The 2023 record temperatures:
correlation to absorbed shortwave radiation anomaly

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Abstract

According to the paradigm of the IPCC global warming is solely due to anthropogenic causes. Record-high temperatures have been measured for the summer months of 2023 and the anthropogenic climate drivers – mainly greenhouse gases - have been named as culprits. Simple analyses reveal that the temperature increase of the year 2023 cannot be explained exclusively by anthropogenic climate drivers. The hypothesis of this study is to show that the main climate driver for the high temperature of 2023 has been the Absorbed Shortwave Radiation (ASR). The approach has been to apply the CERES (Clouds and the Earth's Radiant Energy System) satellite radiation measurements, which started in March 2001. Simple climate models have been applied since General Climate Models (GCM) cannot simulate cloudiness and shortwave radiation (SW) changes properly. The ASR changes are related mainly to cloudiness and aerosol particle changes. Since 2014 the global surface temperature growth rate has accelerated but this does not apply to anthropogenic climate drivers, and therefore the ASR changes are probably related to external forcings. The total Radiative Forcing (RF) according to the AR6 was 2.70 Wm^{-2} for the period 1750-2019. This can be compared to the change in the ASR, which was 2.01 Wm^{-2} from the year 2000 to the year 2023. This finding means that natural climate drivers have altogether an important role in recent global warming.

Keywords: High temperatures; absorbed solar radiation; ASR; natural climate drivers; simple climate models; positive water feedback

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1. Introduction

It looks like researchers have not been willing to simulate the temperature effects of ASR increase. A notable step on this issue was the study of Rantanen and Laaksonen (2024). They have concluded that the warmest September on record globally was September of 2023 by a record margin of 0.5°C. They applied the latest generation of GCMs and showed that internal climate variability combined with the steady increase in greenhouse gas forcing would be a highly unlikely climate driver ($p \sim 1\%$). They suggest further analysis of the impact of external forcings on the global climate in 2023. Finally, Rantanen and Laaksonen did not suppose any concrete climate driver that could have contributed to the temperature increase.

Stephens et al. (2022) studied the reasons for the reduced amount of reflected sunlight, and they concluded that there is an equal split between cloudiness reduction and aerosol particles. They applied six different GCMs for temperature simulations and found that they were rather poor in calculating the cloud and aerosol impacts. Another reason is that the present paradigm of climate change is almost totally based on Anthropogenic Global Warming (AGW) theory and that is a reason why observation-based solar input variations have not been included in the GCMs.

The objectives of mainstream research studies normally do not cover solar radiation absorption impacts on the climate since it is not in line with the AGW (Anthropogenic Global Warming) theory of the IPCC. According to the AR6 (IPCC, 2021), the only natural climate driver was solar impact with 0,7 % negative impact on warming. One of the exceptions is Pinker et al. (2005) who studied the long-term variations of solar radiation on the Earth's surface (S) before 2001 using the longest available satellite records. They found that the increase of S was 0.16 $Wm^{-2}yr^{-1}$ from 1983 to 2001.

The probable explanation is the 60- and 88-year temperature oscillations of the climate, which are usually known as the AMO (Atlantic Multidecadal Oscillation) and Gleissberg cycle (Gleissberg, 1958). Ollila and Timonen (2022) have shown that both climate oscillations are global by nature, and the impacts of these cycles have been found employing several proxy temperature indicators in different places on the Earth. The mutual positive peak of the 60- and 88-year oscillations was in 1939, the negative peak was around 1975 and the new positive phases started thereafter. The result of Pinker et al. (2005) is in line with this oscillation behaviour of the climate, and also the reason is partially the same since the Gleissberg cycle is connected to solar radiation variations (Gleissberg, 1958).

It is well-known that clouds are the main challenge to climate change science. Trenberth and Fasullo (2009) concluded that low clouds play an important role as they can reduce ASR while having relatively little impact on OLR (Outgoing Longwave Radiation). They also confirmed that clouds are the largest source of uncertainty in GCMs. The same applies to state-of-the-art GCMs used and referred to in the AR6 of the IPCC (2021). The ERF (Effective Radiative Forcing) of the aerosol-cloud in the AR6 had decreased by 50 % from the AR5 (2013) to the value of -0.22 Wm^{-2} with the great uncertainty band of 0.51 Wm^{-2} describing this problem.

The CERES satellite radiation measurements started in March 2000, and Loeb et al. (2018) recognised the increased trend of ASR according to the CERES observations starting after 2015, Figure 1.

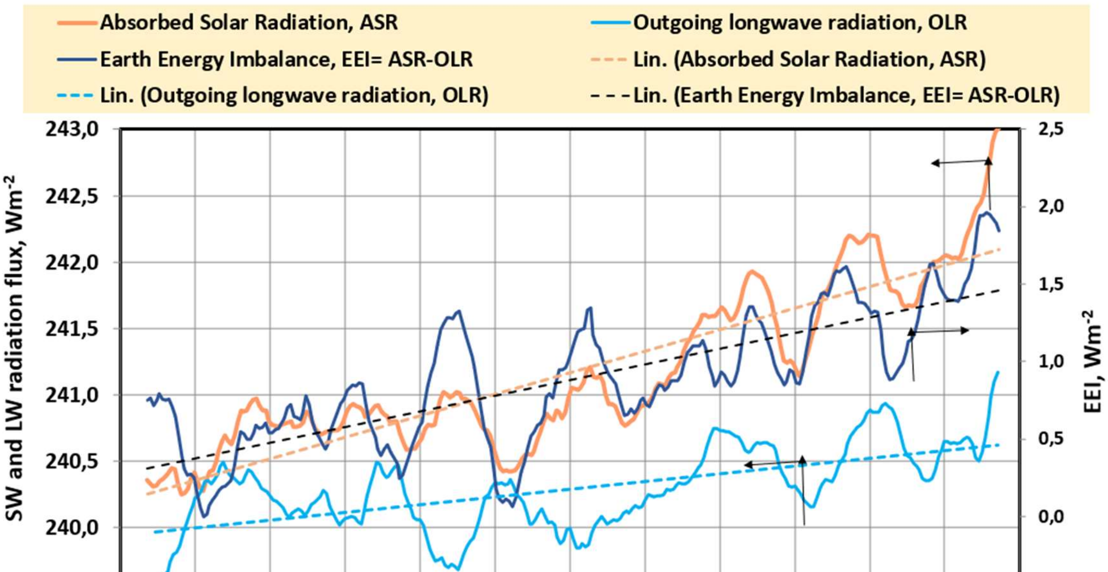

Figure 1: The ASR, OLR and EEI (Earth Energy Imbalance) trends from 2000 to 2023.

Figure 1 shows that the OLR level started to deviate from the ASR level after 2003. Loeb et al. (2021) have concluded that this increased energy input has mainly warmed the ocean, and it also has caused Earth's Energy Imbalance (EEI) since OLR has not been at the same level as the ASR since about 2003. They found that the main reason for increased ASR has been the reduction of low-level clouds.

Kato and Rose (2024) analyzed the EEI and found also a significant SW radiation absorptivity rate of 0.68 $Wm^{-2}dec^{-1}$. In the discussion section, they calculated how much temperature increase and precipitation this would cause.

CERES instruments (Priestley et al., 2011) were designed to provide 2-4 improvements in accuracy and stability over the previous satellite observation system ERBE (Earth Radiation Budget Experiment). There are four instruments on two satellites named *Terra* and *Aqua*, which cover three filtered radiance measurement bands: the shortwave band (0.3 – 5 μm), the total (0.3 – 100 μm), and the atmospheric window (8-12 μm). There is an Internal Calibration Module (ICM), which carries out automatic in-flight calibrations for each instrument. According to Priestley et al. (2011), the long-term ICM calibration stability has been better than 0.2 %, and the calibration traceability from ground to flight is 0.25 %.

Matthews has carried out research studies called the Moon and Earth Radiation Budget Experiment (MERBE) applying the albedo measurements of the Moon, whose reflectivity is very constant. According to Matthews (2021), the MERBE calibration system has revealed instrument telescope degradations, which are undetectable by the CERES calibration system. He has concluded that the Earth's albedo has been constant during his research period from 2001 to 2015, which would mean that the ASR variations by CERES instruments have been artifacts.

The author has not found any comments from NASA for the critics raised by the MERBE results. The research study Matthews was conducted in 2020 but it did not cover the period from 2015 onward, when the ASR variations started to increase significantly, and also the gap between the ASR and OLR increased at the same time. If the constant albedo of the Earth would have continued also during 2015-2020, it would have meant a major failure in the CERES calibration system.

Since mainstream climate scientists have continued to apply the published CERES radiation observations as noticed in the AR6 (IPCC, 2021), the author thinks that it is still justified to use CERES data. On the other hand, the gap between the OLR and the ASR radiation trends can be estimated at least partially to originate from the accuracy problems between these measurements. It should be noticed that the OLR instrument has a significantly broader measurement span than the ASR measuring instruments, which decreases the absolute accuracy of OLR measurements. This issue will be also addressed in the Discussion and Conclusion section.

The purpose and the scope of this study are to carry out analyses on the impact of ASR forcings on the temperature since 2000 except in a couple of studies giving perspective. The present GCMs do not apply to the analyses, since they do not utilise direct CERES radiation observations (Ollila, 2021) and are poor at simulating ASR variations (Trenberth and Fasullo, 2005; Stephens et al., 2022). The later analyses below reveal that GCMs do not consider indirect aerosols and cloud observations or estimates either according to the AR5 and the AR6 (IPCC, 2013; IPCC 2021). Therefore, simple climate models have been applied in this study.

2. Methods

2.1 Data

The temperature data are from GISS (2024) and UAH (2024), radiation data are from ERBE/ ERBS (Wong et al., 2005) and CERES (2024) satellite observations, and the Oceanic Niño Index (ONI, 2024) from NOAA. Greenhouse (GH) gas concentrations are from NOAA (2024) as well as the GH index values (AGGI, 2024).

2.2 Simple climate models

The main method is to analyze the impacts of anthropogenic and natural climate drivers by applying simple climate models and comparing the results to real temperature observations. The surface temperature values can be calculated using Eq. (1), as defined by the IPCC (2013) on page 664

$$dTs = \lambda \cdot RF \text{ [°C]} \quad (1)$$

where dTs is the global mean surface temperature change, and λ is the climate sensitivity parameter. The temperature impact of effective radiative forcings (ERF) can be analyzed by this simple climate model which gives practically the same results as complicated GCMs on the global scale.

A mathematical expression for the climate sensitivity parameter λ can be derived from the Earth's energy balance

$$SC \cdot (1-\alpha) \cdot (\pi r^2) = \varepsilon \cdot \sigma \cdot T_e^4 \cdot (4\pi r^2)\ [Wm^{-2}] \quad (2)$$

where SC is the solar constant, α is the albedo of the Earth, ε is emissivity, σ is the Stefan–Boltzmann constant, and T_e is the average emission temperature of OLR. The emissivity of the Earth's surface can be approximated to be 1, and therefore it can be omitted. From eq. (2) $T_e = (SC(1-\alpha)/(4\sigma))^{0.25} = 255.29$ K = -17.87°C.

The term SC(1-α) is the net radiative forcing RF_{net} of the Earth and eq. (1) can be written as $RF_{net} = \sigma T_e^4$. When this equation is derived, it will be $d(RF_{net})/dT_e = 4\sigma T_e^3 = 4RF_{net}/T_e$. By inverting this equation, λ will be

$$\lambda = dTe/d(RF_{net}) = T_e/(4RF_{net}) = T_e/(SC(1-\alpha))\ [K/(Wm^{-2})] \quad (3)$$

Using the average CERES (2021) values for the period 2008–2014 (Ollila, 2023), λ = 255.29 K/ (1360.04*(1-0.2916) Wm^{-2}) = 0.265 K/(Wm^{-2}). This λ value means no water feedback mechanism and it has been applied in the counterfactual simple climate model called the "Ollila model" in this article utilising the varying radiation flux observations for SC and α calculations.

There might be doubts that the IPCC does not use any more so simple climate model as eq. (1). The IPCC has reported in chapter 7.4.2.1 of AR6 (IPCC, 2021) the latest results in calculating Planck response α_P, called also Planck feedback; α_P is called Planck feedback parameter. Planck feedback plays a fundamental stabilizing role in Earth's climate, and it is strongly negative: a warmer planet's surface radiates more energy to space. The AR6 (IPCC, 2021) defines that the equilibrium temperature change ΔTP is calculated in response to a radiative forcing ΔF like this:

$$\Delta TP = -\Delta F / \alpha_P\ [°C] \quad (4)$$

Eq. (4) is in fact the same as eq. (1), if we notice that ΔTP = dTs, ΔF is the same as RF with the negative sign (RF reduces outgoing OLR), and $\alpha_P = -1/\lambda$.

An interesting analysis can be carried out on the greenhouse (GH) effect G, the magnitude of α_P, and the TCR of the IPCC. The normalized GH effect G_{av} (IPCC, 2021) has been defined as the ratio between G and the upwelling longwave (LW) flux at the surface LW_{up}. Applying the current flux estimates of the IPCC, the magnitude of $G_{av} = 159\ Wm^{-2} / 359\ Wm^{-2} = 0.4$, and this value can be assumed to be fairly constant (IPCC, 2021). LW_{up} can be calculated by the Planck radiation law $LW_{up} = \varepsilon \cdot \sigma \cdot T_s^4$. Planck feedback parameter α_P, which is an angle coefficient of a linearized Planck equation, can be calculated from equation $\alpha_P = -1/\lambda$ by applying the surface temperature T_s temperature 288 K (15 °)

$$\alpha_P = -1/\lambda = SC(1-\alpha)/T_s = (1360.04*(1-0.2916)/288 = -3.345\ [Wm^{-2}K^{-1}] \quad (5)$$

The latest α_P value of the IPCC (2021) is -3.22 $Wm^{-2}K^{-1}$ based on the multi-kernel and multi-model average.

The Transient Climate Response (TCR) value of the AR6 (IPCC, 2021) is 1.8 °C caused by the RF value of 3.9 Wm^{-2}. The temperature increase of 1.8 °C increases the LW_{up} value by 10 Wm^{-2}. It means that the GH effect increase must be 10 Wm^{-2} – 3.9 Wm^{-2} = 6.1 Wm^{-2}. The G_{av} is now 0.61, which is 52.5 % more than G_{av} = 0.40 calculated using the flux and temperature values of the present climate. The reason can be easily identified. By applying the Planck feedback parameter -3.33 $Wm^{-2}K^{-1}$ (or λ value of 0.3 K/(Wm^{-2}), the temperature impact of 3.9 Wm^{-2} would be only 1.17 °C. This is close to 1.2°C as reported in chapter 8.6.2.3 of the AR4 (IPCC, 2007) without water feedback. The LW_{up} value corresponding to the T_s value of 16.3°C + 1.17°C = 17.48° is 404.6 Wm^{-2}, and the GHE effect is 404.6 - 239 = 165.5 Wm^{-2}. It means that the G_{av} = 165.5 Wm^{-2} / 404.6 Wm^{-2} = 0.409. It is close to the G_{av} value in the present climate of 0.40 but using the positive water feedback, the G_{av} value of 0.61 deviates significantly from 0.40, which should not happen according to the AR6 (IPCC, 2021).

The earlier λ values of the IPCC were taken from the study of Ramanathan et al. (1985), based on eight research papers giving an average value of 0.5 K/(Wm^{-2}), varying from 0.47 K/(Wm^{-2}) to 0.53 K/(Wm^{-2}). When Syuruko Manabe was awarded the Nobel Prize for Physics in 2021, one of Manabe's main credits was that Manabe and Wetherald (1967) were the first to introduce positive water feedback. They proposed that water feedback doubles the original RF of CO_2, and their λ value was 0.53 K/(Wm^{-2}). This quality became one of the essential features of GCMs as early as the 1980s.

The λ value of 0.5 K/(Wm^{-2}) was also specified in assessment reports 3 and 4 of the IPCC (2001, 2007). The AR5 of the IPCC (2013) did not specify the exact λ value but it can be calculated. The RF value of CO_2 concentration was 3.70 Wm^{-2} and the average TCR (Transient Climate Response) value was 1.8°C (5% to 95% range 1.2°C to 2.4°C) in the AR5 (IPCC 2013) giving λ value of 0.49 K/(Wm^{-2}).

The IPCC (2021) did not report a λ value for ERF in AR6, but it can be calculated from the data in Fig. 7.6 and Fig. 7.7 of the AR6, which are based on the GCM calculations. The λ value is 1.27 K / 2.70 Wm^{-2} = 0.47 K/(Wm^{-2}), which is applicable for a temperature change calculation according to eq. (1).

Even though eq. (1) looks so simple, it can be applied with astonishing accuracy to the temperature calculations from 1750 onward for monthly, annual, and decadal temperature changes and even to scenario calculations till 2100. Applying eq. (1) gives the TCR value of 1.85°C (= 0.47 °C/(Wm^{-2}) *3.93 Wm^{-2}), while the best estimate of the AR6 (IPCC 2021) is 1.8°C. The dTs for the worst-case Shared Socio-economic Pathway scenario SSP5-8.5 would be according to eq. (1), dTs = 0.47 K/(Wm^{-2}) * 8.5 Wm^{-2} = 4.0°C (IPCC 2021). The average warming value according to the AR6 (IPCC, 2021) is the same. These examples show that the average warming values calculated with the complicated GCMs can be calculated using eq. (1). The explanation is that the temperature changes caused by ERF alternations less than 10 Wm^{-2} depend almost linearly on ERFs (Ollila, 2023). Both the TCR and SSP scenario calculations, reported and approved by the IPCC, assume that positive water feedback duplicates the warming impacts of CO_2.

2.3 ASR trend and impact on temperatures

According to the AR5, the total ERF in 2011 was 2.34 Wm^{-2}, which caused a warming of 1.15°C per eq. (1). This is 0.3°C more than the observed 0.85°C (IPCC, 2013) meaning a 35% error.

The IPCC (2021) writes in the AR6 (Figures 7.6, and 7.7) that the global warming calculated by GCMs by 2019 was 1.27°C and this was caused by the ERF of 2.7 Wm^{-2}. The ERF was a sum of anthropogenic ERF values of 2.72 Wm^{-2} and an insignificant change in solar activity of -0.02 Wm^{-2}. This is an almost perfect result considering IPCC climate models, as the corresponding observed temperature increase in 2020 was 1.26°C according to Figure 1.12 of AR6 (IPCC, 2021). Even though this is looking good, a closer analysis reveals discrepancies.

The observed temperature increased by 0.44°C from 2011 to 2019, and at the same time, the ERF increased from 2.34 Wm^{-2} to 2.70 Wm^{-2} (IPCC, 2013; IPCC, 2021) meaning an increase of 0.36 Wm^{-2}. The ERF change of 0.36 Wm^{-2} from 2011 to 2019 causes a temperature change dTs = 0.47 K/(Wm^{-2}) * 0.36 Wm^{-2} = 0.17°C. Since the observed dTs change of this period was 0.44°C, the non-anthropogenic (natural) climate drivers have caused the rest of the change of 0.27°C. This result is in conflict that the anthropogenic ERF of 2.72 Wm^{-2} alone can cause global warming of 1.27°C. It also raises questions about the role of natural climate drivers in global warming during the longer period from 1750 to 2100.

The same analysis can be carried out for the year 2023. The NOAA Greenhouse Index (AGGI, 2023) collects the annual RF values of GH gases. The annual growth rate has been about 1.8% during recent years, and it means that the annual RF increase for the year 2023 has been about 0.042 Wm^{-2}. The CO_2 forcing according to the IPCC has been 0.032 Wm^{-2} meaning the portion of 79%. The annual temperature increase of 2023 has been 0.28°C (GISS, 2023). Applying eq. (1) the RF of 0.042 Wm^{-2} would mean the temperature impact of 0.47°C/(Wm^{-2}) * 0.042 Wm^{-2} = 0.019°C, which is only 6.8% from the observed temperature increase of 0.28°C. This finding is in line with the conclusion of Rantanen and Laaksonen (2024) that nonanthropogenic forcings must have a significant impact on the September temperatures of 2023.

ASR is the difference between the total solar irradiance (TSI) and the reflected shortwave radiation upward (SWup) from the Earth. The ASR trend of the 2000s cannot be explained by changes in incoming solar radiation, as the TSI trend is negligible (−0.053 Wm^{-2} per decade). Loeb et al. (2021) have concluded that the increase in EEI from 2005 to 2019 is primarily due to an increase in ASR and a decrease in OLR. They also conclude that the increased energy input of the Earth has warmed the ocean, and the land, and melted ice, and therefore the surface temperature has not increased in direct proportion to this energy increase.

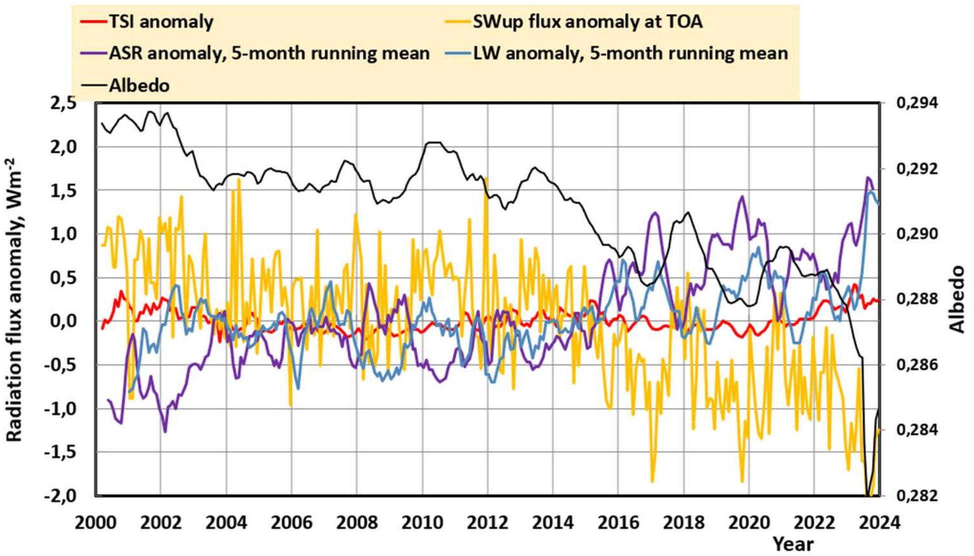

Figure 2: The anomaly trends of TSI, SW flux, LW flux, and ASR at the TOA as well as the albedo trend of the Earth. The numerical values of the radiation flux trends have been excerpted from the CERES (2024) data.

Figure 2 shows the well-known oscillatory behaviour of the solar cycle, which is now closing its maximum peak, which will probably happen in 2024 - 2025. The ASR anomaly (ASRa) trend shows that it has increased from 2015 onward but the TSI anomaly marked as TSIa has had only a small impact on this increase. It means that the ASRa increase is mainly due to the decrease of the Earth's albedo. The maximum difference in monthly ASRa values from March 2000 to October 2023 is 3.5 Wm^{-2}. The annual increase from the first year 2000 to 2023 is 2.01 Wm^{-2}, and the total RF from 1750 to 2019 has been 2.70 Wm^{-2}. By comparing the magnitude of the ASRa signal to the RF value of CO_2 forcing, it is easy to notice that it is a very significant climate driver. The average value of the LW anomaly for 2001-2023 is 0.00 Wm^{-2}, and the same ASR anomaly is +0.05 Wm^{-2}, which is not an essential difference. The problem between the ASR and LW fluxes seems to be in absolute radiation flux observations.

The main objective of this study is to find out the roles of ASR and ENSO (El Niño Southern oscillation) in explaining the high temperatures of the period 2015-2023 and to show that natural climate drivers have a significant role in the temperature increase in the recent years.

3. Results

3.1 Temperature trend correlation to ASR in the 2000s

Before analysing these figures more closely, the surface temperature trends and ASRa trends are useful to depict together.

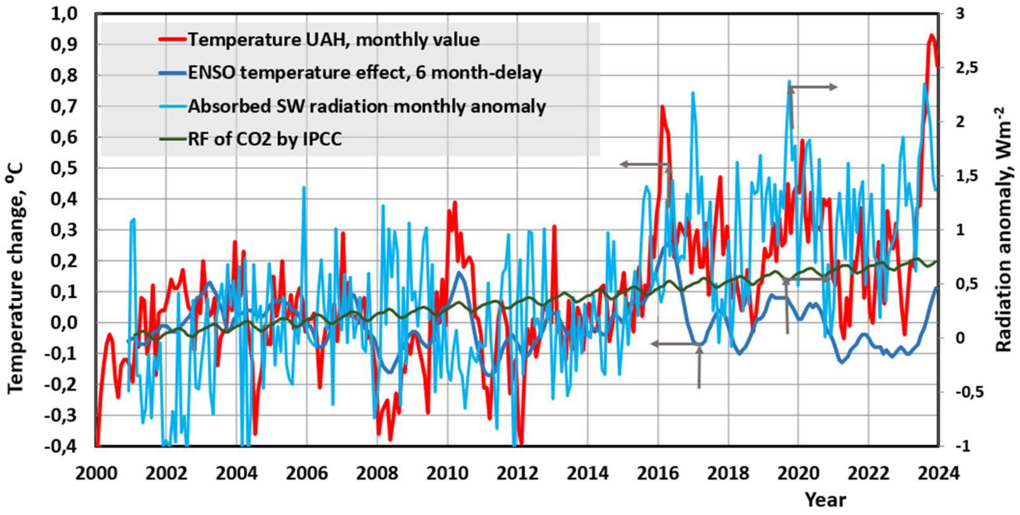

Figure 3: The trend in UAH (2023) temperature anomaly, ASRa trend, change in radiative forcing (RF) of carbon dioxide (NOAA 2023) calculated from 2010 onwards according to the IPCC (2023), and the temperature effect of ENSO.

The growth rates of the temperature trend (GISS 2023) and the ASRa trend (CERES 2023) in Figure 3 show a strong correlation after the temperature pause of 2000-2014. During the period 2011-2019, the ERF value of the IPCC (2021) increased in eight years by 0.36 Wm^{-2} meaning a yearly RF value of 0.045 Wm^{-2} (= 0.36 Wm^{-2} / 8), which causes an insignificant average yearly temperature growth of 0.021°C (=0.47 K/Wm^{-2} * 0.045 Wm^{-2}) according to eq. (1). Figure 3 depicts the ERF impact of CO_2 (IPCC, 2021), which does not correlate to monthly temperature changes, since its monthly RF impacts are exceedingly small: about 0.027 Wm^{-2}.

The ASRa increase from 2011 to 2019 was 1.29 Wm^{-2} having a global temperature impact of 0.34°C (= 0.265 $K/(Wm^{-2})$ * 1.29 Wm^{-2}). Adding this impact to the observed temperature of 0.85°C in 2011 would give a warming value of 1.19°C leaving only 0.10°C for other climate drivers. There is no ASR climate driver among the RF agents in Figures 7.6 and 7.7 of the AR6 (IPCC, 2021). The ASR impacts should be identified in the RF agent “Aerosols-cloud” and/or “Aerosols-radiation”. The sum of the “Aerosols-clouds” has decreased from -0.82 Wm^{-2} in 2011 to -1,00 Wm^{-2} in 2019 per the AR5 and AR6. It means that according to the IPCC science, the ASR, aerosols, and clouds have decreased the radiative forcing and they have decreased temperature by -0.085°C. This is not in line with the CERES observations, which show the opposite change.

Record-high temperatures have been measured for the summer months of 2023, Figure 4. The temperature increase from January 2023 to October 2023 was 1.02°C (UAH, 2024). According to AR6 of the IPCC (2021), global warming is solely due to anthropogenic causes but this rapid warming rate is not in line with this theory considering the warming impacts of anthropogenic climate drivers as analyzed in the Introduction section.

The warming impact of the ENSO effect emerged after April 2023 (ONI, 2023), when La Niña started to fade, and the present El Niño emerged in May. The positive impact of ENSO on surface temperatures started in August-September 2023 since there is a 6-month delay in the temperature impact of the ONI index (Trenberth and Fasullo, 2015; Ollila, 2021). The conclusion is that the increase in recent temperatures in 2023 has mainly been due to non-anthropogenic causes.

The ASR signal trend shows a decrease after August 2023, when at the same time the ONI index starts to increase. This may be connected to the increased cloudiness in the Niña regions. The study of Ollila (2020) found that the cloudiness of Niña regions 3, 4 and 5 increased as the ONI index increased. The ASR forcing increase is very probably related to the decrease of low clouds in the ocean areas (Loeb et al., 2021).

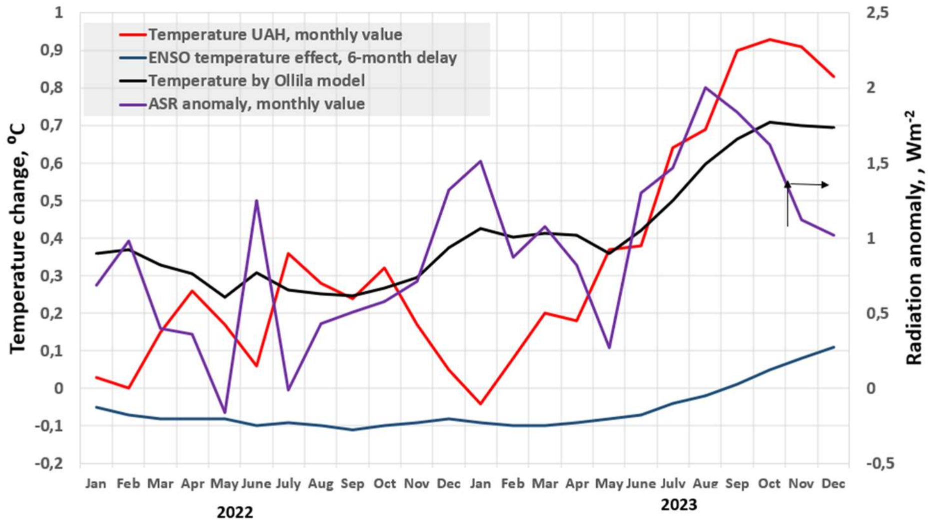

Figure 4: The UAH temperature, ASR, ENSO temperature trends and the Ollilla-model calculated temperature from January 2022 to December 2023.

The trends in Figures 2 and 3 originate from NASA's measurements by CERES satellites, which are also shown in Figure 7.11 of AR6. This issue has been reported or analyzed only in a few publications (Loeb et al., 2018; Stephens et al., 2022; Loeb et al., 2021; IPCC, 2021; Ollila, 2022; Kato and Rose, 2024) and has not been reported in the media. According to the IPCC, anthropogenic radiative forcings for the period 1750 to 2019 were a total of 2.70 Wm^{-2}. The change in ASR in August 2023 was about 3.1 Wm^{-2} more than in 2000 (Figure 2), i.e. more than all anthropogenic factors together from 1750 to 2019 (IPCC, 2021).

The problem is that the IPCC calculation shows no increase in the ASR of 1.29 Wm^{-2} from 2011 to 2019, for which there are direct CERES measurements. It can be estimated that the increase of 1.29 Wm^{-2} according to IPCC science corresponds to a temperature increase of about 0.61°C (= 0.47 K/Wm^{-2} * 1.29 Wm^{-2}). This temperature effect cannot be found in Figures 7.6 and 7.7 of the AR6 (IPCC 2021). A possible explanation is that because climate models cannot reliably calculate changes in cloud cover, the IPCC has completely excluded the ASR impact from warming calculations.

3.2 Connection between ASR and super El Niños

Ollila (2020) noticed that during the two very strong El Niños 1997-1998 and 2015-2016 – also called super El Niños - the ASR temperature effect was slightly more than the El Niño temperature effect. The same phenomenon can be found also during the ongoing El Niño 2023-2024, Fig. 5.

A closer analysis reveals that in these three cases, the ASR anomaly maximum happens in September-October, which is 2-3 months before the El Niño maximum in December. This is a rather strong piece of evidence that the ASR maximum peak may trigger and contribute to El Niño becoming a super El Niño.

An opposite event happened during the strong El Niño 2009-2010. It can be theorized that this El Niño did not develop into a super El Niño, since the ASR anomaly was negative, and also its peak value did not happen 2-3 months before December.

It can be noticed in Figure 5 that the GISS temperature started to deviate from the UAH (the University of Alabama in Huntsville) satellite observations after 2003. It looks like the UAH temperature is more sensitive to El Niño spikes.

It can be also noticed in Figure 5 that during the ongoing El Niño, the ASR temperature effect is about 100% more than the El Niño effect itself. This seems to be related to a higher overall ASR anomaly level after El Niño 2015-2016. It means that there has been an enduring change in the atmospheric conditions – probably in the reduced amount of low-level clouds.

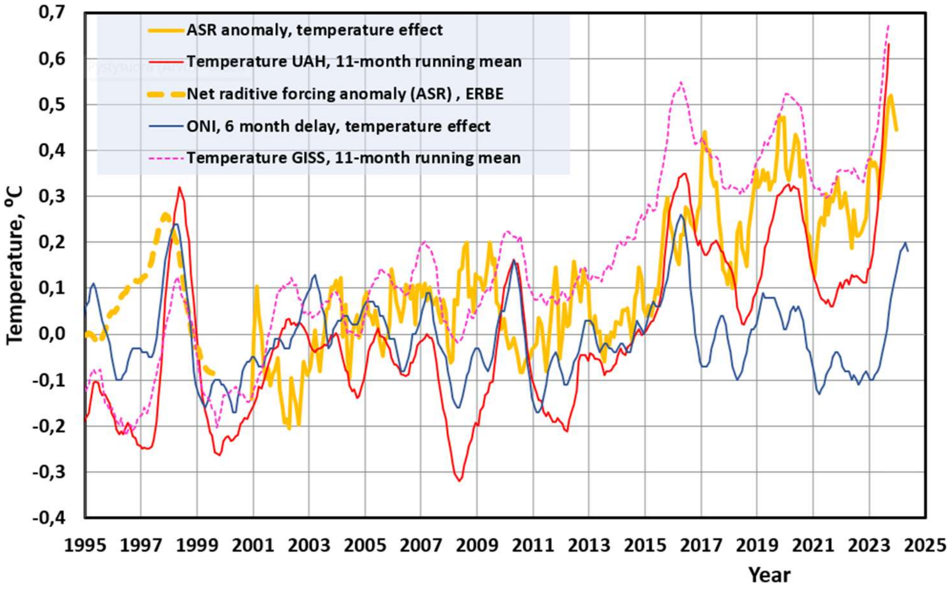

Figure 5: The UAH and GISS temperature trends, ENSO temperature effects and ASR simulated temperature effects according to ERBE and CERES observations.

3.3 Simple climate model simulations

The temperature effects from 2001 to September 2023 can be simulated using both the IPCC's simple climate model and the simple climate model of Ollila (2023) by starting temperature changes from zero in 2001, Figure 6. In the IPCC model, a λ value of 0.47 Wm^{-2} was applied, and the CO_2 impact was calculated using eq. (1), but the other GHG effects were omitted due to their insignificant temperature impact of about 0.02°C in the 21-year simulation period. ERF equation of Ollila (2023) was applied for CO_2 (ERF = 3.83 * ln(CO_2/280)), which gives the ERF value of 2.65 Wm^{-2} for 560 ppm. The ASR value was calculated according to CERES observations as a difference between TSI and SWup anomalies. The λ value was calculated according to the actual CERES observation variations (SWup / TSI). In both models, the temperature impact dTs of the ENSO effect has been calculated from the ONI index by applying an equation dTs = 0.1 * ONI with a 6-month delay in temperature impact (Trenberth and Fasullo, 2013; Ollila 2021). The dynamical time constants for the ocean were 2.74 months and for land 1.04 months (Stine et al., 2009).

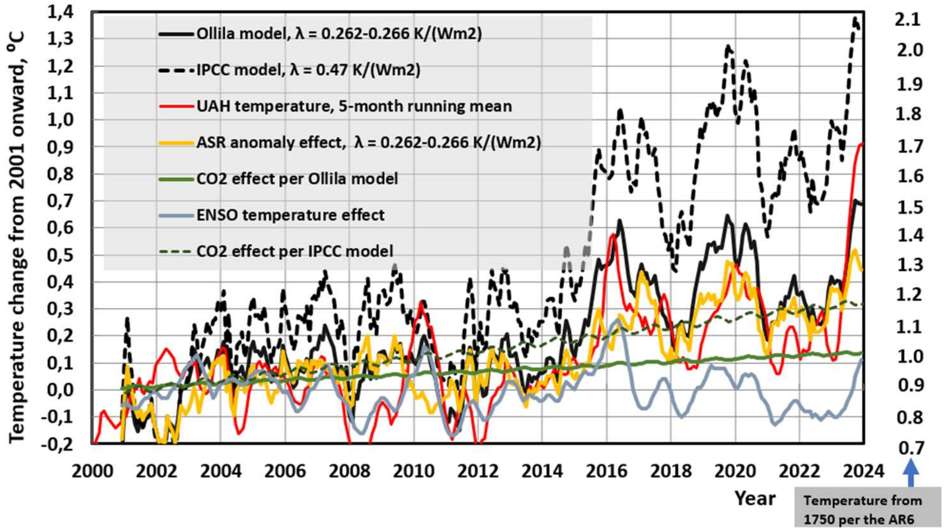

Figure 6: The results of two simple climate models, considering the increase in absorbed solar radiation (ASR) from 2001 onwards.

The temperature increase from the reference period 2001-2014 to 2023 was 0.52°C (UAH, 2024). The corresponding temperature change according to the IPCC's simple model is the sum of the ASR change of 0.68°C, CO_2 forcing 0.22°C, and the ENSO effect, -0.01°C, to give a total of +0.89°C, meaning an error of +0.37°C. The Ollila model is the sum of an ASR change of 0.52°C, CO_2 forcing of 0.09°C, and ENSO effect of -0.01°C, for a total of 0.47°C, meaning an error of +0.05°C in respect of UAH temperature.

The major ASRa increase occurred after the end of the pause of 2014. The average UAH temperature of 2015-2023 is 0.28°C, the Ollila model calculated temperature is 0.39°C and the IPCC-model calculated average value is 0.85°C. Both models follow the dynamic changes of the temperature very well confirming that the time constants of dynamics are correct. The difference between the two models is mainly due to the water feedback mechanism and of course the missing ASRa impact in the IPCC model.

During the simulation period from 2001 to 2024, the albedo value varied from 0.2937 to 0.2819 (Figure 2). The climate feedback parameter λ varied from 0.262 to 0.266 K/(Wm^{-2}). It means that the average λ value 0.265 K/(Wm^{-2}) is applicable in simulations.

There are justified questions about the homogenisation practises applied in the updating GISS temperature data sets, which have decreased the historical temperatures and increased the temperatures of the recent decades. Another problem with global data sets is the UHI (Urban Heat Island) phenomenon which has increased the modern time temperatures due to changes in measurement sites from nonurban areas to urban areas. To avoid these problems, the UAH temperature data set was applied as a reference.

Figure 6 shows that changes in global temperature, especially after 2014, are due to the ASR and the ENSO effect. Carbon dioxide has an insignificant impact on annual and monthly temperature changes. El Niño (ONI, 2023), which has been developing during the summer of 2023, has started to have a temperature impact after August 2023, since its global temperature effects will come with a delay of about six months. The high temperatures of the recent months of 2023 are almost solely due to the increased ASR values, the values of which are currently known only until December 2023.

4. Discussion and conclusion

Some special reasons have been suggested in public discussions as explanations for the high temperatures of 2023, which can be shortly analyzed. The impact of El Niño has been the most popular explanation but as analyzed in the text, its impact in 2023 has not been significant.

A positive anthropogenic effect on the ASR anomaly can be expected from the new regulations of the International Maritime Organization (IMO 2019) limiting sulphur emissions from the shipping industry since a reduction in sulphur aerosols reduces cloudiness. Diamond (2023) has studied the quantitative impacts of sulphur emissions and the result was that the instantaneous radiative forcing on a global scale was at a maximum of 0.1 Wm^{-2} up to date. Rantanen and Laaksonen (2024) have estimated this impact to be from 0.02 to 0.06 Wm^{-2}, and the effects of Hunga Tonga volcano eruption to be from 0.02 to 0.07 Wm^{-2}. These impacts are insignificant in relationship to ASR forcing changes. Stephens et al. (2022) estimated that aerosol reductions have a greater impact.

Hodnebrog et al. (2024) have also concluded that aerosol emission reductions have increased the ASR but during the last two decades according to GCM simulations, the major impact has increased EEI. They estimated that accelerated surface warming may be expected in this decade. The GCMs could not explain about 40 % of the extra ASR indicating the well-known problems of GCMs in aerosol and cloud simulations. The CERES data shows that reflectivity has been falling in both hemispheres whereas pollution has fallen mainly in the north.

Gavin Schmidt, who is the director of the NASA Goddard Institute for Space Studies (GISS), has written in the World View article (Nature, 2024) that the anthropogenic drivers have increased the temperature since 2022 by only about 0.02 °C, and even taking all plausible explanations into account, the gap between the expected and observed annual mean temperatures in 2023 remains about 0.2 °C. This opinion is noteworthy since it may be the first time that an acknowledged climate scientist admits that they are confounded since it looks like they are on unchartered territory.

Marsh and Svensmark (2000) have found a likely reason for cloudiness changes as they identified a relationship between the solar-modulated cosmic rays on global cloud cover (≤ 3 km). The Sun itself is also a secondary source of cosmic rays in the form of charged energetic particles known as the solar wind. So far there is no generally accepted evidence about the reasons for the changes in the Earth's albedo causing the changes in the ASR. The ASR trends during the last ten years urge further research on this subject.

The analyses of this study show that natural climate drivers have had a significant role in global warming after the temperature pause ended in 2014. In September 2023, the radiative forcing of ASR anomaly has been greater than the sum of the anthropogenic climate drivers from 1750 to 2019 according to the IPCC science. The IPCC has omitted the ASR anomaly impacts in the summary of the climate radiative forcings in Figure 7.6 and Figure 7.7 of the AR6 (IPCC, 2021) even though they have referred to this anomaly in Figure 7.3, which is consistent with the CERES observation data and the graphs of Loeb et al. (2018) and Ollila (2021).

The analysis revealed that the positive water feedback in TCR values - GCM-calculated or by a simple climate model - conflicts with the normalized G effect values (G_{av}) calculated by applying the IPCC's method and numerical values. The temperature simulations by simple climate models show that the positive water feedback results in significant errors during the period from 2000 to 2024.

Ten researchers of Hadley Center have proposed in their comment article (Betts et al., 2023) a new procedure to define the temperature calculation method, which could be used for recognising overriding the 1.5°C threshold. They got an incentive since they thought that there was no definition for the reference period nor the actual temperature measurement period in the Paris Agreement in 2015 (IPCC, 2015).

Indeed, these definitions cannot be found in the Paris Agreement (COP21, 2015) but they were defined later in the document of the IPCC (2018). In this document, the reference period is calculated from 1850 to 1900 representing the preindustrial time. Warming will be calculated for any given time as a 30-year average for smoothing out natural variability, which means a period starting 30 years before the calculation point. Betts et al. (2023) propose a 20-year period, which is a combination of ten historical yearly values concerning the last observation year and ten years of forecast values based on estimated emissions used as input in GCMs. This procedure would react faster to temperature changes than the IPCC definition giving thus more time for cutting emissions. This proposal is based on the IPCC science that global warming is almost solely due to anthropogenic causes, and ASR rapid and strong anomalies have no impacts.

Two observations can be made. CO_2 emissions reached the present rate of about 10 GtC (gigatons of carbon) during the COVID-19 pandemic. Still, the CO_2 concentration has been increasing at almost a constant rate. On the other hand, the climate community have closed their eyes to the fact that the ASR has increased at a significant rate varying from -1.52 Wm^{-2} to +1.84 Wm^{-2} from 2001 to December 2023. The RF value of the ASR has increased from 2001 to 2023 with the value of 2.01 Wm^{-2}, which is 74 % of the total RF value of 2.70 Wm^{-2} reported by the IPCC from 1750 to 2019. The ASR variations together with the ENSO effects explain quite well the global temperature variations.

There are scientific groundings to question the accuracy and calibration capabilities of the CERES measurements. The analyses and the results of this study show that the ASR based on the CERES observations can explain the temperature variations of the 2000s exceptionally well. It is a good reason to use the CERES measurements until more evidence can be gathered against the CERES calibration deficiencies.

Anyway, the temperature simulations by a simple climate model show that the observed and model-calculated temperatures have good equivalence. Since the surface temperature is closely related to the longwave radiation of the surface and further to the OLR, it raises a justified question that EEI may be an artifact based on the accuracy problems between the SW and LW measurements by the CERES instruments.

It looks like at least one natural climate driver - which has a name and measurable radiative forcing value - has a significant role in the recent high temperatures. Media and politicians are not aware of this fact. This also means that the planned and agreed actions on CO_2 emissions are not based on the real impacts of the anthropogenic climate drivers.

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References

AGGI, 2024: *The NOAA annual Greenhouse Index (AGGI)*. https://gml.noaa.gov/aggi/aggi.html

Betts RA, Belcher SE, Hermanson L, Klein Tank A, Lowe JA, Jones CD, Morice CP, Rayner NA, Scaife AA, Stott PA, 2023: *Approaching 1.5°C: how will we know we've reached this crucial warming mark?* Nature 624, 33-35. https://doi.org/10.1038/d41586-023-03775-z

CERES, 2024: *CERES EBAF-TOA Data.* The National Oceanic and Atmospheric Administration (NOAA). https://ceres-tool.larc.nasa.gov/ord-tool/jsp/EBAFTOA42Selection.jsp

COP21, 2015: *Adoption of the Paris Agreement framework convention on climate change*. UNFCCC, Paris, 1-32, https://unfccc.int/sites/default/files/english_paris_agreement.pdf

Diamond MS, 2023: *Detection of large-scale cloud microphysical changes within a major shipping corridor after implementation of the International Maritime Organization 2020 fuel sulfur regulations.* Atmos. Chem. Phys. 23, 8259–8269.
https://acp.copernicus.org/articles/23/8259/2023/

GISS, 2024: *Land-ocean temperature index of NASA*.
https://data.giss.nasa.gov/gistemp/tabledata_v4/GLB.Ts+dSST.txt

Gleissberg W, 1958: *The eighty-year sunspot Cycle.* J. Br. Astron. 68, 148-152.

Hodnebrog Ø, Myhre G, Jouan C, Andrews T, Forster PM, Jia H, Loeb NG, Olivié DJL, Paynter D, Quaas J, Raghuraman SP, Schulz M, 2024: *Recent reductions in aerosol emissions have increased Earth's energy imbalance.* Commun Earth Environ. 5, 166.
https://www.nature.com/articles/s43247-024-01324-8

IMO, 2019: *Resolution mepc.320(74) 2019 guidelines for consistent implementation of the 0.50 % sulphur limit under marpol annex v*. London, UK. https://www.imo.org/en/OurWork/Environment/Pages/Index-of-MEPC-Resolutions-and-Guidelines-related-to-MARPOL-Annex-VI.aspx

IPCC, TAR, 2001: *Climate Change 2001, The Physical Science Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge Univ. Press, Cambridge, U.K., and New York,
https://www.ipcc.ch/site/assets/uploads/2018/03/WGI_TAR_full_report.pdf

IPCC, AR4, 2007: *Climate Change 2007, The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge Univ. Press, Cambridge, U.K., and New York,
https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-frontmatter-1.pdf

IPCC, AR5, 2013: *Climate Change 2013, The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge Univ. Press, Cambridge, U.K., and New York, https://www.ipcc.ch/site/assets/uploads/2017/09/WG1AR5_Frontmatter_FINAL.pdf

IPCC, 2018: *Summary for Policymakers, Global Warming of 1.5 °C*. World Meteorological Organization., Geneva, Switzerland, https://www.ipcc.ch/sr15/

IPCC, AR6, 2021: *Climate Change 2021, The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge Univ. Press, Cambridge U.K., https://www.ipcc.ch/report/ar6/wg1/

Kato S, Rose FG, 2024: *Global and regional entropy production by radiation estimated from satellite observations.* AIP Conf. Proc. 2988, 050007. https://pubs.aip.org/aip/acp/article/2988/1/050007/3022156/Global-and-regional-entropy-production-by

Loeb NG, Thorsen TJ, Norris JR, Wang H, Su W, 2018: *Changes in Earth's energy budget during and after the "pause" in global warming: An observational perspective.* Climate 6, 62, https://www.mdpi.com/2225-1154/6/3/62

Loeb NG, Johnson GC, Thorsen TJ, Lyman JM, Rose FG, Kato S, 2021: *Satellite and ocean data reveal marked increase in Earth's heating rate*. Geophys. Res. Lett. 48, e2021GL093047. https://doi.org/10.1029/2021GL093047

Manabe S, Wetherald RT, 1967: *Thermal equilibrium of the atmosphere with the given distribution of relative humidity.* J. Atm. Sci. 24(3), 241-259. https://climate-dynamics.org/wp-content/uploads/2016/06/manabe67.pdf

Marsh ND, Svensmark H, 2000: *Low cloud properties influenced by cosmic rays*. Phys. Rev. Lett. 85(23), 5004–5007, https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.85.5004

Matthews G, 2021: *NASA CERES spurious calibration drifts corrected by lunar scans to show the Sun is not increasing global warming and allow immediate CRF detection.* Geophys. R. ch Lett. 48, e2021GL092994. https://doi.org/10.1029/2021GL092994

NOAA, 2024: *Carbon dioxide, methane and nitrogen oxide concentrations.* Global Monitoring Laboratory (GML) of the National Oceanic and Atmospheric Administration (NOAA). https://gml.noaa.gov/ccgg/trends/

Ollila A, 2020: *The pause end and major temperature impacts during super El Niños are due to shortwave radiation anomalies.* PSIJ 24(2), 1-20, https://doi.org/10.9734/psij/2020/v24i230174

Ollila A, 2021: *Global Circulation Models (GCMs) simulate the current temperatures only if the shortwave radiation anomaly of the 2000s has been omitted*. Curr. J. App. Sci. Techn. 42(46), 111-183, https://doi.org/10.9734/cjast/2021/v40i1731433

Ollila A, 2023: *Radiative forcing and climate sensitivity of carbon dioxide (CO_2) fine-tuned with CERES data.* Curr. J. App. Sci. Techn. 40(17), 45-52, https://doi.org/10.9734/cjast/2023/v42i464300

Ollila A, Timonen M, 2023*: Two main temperature periodicities related to planetary and solar activity oscillations.* https://hal.science/hal-04160543

ONI, 2024: *Oceanic Niño Index (ONI),* NOAA, https://ggweather.com/enso/oni.htm

Pinker RT, 2005: *Do Satellites Detect Trends in Surface Solar Radiation?* Science, 308(5723). 850–854. https://doi.org/10.1126/science.1103159

Priestley KJ, Smith GL, Thomas S, Cooper D, Lee III RB, Walikainen D, Hess P, Szewczyk ZP, Wilson R, 2011: *Radiometric Performance of the CERES Earth Radiation Budget Climate Record Sensors on the EOS Aqua and Terra Spacecraft through April 2007*. J. Tech. 28(1), 3–21. https://doi.org/10.1175/2010JTECHA1521.1

Ramanathan V, Cicerone RJ, Singh HB, Kiehl TJ, 1985: *Trace gas trends and their potential role in climate change*. J. Geophys. Res. 90, 5547-5566, https://doi.org/10.1029/JD090iD03p05547

Rantanen M, Laaksonen A, 2024: *The jump in global temperatures in September 2023 is extremely unlikely due to internal climate variability alone*. npj. Clim. Atmos. Sci. 7, 34, https://www.nature.com/articles/s41612-024-00582-9

Schmidt G, 2024: *Climate models can't explain 2023's huge heat anomaly — we could be in uncharted territory*. Nature 627, 467, https://www.nature.com/articles/d41586-024-00816-z

Stephens GL, Hakuba MZ, Kato S, Gettelman A, Dufresne J-L, Andrews T, Cole JNS, Willen U, Mauritsen T, 2022: *The changing nature of Earth's reflected sunlight*. Proc. R. Soc. A 478, 20220053, https://doi.org/10.1098/rspa.2022.0053

Stine AR, Huybers P, Fung IY, 2009: *Changes in the phase of annual cycle of surface temperature.* Nature 457, 435-441, https://www.nature.com/articles/nature07675

Trenberth KE, Fassullo JT, 2009: *Global warming due to increasing absorbed solar radiation*. Geophys. Res. Lett. 36, L07706. https://doi.org/10.1029/2009GL037527

Trenberth KE, Fasullo JT, 2013: *An apparent hiatus in global warming*? Earth's Future, 1(1), 19-32. https://doi.org/10.1002/2013EF000165

UAH, 2024: *UAH global temperature data set*. The University of Alabama Huntsville. https://www.nsstc.uah.edu/data/msu/v6.0/tlt/uahncdc_lt_6.0.txt

Wong T, Wielicki BA, Lee III RB, Smith LS, Bush KA, Willis JK, 2005: *Reexamination of the observed decadal variability of the Earth radiation budget using altitude-corrected ERBE/ERBS nonscanner WFOV data.* J, Climate 19, 4028-4040. https://ntrs.nasa.gov/api/citations/20080014856/downloads/20080014856.pdf