341.70	102.09	29.88%	239.61	238.71	0.90	254.66	79.00	23.0854	160.6536	78.0000	333.00	398.28	40.00	0.9000	80.00	17.00
2035	341.70	102.06	29.87%	239.64	238.74	0.90	254.67	79.00	23.0592	160.6798	78.0000	333.00	398.31	40.00	0.9000	80.00	17.00
2036	341.70	102.01	29.85%	239.69	238.79	0.90	254.68	79.00	23.0108	160.7282	78.0000	333.00	398.36	40.00	0.9000	80.00	17.00
2037	341.70	101.99	29.85%	239.71	238.81	0.90	254.68	79.00	22.9896	160.7494	78.0000	333.00	398.38	40.00	0.9000	80.00	17.00
2038	341.70	101.97	29.84%	239.73	238.83	0.90	254.69	79.00	22.9685	160.7705	78.0000	333.00	398.40	40.00	0.9000	80.00	17.00
2039	341.70	101.92	29.83%	239.78	238.88	0.90	254.70	79.00	22.9244	160.8146	78.0000	333.00	398.45	40.00	0.9000	80.00	17.00
2040	341.70	101.91	29.82%	239.79	238.89	0.90	254.71	79.00	22.9070	160.8320	78.0000	333.00	398.46	40.00	0.9000	80.00	17.00
2041	341.70	101.87	29.81%	239.83	238.93	0.90	254.72	79.00	22.8681	160.8709	78.0000	333.00	398.50	40.00	0.9000	80.00	17.00
2042	341.70	101.86	29.81%	239.84	238.94	0.90	254.72	79.00	22.8559	160.8831	78.0000	333.00	398.51	40.00	0.9000	80.00	17.00
2043	341.70	101.82	29.80%	239.88	238.98	0.90	254.73	79.00	22.8228	160.9162	78.0000	333.00	398.55	40.00	0.9000	80.00	17.00
2044	341.70	101.82	29.80%	239.88	238.98	0.90	254.73	79.00	22.8151	160.9239	78.0000	333.00	398.55	40.00	0.9000	80.00	17.00
2045	341.70	101.79	29.79%	239.91	239.01	0.90	254.74	79.00	22.7866	160.9524	78.0000	333.00	398.58	40.00	0.9000	80.00	17.00
2046	341.70	101.78	29.79%	239.92	239.02	0.90	254.74	79.00	22.7846	160.9544	78.0000	333.00	398.59	40.00	0.9000	80.00	17.00
2047	341.70	101.76	29.78%	239.94	239.04	0.90	254.75	79.00	22.7605	160.9785	78.0000	333.00	398.61	40.00	0.9000	80.00	17.00
2048	341.70	101.76	29.78%	239.94	239.04	0.90	254.74	79.00	22.7632	160.9759	78.0000	333.00	398.61	40.00	0.9000	80.00	17.00
2049	341.70	101.74	29.78%	239.96	239.06	0.90	254.75	79.00	22.7445	160.9945	78.0000	333.00	398.63	40.00	0.9000	80.00	17.00
2050	341.70	101.75	29.78%	239.95	239.05	0.90	254.75	79.00	22.7522	160.9868	78.0000	333.00	398.62	40.00	0.9000	80.00	17.00
2051	341.70	101.74	29.77%	239.96	239.06	0.90	254.75	79.00	22.7390	161.0000	78.0000	333.00	398.63	40.00	0.9000	80.00	17.00
	0.0000	−5.9218	−0.0173	5.9218	5.9218	0.0000	1.5891	0.0000	−5.9218	5.9218	0.0000	0.0000	5.9218	0.0000	0.0000	0.0000	0.0000

Table S2. Summary of temperature calculation.

		Removal of Atmospheric Atomic Testing years. Therefore 1946 temperature reading is moved to 1981									
		PEARSON CORRELATION CALCULATION									
		temp to NOAA (ii)	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
		Temp to NOAA (i)	0.65	0.65	0.65	0.65	0.65	0.65	0.97	0.97	0.97
		t test Paired	4.84E−11	3.16E−13	4.98E−14	3.44E−24	1.02E−10	4.18E−07	1.99E−24	1.62E−10	2.59E−07
Year	NOAA GLOBAL TEMP 1880-2016	(i) Adjusted NOAA GLOBAL TEMP FROM 1910	(ii) Adjusted NOAA GLOBAL TEMP FROM 1910. Remove Atm Atomic T (1981 moved to 1946)	(a) Albedo −10% lower or 4.66 W·m⁻². 100%:0% Grassland: Forest to cropland	(b) Albedo −15% lower or 6.98 W·m⁻². 100%:0% Grassland: Forest to cropland	(c) Albedo −20% lower or 9.91 W·m⁻². 100%:0% Grassland: Forest to cropland	(a) Albedo −10% lower with offset. 0.82 W·m⁻². 55%:45% Grassland: Forest to cropland (C)	(b) Albedo −15% lower with offset. 2.10 W·m⁻². 55%:45% Grassland: Forest to cropland (C)	(c) Albedo −20% lower with offset. 3.38 W·m⁻². 55%:45% Grassland: Forest to cropland (C)	(a) Albedo −10% lower with off-set. 0.82 W·m⁻². 55%:45% Grassland: Forest to cropland (C)	(b) Albedo −15% lower with offset. 2.10 W·m⁻². 55%:45% Grassland: Forest to cropland (C)	(c) Albedo −20% lower with offset. 3.38 W·m⁻². 55%:45% Grassland: Forest to cropland (C)
1880	−0.13										
1881	−0.08										
1882	−0.08										
1883	−0.15										
1884	−0.22										
1885	−0.23										
1886	−0.21										
1887	−0.25										
1888	−0.15										
1889	−0.1										
1890	−0.32										
1891	−0.25										
1892	−0.3										
1893	−0.31										
1894	−0.28										
1895	−0.22										
1896	−0.09										
1897	−0.12										
1898	−0.26										
1899	−0.12										
1900	−0.07										

Continued

1901	−0.14											
1902	−0.25											
1903	−0.34											
1904	−0.42											
1905	−0.29											
1906	−0.22											
1907	−0.37											
1908	−0.44											
1909	−0.43											
1910	−0.39	0.000	0.000	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00
1911	−0.44	−0.050	−0.050	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00
1912	−0.33	0.060	0.060	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00
1913	−0.32	0.070	0.070	0.0	0.0	0.0	0.00	0.00	0.01	0.00	0.00	0.01
1914	−0.14	0.250	0.250	0.0	0.0	0.0	0.00	0.01	0.01	0.00	0.01	0.01
1915	−0.07	0.320	0.320	0.0	0.0	0.0	0.00	0.01	0.02	0.00	0.01	0.02
1916	−0.3	0.090	0.090	0.0	0.0	0.1	0.01	0.01	0.02	0.01	0.01	0.02
1917	−0.32	0.070	0.070	0.0	0.1	0.1	0.01	0.02	0.03	0.01	0.02	0.03
1918	−0.2	0.190	0.190	0.0	0.1	0.1	0.01	0.02	0.04	0.01	0.02	0.04
1919	−0.2	0.190	0.190	0.1	0.1	0.1	0.01	0.03	0.04	0.01	0.03	0.04
1920	−0.21	0.180	0.180	0.1	0.1	0.1	0.01	0.03	0.05	0.01	0.03	0.05
1921	−0.15	0.240	0.240	0.1	0.1	0.2	0.02	0.04	0.06	0.02	0.04	0.06
1922	−0.23	0.160	0.160	0.1	0.2	0.2	0.02	0.05	0.08	0.02	0.05	0.08
1923	−0.21	0.180	0.180	0.1	0.2	0.2	0.02	0.06	0.09	0.02	0.06	0.09
1924	−0.25	0.140	0.140	0.1	0.2	0.3	0.02	0.06	0.10	0.02	0.06	0.10
1925	−0.14	0.250	0.250	0.2	0.2	0.3	0.03	0.07	0.12	0.03	0.07	0.12
1926	−0.06	0.330	0.330	0.2	0.3	0.4	0.03	0.08	0.13	0.03	0.08	0.13
1927	−0.15	0.240	0.240	0.2	0.3	0.4	0.04	0.10	0.15	0.04	0.10	0.15
1928	−0.17	0.220	0.220	0.2	0.4	0.5	0.04	0.11	0.17	0.04	0.11	0.17
1929	−0.29	0.100	0.100	0.3	0.4	0.5	0.05	0.12	0.19	0.05	0.12	0.19
1930	−0.1	0.290	0.290	0.3	0.4	0.6	0.05	0.13	0.21	0.05	0.13	0.21
1931	−0.07	0.320	0.320	0.3	0.5	0.6	0.06	0.15	0.24	0.06	0.15	0.24
1932	−0.12	0.270	0.270	0.4	0.5	0.7	0.06	0.16	0.26	0.06	0.16	0.26
1933	−0.24	0.150	0.150	0.4	0.6	0.8	0.07	0.18	0.28	0.07	0.18	0.28
1934	−0.1	0.290	0.290	0.4	0.6	0.8	0.07	0.19	0.31	0.07	0.19	0.31
1935	−0.14	0.250	0.250	0.5	0.7	0.9	0.08	0.21	0.33	0.08	0.21	0.33
1936	−0.12	0.270	0.270	0.5	0.7	1.0	0.09	0.22	0.36	0.09	0.22	0.36
1937	−0.02	0.370	0.370	0.5	0.8	1.1	0.09	0.24	0.39	0.09	0.24	0.39

Continued

1938	−0.03	0.360	0.360	0.6	0.9	1.2	0.10	0.26	0.42	0.10	0.26	0.42
1939	−0.02	0.370	0.370	0.6	0.9	1.2	0.11	0.28	0.45	0.11	0.28	0.45
1940	0.09	0.480	0.480	0.7	1.0	1.3	0.12	0.30	0.48	0.12	0.30	0.48
1941	0.19	0.580	0.580	0.7	1.1	1.4	0.12	0.32	0.51	0.12	0.32	0.51
1942	0.15	0.540	0.540	0.7	1.1	1.5	0.13	0.34	0.54	0.13	0.34	0.54
1943	0.15	0.540	0.540	0.8	1.2	1.6	0.14	0.36	0.58	0.14	0.36	0.58
1944	0.29	0.680	0.680	0.8	1.3	1.7	0.15	0.38	0.61	0.15	0.38	0.61
1945	0.17	0.560	0.560	0.9	1.3	1.8	0.16	0.40	0.64	0.16	0.40	0.64
1946	−0.01	0.380	0.690	0.9	1.4	1.9	0.16	0.42	0.67	0.16	0.42	0.67
1947	−0.05	0.340	0.570	1.0	1.5	2.0	0.17	0.44	0.71			
1948	−0.06	0.330	0.730	1.0	1.5	2.0	0.18	0.46	0.74			
1949	−0.06	0.330	0.540	1.1	1.6	2.1	0.19	0.48	0.78			
1950	−0.16	0.230	0.520	1.1	1.7	2.2	0.20	0.51	0.81			
1951	−0.01	0.380	0.620	1.2	1.8	2.3	0.21	0.53	0.85			
1952	0.03	0.420	0.760	1.2	1.8	2.4	0.21	0.55	0.89			
1953	0.1	0.490	0.770	1.3	1.9	2.5	0.22	0.57	0.92			
1954	−0.11	0.280	0.680	1.3	2.0	2.6	0.23	0.59	0.96			
1955	−0.13	0.260	0.820	1.4	2.1	2.7	0.24	0.62	1.00			
1956	−0.2	0.190	0.790	1.4	2.1	2.8	0.25	0.64	1.03			
1957	0.05	0.440	0.650	1.5	2.2	2.9	0.26	0.66	1.07			
1958	0.11	0.500	0.670	1.5	2.3	3.0	0.27	0.69	1.11			
1959	0.06	0.450	0.730	1.6	2.4	3.1	0.28	0.71	1.14			
1960	0.02	0.410	0.850	1.6	2.4	3.2	0.29	0.73	1.18			
1961	0.08	0.470	0.710	1.7	2.5	3.4	0.30	0.76	1.22			
1962	0.09	0.480	0.910	1.7	2.6	3.5	0.30	0.78	1.25			
1963	0.11	0.500	1.020	1.8	2.7	3.6	0.31	0.80	1.29			
1964	−0.15	0.240	0.830	1.8	2.7	3.7	0.32	0.83	1.33			
1965	−0.08	0.310	0.810	1.9	2.8	3.8	0.33	0.85	1.37			
1966	−0.02	0.370	0.930	1.9	2.9	3.9	0.34	0.87	1.40			
1967	−0.01	0.380	0.990	2.0	3.0	4.0	0.35	0.90	1.44			
1968	−0.03	0.360	1.000	2.0	3.1	4.1	0.36	0.92	1.48			
1969	0.09	0.480	0.970	2.1	3.1	4.2	0.37	0.94	1.52			
1970	0.04	0.430	1.050	2.1	3.2	4.3	0.38	0.96	1.55			
1971	−0.08	0.310	1.000	2.2	3.3	4.4	0.39	0.99	1.60			
1972	0.03	0.420	1.000	2.2	3.4	4.5	0.40	1.01	1.63			
1973	0.17	0.560	0.930	2.3	3.5	4.6	0.41	1.04	1.68			
1974	−0.07	0.320	1.020	2.4	3.5	4.7	0.42	1.06	1.71			

Continued

1975	0	0.390	1.090	2.4	3.6	4.8	0.43	1.09	1.75			
1976	−0.08	0.310	0.970	2.5	3.7	4.9	0.43	1.11	1.78			
1977	0.2	0.590	1.010	2.5	3.8	5.0	0.44	1.13	1.83			
1978	0.11	0.500	1.060	2.6	3.8	5.1	0.45	1.15	1.86			
1979	0.23	0.620	1.130	2.6	3.9	5.2	0.46	1.18	1.90			
1980	0.27	0.660	1.290	2.7	4.0	5.3	0.47	1.20	1.93			
1981	0.3	0.690	1.330	2.7	4.1	5.4	0.48	1.22	1.96	0.16	0.42	0.67
1982	0.18	0.570		2.7	4.1	5.5	0.48	1.24	1.99	0.17	0.44	0.71
1983	0.34	0.730		2.8	4.2	5.6	0.49	1.26	2.03	0.18	0.46	0.74
1984	0.15	0.540		2.8	4.2	5.7	0.50	1.28	2.06	0.19	0.48	0.78
1985	0.13	0.520		2.9	4.3	5.8	0.51	1.30	2.09	0.20	0.51	0.81
1986	0.23	0.620		2.9	4.4	5.8	0.51	1.32	2.12	0.21	0.53	0.85
1987	0.37	0.760		3.0	4.4	5.9	0.52	1.34	2.15	0.21	0.55	0.89
1988	0.38	0.770		3.0	4.5	6.0	0.53	1.35	2.18	0.22	0.57	0.92
1989	0.29	0.680		3.0	4.6	6.1	0.54	1.37	2.21	0.23	0.59	0.96
1990	0.43	0.820		3.1	4.6	6.1	0.54	1.39	2.23	0.24	0.62	1.00
1991	0.4	0.790		3.1	4.7	6.2	0.55	1.41	2.26	0.25	0.64	1.03
1992	0.26	0.650		3.1	4.7	6.3	0.55	1.42	2.28	0.26	0.66	1.07
1993	0.28	0.670		3.2	4.8	6.4	0.56	1.44	2.31	0.27	0.69	1.11
1994	0.34	0.730		3.2	4.8	6.4	0.57	1.45	2.33	0.28	0.71	1.14
1995	0.46	0.850		3.2	4.9	6.5	0.57	1.46	2.36	0.29	0.73	1.18
1996	0.32	0.710		3.3	4.9	6.5	0.58	1.47	2.37	0.30	0.76	1.22
1997	0.52	0.910		3.3	5.0	6.6	0.58	1.49	2.40	0.30	0.78	1.25
1998	0.63	1.020		3.3	5.0	6.6	0.59	1.50	2.41	0.31	0.80	1.29
1999	0.44	0.830		3.4	5.0	6.7	0.59	1.51	2.43	0.32	0.83	1.33
2000	0.42	0.810		3.4	5.1	6.7	0.59	1.52	2.45	0.33	0.85	1.37
2001	0.54	0.930		3.4	5.1	6.8	0.60	1.53	2.47	0.34	0.87	1.40
2002	0.6	0.990		3.4	5.1	6.8	0.60	1.54	2.48	0.35	0.90	1.44
2003	0.61	1.000		3.4	5.2	6.9	0.61	1.55	2.50	0.36	0.92	1.48
2004	0.58	0.970		3.4	5.2	6.9	0.61	1.55	2.50	0.37	0.94	1.52
2005	0.66	1.050		3.5	5.2	6.9	0.61	1.56	2.52	0.38	0.96	1.55
2006	0.61	1.000		3.5	5.2	7.0	0.61	1.57	2.52	0.39	0.99	1.60
2007	0.61	1.000		3.5	5.2	7.0	0.62	1.58	2.54	0.40	1.01	1.63
2008	0.54	0.930		3.5	5.2	7.0	0.62	1.58	2.54	0.41	1.04	1.68
2009	0.63	1.020		3.5	5.3	7.0	0.62	1.59	2.55	0.42	1.06	1.71
2010	0.7	1.090		3.5	5.3	7.0	0.62	1.59	2.56	0.43	1.09	1.75
2011	0.58	0.970		3.5	5.3	7.1	0.62	1.59	2.57	0.43	1.11	1.78
2012	0.62	1.010		3.5	5.3	7.1	0.62	1.59	2.56	0.44	1.13	1.83
2013	0.67	1.060		3.5	5.3	7.1	0.62	1.60	2.57	0.45	1.15	1.86

Continued

2014	0.74	1.130	3.5	5.3	7.1	0.62	1.60	2.57	0.46	1.18	1.90
2015	0.9	1.290	3.5	5.3	7.1	0.63	1.60	2.58	0.47	1.20	1.93
2016	0.94	1.330	3.5	5.3	7.1	0.62	1.60	2.57	0.48	1.22	1.96
2017									0.48	1.24	1.99
2018									0.49	1.26	2.03
2019									0.50	1.28	2.06
2020									0.51	1.30	2.09
2021									0.51	1.32	2.12
2022									0.52	1.34	2.15
2023									0.53	1.35	2.18
2024									0.54	1.37	2.21
2025									0.54	1.39	2.23
2026									0.55	1.41	2.26
2027									0.55	1.42	2.28
2028									0.56	1.44	2.31
2029									0.57	1.45	2.33
2030									0.57	1.46	2.36
2031									0.58	1.47	2.37
2032									0.58	1.49	2.40
2033									0.59	1.50	2.41
2034									0.59	1.51	2.43
2035									0.59	1.52	2.45
2036									0.60	1.53	2.47
2037									0.60	1.54	2.48
2038									0.61	1.55	2.50
2039									0.61	1.55	2.50
2040									0.61	1.56	2.52
2041									0.61	1.57	2.52
2042									0.62	1.58	2.54
2043									0.62	1.58	2.54
2044									0.62	1.59	2.55
2045									0.62	1.59	2.56
2046									0.62	1.59	2.57
2047									0.62	1.59	2.56
2048									0.62	1.60	2.57
2049									0.62	1.60	2.57
2050									0.63	1.60	2.58
2051									0.62	1.60	2.57

Year	ENERGY CHARTS (Total Joules)					
	(d) Albedo −10% lower with offset. 0.82 W·m^{-2}. 55%: 45% Grassland: Forest to cropland (J)	(e) Albedo −15% lower with offset. 2.10 W·m^{-2}. 55%: 45% Grassland: Forest to cropland (J)	(f) Albedo −20% lowerwith offset. 3.38 W·m^{-2}. 55%: 45% Grassland: Forest to cropland (J)	(d) Albedo −10% lower with offset. 0.82 W·m^{-2}. 55%: 45% Grassland: Forest to cropland (J)	(e) Albedo −15% lower with offset. 2.10 W·m^{-2}. 55%: 45% Grassland: Forest to cropland (J)	(f) Albedo −20% lower with offset. 3.38 W·m^{-2}. 55%: 45% Grassland: Forest to cropland (J)
1880						
1881						
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1909						
1910	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1911	6.57E+19	1.68E+20	2.70E+20	6.57E+19	1.68E+20	2.70E+20

Removal of Atmospheric Atomic Testing years. Therefore 1946 temperature reading is moved to 1981

Continued

1912	1.30E+20	3.33E+20	5.36E+20	1.30E+20	3.33E+20	5.36E+20
1913	2.59E+20	6.62E+20	1.07E+21	2.59E+20	6.62E+20	1.07E+21
1914	3.85E+20	9.85E+20	1.59E+21	3.85E+20	9.85E+20	1.59E+21
1915	5.75E+20	1.47E+21	2.37E+21	5.75E+20	1.47E+21	2.37E+21
1916	7.60E+20	1.94E+21	3.13E+21	7.60E+20	1.94E+21	3.13E+21
1917	1.01E+21	2.58E+21	4.15E+21	1.01E+21	2.58E+21	4.15E+21
1918	1.25E+21	3.20E+21	5.15E+21	1.25E+21	3.20E+21	5.15E+21
1919	1.55E+21	3.97E+21	6.40E+21	1.55E+21	3.97E+21	6.40E+21
1920	1.85E+21	4.73E+21	7.62E+21	1.85E+21	4.73E+21	7.62E+21
1921	2.25E+21	5.75E+21	9.25E+21	2.25E+21	5.75E+21	9.25E+21
1922	2.64E+21	6.74E+21	1.09E+22	2.64E+21	6.74E+21	1.09E+22
1923	3.12E+21	7.98E+21	1.29E+22	3.12E+21	7.98E+21	1.29E+22
1924	3.60E+21	9.20E+21	1.48E+22	3.60E+21	9.20E+21	1.48E+22
1925	4.17E+21	1.07E+22	1.72E+22	4.17E+21	1.07E+22	1.72E+22
1926	4.73E+21	1.21E+22	1.95E+22	4.73E+21	1.21E+22	1.95E+22
1927	5.38E+21	1.38E+22	2.22E+22	5.38E+21	1.38E+22	2.22E+22
1928	6.02E+21	1.54E+22	2.48E+22	6.02E+21	1.54E+22	2.48E+22
1929	6.75E+21	1.73E+22	2.78E+22	6.75E+21	1.73E+22	2.78E+22
1930	7.46E+21	1.91E+22	3.07E+22	7.46E+21	1.91E+22	3.07E+22
1931	8.27E+21	2.11E+22	3.40E+22	8.27E+21	2.11E+22	3.40E+22
1932	9.06E+21	2.32E+22	3.73E+22	9.06E+21	2.32E+22	3.73E+22
1933	9.94E+21	2.54E+22	4.09E+22	9.94E+21	2.54E+22	4.09E+22
1934	1.08E+22	2.76E+22	4.45E+22	1.08E+22	2.76E+22	4.45E+22
1935	1.18E+22	3.00E+22	4.84E+22	1.18E+22	3.00E+22	4.84E+22
1936	1.27E+22	3.24E+22	5.22E+22	1.27E+22	3.24E+22	5.22E+22
1937	1.37E+22	3.50E+22	5.64E+22	1.37E+22	3.50E+22	5.64E+22
1938	1.47E+22	3.76E+22	6.05E+22	1.47E+22	3.76E+22	6.05E+22
1939	1.58E+22	4.03E+22	6.49E+22	1.58E+22	4.03E+22	6.49E+22
1940	1.68E+22	4.30E+22	6.92E+22	1.68E+22	4.30E+22	6.92E+22
1941	1.79E+22	4.59E+22	7.39E+22	1.79E+22	4.59E+22	7.39E+22
1942	1.90E+22	4.87E+22	7.84E+22	1.90E+22	4.87E+22	7.84E+22
1943	2.02E+22	5.16E+22	8.31E+22	2.02E+22	5.16E+22	8.31E+22
1944	2.13E+22	5.45E+22	8.78E+22	2.13E+22	5.45E+22	8.78E+22
1945	2.25E+22	5.76E+22	9.27E+22	2.25E+22	5.76E+22	9.27E+22
1946	2.37E+22	6.05E+22	9.75E+22	2.37E+22	6.05E+22	9.75E+22
1947	2.49E+22	6.37E+22	1.03E+23			
1948	2.61E+22	6.67E+22	1.07E+23			

Continued

1949	2.73E+22	6.99E+22	1.13E+23			
1950	2.86E+22	7.30E+22	1.18E+23			
1951	2.98E+22	7.63E+22	1.23E+23			
1952	3.11E+22	7.94E+22	1.28E+23			
1953	3.24E+22	8.28E+22	1.33E+23			
1954	3.36E+22	8.60E+22	1.38E+23			
1955	3.49E+22	8.93E+22	1.44E+23			
1956	3.62E+22	9.26E+22	1.49E+23			
1957	3.75E+22	9.60E+22	1.55E+23			
1958	3.88E+22	9.92E+22	1.60E+23			
1959	4.01E+22	1.03E+23	1.65E+23			
1960	4.14E+22	1.06E+23	1.71E+23			
1961	4.28E+22	1.09E+23	1.76E+23			
1962	4.41E+22	1.13E+23	1.81E+23			
1963	4.54E+22	1.16E+23	1.87E+23			
1964	4.67E+22	1.19E+23	1.92E+23			
1965	4.80E+22	1.23E+23	1.98E+23			
1966	4.93E+22	1.26E+23	2.03E+23			
1967	5.06E+22	1.29E+23	2.08E+23			
1968	5.19E+22	1.33E+23	2.14E+23			
1969	5.32E+22	1.36E+23	2.19E+23			
1970	5.45E+22	1.39E+23	2.24E+23			
1971	5.61E+22	1.43E+23	2.31E+23			
1972	5.73E+22	1.47E+23	2.36E+23			
1973	5.89E+22	1.51E+23	2.42E+23			
1974	6.00E+22	1.54E+23	2.47E+23			
1975	6.15E+22	1.57E+23	2.53E+23			
1976	6.27E+22	1.60E+23	2.58E+23			
1977	6.41E+22	1.64E+23	2.64E+23			
1978	6.52E+22	1.67E+23	2.68E+23			
1979	6.66E+22	1.70E+23	2.74E+23			
1980	6.76E+22	1.73E+23	2.78E+23			
1981	6.90E+22	1.76E+23	2.84E+23	2.37E+22	6.05E+22	9.75E+22
1982	6.99E+22	1.79E+23	2.88E+23	2.49E+22	6.37E+22	1.03E+23
1983	7.13E+22	1.82E+23	2.93E+23	2.61E+22	6.67E+22	1.07E+23
1984	7.22E+22	1.85E+23	2.97E+23	2.73E+22	6.99E+22	1.13E+23
1985	7.35E+22	1.88E+23	3.02E+23	2.86E+22	7.30E+22	1.18E+23

Continued

1986	7.44E+22	1.90E+23	3.06E+23	2.98E+22	7.63E+22	1.23E+23
1987	7.56E+22	1.93E+23	3.11E+23	3.11E+22	7.94E+22	1.28E+23
1988	7.64E+22	1.95E+23	3.15E+23	3.24E+22	8.28E+22	1.33E+23
1989	7.76E+22	1.98E+23	3.19E+23	3.36E+22	8.60E+22	1.38E+23
1990	7.84E+22	2.00E+23	3.23E+23	3.49E+22	8.93E+22	1.44E+23
1991	7.95E+22	2.03E+23	3.27E+23	3.62E+22	9.26E+22	1.49E+23
1992	8.02E+22	2.05E+23	3.30E+23	3.75E+22	9.60E+22	1.55E+23
1993	8.12E+22	2.08E+23	3.34E+23	3.88E+22	9.92E+22	1.60E+23
1994	8.18E+22	2.09E+23	3.37E+23	4.01E+22	1.03E+23	1.65E+23
1995	8.28E+22	2.12E+23	3.41E+23	4.14E+22	1.06E+23	1.71E+23
1996	8.33E+22	2.13E+23	3.43E+23	4.28E+22	1.09E+23	1.76E+23
1997	8.42E+22	2.15E+23	3.47E+23	4.41E+22	1.13E+23	1.81E+23
1998	8.47E+22	2.17E+23	3.49E+23	4.54E+22	1.16E+23	1.87E+23
1999	8.55E+22	2.19E+23	3.52E+23	4.67E+22	1.19E+23	1.92E+23
2000	8.59E+22	2.20E+23	3.54E+23	4.80E+22	1.23E+23	1.98E+23
2001	8.66E+22	2.21E+23	3.57E+23	4.93E+22	1.26E+23	2.03E+23
2002	8.69E+22	2.22E+23	3.58E+23	5.06E+22	1.29E+23	2.08E+23
2003	8.76E+22	2.24E+23	3.61E+23	5.19E+22	1.33E+23	2.14E+23
2004	8.79E+22	2.25E+23	3.62E+23	5.32E+22	1.36E+23	2.19E+23
2005	8.85E+22	2.26E+23	3.64E+23	5.45E+22	1.39E+23	2.24E+23
2006	8.86E+22	2.27E+23	3.65E+23	5.61E+22	1.43E+23	2.31E+23
2007	8.91E+22	2.28E+23	3.67E+23	5.73E+22	1.47E+23	2.36E+23
2008	8.93E+22	2.28E+23	3.67E+23	5.89E+22	1.51E+23	2.42E+23
2009	8.97E+22	2.29E+23	3.69E+23	6.00E+22	1.54E+23	2.47E+23
2010	8.97E+22	2.29E+23	3.69E+23	6.15E+22	1.57E+23	2.53E+23
2011	9.01E+22	2.30E+23	3.71E+23	6.27E+22	1.60E+23	2.58E+23
2012	9.00E+22	2.30E+23	3.71E+23	6.41E+22	1.64E+23	2.64E+23
2013	9.03E+22	2.31E+23	3.72E+23	6.52E+22	1.67E+23	2.68E+23
2014	9.02E+22	2.31E+23	3.71E+23	6.66E+22	1.70E+23	2.74E+23
2015	9.04E+22	2.31E+23	3.72E+23	6.76E+22	1.73E+23	2.78E+23
2016	9.02E+22	2.31E+23	3.71E+23	6.90E+22	1.76E+23	2.84E+23
2017				6.99E+22	1.79E+23	2.88E+23
2018				7.13E+22	1.82E+23	2.93E+23
2019				7.22E+22	1.85E+23	2.97E+23
2020				7.35E+22	1.88E+23	3.02E+23
2021				7.44E+22	1.90E+23	3.06E+23
2022				7.56E+22	1.93E+23	3.11E+23
2023				7.64E+22	1.95E+23	3.15E+23

Continued

2024		7.76E+22	1.98E+23	3.19E+23
2025		7.84E+22	2.00E+23	3.23E+23
2026		7.95E+22	2.03E+23	3.27E+23
2027		8.02E+22	2.05E+23	3.30E+23
2028		8.12E+22	2.08E+23	3.34E+23
2029		8.18E+22	2.09E+23	3.37E+23
2030		8.28E+22	2.12E+23	3.41E+23
2031		8.33E+22	2.13E+23	3.43E+23
2032		8.42E+22	2.15E+23	3.47E+23
2033		8.47E+22	2.17E+23	3.49E+23
2034		8.55E+22	2.19E+23	3.52E+23
2035		8.59E+22	2.20E+23	3.54E+23
2036		8.66E+22	2.21E+23	3.57E+23
2037		8.69E+22	2.22E+23	3.58E+23
2038		8.76E+22	2.24E+23	3.61E+23
2039		8.79E+22	2.25E+23	3.62E+23
2040		8.85E+22	2.26E+23	3.64E+23
2041		8.86E+22	2.27E+23	3.65E+23
2042		8.91E+22	2.28E+23	3.67E+23
2043		8.93E+22	2.28E+23	3.67E+23
2044		8.97E+22	2.29E+23	3.69E+23
2045		8.97E+22	2.29E+23	3.69E+23
2046		9.01E+22	2.30E+23	3.71E+23
2047		9.00E+22	2.30E+23	3.71E+23
2048		9.03E+22	2.31E+23	3.72E+23
2049		9.02E+22	2.31E+23	3.71E+23
2050		9.04E+22	2.31E+23	3.72E+23
2051		9.02E+22	2.31E+23	3.71E+23

	EARTH ALBEDO					
Year	(b) Albedo—15% lower with offsetor 2.10 W·m⁻². 55%:45% Grassland: Forest to cropland	(b) Albedo—15% lower with offset 2.10 W·m⁻². 55%:45% Grassland: Forest to cropland	temp k	TOA albedo	Temp K	Observed temp (K)
1880						
1881						
1882						
1883						
1884						
1885						

Continued

			Temp K					
1886								
1887								
1888								
1889								
1890								
1891								
1892								
1893								
1894								
1895								
1896								
1897								
1898								
1899								
1900								
1901								
1902								
1903								
1904								
1905								
1906								
1907								
1908								
1909			Temp K					
1910	0.316065337	0.316065337	253.16	0.3161	253.16	0.3161	286.16	286.16
1911	0.316052906	0.316052906	253.16	0.3161	253.16	0.3161	286.16	286.16
1912	0.316040712	0.316040712	253.16	0.3160	253.16	0.3160	286.16	286.16
1913	0.316016323	0.316016323	253.17	0.3160	253.17	0.3160	286.17	286.17
1914	0.315992407	0.315992407	253.17	0.3160	253.17	0.3160	286.17	286.17
1915	0.315956531	0.315956531	253.17	0.3160	253.17	0.3160	286.17	286.17
1916	0.315921365	0.315921365	253.18	0.3159	253.18	0.3159	286.18	286.18
1917	0.315874474	0.315874474	253.18	0.3159	253.18	0.3159	286.18	286.18
1918	0.315828528	0.315828528	253.18	0.3158	253.18	0.3158	286.18	286.18
1919	0.315771092	0.315771092	253.19	0.3158	253.19	0.3158	286.19	286.19
1920	0.315714837	0.315714837	253.19	0.3157	253.19	0.3157	286.19	286.19
1921	0.315639682	0.315639682	253.20	0.3156	253.20	0.3156	286.20	286.20
1922	0.315566103	0.315566103	253.21	0.3156	253.21	0.3156	286.21	286.21
1923	0.315474016	0.315474016	253.22	0.3155	253.22	0.3155	286.22	286.22

Continued

1924	0.315383901	0.315383901	253.22	0.3154	253.22	0.3154	286.22	286.22
1925	0.315275668	0.315275668	253.23	0.3153	253.23	0.3153	286.23	286.23
1926	0.315169801	0.315169801	253.24	0.3152	253.24	0.3152	286.24	286.24
1927	0.315046208	0.315046208	253.26	0.3150	253.26	0.3150	286.26	286.26
1928	0.314925375	0.314925375	253.27	0.3149	253.27	0.3149	286.27	286.27
1929	0.314787206	0.314787206	253.28	0.3148	253.28	0.3148	286.28	286.28
1930	0.314652192	0.314652192	253.29	0.3147	253.29	0.3147	286.29	286.29
1931	0.314499006	0.314499006	253.31	0.3145	253.31	0.3145	286.31	286.31
1932	0.3143494	0.3143494	253.32	0.3143	253.32	0.3143	286.32	286.32
1933	0.314182038	0.314182038	253.34	0.3142	253.34	0.3142	286.34	286.34
1934	0.314018679	0.314018679	253.35	0.3140	253.35	0.3140	286.35	286.35
1935	0.313837981	0.313837981	253.37	0.3138	253.37	0.3138	286.37	286.37
1936	0.31366171	0.31366171	253.38	0.3137	253.38	0.3137	286.38	286.38
1937	0.313468515	0.313468515	253.40	0.3135	253.40	0.3135	286.40	286.40
1938	0.313280172	0.313280172	253.42	0.3133	253.42	0.3133	286.42	286.42
1939	0.313075321	0.313075321	253.44	0.3131	253.44	0.3131	286.44	286.44
1940	0.312875747	0.312875747	253.46	0.3129	253.46	0.3129	286.46	286.46
1941	0.312662756	0.312662756	253.48	0.3127	253.48	0.3127	286.48	286.48
1942	0.312455398	0.312455398	253.50	0.3125	253.50	0.3125	286.50	286.50
1943	0.31223497	0.31223497	253.52	0.3122	253.52	0.3122	286.52	286.52
1944	0.31202053	0.31202053	253.54	0.3120	253.54	0.3120	286.54	286.54
1945	0.311793368	0.311793368	253.56	0.3118	253.56	0.3118	286.56	286.56
1946	0.311572552	0.311572552	253.58	0.3116	253.58	0.3116	286.58	286.58
1947	0.311339361		253.60	0.3113				286.60
1948	0.311112873		253.62	0.3111				286.62
1949	0.310874359		253.64	0.3109				286.64
1950	0.310642905		253.66	0.3106				286.66
1951	0.310399775		253.68	0.3104				286.68
1952	0.310164064		253.71	0.3102				286.71
1953	0.309917026		253.73	0.3099				286.73
1954	0.309677767		253.75	0.3097				286.75
1955	0.309427531		253.77	0.3094				286.77
1956	0.309185435		253.80	0.3092				286.80
1957	0.308932711		253.82	0.3089				286.82
1958	0.308688489		253.84	0.3087				286.84
1959	0.308433992		253.87	0.3084				286.87
1960	0.308188358		253.89	0.3082				286.89
1961	0.307932801		253.91	0.3079				286.91

Continued

1962	0.30768647		253.93	0.3077				286.93
1963	0.30743057		253.96	0.3074				286.96
1964	0.307184258		253.98	0.3072				286.98
1965	0.306928731		254.00	0.3069				287.00
1966	0.306683158		254.03	0.3067				287.03
1967	0.306428723		254.05	0.3064				287.05
1968	0.306184607		254.07	0.3062				287.07
1969	0.305931985		254.09	0.3059				287.09
1970	0.305690048		254.12	0.3057				287.12
1971	0.30538363		254.14	0.3054				287.14
1972	0.305150437		254.17	0.3052				287.17
1973	0.304852881		254.19	0.3049				287.19
1974	0.304628748		254.21	0.3046				287.21
1975	0.304340371		254.24	0.3043				287.24
1976	0.304125612		254.26	0.3041				287.26
1977	0.303846731		254.28	0.3038				287.28
1978	0.303641662		254.30	0.3036				287.30
1979	0.303372594		254.33	0.3034				287.33
1980	0.303177531		254.35	0.3032				287.35
1981	0.302915701	0.311572552	254.37	0.3029	253.58	0.3116	286.58	287.37
1982	0.302728232	0.311339361	254.39	0.3027	253.60	0.3113	286.60	287.39
1983	0.302474283	0.311112873	254.41	0.3025	253.62	0.3111	286.62	287.41
1984	0.302295052	0.310874359	254.43	0.3023	253.64	0.3109	286.64	287.43
1985	0.302049628	0.310642905	254.45	0.3020	253.66	0.3106	286.66	287.45
1986	0.301879277	0.310399775	254.46	0.3019	253.68	0.3104	286.68	287.46
1987	0.301643024	0.310164064	254.49	0.3016	253.71	0.3102	286.71	287.49
1988	0.301482196	0.309917026	254.50	0.3015	253.73	0.3099	286.73	287.50
1989	0.301255759	0.309677767	254.52	0.3013	253.75	0.3097	286.75	287.52
1990	0.301105099	0.309427531	254.53	0.3011	253.77	0.3094	286.77	287.53
1991	0.300893544	0.309185435	254.55	0.3009	253.80	0.3092	286.80	287.55
1992	0.300757763	0.308932711	254.57	0.3008	253.82	0.3089	286.82	287.57
1993	0.300561033	0.308688489	254.58	0.3006	253.84	0.3087	286.84	287.58
1994	0.300440073	0.308433992	254.60	0.3004	253.87	0.3084	286.87	287.60
1995	0.30025811	0.308188358	254.61	0.3003	253.89	0.3082	286.89	287.61
1996	0.300151911	0.307932801	254.62	0.3002	253.91	0.3079	286.91	287.62
1997	0.299984657	0.30768647	254.64	0.3000	253.93	0.3077	286.93	287.64
1998	0.299893156	0.30743057	254.65	0.2999	253.96	0.3074	286.96	287.65
1999	0.29974055	0.307184258	254.66	0.2997	253.98	0.3072	286.98	287.66

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2000	0.299663684	0.306928731	254.67	0.2997	254.00	0.3069	287.00	287.67
2001	0.299522065	0.306683158	254.68	0.2995	254.03	0.3067	287.03	287.68
2002	0.299460133	0.306428723	254.68	0.2995	254.05	0.3064	287.05	287.68
2003	0.299330941	0.306184607	254.69	0.2993	254.07	0.3062	287.07	287.69
2004	0.299280124	0.305931985	254.70	0.2993	254.09	0.3059	287.09	287.70
2005	0.29916625	0.305690048	254.71	0.2992	254.12	0.3057	287.12	287.71
2006	0.299130571	0.30538363	254.72	0.2991	254.14	0.3054	287.14	287.72
2007	0.299033475	0.305150437	254.72	0.2990	254.17	0.3052	287.17	287.72
2008	0.299011136	0.304852881	254.73	0.2990	254.19	0.3049	287.19	287.73
2009	0.298927611	0.304628748	254.73	0.2989	254.21	0.3046	287.21	287.73
2010	0.298921702	0.304340371	254.74	0.2989	254.24	0.3043	287.24	287.74
2011	0.298851239	0.304125612	254.74	0.2989	254.26	0.3041	287.26	287.74
2012	0.298858973	0.303846731	254.75	0.2989	254.28	0.3038	287.28	287.75
2013	0.298804407	0.303641662	254.74	0.2988	254.30	0.3036	287.30	287.74
2014	0.298826979	0.303372594	254.75	0.2988	254.33	0.3034	287.33	287.75
2015	0.298788269	0.303177531	254.75	0.2988	254.35	0.3032	287.35	287.75
2016	0.298826979	0.302915701	254.75	0.2988	254.37	0.3029	287.37	287.75
2017		0.302728232			254.39	0.3027	287.39	
2018		0.302474283			254.41	0.3025	287.41	
2019		0.302295052			254.43	0.3023	287.43	
2020		0.302049628			254.45	0.3020	287.45	
2021		0.301879277			254.46	0.3019	287.46	
2022		0.301643024			254.49	0.3016	287.49	
2023		0.301482196			254.50	0.3015	287.50	
2024		0.301255759			254.52	0.3013	287.52	
2025		0.301105099			254.53	0.3011	287.53	
2026		0.300893544			254.55	0.3009	287.55	
2027		0.300757763			254.57	0.3008	287.57	
2028		0.300561033			254.58	0.3006	287.58	
2029		0.300440073			254.60	0.3004	287.60	
2030		0.30025811			254.61	0.3003	287.61	
2031		0.300151911			254.62	0.3002	287.62	
2032		0.299984657			254.64	0.3000	287.64	
2033		0.299893156			254.65	0.2999	287.65	
2034		0.29974055			254.66	0.2997	287.66	
2035		0.299663684			254.67	0.2997	287.67	
2036		0.299522065			254.68	0.2995	287.68	
2037		0.299460133			254.68	0.2995	287.68	

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2038	0.299330941	254.69	0.2993	287.69	
2039	0.299280124	254.70	0.2993	287.70	
2040	0.29916625	254.71	0.2992	287.71	
2041	0.299130571	254.72	0.2991	287.72	
2042	0.299033475	254.72	0.2990	287.72	
2043	0.299011136	254.73	0.2990	287.73	
2044	0.298927611	254.73	0.2989	287.73	
2045	0.298921702	254.74	0.2989	287.74	
2046	0.298851239	254.74	0.2989	287.74	
2047	0.298858973	254.75	0.2989	287.75	
2048	0.298804407	254.74	0.2988	287.74	
2049	0.298826979	254.75	0.2988	287.75	
2050	0.298788269	254.75	0.2988	287.75	
2051	0.298826979	254.75	0.2988	287.75	