A NEW METHOD OF ASSESSING CLIMATE SENSITIVITY BY C.BARNES JULY 2025

A new method of assessing Climate Sensitivity.

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Chris Barnes*

Manager, Bangor Scientific and Educational Consultants

Email address: gmbarnes@btinterent.com

**Corresponding Author: doctor.barnes@yahoo.co.uk*

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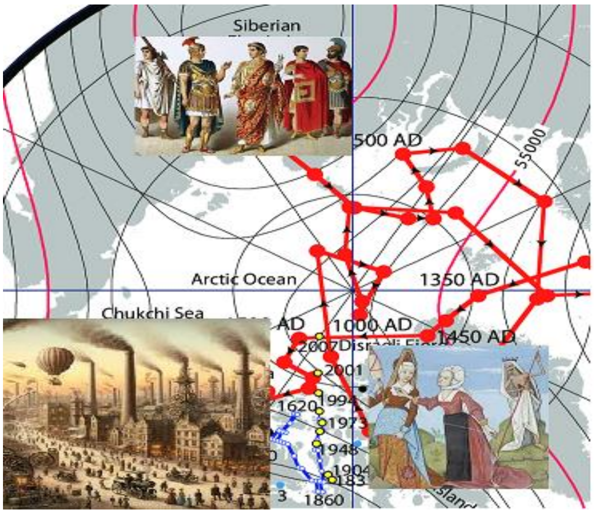
Abstract— The IPCC regards carbon dioxide as the most relevant driver of climate warming and their Sixth Assessment Report (AR6) refines this to a likely range of 2.5°C to 4.0°C and a very likely range of 2.0°C to 5.0°C for climate sensitivity to a doubling of present levels of atmospheric carbon dioxide. Since this is a very large range the need exists to find a method to better quantify climate sensitivity. Previous methods do not consider that there could be other hitherto undiscovered climate drivers, which may be heavily inter-correlated with carbon dioxide. Such a driver is magnetic pole shift, which via energetic particle precipitation impacts on cloud albedo, which would be expected to mimic the effect of a non-constant climate feedback. Climate sensitivity is usually estimated by direct observation of SST and cloud tops or by Global Climate models. The question posited here is concerned with how much the temperature increase is due to pole shift induced albedo reduction and how much it is due to CO2. Granger causality is employed to confirm the validity of the method and independent paleo-climate data is employed together with the GISTEMP v4 dataset to develop a simple new method to estimate climate sensitivity, which works because carbon dioxide concentration was almost flat in the two warm periods preceding the industrial era. The model yields a range of climate sensitivities for a doubling of CO2 of between .105K and .318K depending on the date range of the modern warming data set employed. Higher sensitivity occurs post 1970. A sensitivity of .372 K for doubling was required to produce the best retrospective model data fit. This is probably an overestimate, as other warming factors were not modelled.

Keywords— IPCC, climate sensitivity, climate model, magnetic pole shift, carbon dioxide, CO2, albedo, cloud albedo, paleo-climate, ENSO, SST, climate feedback, MWP, RWP, modern warm period, post-industrial, climate driver.



Graphical Abstract

- As dip pole moves North –planet warms
- Warming slope RWP to MWP =67 mK/degree
- With CO2 fixed
- Modern warming same process + effect of CO2
- Slope =74 mK/degree hence estimate climate sensitivity

1. Introduction

1.1 The need for a method to assess climate sensitivity.

The IPCC regards carbon dioxide is the most relevant driver of climate warming and their Sixth Assessment Report (AR6) refines this to a likely range of 2.5°C to 4.0°C and a very likely range of 2.0°C to 5.0°C for climate sensitivity to a doubling of present levels of atmospheric carbon dioxide. Since this is a very large range the need exists to find a method to better quantify climate sensitivity. This present paper addresses that need. Few estimates of climate sensitivity use direct observational methods, most use climate modelling and consider many parameters and feedback, especially water vapour feedback. If models are under-parameterised or incorrectly parameterised or if the sign and/or magnitude of any feedback is incorrectly specified large errors could occur. Moreover, in making these estimates, the IPCC do not consider that there could be other hitherto undiscovered and major climate drivers, which may be heavily inter-correlated with carbon dioxide. Such a driver, proposed by the present author, is the effect of magnetic pole shift via EEP on cloud albedo, which would be expected to mimic the effect of non-constant feedback. Knutti and Rugenstein (2015) discuss problems due to the non-constant feedback.

1.2 Other and inter-correlated drivers

It has been suggested several times that earth's climate may be to some extent geomagnetically controlled, see Bucha (1980) [2] and Kerton (2009) [3]. More recently the present author has advanced and explained the mechanism for such control as being the predominant driver of climate, up to some 90% of post industrial temperature increase, and has further showed that this allows seamless modeling of our present modern warm period with previous cold and warm periods as far back as Roman times, this modeling method only being limited by availability of paleomagnetic data, see Barnes (2025) [4]. It has also been shown how the method is not only applicable to global average temperatures, but also with those in latitudinal bands, see Barnes (2025) [5].

In the first paper the author developed a model employing the latitudinal position of the Magnetic Dip Pole alone and estimated a maximum contribution to warming of only about 6% due to CO2 based on model regression alone. It was, however, pointed out that there existed a strong multi-collinearly of Northern Dip Pole position and atmospheric Carbon dioxide concentration. Predicted amplitudes and epochs for previous cold and warm periods were also evaluated for two models, one with CO2 included and one without. Of particular interest to this present work is that the model without CO2 included predicted amplitudes for the medieval warm period very similar to that of our present warm period.

In the second paper residuals from a more complex two Pole magnetic model were used in additional linear regressions with known and potentially suspected additional climate drivers including inter-alia, carbon dioxide and sulfur dioxide. The conclusion again broadly in line with the first paper was that CO2 only produces weak warming corresponding to about 1% of warming or only 2mK per decade, in Northern mid-latitudes and to 5% or 32 mK per decade in Polar regions. This latter figure is not unlike the estimate reached in the first paper. Although a body of evidence exists to suggest that climate sensitivity to carbon dioxide could be low and was discussed at length in the second paper [5], clearly and nevertheless these values fall well short of traditional expectations maybe in view of multi-collinearity [4]. This will be discussed and employed below to develop the said new method of assessment.

1.3 Paper Layout

Section 2 of this paper discusses related work for obtaining climate sensitivity. Section 3 explains the theory behind the multi-colinear behavior of magnetic pole shift and CO2 as drivers. Further discussed here is the proposed paleo-based methodology to unlock in order to estimate climate sensitivity. Section 4 describes the steps of the proposed experimental procedure. Section 5 describes in more detail how the procedure was carried out, the results obtained and their implications for climate science in general. Finally, section 6 describes the conclusions and future scope of the work.

2. Related Work

2.1 Climate sensitivity

There are literally thousands of academic papers and articles dealing with climate sensitivity. It is therefore not possible to review them all in the short space available here. Since ‘traditional’ climate science regards CO2 along with water vapor and to lesser extent ice albedo feedback as being the main climate driver, then as a first approximation then an idea of climate sensitivity ought to be able to be obtained directly from a linearized approximation of the temperature/time slope from pre-industrial to present day. This equates to 76 mK/decade globally but 97 mK/decade at Northern mid latitudes and about 170 mK/decade at the North Pole. Assuming a linear model for CO2 and that the added 130 ppm of CO2 has caused all the warming is suggestive of circa 2.6K per doubling. Although this simple method produces a value, which lines up well with IPCC estimates it does not include the crucial non-constant feedback (driver), which is the topic of this and the author’s other work. Such assumptions are also far from ideal and Munshi (2018) has discussed uncertainty in empirical climate sensitivity estimates [6].

2.2 Direct observation methods

In practice, however, climate sensitivity is estimated by direct observation of SST and cloud tops or by Global Climate models.

Gregory et al (2002) discussed ‘An Observationally Based Estimate of the Climate Sensitivity’ and evaluated a minimum of 1.6 K to doubling and a maximum of 4.5K based on data from 1860 onwards [7]. Moreover, they concluded that radiative forcing is the greatest source of uncertainty in calculation. Of course, at the time they were unaware of the uncertainties being introduced by Pole shift and present author’s finding on its impact on cloud albedo, hence that very radiative forcing.

2.3 GCM Methods

Calculations of climate sensitivity based on Global Climate Models (GCMS) yield the largest possible range from as low as .7 K per doubling, see Washington and Meehl (1989) [8], to moderate values such as 1.6 K per doubling, see Bengtsson and Schwartz (2013) [9] and values closer to 4K, see for example but not exclusively Cesana and Del Genio (2021) [10].

2.4 Unaccounted feedback

Lindzen and Choi (2011) find hitherto unaccounted negative feedback in relation to SST behavior, which reduces climate sensitivity [11].

2.5 Cloud and cloud albedo

Crucial to this present work, it is increasingly recognized that clouds and cloud albedo play an important role in climate change and modify water vapor (WV) feedback, see for example Hartmann and Larssen (2002) [12].

For example, the disappearance of ship tracks due to cleaner fuel has caused significant and possibly unexpected heating; see for example Manshausen et al (2022) [13].

Clouds, their disappearance and distribution are of course fundamental to the present author's previous and recent work [4,5]. Clouds are an extremely important feature, emphasized by Mueller et al (2011) [14]. Interestingly, their data show exactly what was implied by the present author's pole shift hypothesis i.e. warming due to reduced cloud albedo everywhere except over the oceans of the southern hemisphere, especially near to its geomagnetic anomaly, see Barnes (2025) [5].

2.6 Paleoclimate and the common geomagnetic driver

Feng Shi et al (2022) point out that the RWP was warm through the mechanisms of surface albedo and lapse rate feedback [15]. Low volcanism is postulated as a cause, but the present author's EEP hypothesis was unknown and unexplained at their time of writing and of course yields the same kinds of changes. Chen et al (2011) suggest that the changes in the RWP were cyclic climate changes are linked to the North Atlantic Oscillation and solar forcing as there were warmer SSTS [16]. Warmer SST's in the Northern Hemisphere are also exactly as predicted by EEP hypothesis and low cloud disappearance.

Volpert and Chubara (2021) show that for the modern period 1968-2016 solar heating is not so much due to change in the sun but rather because of non-linear transmission changes in cloud optical density and its amount, except where cloud is heavily entrained with industrial aerosol [17]. Again, this can be explained by the author's EEP process [4,5] and is highly suggestive of the fact that the same process that caused the RWP is also causing modern warming. Hunt (2006) uses the CSIRO MK2 GCM to model and explain the MWP and is unable to do so. Hence it was concluded that 'external forcing must have been involved' [18]. Since the notion and effects of a geomagnetic driver were not built into the model, this conclusion is hardly surprising and does not detract from the present findings.

Reinforcing the present author's assertion of a common geomagnetic driver across all three warm periods, Diodato et al (2025) consider phases of the Atlantic Multidecadal Oscillation. They suggest that complex dynamics have brought modern warming cloud patterns closer to those observed during the medieval period before c. 1250, exceeding the background variability of the Little Ice Age (c. 1250 to 1849) [19]. Moreover, recent decades have witnessed an unprecedented coupling of intense solar activity, high temperatures, and the lowest cloud cover on record. Nikolov and Zeller (2024) have also exposed low cloud cover, which lowers cloud albedo [20]. Allan and Merchant (2025) also confirm that there has been a doubling of Earth's energy imbalance from 0.6±0.2 Wm−2 in 2001–2014 to 1.2±0.2 Wm−2 in 2015–2023 which is primarily explained by increases in absorbed sunlight related to cloud-radiative effects over the oceans. Moreover, they confirm that observed increases in absorbed sunlight are not fully captured by ERA5 and determined by widespread decreases in reflected sunlight by cloud over the global ocean [21].

The present author believes that the evidence contained in the above references together with his previous work is sufficient proof that the same Pole Shift phenomenon and associated reduced cloud albedos are responsible for all three warm epochs. See additional work at section 6 below.

3. Theory/Calculation

3.1 CO2 and Pole shift dual drivers

The incredibly high correlation regression coefficient, see Figure 1, between carbon dioxide and dip pole latitude seems unlikely to arise by chance and is the driver of the high multi-collinearity between temperature and these two parameters. Indeed, this coefficient is substantially higher than either carbon dioxide or pole shift individually with temperature. Implicating they could both have a part to play?

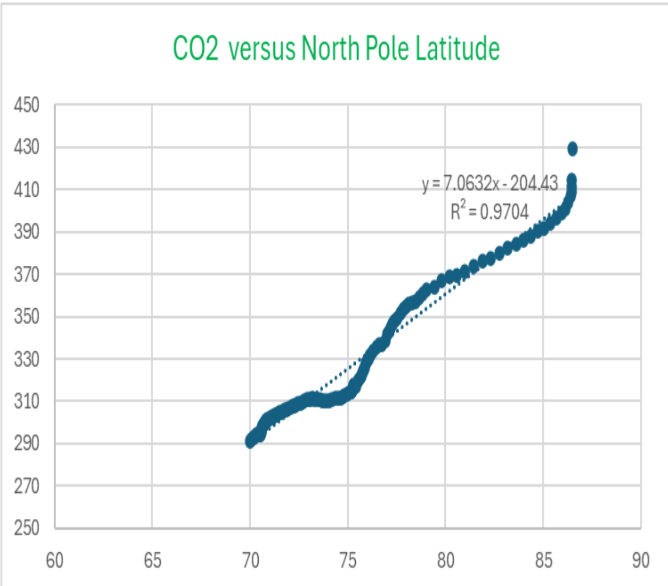


Figure 1: CO2 concentration (ppm) y-axis versus Northern dip pole latitude (degrees) x-axis. Also shown is linear trendline and correlation coefficient.

It is thus necessary to explore the relationship in more detail. It is hard to visualize how carbon dioxide could be the driver of pole shift. But similarly at first glance, so is the reverse.

In situations like this it is instructive to take the Granger Causality test. Consider first Granger PS = f (CO_2). Although the p -value for 1 year lag is quite low 0.02 so is the F value 5.5, which could potentially indicate a causality, yet there is no known physical mechanism for the same. On the other hand with a 3-year lag Granger CO_2 = f (PS) produces astounding results, summarized also with other lags, see Table 1, where PS = Latitudinal pole shifts in degrees.

Table 1: Granger p and F values for CO_2 =f (PS)

Lag years	P-value	F-value
1	0.157	2.01
2	2*10^-5	9.08
3	5.5*10^-6	10.01
4	1.08*10^-5	7.85
5	2.7*10^-5	6.35
11	4.9*10^-5	4.1

3.2 The link with ENSO

It is well known that ENSO drives changes in CO_2; see Betts et al 2020 [22]. The implication proposed here is that by changing clouds, albedo and hence SSTS, Pole Shift together with solar forcing facilitates ENSO events. The causal link proposed is in EEP driven albedo change is as discussed previously by the present author [4,5].

Essentially, the result produced should be a repeating oscillatory signal with delay on a gradually increasing background. Thus, as pole shifts, albedo falls, temperature rises, and Henry's Law releases more CO_2 from the oceans. Part of the released CO_2 being in proportion to that which was initially anthropogenically added and initially absorbed, prior to re-release and or re-release + additional release by the oceans. In pre-industrial times the oscillatory process would still have been present but overall, but by design the CO_2 levels were more stable. This is the only sensible way in which PS is seen as the lagged driver and explains the very high correlation seen.

3.3 The weighting of the drivers.

The question posited here then concerns the weighting of these drivers, and is and has critically to be how much the temperature increase is due to albedo shift and how much it is due to CO_2? Because of multicollinearity, this is at first sight seemingly extremely difficult or almost impossible question to answer. Both have extremely high regression coefficients and both Granger very similarly with lowest p value and highest F value at 1-year lag showing both are climate drivers. It may not be adequate to simply employ whichever has best correlation coefficient, although for simplicity the author has used this approach before [4]. For example, Caldwell et al (2014) have shown by data mining that correlation magnitude is not necessarily proof of predictive skill in Climate models [23].

3.4 Estimating if and how much paleo warming CO_2 caused between RWP and MWP.

The secret is to find an independent way to unlock the co-linearity. The author's first paper provided two models capable of hindcasting the presence of a Roman Warm Period (RWP) and a Medieval Warm Period (MWP). Since carbon dioxide was relatively flat during those periods it is sensible to propose that all the warming was due to Pole shift. According to the one available reference, CO_2 was almost stable at between 260-280 ppm in the RWP. The other two references state that CO_2 was flat at exactly 280 ppm, thus based on which ranges quoted the author calculate an average of 276.7 ppm for the RWP. Four references quote CO_2 as 275-280 ppm in the MWP and one other states 'not exceeding 300 ppm; this gives a weighted average in the region of 280 ppm. Purely for the basis of testing if this small difference in concentration found between the two historic warm periods under consideration, a traditional climate science approach that modern warming has been due to CO_2 has been used to yield the equivalent temperature difference for the 3.3 ppm between the RWP and MWP. This would set lower and upper limits of the temperature of the MWP relative to the RWP at a +6mK and +36.5mK warmer than the RWP respectively. This is not what is observed and clearly the real and significantly larger difference found either by the author's previous pole shift modelling [4] or by inspection of paleo-data Figure 2 below, is some 480 mK.

What would not be reasonable, however, would be to simply use the modelled values [4] for the proposed methodology to be developed here. If, on the other hand, independent data were available for temperatures at the peaks of those two historic periods, which could be then used in conjunction with the degree of magnetic Pole shift encountered, a new method for climate sensitivity could be developed, see section 4 below.

4. Proposed Experimental Procedure.

1. Assume all temperature change between RWP and MWP was due to Pole Shift, discussed and justified in section (3) above.

2. Record starting (RWP) and ending (MWP) latitudes, hence difference in degrees.

3. Calculate temperature change MWP-RWP.

4. Divide said change at (3) by said difference at (2) to calculate an effective warming slope per degree of pole shift.

5. Plot modern warming data set (GISTEMP v4) temperatures versus latitude and calculate modern 'equivalent' slope. Graph slope.

6. If slope is equal to slope at (4), all warming is magnetically driven.

7. If slope exceeds slope at ascribe difference to anthropogenic drivers and entirely to CO_2 to represent the worst-case CO_2 scenario.

8. Convert slope difference to temperature.

9. Look up CO_2 concentrations at dates in dataset as in (5).

10. Calculate temperature change per ppm of CO_2.

11. Hence from (10) calculate climate sensitivity for CO_2 doubling. A simple linear approximation is made.

5. Results and Discussion

5.1 Applying the procedure and obtaining results

The Northern magnetic dip pole position at the peak of the RWP was 82 degrees North and at the peak of the MWP it was 89 degrees North, data obtained by interpolation from graphic presented in a paper by St. Onge and Stoner [24]. Applying step 2 of the experimental procedure yields a difference of 7 degrees.

There are several references suggesting that the MWP was 1-2C warmer than the period around the 1900's, e.g. Lamb (1965) [25]. There is evidence that the MWP was global but not necessarily synchronized on a global basis, see Cook et al (2002) [26].

There is less specific information available on the RWP but Desprat et al. (2009) concludes the existence of "a millennial-scale climatic cyclicity over the last 3000 years which was detected for the first time in NW Iberia paralleling global climatic changes recorded in North Atlantic marine records (Bond et al., 1997; Bianchi and McCave, 1999; Chapman and Shackelton, 2000)" [27]. On this basis the establishment of the Modern Warm Period over the course of recent history may be nothing more than the most recent manifestation of the warming phase of this ever-recurring cycle of climate, which is totally unrelated to or the most only weakly related to increases in the air's CO_2 content.

In the book 'The Science of Roman History Biology, Climate, and The Future of The Past Edited by Walter Scheidel, Chapter 1 Kyle Harper & Michael McCormick discuss 'Reconstructing the Roman Climate' and a plot of temperature anomaly is supplied, see Figure 2 [28].

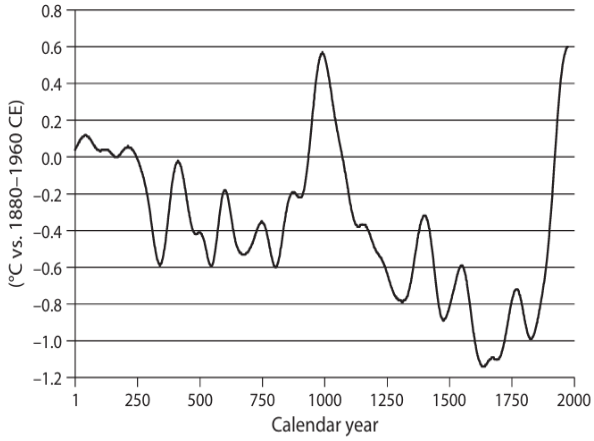


Figure 2: Temperature anomaly, two thousand years from year 1 A.D., courtesy of NOAA public data, paleo contributions.

Applying steps 3 and 4 of the experimental procedure MWP-RWP yields at temperature difference of 480 mK. Step 4 hence yields a warming rate of 68.57 mK/degree.

The result-applying step 5 for the entire modern warming period is shown in Figure 3 below.

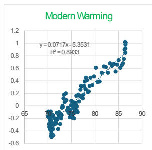


Figure 3: Modern warming whole post-industrial period temperature anomaly y-axis versus Northern dip pole latitude x-axis.

The slope of 71.7 mk/degree is slightly greater than that for the paleo- climate condition defined by steps 1-4 above. Applying steps 8-11 yields an excess warming rate of 3.13 mK/degree, which if all applied to anthropogenic CO2 would yield 53.953 mK per 138 ppm of CO2 additional beyond pre-industrial and using a simple linear extrapolation yields some 105 mK or .105 K per doubling.

5.2 Accelerating emissions

However, CO2 emissions have not been constant throughout the period but instead have been accelerating and in recent years SO2 emissions have been falling, see Sun et al (2018) [29]. It is known that SO2 has offset warming; see, for example, Mitchell and Johns (1997)[30]. Inspection of the rate of change of CO2 with time shows a breakpoint at circa 1970 thereafter emissions increase more steeply. It must not be forgotten that decreased albedo can cause more ocean out-gassing in this respect. It is therefore pertinent to inspect the warming rate from 1970 –2020, shown in Figure 4 below.

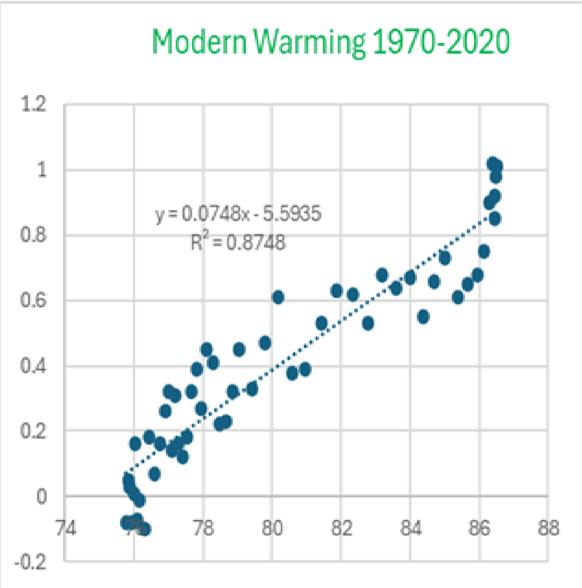


Figure 4: Modern warming temperature anomaly y-axis versus Northern dip pole latitude x-axis. Plot for period 1970-2020 only.

The slope of 74.8 mK/degree is greater than that for the entire pre-industrial period and for the paleo- climate condition defined by steps 1-4 above. Applying steps 8-11 yields an excess warming rate of 6.23 mK/degree, which if all applied to anthropogenic CO2 would yield 64.415 mK per 104 ppm of CO2 additional beyond 1970 and using a simple linear extrapolation yields some 318 mK or .318 K per doubling.

5.3 Time series

Thus, a range of climate sensitivities of between .105K and ,318K per doubling has been obtained. These effectively represent changes over a time series.

Kaufmann et al (2006) have considered the notion of climate sensitivity increasing over a time series and also comment that the bulk of warming over the post-industrial period can be accounted for simply by considering CO2 and SO2 [31]. Their comment on regression results also indicating that increases in surface temperature since 1870 have changed the flow of carbon dioxide to and from the atmosphere in a way that increases its atmospheric concentration is particularly interesting as it is exactly as is predicted by the present author's work [4,5]. Of course, they did not at the time of writing have access to this or knowledge of albedo driven ENSO changes.

5.4 Comparison with IPCC and other estimates.

To date IPCC have presumably been unaware of magnetic pole shift as a major climate driver or for whatever reason unable or unwilling to acknowledge the same. The climate sensitivities to CO2 obtained by decoupling it from the pole shift driver not considered by IPCC and not included in GCMS yields sensitivities to doubling of CO2 some 13 -40 times lower than most estimates. The results are significantly lower than IPCC estimates and even at worst are just under half the value obtained by Washington and Meehl (1989) [8].

6. Conclusions and Future Scope

6.1 Conclusions

This research has confirmed the low climate sensitivity to CO2 hinted at in the author's previous work. Sensitivity to doubling lies in the range .105-.318K depending on the length of the time series considered. The work further confirms that our climate is predominantly geomagnetically driven and by CO2 as a secondary and highly inter-correlated driver. We are now at the time where an urgent paradigm shift in both climate science and climate policy is required. Those responsible for climate modeling will now be able to incorporate this new, exciting and hitherto unknown or ignored parameter into their models.

6.2 Further testing

This work and previous works of the author [4.5] have raised an assertion that the process of geomagnetic pole shift can describe our modern warming predominantly. The power of this assertion is tested as follows see Figure 5.

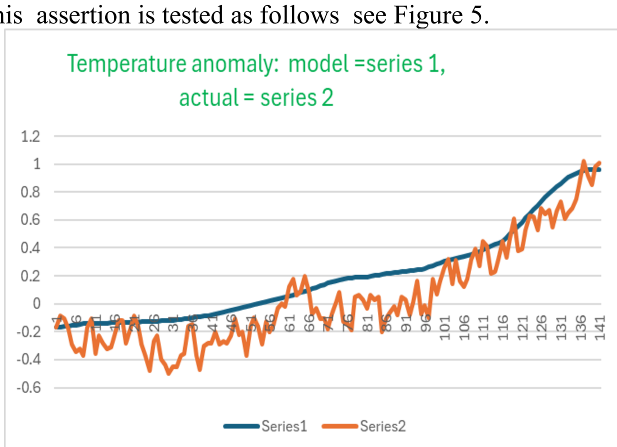


Figure 5: Temperature anomaly y axis versus years since 1880 (postindustrial period) x-axis modelled on zero CO2 slope of 68.57mK per degree of dip pole latitude as per step 4 of procedure. R^2 =.895.

It can be seen from figure 5 that an extremely good fit to the modern warming data post 1880 is obtained by simply using the paleo temperature versus latitude slope established from the difference between the peaks of the RWP and MWP. Indeed, it was not readily possible to improve upon the correlation by adding in any CO2 functionality.

As post-industrial time evolves, however, some slight warming over and above that predicted by magnetic Pole shift alone is evident, see Figure 6.

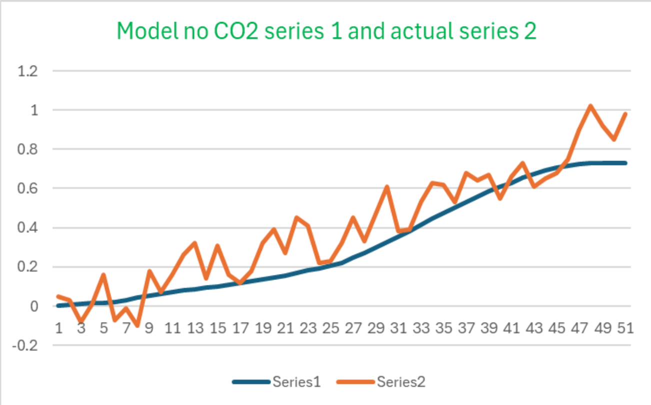


Figure 6: Temperature anomaly y-axis versus years since 1969 x-axis modelled on zero CO2 slope of 68.57mK per degree of dip pole latitude as per step 4 of procedure. R^2 =. 8674

The correlation coefficient remains respectable, and it could be argued it is slightly lower on the basis of a smaller data set but the time series change means that increasing CO2 evolution and/or other drivers must be having some kind of effect.

The best fit obtained, Figure 7, was to keep the Pole shift slope at 68.57 mK/degree as above and factor in CO2 at .724 mK/ppm equivalent to 75.4 mK since 1969 or just slightly greater than the worst estimate for doubling, now yielding .372K for doubling.

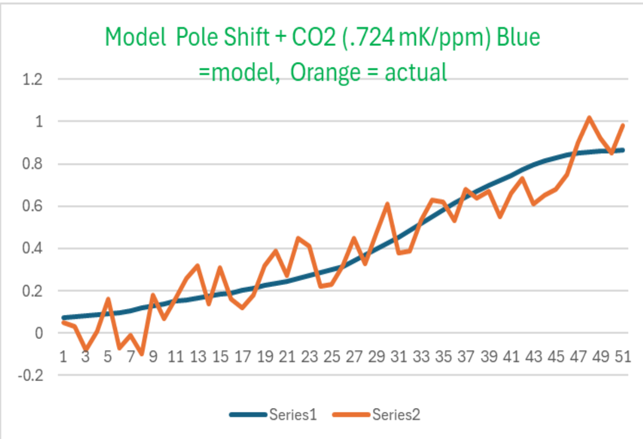


Figure 7: Temperature anomaly y axis versus years since 1969 x-axis modelled on zero CO2 slope of 68.57mK per degree of dip pole latitude as per step 4 of procedure plus CO2 according to procedure. R^2= .8718

It should be born in mind, however, that two other factors besides CO2 were exposed as warming candidates in the author's previous work, namely aviation and world electrical energy transmission [5] and hence the figure of .372 K is probably an overestimate.

6.2 Future scope

There is a future scope for checking this method again within the next few years, as magnetic Pole Shift is now slowing again.

There is also scope for building a simple climate model based on Pole Shift and the above climate sensitivities combined with other parameters. For example, there is also scope for building a three-parameter climate model built on magnetic Pole Shift, CO2 and SO2 sensitivity of the latter being obtained from the author's earlier work [5]. There is similar scope for building a four-parameter model with the three parameters referred to above and including the effects of the other warming drivers from the author's earlier work [5].

Data Availability

The climate data employed is readily available online and is GISTEMP v4.

For the position of the magnetic North Dip Pole, data from NOAA [IGRF] was employed. For Paleomagnetic data, reference [24] was employed the only limitation being the need for visual extrapolation from the pole shift diagram.

Conflict of Interest

None.

Funding Source

None.

Authors' Contributions

The entire work was researched and drafted by author 1 including all ideas, models and calculations and conclusions.

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AUTHOR PROFILE

Chris Barnes earned his BSc Hons. in Materials Science from Bangor University in 1977, with subsequent degrees of MSc and PhD in Electronics in 1979 and 1982. He worked as a university research fellow in Medical Ultrasonics and Biosensors until 1991. He then ran his own business, during which time he became holder of several UK and International Patents. Chris then entered a teaching career and progressed quickly to become Head of Chemistry at Hillgrove School and Deputy Head of Electronics and Physics at Nelson Thornes Distance Learning. Chris was also a Lead teacher in Physics and Electronics at Inter-High online International School. Chris also holds UK QTS and Chartered Educational Assessor status. Chris has some 40 publications spanning a wide range of scientific and engineering disciplines and of late does independent and innovative multi-disciplinary research including in Climate and Biological Sciences under the umbrella of Bangor Scientific and Educational Consultants a wholly non-profit organisation. Of late Chris has developed single-handed magnetic models of climate and has published the same in the previous two issues of this year's IJSRPAS.