An Analysis of the Mean Global Temperature Anomaly in 2031 (Draft)

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Introduction

After reading a recent book by John L. Casey, *Dark Winter*, 2014, about the start of a global cooling event due to a sunspot minimum, a post by Dan Pangburn on the HOCKEYSCHTICK website, 2013, recent comments on Casey's research posted on Jim Milks website, January 8, 2015, Alan Carlin's book, *Environmentalism Gone Mad,* 2015, and John Christy's testimony to a Congressional committee on climate change, February 2, 2016, I felt compelled to comment on the issue of global warming. I acknowledge that I have only a general knowledge of climate science. However, most of my career in the oil industry has involved solving problems based in geology and making predictions on where to find oil and gas and the amount to be expected. Predictions are also the main currency of climate scientists.

Background and Data

Three predictions of the mean global surface temperature anomaly in 2031 are 0.91^oC (Milks, 2015), 0.15 ^oC (average of two estimates) (Pangburn, 2013) and -0.75 ^oC (Casey, 2014, Figure 1). The reference temperature is the mean temperature over the 30-year period from 1961-1990.

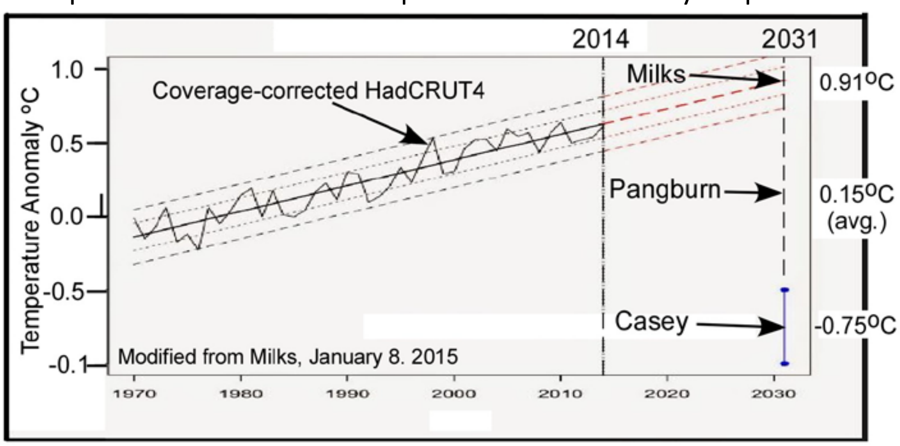

Figure 1: Milks' prediction (2015) for the global temperature anomaly in 2031 compared to Casey's prediction (2014) and the average of Pangburn's predictions (2013).

The main driver for Milks' high prediction is increased green-house gases in the atmosphere. The main driver for Casey's and Pangburn's low predictions is low sun spot activity. This analysis will use a simple but rigorous mathematical analysis to calculate a most likely estimate of the temperature range in which the 2031 temperature anomaly will lie by statistically weighting the high and low best estimates. (See references 5, 6, 7, 9 and 10 for other viewpoints on the quality of global temperature datasets and the influence of solar activity on climate change.)

The average measured slope of the temperature anomaly trendline for over 100 years is 0.08 ^{o}C per decade to 2016. The approximate slopes of the trend lines from 2016 to 2031 that fit Milks' and Pangburn's predictions are 0.20 ^{o}C per decade and -0.31 ^{o}C per decade, respectively. These slopes are 3 and 5 times greater than the historical average slope. Because of the high positive and negative predicted slopes with respect to the historical data, Pangburn's and Milks' predictions are taken to be representative of low and high estimates of the 2031 temperature anomaly trendline for this analysis. The relevancy of establishing low and high estimates for this analysis is discussed in more detail below. Casey's prediction is considered to be an outlier because of the substantially lower 2031 temperature estimate of -0.75 ^{o}C and a very high slope of approximately -0.9 ^{o}C per decade.

The graphs in Figures 2 and 3 show the relationships between the monthly global mean surface temperature anomalies (HadCRUT4 time series relative to the 1961-1990 mean temperature) with trend lines fitted to the data and the 2031 temperature anomalies predicted by Milks and Pangburn for 2031. For each graph, the predicted temperature anomaly estimate for 2031 has been added to the HadCRUT4 dataset to extend the polynomial trendline to 2031.

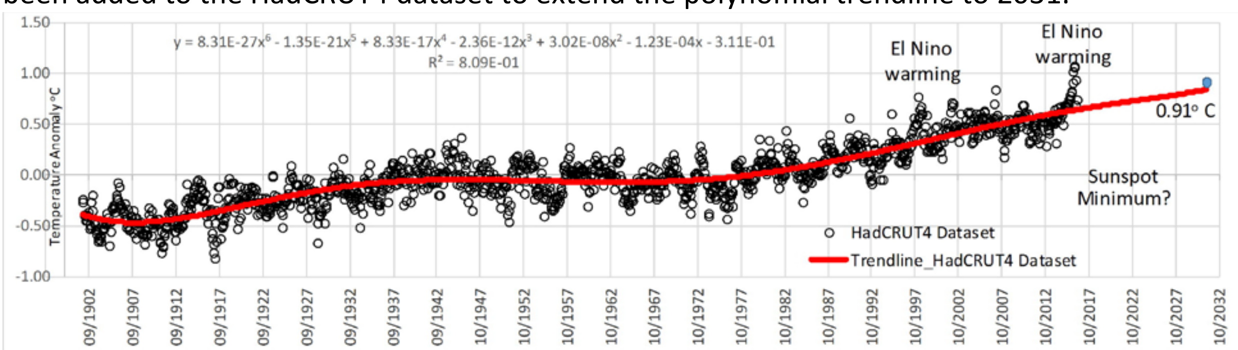

Figure 2: Jim Milks' temperature anomaly prediction for 2031 of 0.91^{o}C and the HadCRUT4 monthly global mean surface temperature anomaly dataset and trendline projected to that point and the trendline equation. The future slope of the trendline reflects the addition of Milks' 2031 prediction to the HadCRUT4 dataset.

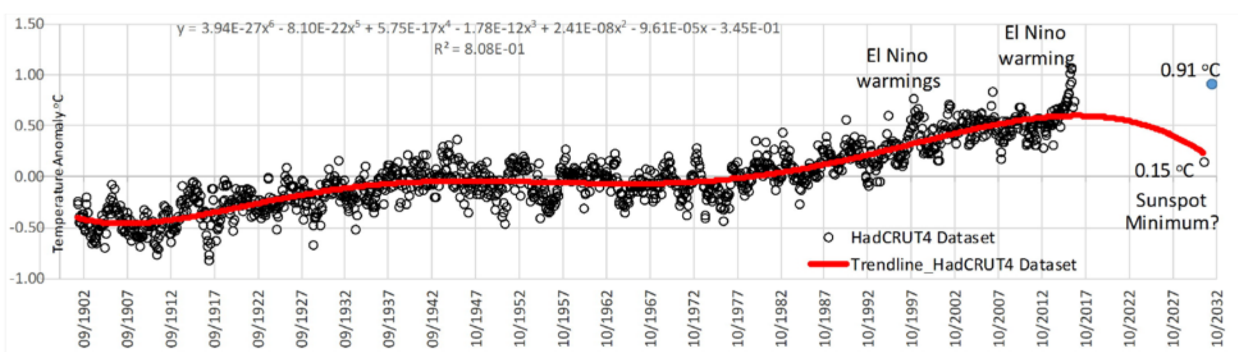

Figure 3: Dan Pangburn's average temperature anomaly prediction for 2031 of 0.15 ^{o}C and the HadCRUT4 monthly global mean surface temperature anomaly dataset and trendline projected to that point and the trendline equation. The future slope of the trendline reflects the addition of Pangburn's 2031 prediction to the HadCRUT4 dataset. For comparison, the 0.91^{o} C point is Milks' prediction for 2031.

Explanation of Triangular Probability Distribution Function

To work around unavoidable prediction errors because of incorrect assumptions and limited data, petroleum scientists often present predictions as a range of expected values or best estimates. An expected value converges to a more accurate prediction as the available data increase and the methodology improves. A mathematically exact formula can be derived to calculate a best estimate from a continuous probability function. In the absence of a large dataset of predictions, in this case, independent global mean temperature anomaly predictions, a good approximation of a best estimate can be calculated from a triangular distribution function (Figure 4).

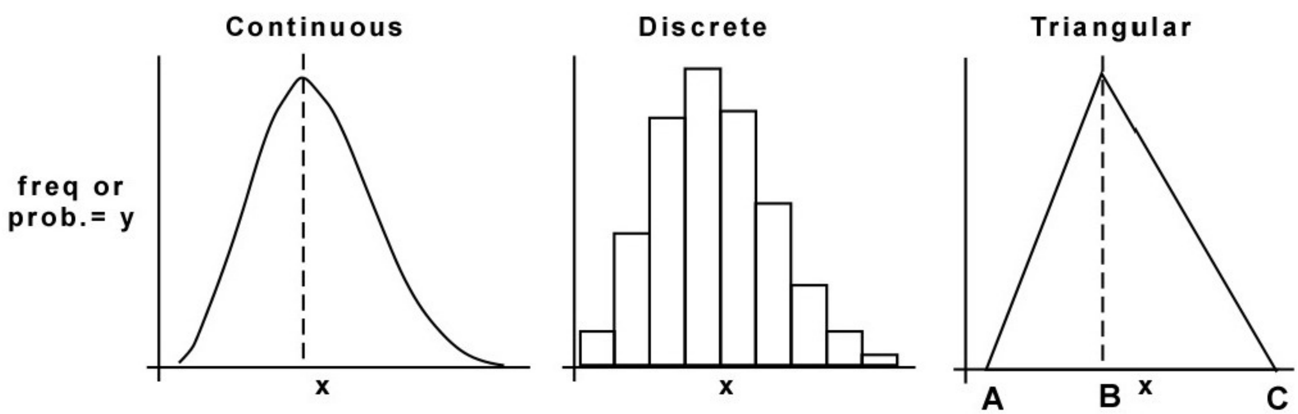

Figure 4: Three ways to represent the probability distribution of the same dataset. The area under the continuous function is 1.0, and the curve can be expressed by an equation. The discrete function can be represented by a table of values or a bar graph. The triangular distribution function is a special case of a continuous function defined by three vertices and the connecting straight lines and is the method used in this commentary to analyze 2031 temperature predictions.

For the triangular distribution, $\int_A^B f(x)dx + \int_B^C f(x)dx$ can be shown to equal the value of (A + B +C)/3, which is the probability weighted average of the function, that is, the expected value or best estimate for the event represented by the distribution. For this discussion, the event is a predicted temperature anomaly in 2031 (x axis on graphs).

A = A low predicted value (a value near the 2.5% percentile of a probability function, i.e., Pangburn's prediction for this analysis, 0.15 ^{o}C)

C = A high predicted value (a value near the 97.5% percentile of a probability function, i.e., Milks' prediction for this analysis, 0.91 ^{o}C)

B = The mode of the probability function (the most frequently occurring value of a probability function. For a normal distribution, mode = mean = best estimate = expected value.)

The triangular distribution is well-suited to analyze the statistical implications of Milks' and Pangburn's predictions of the global mean temperature anomaly in 2031 as well as other climate predictions.

Calculation of Best Estimate of the Global Mean Temperature Anomaly Range in 2031

Based on the large departures of Milks' and Pangburn's 2031 temperature anomaly estimates from the past temperature anomaly trendline, reasonable estimates of the A and C values in the calculation of the probability weighted mean for a triangular distribution function described above are 0.91 ^oC and 0.15 ^oC, the high and low predicted values of the function. The value of the mode B is unknown but must lie between 0.91 ^oC and 0.15 ^oC. Without knowing the mode of the distribution, a single best estimate for the 2031 temperature anomaly cannot be calculated, but the highest and lowest best estimate values can be calculated to establish a range in which the best estimate or expected temperature anomaly would lie. For this analysis, the value of both A and B, the high estimate and the mode, is taken to be 0.91 ^oC, which results in a positive-skewed distribution function from which the high best estimate can be calculated. The value of both C and B, the low estimate and the mode, is taken to be 0.15 ^oC, which results in a negative-skewed distribution function from which the low best estimate can be calculated. These calculations determine that the range of likely values for the 2031 temperature anomaly would be expected to lie between 0.40 ^oC and 0.65 ^oC (Figure 5). Current technology and databases available to climate scientists are simply not yet adequate to predict future temperature anomalies other than over a range of values for a relatively short time into the future. (The use of triangular distribution functions to predict best estimates is based on notes from W. C. Hauber, Shell Oil Company, circa 1967. For more details on the methodology, refer to https://en.wikipedia.org/wiki/Three-point_estimation.)

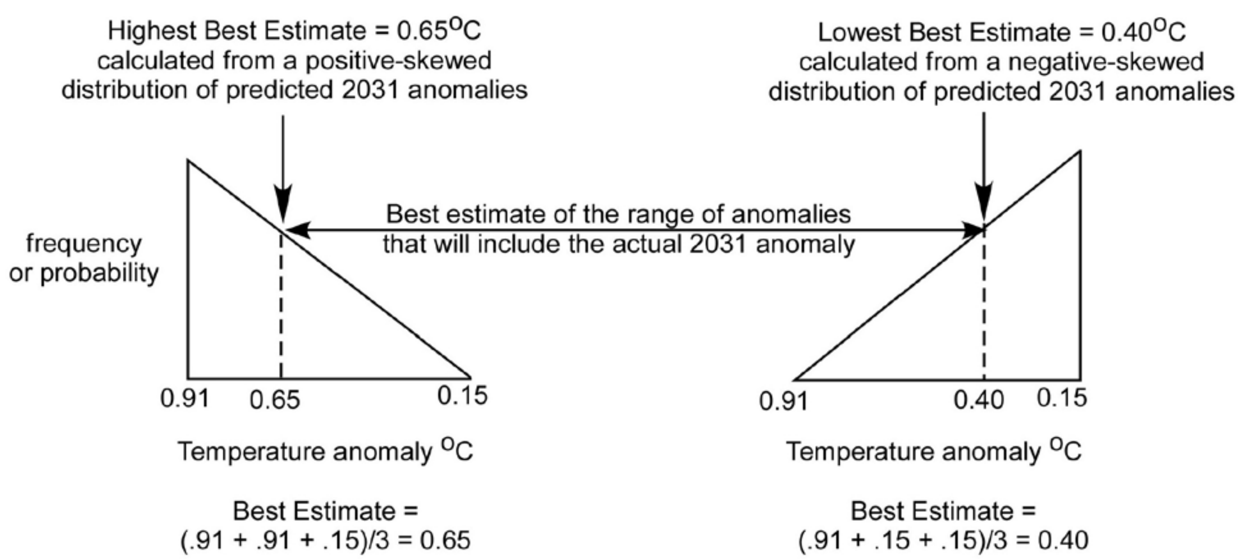

Figure 5: The best estimate of the trendline global temperature anomaly in 2031 is a value between 0.65 ^oC and 0.40 ^oC based on triangular distribution functions and Milks' prediction (0.91 ^oC) and Pangborn's prediction (0.15 ^oC average). The expectation of the 2031 temperature anomaly is a rectangular distribution function ranging from 0.65 ^oC and 0.40 ^oC.

The most important result from this statistical analysis is that a best estimate of the temperature anomaly trendline value in 2031 is within the range from 0.40°C to 0.65°C (Figure 6). This is a remarkable result. High and low probability weighted estimates of the trendline anomaly projected to 2031 indicate that the relatively stable global temperature trend of the past 18 years could be followed by a slow cooling period lasting at least another fifteen years and possibly longer.

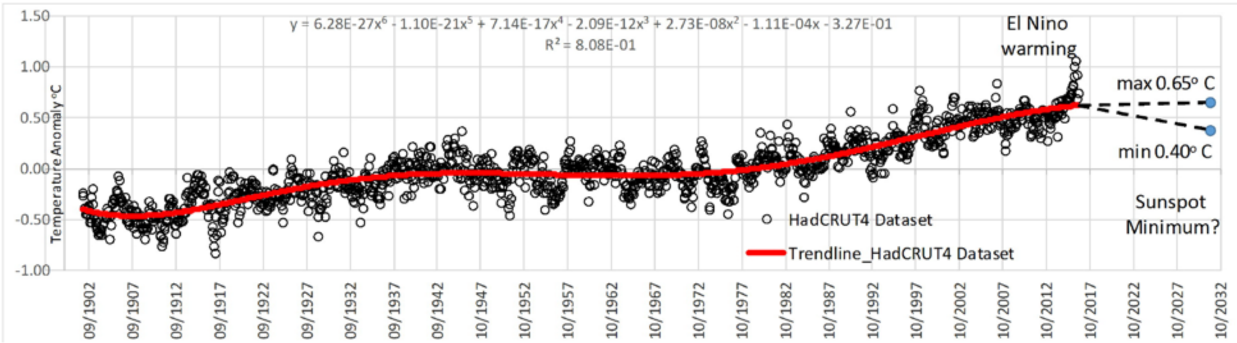

Figure 6: Prediction of likely range of global temperatures to expect in 2031 based on triangular probability distribution functions and predictions from outside studies (Milks, 2015 and Pangburn, 2013). Possible values of the 2031 temperature anomaly range from 0.40 °C to 0.65 °C with a likelihood of about 95 percent that the actual 2031 trendline anomaly will lie within that range. (The HadCRUT4 anomaly for November 2018 is 0.591.)

Another method to evaluate the likely global temperature change from 2016 to 2031 is to project the trendline of the HadCRUT4 temperature anomaly time series and the rate of change of the trendline anomaly curve into the future. Figure 7 shows the HadCRUT4 dataset temperature anomalies from 1902 to 2016 and the red trendline for that dataset, which is discussed above. The first derivative of the trendline is the green curve, the rate of change of the temperature anomaly trendline in °C per decade.

The sinusoidal shape of the first derivative trendline curve clearly displays the oscillatory behavior the time series of temperature anomalies that is not so easily recognized from the modulated temperature series trendline curve alone. Over the last 110 years, half cycles (zero slope to zero slope) of the temperature trendline have ranged from about 18 to 57 years and averaged 38 years (See the red arrows in Figure 7 that mark times of zero slope and indicate trendline temperature reversals). If that oscillatory behavior of more than 100 years is indicative of the future behavior of the trendline of the temperature anomaly data, then the current period of declining rates of increase in trendline temperatures, which began in 1998 could reverse to a negative slope by 2021 and increase in negative slope well into the 2030s, i.e., the mean global surface temperature trendline will decline.

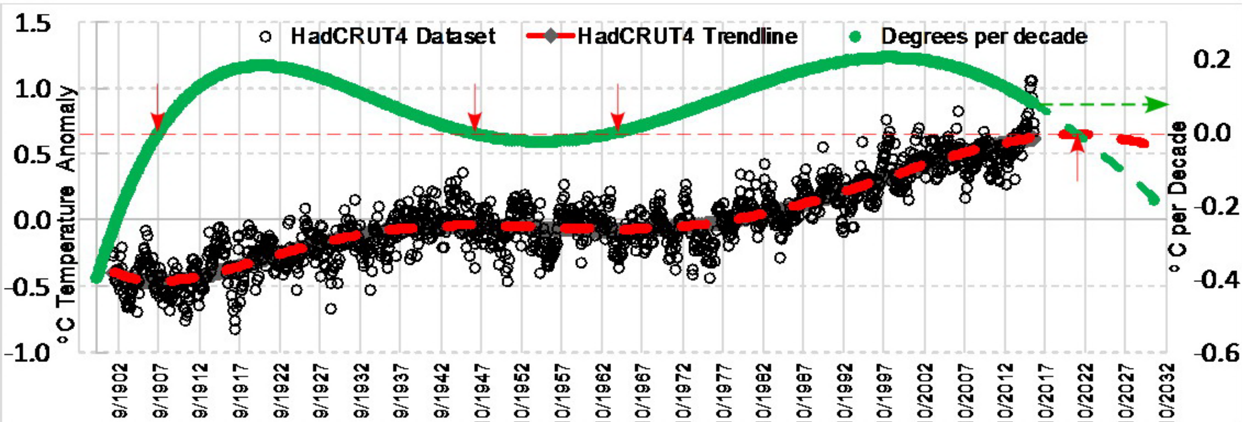

Figure 7: The red dashed curve is the trendline of the HadCRUT4 temperature anomaly dataset in units of °C relative to the 1961-1990 mean temperature of the dataset. The first derivative of the red trendline in units of °C per decade is the green curve. The red arrows mark times of zero slope and indicate trendline temperature reversals. The projections of the curves from 2016 to 2031 are calculated from the polynomial trendline equation derived from the 1902 to present dataset. This time period has the best fit for a polynomial trendline. In April, 2016, the upward increase of the HadCRUT4 temperatures peaked, and the monthly average temperature fell below 1.0 °C. The temperature anomalies are also below 1.0 °C in May and June.

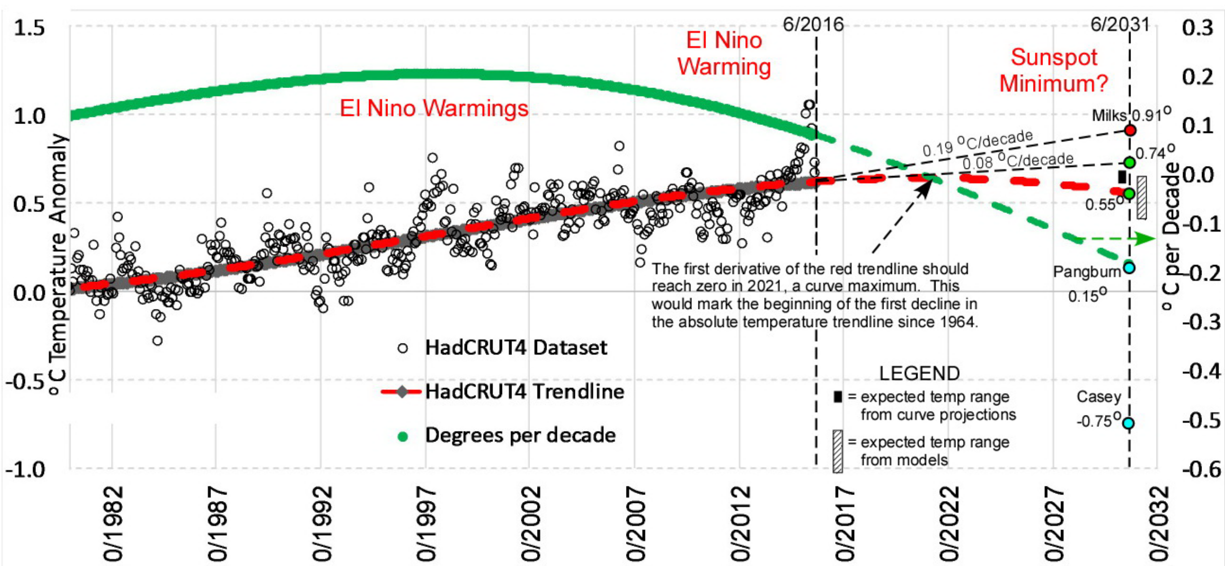

Figure 8: This is a summary of the results of the two methods used to evaluate the likely range of the mean global temperature anomaly in 2031. The statistical analysis of climate model studies (Pangburn, 2013 and Milks, 2015) predicts a range of 0.40 °C to 0.65 °C in 2031 (hachured vertical bar on graph). The analysis of forward projections of the HadCRUT4 time series predicts a range of 0.61 °C to 0.68 °C (small solid black vertical bar on graph). The ranges overlap in the interval from 0.61 °C to 0.65 °C. The green curve (first derivative of the temperature anomaly trendline) reaches zero in 2021, which would be the first temperature maximum for the trendline since 1964 and the beginning of a period of declining absolute temperatures and a negative slope of the temperature anomaly trendline that may persist for decades.

Figure 8 is an enlarged view of the last 50 years of the graph in Figure 7. The red curve is the trendline of the HadCRUT4 monthly temperature anomalies. The green curve is the first derivative of the trendline curve; that is, the slope of the trendline curve. The slope decreased from 0.21 ^oC per decade in 1996 to 0.08 ^oC per decade in 2016, a reduction of 62 percent in 20 years. Since the rate of increase of the mean global trendline temperature has been declining for 20 years and is likely to continue to decline for an unknown time in the future, the greatest positive slope of the trendline for the next 15 years is likely to be no greater than the current slope, 0.08 ^oC per decade. A linear projection of a slope of 0.08 ^oC per decade to 2031 predicts a temperature anomaly in 2031 of 0.74 ^oC, an assumed maximum possible value for the triangular probability function discussed above. A forward projection of the mean global temperature trendline (Figure 6 polynomial equation) predicts a temperature anomaly of 0.55 ^oC and a rate of decrease of temperature of -0.18 ^oC per decade in 2031. Based on the curve projections, the assumed minimum possible value for the triangular probability function in 2031 is 0.55 ^oC, since a rate of decrease in temperature is not likely to be greater than -0.18 ^oC per decade. Such a high negative rate of change of temperature has not been observed since 1903, and the observed periodicity of the temperature anomaly curve for over 100 years would suggest the likelihood that the rate of decrease of the temperature anomaly would begin to moderate before 2031 rather than continue to decease.

Applying the triangular distribution function analysis described above to the maximum and minimum temperature predictions based on the forward extrapolation of curves (0.74 ^oC and 0.55 ^oC), the best estimate of the temperature anomaly trendline value in 2031 is within the range from 0.61 ^oC to 0.68 ^oC (small solid bracket in Figure 8). This narrow temperature anomaly range, which is based on HadCRUT4 time series dataset projections, is probably more credible than the wider temperature anomaly range from 0.40 ^oC to 0.65 ^oC (large hachured bracket in Figure 8) that is based on only three representative climate model studies. The two range estimates for 2031 have points in common from 0.61 ^oC to 0.65 ^oC. The present trendline temperature for May, 2016 is 0.62 ^oC.

Summary of Global Mean Temperature Anomaly Estimates for 2031

All estimates of the mid-2031 temperature anomaly in this analysis are relative to the HadCRUT4 time series dataset and the 1961-1990 mean temperature of the dataset. A statistical analysis of a high, greenhouse gas-derived prediction of 0.91 ^oC and a low, solar activity-derived prediction of 0.15 ^oC predicts that the temperature anomaly trendline will lie between 0.40 ^oC and 0.65 ^oC in 2031. A linear projection to 2031 of the present slope of the temperature anomaly trendline of the HadCRUT4 dataset predicts a maximum temperature anomaly of 0.74 ^oC in 2031. A non-linear (polynomial) projection of the temperature anomaly trendline predicts a minimum temperature anomaly of 0.55 ^oC in 2031. A statistical analysis of these data predicts that the temperature anomaly trendline will lie between 0.61 ^oC and 0.68 ^oC in 2031. All together, these results indicate that, with a high degree of certainty, the temperature anomaly trendline will lie between 0.40° C and 0.68°C in 2031, with the narrow range of 0.61 °C to 0.68 °C probably the most credible. The climate of the next 15 years and possibly for decades longer might prove to be described best by a Goldilocks' Climate Doctrine; that is, a climate that will be neither too hot nor too cold but just right.

Epilogue

John Casey (2014) and Dan Pangburn (November 25, 2013) in separate studies analyzed sun spot time series trends to forecast a cooling period that has already begun and might last for decades. Many similar studies have been carried out by others world-wide. The sensitivity of changes in solar activity on future temperatures should be an essential component of Global Circulation Models. Greenhouse gas modelers and solar scientists need to get together and compare notes. Climate science is far from being settled.

THE TRUTH SHALL MAKE YOU FREE!

References

1. Carlin, Alan, 2015, Environmentalism Gone Mad: How a Sierra Club Activist and Senior EPA Analyst Discovered a Radical Green Energy Fantasy
2. Casey, John L., 2014, Dark Winter: How the Sun Is Causing a 30-Year Cold Spell
3. Christy, John R., February 2,2016, Testimony to the U.S. House Committee on Science, Space & Technology.

   Christy's "*analysis of the current situation regarding (1) the temperature datasets used to study climate, (2) our basic understanding of climate change and (3) the effect that regulations, such as the Paris agreement, might have on climate. I have also attached an extract from my Senate Testimony last December in which I address (1) the popular notion that extreme climate events are increasing due to human induced climate change (they are not), and (2) the unfortunate direction research in this area has taken.*"
4. HadCrut4 dataset, http://www.metoffice.gov.uk/hadobs/hadcrut4/data/current/series_format.html
5. Hauber, W. C., circa 1967, Shell Oil Company notes.
6. Karl, Thomas R. et al., Science 26 June 2015: Vol. 348 no. 6242 pp. 1469-1472, http://www.sciencemag.org/content/348/6242/1469.full

   Karl, et al. claim that the past 18 years of stable global temperatures is due to the use of biased ocean buoy-based data. Karl, et al. state that a "*bias correction involved calculating the average difference between collocated buoy and ship SSTs. The average difference globally was −0.12°C, a correction that is applied to the buoy SSTs at every grid cell in ERSST version 4.*" This analysis is not consistent with an interpretation of the past 18-year pause in global warming.
7. Mckitrick, Ross, Department of Economics, University of Guelph http://www.rossmckitrick.com/uploads/4/8/0/8/4808045/mckitrick_comments_on_karl2015_r1.pdf, A First Look at 'Possible artifacts of data biases in the recent global surface warming hiatus' by Karl et al., Science 4 June 2015

Mckitrick's conclusions on the Karl, et al. article (called K15 below)*: "All the underlying data (NMAT, ship, buoy, etc.) have inherent problems and many teams have struggled with how to work with them over the years. The HadNMAT2 data are sparse and incomplete. K15 take the position that forcing the ship data to line up with this dataset makes them more reliable. This is not a position other teams have adopted, including the group that developed the HadNMAT2 data itself. It is very odd that a cooling adjustment to SST records in 1998-2000 should have such a big effect on the global trend, namely wiping out a hiatus that is seen in so many other data sets, especially since other teams have not found reason to make such an adjustment. The outlier results in the K15 data might mean everyone else is missing something, or it might simply mean that the new K15 adjustments are invalid."*

8. Mears, C., and F. Wentz, 2016: Sensitivity of satellite-derived tropospheric temperature trends to the diurnal cycle adjustment. J. Climate. doi:10.1175/JCLID-15-0744.1, in press. http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-15-0744.1?af=R

    Mears and Wentz discuss adjustments to satellite data and their new dataset, which *"shows substantially increased global-scale warming relative to the previous version of the dataset, particularly after 1998. The new dataset shows more warming than most other middle tropospheric data records constructed from the same set of satellites."*

9. Milks, Jim, http://environmentalforest.blogspot.com/2015/01/john-l-casey-and-climate-denial.html
10. Pangburn, Dan, November 25, 2013, http://hockeyschtick.blogspot.se/2013/11/the-sun-explains-95-of-climate-change.html

    The Sun explains 95% of climate change over the past 400 years; CO2 had no significant influence.

11. pnuetz (pseudonym), June 6, 2015, http://sacredcowchips.net/2015/06/08/fitting-data-to-models-at-noaa/

    A collection of comments on the tendencies of climate modelers to change the data to fit the models instead of applying the scientific method and changing the models to fit the data.

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