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Global Circulation Models (GCMs) Simulate the Current Temperature Only If the Shortwave Radiation Anomaly of the 2000s Has Been Omitted

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Author's contribution

The sole author designed, analysed, inteprted and prepared the manuscript.

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ABSTRACT

The research article of Gillett et al. was published in *Nature Climate Change* (*NCC)* in March 2021. The objective of the NCC study was to simulate human-induced forcings to warming by applying 13 CMIP6 (Coupled Model Intercomparison Project Phase 6) climate models. *NCC* did not accept the author's remarks as a "Matters arising" article. The purpose of this article is to detail the original three remarks and one additional remark: 1) the discrepancy between the graphs and reported numerical values, 2) the forcings of aerosols and clouds, 3) the positive water feedback, and 4) the calculation basis of the Paris agreement. The most important finding is that General Circulation Models (GCMs) used in simulations omit the significant shortwave anomaly from 2001 to 2019, which causes a temperature error of 0.3°C according to climate change physics of Gillett et al. For the year 2019, this error is 0.8°C showing the magnitude of shortwave anomaly impact. The main reason for this error turns out to be the positive water feedback generally applied in climate models. The scientific basis of the Paris climate agreement is faulty for the same reason.

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1. INTRODUCTION

The objective of this study is to analyze the reasons for differences and errors between the observations of Clouds and the Earth's Radiant Energy System (CERES) radiation measurements and global temperature measurements in respect to the simulation results of [1] (later Gillett). The GCMs of Gillett simulations follow the basic climate change science of the Intergovernmental Panel on Climate Change (IPCC). The most important result is the warming caused by carbon dioxide (CO_2). The same average results for warming can be calculated applying the simple climate model, which is called the IPCC model in this study. An alternative simple climate model called the Ollila model has been applied as a reference in calculating temperature impacts.

The simulations of Gillett using 13 GCMs show that anthropogenic forcings have caused warming 0.9°C to 1.3°C of warming in the global surface temperature in 2010-2019 relative to 1850-1900. This average warming is the same as the observed warming of 1.1°C according to Gillett. An analysis of the simulations by Gillett reveal that they have totally omitted strong positive shortwave (SW) radiation anomaly of the 2000s, which causes a temperature impact of 0.3°C to 2010-2019 and 0.8°C for the year 2019 according to climate science applied by Gillett.

2. MATERIALS AND METHODS

The material is based on the common databases available through internet and they are referred to the original source as they appear the first time in the text.

The analysis method is to compare the simulation results of Gillett to the calculation methods and results of the IPCC as found in the latest assessment report (AR5) [2] in the first step. In the second step the results are compared to the simple model of the author (Ollila model). IPCC uses both ECS (Equilibrium Climate Sensitivity) and TCS (Transient Climate Sensitivity) concepts and summarizes the differences in AR5 [2], p. 1110: "ECS determines the eventual warming in response to stabilization of atmospheric composition on multi-century time scales, while TCR determines the warming expected at a given time following any steady increase in forcing over a 50- to 100-year time scale." IPCC has changed the TCS to TCR (transient climate response). On page 1112 of AR5, IPCC states that "TCR is a more informative indicator of future climate than ECS."

The warming values of any Radiative Forcings (RF) can be calculated according to the [2] as

$$dT = \lambda * RF \quad (1)$$

where dT is the global surface temperature change (K or °C) starting from the year 1750 and λ is climate sensitivity parameter (K/Wm^{-2}) or ($°C/Wm^{-2}$). The λ value of 0.5 $K/(Wm^{-2})$ of the IPCC (2013) means positive water feedback, and it is applicable in calculating temperature responses for scenarios up to 1370 ppm CO_2 concentration during this century. For example, according to equation (1), the TCS value is 1.85^0C. It can be compared to the IPCC's official TCS value, which is between 1.0 and 2.5^0C, meaning an average value of 1.75^0C. In Table 9.5 of AR5 [2] is the average value of TCS/TCR of the 30 most complicated GCMs, and the value is 1.8^0C.

Since it turns out that the temperature responses of Gillett's simulations are much greater than the observed temperatures of the present day, another option of equation (1) has been applied in the Ollila model without the positive water feedback with λ value of 0.27 $K/(Wm^{-2})$ [3].

The RF values of anthropogenic climate drivers in the IPCC model are based on the data of the AR5 [2] for the period from 1750 to 2013 and thereafter to the Annual Greenhouse Gas Index (AGGI) data of National Oceanic and Atmospheric Administration (NOAA) [4]. In the Ollila model the same values are calculated for the period from 2001 to 2019 using the equation in the Ollila model.

$$RF = 3.12 * \ln (C/280), \quad (2)$$

where C is the CO_2 concentration in ppm [3].

Both in the IPCC model and in the Ollila model the El Nino Southern Oscillation (ENSO) temperature effects have been calculated from the Oceanic Nino Index (ONI) [5]

$$dT = 0.1 * ONI \quad (3)$$

Equation (3) has been applied with 6 months delay [6,7].

3. RESULTS

3.1 Discrepancy between the Graphs and Numerical Values

The reported anthropogenic forcing from Gillett is 0.9 to 1.3°C in 2010–2019 relative to 1850–1900, meaning the average value of 1.1°C. The graphical presentation of the included data files and Fig. 1b of Gillett shows that the average value for the period of 2010–2019 is about 0.8°C, which is the sum of greenhouse gases 1.3°C and the aerosols -0,5°C. So, there is a relatively great difference between the values of 1.1°C and 0.8°C which has not been explained in the paper of Gillett. The value of 1.1°C in the graphical presentations is for the end of 2019.

3.2 Forcing of Aerosols and Clouds

According to graphical presentations on the temperature effect of aerosols by Gillett, the aerosol effect has been slowly declining since 1920 and being about -0.5 °C from 1990 onward. There are research results based on ground stations and satellite observations showing that the global dimming turned into brightening about 1985 to 1990 [8,9,10]. The decisive evidence has come from the shortwave (SW) radiation measurements by the (CERES) satellites since March 2000 [11]. These satellites measure total solar irradiation (TSI) and upwelling SW radiation, and the difference is the downwelling SW radiation [7], Fig. 1.

The average temperature effect of the SW anomaly in 2000–2019 is about 0.6 Wm^{-2} corresponding to +0.3°C by using λ value of 0.5 $K/(Wm^{-2})$. If this effect is added to the reported total warming value, it would be from 1.2 to 1.6°C. It should be noted that SW radiation upwelling depends on all factors affecting the SW radiation travelling through the atmosphere and reflecting from the atmosphere, the clouds, and the Earth's surface. In this sense, it is the observation-based magnitude of three different aerosol related climate drivers as defined by the IPCC in AR5 [2] for 2011: aerosols and precursors, -0.27 Wm^{-2}; cloud adjustments due to aerosols, -0.55 Wm^{-2}; and albedo changes due to land use, -0.15 Wm^{-2}. Altogether, these total -0.97 Wm^{-2}, corresponding to the -0.5°C, which is the same as the aerosol effect of Gillett from 1990 onward. The authors of the Gillett study have not commented on this drastic change of SW forcing caused by the atmospheric aerosol and/or cloud conditions, even though it questions the most important results of GCMs.

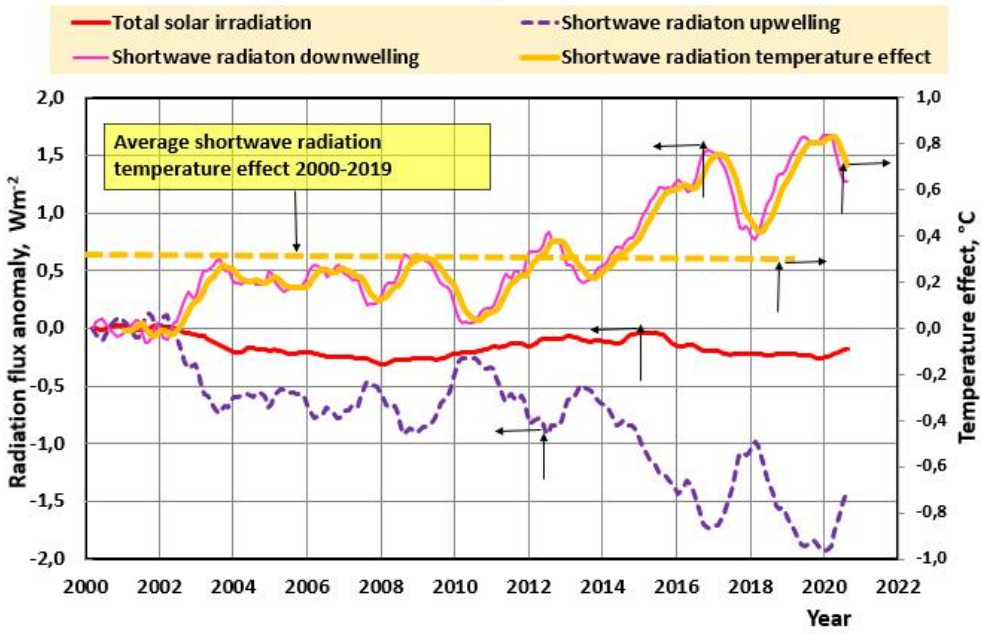

Fig. 1. SW fluxes since March 2000 and the temperature anomaly effect of the downwelling SW radiation based on dynamic simulation

3.3 Positive Water Feedback

The term *Radiative Forcing* (RF) has not been used in the article of Gillett, but it is an essential concept of the IPCC in calculating warming impacts as explained in section 2. The positive water feedback is a common property in GCMs, and it means duplicating the original forcing values of other climate drivers. This property of GCMs applied in the article can be tested using the RF effect of carbon dioxide, which is the most accurate RF value according to the IPCC [1] (very high confidence). Since the CO_2 forcing of GCMs in 2019 is about 1.0°C, it means that λ value of 0.5 K/(Wm^{-2}) has been applied together with the RF value according to the equation of [12]: dT = 0.5 * 5.35 * ln(411.16/280) = 1.03°C.

The strong impact of positive water feedback can be seen in Fig. 3, where the temperature simulations of two models have been depicted for the period from March 2001 to the end of 2019.

The author has shown that the temperature impacts of GCMs and the simple IPCC model are practically the same for the simulation period of Gillett since they are based on water feedback. The temperature effects of three major climate drivers of the simple IPCC model in 2019 are: anthropogenic factors 0.29°C, ENSO effect 0.08°C, and SW radiation forcing 0.8°C, totaling 1.17°C. The Ollila model is without water feedback, and the same temperature effects are: anthropogenic factors 0.1°C, ENSO effect 0.08°C, and SW radiation forcing 0.37°C, totaling 0.55°C. The Ollila model follows very well the temperature changes from 2000 to 2019, Fig. 3.

The SW radiation anomaly of 1.6 Wm^{-2} in 2019 is about the same as 1.68 Wm^{-2} by CO_2 from 1750 to 2011 [2], meaning the temperature effect of +0.8°C. The SW anomaly is probably due to the changes in low-level clouds [13], and it may be mainly caused by natural changes, which are not known by climate researchers, but the mechanism has been proposed [14]. Since this positive SW anomaly temperature effect is based on the most accurate available radiation measurements with the same accuracy as the TSI, it should be added to the final temperature. In this case, the average simulated temperature of 2019 by Gillett would increase to 1.7–2.1°C, causing an error of 55–91% in respect to HadCRUT4 [15].

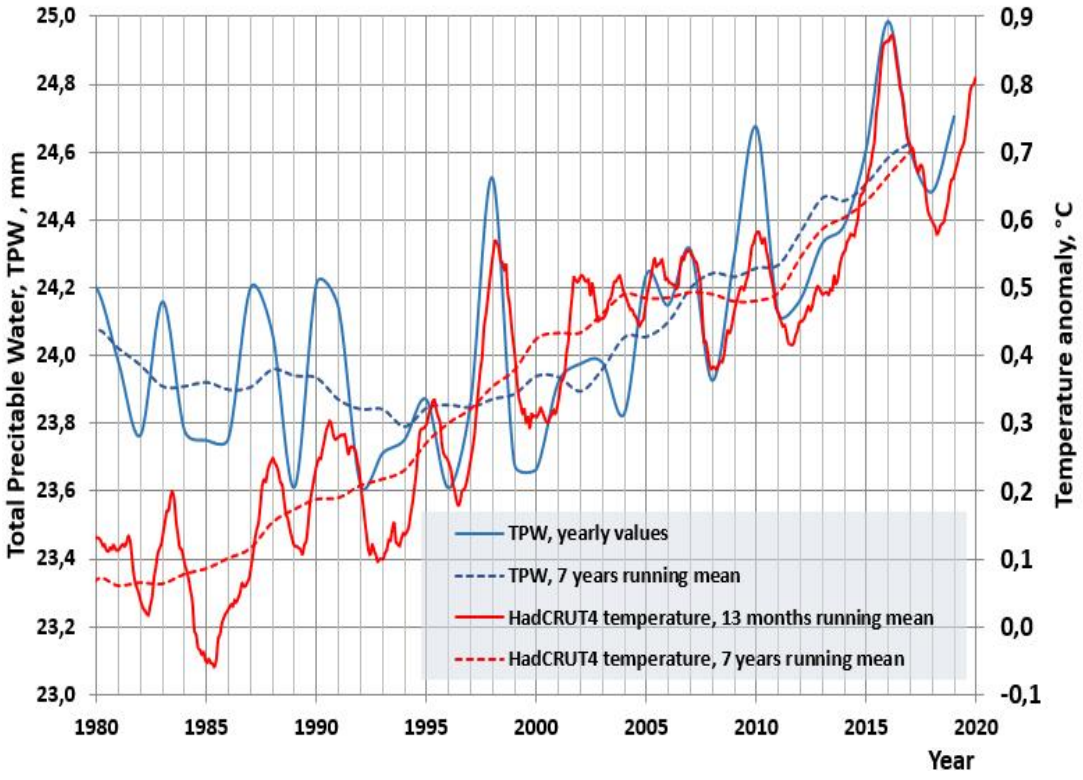

Fig. 2. The temperature trend and TPW (Total Precipitable Water) [16] trends from 1980 to 2020

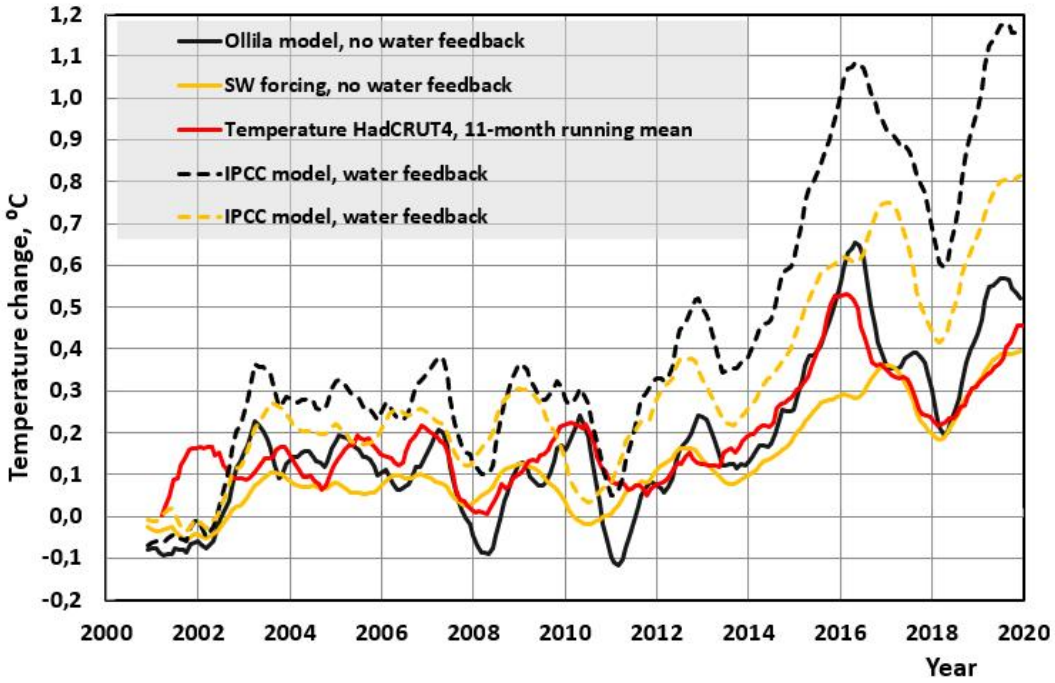

Fig. 3. The temperature effects of three major climate drivers applying water feedback (IPCC model) or without water feedback (Ollila model)

This great error is probably due mainly to the positive water feedback applied in GCMs and by the IPCC. The theory of positive water feedback is based on the equation of Clausius-Clapeyron (C-C), which shows the relationship between the saturated water pressure and the temperature. The atmosphere's relative humidity varies typically from 35% to 90% and only occasionally and locally the value is 100%. The conditions are not applicable for C-C theory in climate science. A common C-C relationship applied in climate models is that the tropospheric water amount increases at the rate of 7% per degree Celsius, meaning positive water feedback. Direct observations do not show the positive water feedback (Fig. 2).

The surface temperature increased according to all temperature data sets from 1980 to 2000, but the TPW value declined during this period [16]. Only during ENSO (El Nino Southern Oscillation) events, which are short-term climate disturbances, does the positive water feedback mechanism work, but the overall long-term absolute humidity trend does not behave in this way. The inaccuracies of humidity measurements cannot be blamed, since both short-term and long-term effects are based on the same measurement data sets.

The λ is related to the Earth's radiation balance [3]:

$$SC(1-\alpha) * ¶r^2 = sT^4 * 4¶r^2 \quad (3)$$

where SC is the solar constant, T is the temperature corresponding to the emitted longwave radiation by the surface, α is the average albedo, and s is the Stefan-Boltzmann constant. Since the term SC(1-α)/4 is the same as the net RF, equation (3) can be written in the form $RF = sT^4$. Using derivation, the λ value can be calculated to be:

$$dT/(dRF)) = \lambda = T/(4RF) = T/(SC(1-\alpha)) \quad (4)$$

Using the present numerical flux values, λ is about 0.27 K(/Wm^2). It means no positive water feedback.

3.4 The Calculation Basis of the Paris Agreement

The anthropogenic warming calculations of the Paris agreement (also called the 21st Conference of the Parties – COP21) are based on IPCC science. The UNFCCC (United Nations Framework Convention on Climate Change) has used the calculation methods of the

IPCC and the RCP8.5 (Representative Concentration Pathway) scenario for defining the baseline scenario to calculate future temperature impacts of human-induced climate change [17]. The original goal of COP21 was to limit the temperature increase to 2.0°C. The IPCC's Special Report on Global Warming [18] has recommended keeping it at 1.5°C.

The results of Gillett's simulations show the warming is caused mainly by two anthropogenic warming drivers, which are greenhouse gases and aerosols, causing a temperature change of between 0.9 to 1.3°C, meaning an average value of 1.1°C. In the year 2019 the SW forcing was 1.61 Wm^{-2}, causing the temperature effect of 0.8°C, according to the calculation basis of the IPCC and Gillett simulations. Thus, the temperature increase would have been 1.1 + 0.8 = 1.9°C, overshooting the COP21 limit of 1.5°C.

4. DISCUSSION

One can only speculate what the reasons could be for omitting the SW radiation anomaly of the 2000s.

1) The model-calculated temperatures are approaching the observed temperatures, which are the same for the period of 2000-2019 according to Gillet. This is a piece of good news for the climate society since the different has been significant in 2011: the model calculated temperature 1.37°C versus the observed temperature of 0.85°C [2].

2) The SW anomaly impacts show that there are natural climate drivers that have rapid and significant temperature impacts exceeding the anthropogenic drivers for the period of 2000-2019. The IPCC and the climate community have claimed that the natural climate impacts have been close to zero as also shown by the GCM simulations by Gillet. The GCMs show still the same perception. For climate scientists, it is well-known that the present average yearly CO_2 increase of 2.5 ppm causes only a 0.02°C temperature increase. Also, the rapid temperature decline from 0.4°C in October 2020 to -0.05°C in April 2021 per UAH temperature [19]. shows that it cannot be due to anthropogenic reasons. The temperature increase since the 2015–16 El Nino year cannot be due to anthropogenic reasons, but it has been omitted, even though the SW anomaly should be well-known. This is worrisome since this fact will emerge to general awareness sooner or later.

3) The author has received feedback from some climate scientists that the existence and the magnitude of the SW anomaly from 2001 to 2021 might be a wrong misconception of the author since there are no other published researched results of this matter. This remark is justified since there is no data bank source representing SW radiation graphical trends. The recent research paper of Loeb et al. [20] published in May 2021 contains Fig. 2a showing the same SW radiation trend as in Fig. 3 of this paper. Dr. Norman Loeb is responsible director of the CERES satellite program. There is no slightest suspicion that the SW anomaly is a real and strong phenomenon.

4) Natural and anthropogenic forcings should have caused a temperature increase of about 1.9°C for the year 2019, according to the IPCC and COP21 science, but the observed temperature rise is only 1.1°C per Gillett's simulations applying 13 climate models. This fact would crumble the scientific basis of the Paris agreement and the agreement would lose its credibility.

5. CONCLUSIONS

The main result of this article is that the GCMs do not consider the significant SW radiation anomaly happening from 2001 onward and having a maximum value of 1.61 Wm^{-2} in 2019. This effect is almost the same as the CO_2 RF of the value of 1.68 from 1750 to 2011 [2], which corresponds to the temperature effect of 0.8°C according to the IPCC science. It is a general observation that the climate community has been silent about this SW anomaly and has omitted its impacts on temperature, since only three articles have been published on this matter [5,13,20].

The basic scientific reason behind these errors between the observations and models is the positive water feedback applied in both simple and complicated climate models, as also used in the GCMs of Gillett's simulations. These findings mean that climate models applying positive water feedback result in about 50% too high warming values.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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