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The Sun Versus CO_2 as the Cause of Climate Change Projected to 2050

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Abstract:

The current controversy over the cause of increasing global temperatures since the middle of the 20th century comes from the IPCC First Assessment Report issued in 1990. The report states rising carbon dioxide (CO_2) warms the air, thereby holding more of the significant warming gas, water vapor. This additional water vapor feeds back to amplify the warming by CO_2. The IPCC has continually promoted this concept in its reports since 1990. Up-to-date science proves the IPCC concept is faulty. Scientists discovered that when the Sun's energy output changes, it impacts the Earth's temperature, and it does this cyclically. Current, reliable evidence shows the Earth has just come through a warm period. It is now in the early stages of cooling that might be similar to the Dalton Minimum and last for three or four decades. Average temperatures can drop by up to 1.5°C and increase the rate of crop failures that have already started. It won't be easy to maintain the benefits of the recent warm phase of the Sun during the upcoming solar minimum.

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1. INTRODUCTION

The current controversy over the absorption of the Sun's radiation by water vapor and carbon dioxide (CO_2) began in 1856 with an experiment by Eunice Newton Foote. John Tyndall followed up on this experiment and confirmed it. The work of Foote and Tyndall was the beginning of the Greenhouse Theory of gases warming the Earth [1].

The Swedish scientist, Svante Arrhenius, developed a theory in 1896 to explain the temperature difference between the Ice Ages and the interglacial periods. The approach suggested the rate of CO_2 increase is faster than that of the temperature growth rate. Scientists met this idea with skepticism, and Arrhenius eventually confirmed he had overestimated by more than 300%. The scientific community rejects this theory [1].

The First Assessment Report (FAR) in 1990 of the Intergovernmental Panel on Climate Change (IPCC) [2] discusses warming by CO_2. It states:

> "The simplest of these feedbacks arises because as the atmosphere warms, the amount of water vapor it holds increases. Water vapor is an important greenhouse gas and will amplify the warming."

Although many competent scientists dispute this concept, the IPCC has vigorously defended it. The IPCC has moved on to Climate Change 2021: The Physical Science Basis (AR6). It says increasing CO_2 levels can raise the Earth's temperature to disastrous levels. The IPCC claims to avoid this catastrophe, we must limit the rise in temperature to not more than 1.5^{o}C above pre-industrial conditions. To do this means eliminating carbon dioxide emissions from burning fossil fuels. This IPCC frightening claim results from climate models driven by increasing CO_2, and some are in IPCC AR6. Since 1990, when the IPCC first claimed CO_2 to be the driving force of the Earth's climate, there has been a significant increase in climate knowledge.

For example, early in IPCC report AR5 issued in 2013, water vapor was shown to have raised the Earth's temperature by 0.5^{o}C over the mid-1970s to 2011. The specific humidity, grams of water per kilogram of dry air, is remarkably well correlated with the Earth's temperature in sub-figures of Figure TS.1 on page 38. On page 42 is a description:

> "The magnitude of the observed global change in tropospheric water vapor of about 3.5% in the past 40 years is consistent with the observed temperature change of about 0.5°C during the same period."

Thus, in 2013 the IPCC began to cast doubt on the CO_2 theory. It also opens the suggestion that the Sun controls the level of water vapor. For example, one-quarter of the Sun's energy reaching the Earth evaporates water to water vapor [3]. Logically, only the Sun has the energy capacity to evaporate enough water to change the specific humidity significantly. This statement is the first indication by the IPCC that the Sun has more than a negligible influence on the Earth's temperature. The study of the Sun's behavior over the 400 years of sunspot records taught us much about its energy output variability. Data from satellites since 1979 improved our knowledge.

Forecasts of where the Earth's temperature might be in 2050, with drastic reductions in carbon dioxide emissions or without, are made by many people. Some accept the IPCC claim, and others do not. This study makes a forecast for 2050 based on new information available since the first IPCC report in 1990.

The analysis starts with the best possible current technology for measuring Earth's temperature: satellite measurements. It then compares these temperature measurements with measurements of the CO_2 level in the atmosphere.

The graphs of these two items provide a verifiable base from which to evaluate the Earth's temperature and to make estimates of where it might be in 2050. The purpose of this study is to use the new information about the Earth's climate that became available since 1990 to make a reasonable projection of the Earth's temperature to 2050. An essential part of the new information is the role of the Sun in affecting the Earth's temperature [4].

Figure **1** summarizes the data. Numbers in yellow circles represent the critical information in Figure **1**. The following sections explain the background of the items represented by each number.

2. DESCRIPTIONS OF THE SCIENCE BEHIND THE NUMBERS 1 TO 11 IN FIGURE 1

2.1. Circle 1

Scripps is the source of the Keeling curve of the carbon dioxide (CO_2) level in the atmosphere [5]. It is a highly

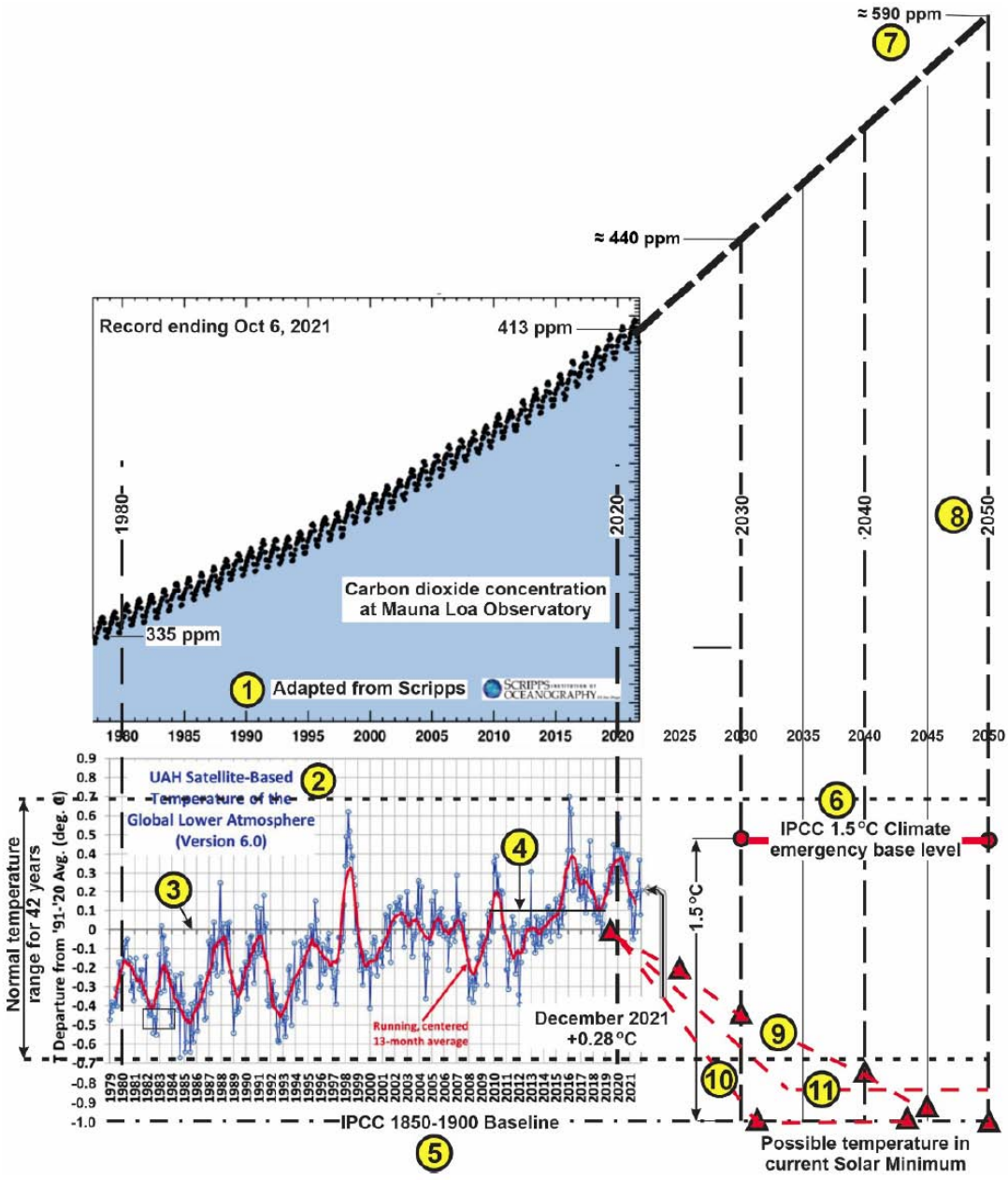

Figure 1: CO_2 level, Earth's temperature by satellite, and temperature projection to 2050.

accurate measurement of the number of molecules of CO_2 in one million molecules of dry air (ppm). It is updated every day.

Charles Keeling first measured these values very accurately in 1959. He soon noticed a cyclical variation, i.e., the sawtooth pattern. Vegetation in the Northern Hemisphere takes CO_2 out of the air starting in May and lowers its level in the atmosphere. After September, growth stops, and the number of molecules of CO_2 per cubic meter of dry air begins to increase as people, animals, and microbes eat the vegetation, exhale CO_2, and recycle it.

Over the 1979 to 2021 period, carbon dioxide (CO_2) concentration increased by 78 ppm from 335 ppm to 413 ppm, i.e., 23%. Comparing graphs drawn on the same horizontal scale shows little, if any, the correlation between the level of CO_2 and the Earth's temperature over the 42 years. This result is not surprising because CO_2 is very close to its upper limit for warming the atmosphere, i.e., within approximately 1.5 Watts per square meter [6, 7].

Another constraint on the warming effect of CO_2 is that warming by water vapor overwhelms its warming [8]. Back radiation is a measured value of all of the

radiation back to the Earth from greenhouse gases. Water vapor causes approximately 91% at the Poles and 97.5% at the Tropics. The remainder of 2.5% to 9% is the sum of the warming by CO_2, methane, nitrous oxide, and the remaining trace gases [9].

2.2. Circle 2

Most of the current Earth's temperature measurements use Earth-based instruments. Measurements at some locations are suspect because the heat island effect around cities influences them. The basis of this study is satellite temperature measurements that include the entire Earth. Including Earth as a whole minimizes the impact of heat islands.

Satellite measurements only became available in 1979. Temperatures are updated at the end of every month by the University of Alabama at Huntsville [10, 11]. Since 1979, satellite measurements show temperatures range from 0.5°C below the 1991 to 2020 average to 0.7°C above, for a total range of 1.2°C.

The Earth's temperature is constantly changing and has done so since the beginning of time. In addition to the effect of the Sun, the leading causes are El Nino, which causes the temperature to rise, and La Nina, which causes the temperature to fall. Volcanoes discharge dust into the air, and cosmic rays cause clouds—both cool the Earth [12].

2.3. Circle 3

The baseline for the University of Alabama at Huntsville (UAH) record of satellite temperatures of the Earth is the average from 1991 to 2020. The monthly result at the end of December 2021 is 0.28°C above the baseline.

The box in dashes of Figure **1** is the recorded temperature range for the 42 years of observations, i.e., 1979 to 2021. The box area extended to 2050 is the expected range based on the 42-year history.

2.4. Circle 4

The IPCC establishes the short baseline in AR6 based on the average of temperatures from 2010 to 2019. See Panel (a) of Figure SPM.2 [13]. The difference between the estimated increase in temperature between preindustrial conditions and today from Figure **2** is ≈1.06°C.

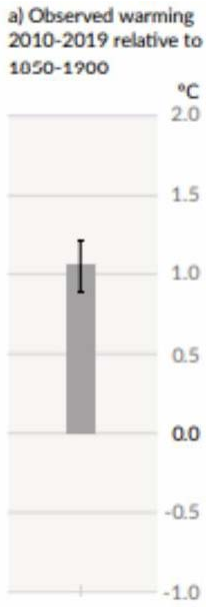

Figure 2: Adapted from Figure SPM.2.

2.5. Circle 5

The 0.0 line of Figure **2** is the IPCC baseline for the pre-industrial temperature conditions. To quote IPCC AR6 on page SPM.5:

> "The period 1850–1900 represents the earliest period of sufficiently globally complete observations to estimate global surface temperature and, consistent with AR5 and SR1.5, is used as an approximation for pre-industrial conditions [11]."

2.6. Circle 6

The temperature increase of 1.5°C above preindustrial conditions that the IPCC claims will be disastrous for people and the Earth.

The range of natural variation shown by the dashed box area will continue even if the baseline reaches 1.5°C above preindustrial temperatures, as shown in Figure **3**. To quote AR6, section B.1.4, page SPM-19 [14]:

> "Global surface temperature in any single year can vary above or below the long-term human-induced trend due to substantial natural variability. Individual years with the global surface temperature above 1.5°C or 2ºC, relative to 1850–1900, does not imply that this global warming level has been reached."

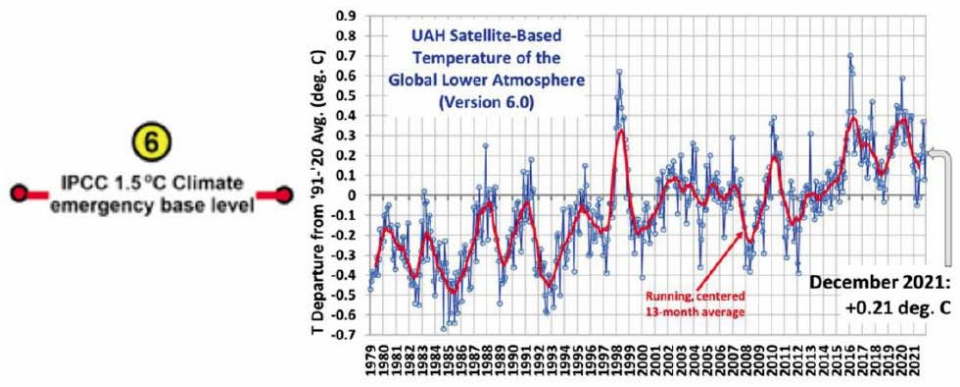

Figure 3: Range of natural variation at 1.5°C above preindustrial conditions.

2.7. Circle 7

Extrapolating the Keeling curve of **Circle 1** by a straight line gives ≈590 ppm in 2050. The increase in CO_2 from 335 to 423 ppm did not move the temperature outside of the range of natural variability. The main reason is that CO_2 is close to its upper limit for warming the Earth's atmosphere [15, 16].

Therefore, it is reasonable to assume the increase to ≈590 ppm by 2050 will not move the temperature outside the natural variability range. Thus, Figure **3** is typical of the temperature range at ≈590 ppm.

2.8. Circle 8

The vertical line represents the year 2050. Similar vertical lines represent years 2030 and 2040.

2.9. Circle 9. H. Abdussamatov

Astrophysicist Dr. Habibullo Abdussamatov is the head of the Space Research Laboratory at the Pulkovo Observatory of the Russian Academy of Sciences, St. Petersburg, Russia. He began publishing work about the Sun in 2007 [17]. In 2016 he published work [18] about the relationships between sunspots and the Earth's temperature. Reference [19] indicates the Earth's temperature could fall to 1.2°C below current levels. A summary of the abstract below shows where he relies on several factors, including the total irradiance (TSI) of the Sun.

Since 1990, the TSI of the Sun has declined. The Earth's previous high level of infrared radiation to space did not decrease the TSI because of the thermal inertia of the oceans. The Earth has a negative average energy balance. Consequently, a new "Little Ice Age" began at the end of the maximum phase of Cycle 24 in 2015. A grand solar minimum can start in the solar cycle 27 ± 1 in 2042 ± 11 as in Figure **4** [19]. The year 2060 ± 11 can experience a phase of deep cooling.

2.10. Circle 10. Zharkova and Shepherd

Zharkova VV, Shepherd SJ, Popova E, *et al*. [20, 21] published their work in 2015. They used principal component analysis and Eureqa artificial intelligence software to predict solar activity on a millennium timescale. The basis of their study is 33 years of data from the Stanford Wilcox Observatory. They used their method to hindcast backward ten millennia. This exercise identified the Little Ice Age, the warm Roman period, and the Minoan warm period. They had a good

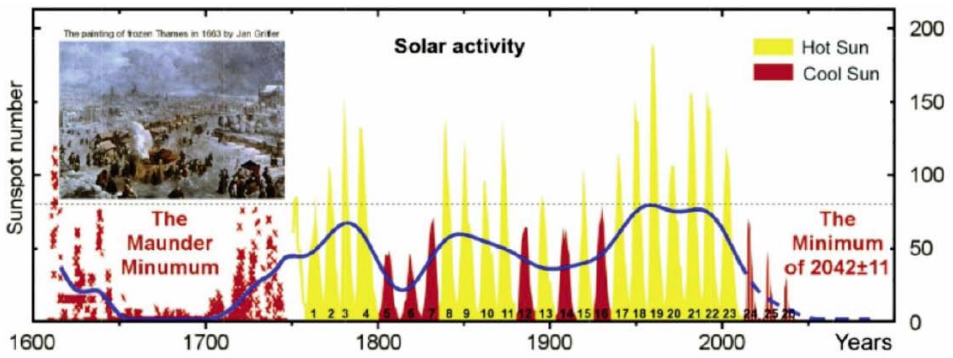

Figure 4: The lower part of Figure **3**: Sunspot record since 1600 with projection of the next solar minimum.

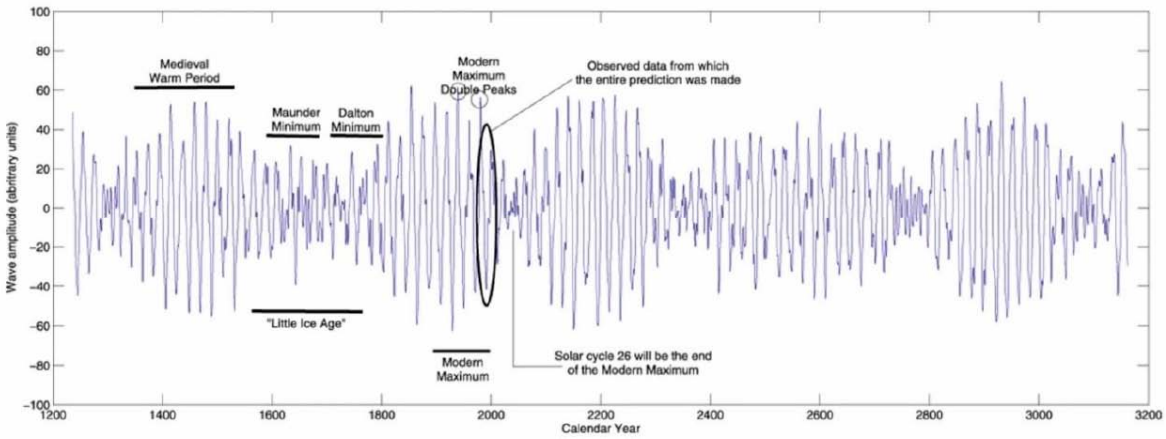

Figure 5: Figure **4** from Reference [20]. Calculated sunspot count from 1200 to 3200 years based on the record of cycles 21–23 marked with a black oval.

fit and extended the method forward to 3200, as in Figure **5**.

As they point out, it is not well known that the sun's output is continually changing. Changes in luminosity, wavelength distribution, sunspots, and outbound plasma streams increase and decrease during the approximately eleven-year solar cycles. The eleven-year cycles increase and decrease in intensity over about 350 to 400-year cycles, as in Figure **5**.

In Figure **5**, they look for a modern minimum in 2030 to 2053 and another in 2350 to 2415.

Figure **6** shows the relevant sunspot activity leading up to the modern minimum that they conclude started with Cycle 25 in June 2020. They estimate the Earth's temperature will drop in the upcoming GSM by about 1^{o}C, or to the level of the IPCC estimate of preindustrial conditions [24].

2.11. Circle 11. Herrera, Soon and Legates

The authors used machine learning similar to the Eureqa software used by Zharkova *et al*. They do the best fit technique to allow for validation over the range 1700 to 2019 and can project forward to 2100. Their results as similar to those of Zharkova *et al*. and indicate a solar minimum is in progress. Their validation and prediction ranges are shorter than that of Zharkova *et al*. However, like Zharkova *et al*., Cycle 24 is smaller than Cycle 23, and projected Cycle 25 is smaller than Cycle 24 as in Figure **4** [19]. Their model forecasts a solar minimum starting in Cycle 24 (2008 to 2019) and continuing to Cycle 27, around 2050. The

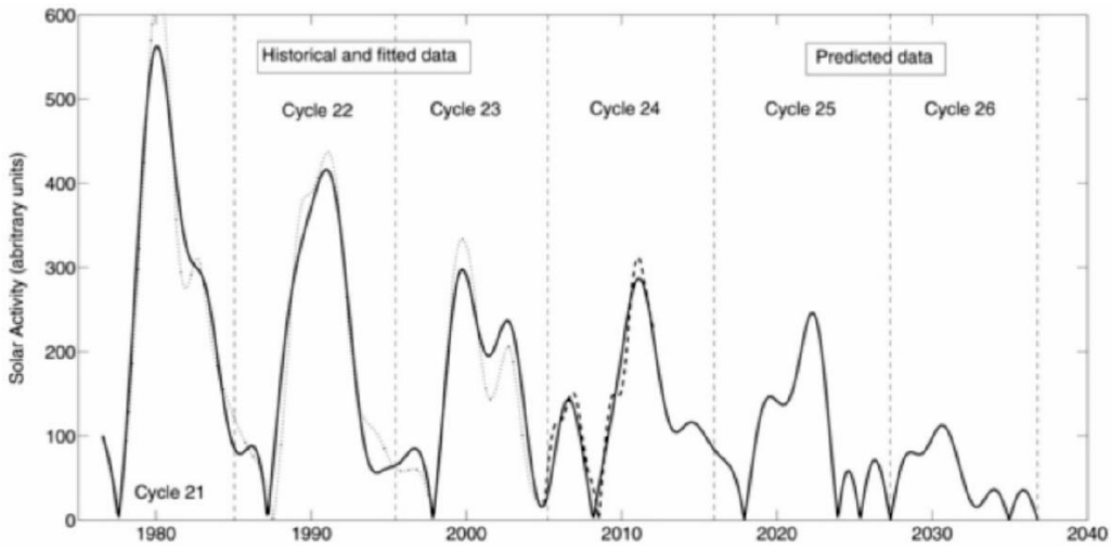

Figure 6: from Reference [22] showing the accuracy of the hindcast and the expected accuracy of the predictions. The solid line is the calculated principal component (solid curve) for cycles 21–23 and predicted for cycles 24–26. The principal component derived from the solar background magnetic field in cycles 21-23 is the dotted curve and for cycle 24 it is the dashed curve.

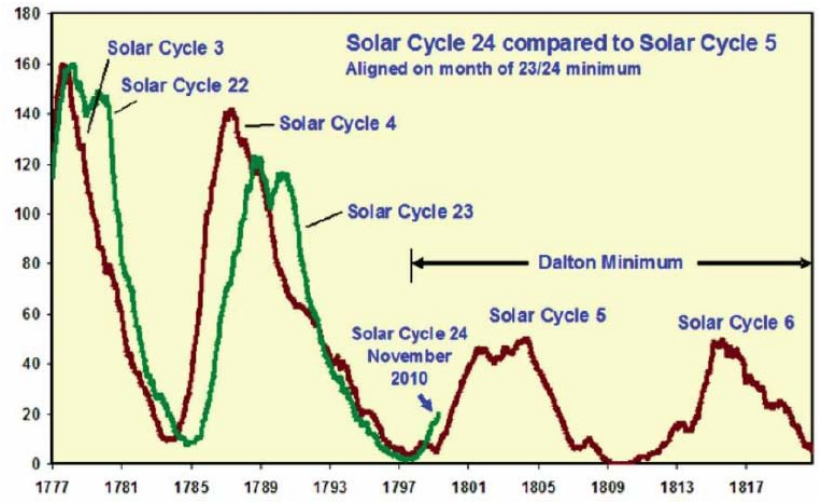

Figure 7: Comparison of Cycles 3 and 4 with Cycles 22 and 23.

expected intensity is similar to that of the Dalton Minimum.

3. OTHER SOURCES NOT CIRCLED IN FIGURE 1

3.1. Predication by Bhownik and Nandy

Solar physicist Dibyendu Nandi and his Ph.D. student Prantika Bhowmik devised a new prediction technique. It simulates conditions in the Sun's interior, where sunspots are created, and on the solar surface, where sunspots are destroyed [23].

Predictions by other researchers suggest sunspot Cycle 25 will be weaker than Cycle 24. But, based on their model, Nandi and Bhowmik believe cycle 25 might be similar to or even more robust than 24. They expect Cycle 25 to start in 2019 and to peak in 2024. They did not make further predictions.

3.2. David Archibald

In 2010, David Archibald studied the energy output of the Sun and prepared Figure **7** [24]. It indicates that Cycles 22 and 23 are similar to Cycles 3 and 4, which constitute the Dalton Minimum of 1790 to 1830. His method appears to be finding previous cycle configurations that match current experience.

3.3. Royal Observatory of Belgium

The Royal Observatory of Belgium is the repository for the Sunspot Index and Long-Term Solar Observations (SILSO). It is the World Data Center for producing, preserving, and disseminating the international sunspot number [25].

Figure **8** shows Sunspot cycle 24 and the start of Cycle 25 to December 1, 2021. Extending the horizontal axis and adding line AB should help indicate which of the five estimates studied are correct. Only the average prediction by Bhownik and Nandy should be above line AB.

4. WATER VAPOR

The IPCC report Climate Change 2013: The Physical Science basis brought to the fore the important role of water vapor in the Earth's temperature. It states an increase in specific humidity caused an increase in the Earth's temperature over the 40-year period mid-70s to 2011. This is sunspot cycles 21, 22. and 23. From Figure **4**, all three have substantially more sunspots than either cycle 20 or 24. As we know, the earth's temperature is related to sunspot activity; therefore, it is reasonable to conclude the increase in temperature of 0.5 ˚C was caused by the Sun [26].

5. SUMMARY AND CONCLUSIONS

In Figure **1**, the upper line of triangles is an estimate by H. Abdussamatov [27]. The history of reduced sunspots, the TSI, and other factors are the basis for his assessments. From 1645 to 1710, the Maunder Minimum was when the number of sunspots was at a minimum, and the Thames River in England was frozen over. Paintings in 1677, 1683, and 1684 show cultural events held on the ice.

Shepherd and Zharkova estimated the lower range of triangles. Estimates by other researchers predicting a Dalton Minimum, shorter and less deep, fall between the two lines of triangles.

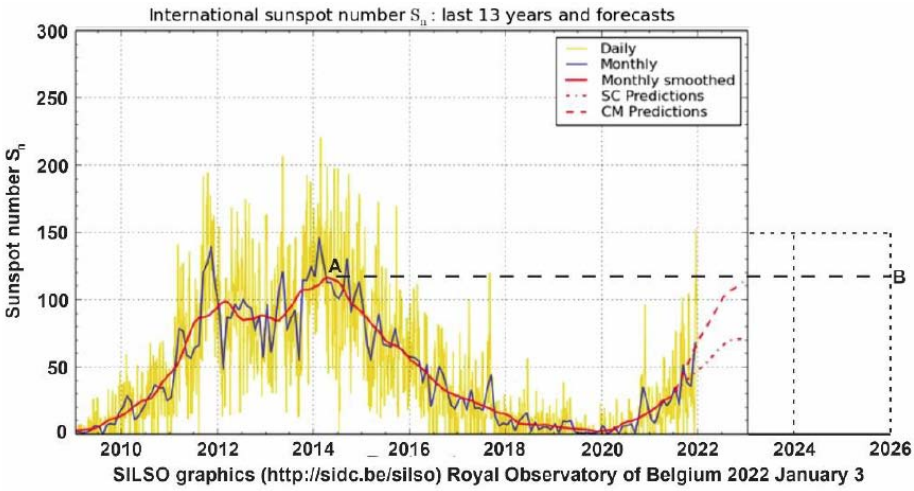

Figure 8: Adapted from: SILSO data/image, Royal Observatory of Belgium, Brussels. Sunspot numbers to January 3, 2022.

In addition to the diminishing sunspots, the magnetic fields of the Sun change as its energy output falls [20, 28]. Based on previous events when the energy output of the Sun diminished, it is not unreasonable to expect the baseline temperatures to fall below the 1991-2020 baseline of Figure **1**.

This study estimates the Earth's average temperature in 2050 based on information not available to the authors of the IPCC First Assessment Report issued in 1990. This report claimed that increasing CO_2 increases the Earth's temperature. The increase allows the air to hold more water vapor that amplifies the warming by CO_2, a concept promoted in IPCC reports since 1990.

Since then, much has been learned about the factors affecting the Earth's climate to prove the IPCC concept is incorrect. Satellites now accurately measure temperature all around the Earth. The warming effect of CO_2 is limited. Water vapor has a much more significant impact on warming and overwhelms warming by CO_2. The results of the Sun's variation in energy output on the Earth's temperature are much better known now. As the Sun's energy output falls, the Earth experiences cold periods, such as the Maunder Minimum, when average temperatures dropped by 1 to 1.5^{o}C. There is some controversy over whether or not the incidence of volcanic activity is related to low energy output by the Sun. It is irrelevant. If it is true, then part of the cooling of the Earth can be attributed to volcanic action during a solar minimum. If it is not valid, the Sun contributes all of the cooling. In either case, the result is the same. This study compares the IPCC forecast of temperatures to a prediction based on up-to-date science.

Ocean currents that result in El Nino and La Nina cause various ups and downs in the satellite temperature record. Volcanic eruptions eject dust and gases into the atmosphere and block the sunlight. Cosmic rays affect cloud cover that cools the Earth.

Reliable evidence shows that a solar minimum has started, causing significant crop failures due to frost and excessive heat.

Four different methods lead to the same conclusion; the Solar Minimum is here. This fact is compelling. Ignoring science is not an option. The uncertainty lies in the temperature drop that it will produce. Will it be deep and long like the Maunder Minimum or shorter and less deep like the Dalton Minimum? There is physical evidence the solar minimum has started. For example, when the Sun's energy output falls, the Jet Stream is not as steady and uniform as when the Sun is strong. The variation in the Jet Stream is one indication the Sun is not putting out as much energy. At present, the Jet Stream pushes extreme heat and cold to places that do not usually experience such extremes. Thus, in 2021, there were crop failures caused by frost and too much heat.

ADDITIONAL CONCLUSIONS

1. A solar minimum appears to have started around the beginning of sunspot cycle 25. During this current minimum, the Earth's average temperature can fall as low as 1^{o}C to 1.2^{o}C below the current 1991 to 2020 average.

2. Because of significant crop failures, governments must now provide sufficient food

and warmth for their citizens as the solar minimum progresses. Between 2030 and 2050 is expected to be the time of deepest cooling.

3. The Sun's energy output is the primary control of the Earth's temperature. It does this by evaporating enough water to control the level of water vapor in the air.

4. The monthly reports of the satellite measurements of the Earth's temperature and the number of sunspots are available to help follow the course of the solar minimum.

5. The IPCC concept that increasing carbon dioxide in the atmosphere causes global warming is three decades out-of-date. Recent information proves it is obsolete and incorrect. It is time to strengthen the IPCC Executive Committee by adding three independent members who include individuals from outside the climate community as recommended by the InterAcademy Council in 2010 [29].

CONFLICT OF INTEREST

There is no conflict of interest with either author.

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