A draft version of the paper that was blocked from publication and is the subject of discussion in an email from Richard S Courtney dated 23 Nov 2003 that was among those hacked or leaked from CRU

Repeated attempts to obtain peer reviewed publication of various versions of this paper were blocked in the manner explained in paragraphs 7 and 8 of the Submission to the Parliamentary Science and Technology Committee from Richard S Courtney. This draft has the same contents (except for the precise data: see paragraphs 7 and 8 of the Submission) as each of the final versions. But it is a pre-publication draft and does not include its bibliography of references.

**A call for revision of Mean Global Temperature (MGT) data sets**

**1. Mean global temperature (MGT)**

Mean global temperature (MGT) is the average temperature of the air near the surface of the Earth derived from measurements mostly made at weather stations using thermometers. This short discussion paper calls for a revision to MGT procedures and titles and for the results of that revision to be published.

One could imagine an instantaneous value for MGT but there is no method to determine it. Therefore periodic, individual measurements (mostly made at weather stations) are used to determine an average MGT for periods of time such as days, months or years. Determination of the annual MGT has particular importance because historic data is utilized to compile time-series of MGT since ~1880 and, thus, to gain an indication of the change in MGT since then. This paper comments on the several reported cumulative data sets for these annual values of MGT.

Three different research teams provide values of MGT that are widely used (e.g. Jones et al., GISS, GHCN). They present their results as ‘anomalies’ from a set value (usually the average MGT of a specified period of years e.g. 1961-90). The ‘anomaly’ is obtained by subtracting this average temperature value from the determined MGT. Use of anomalies permits direct comparison of the results between teams, because temperature subtractions can be used to adjust the start points of the data sets for comparison.

One important use of data sets of MGT anomalies is in ‘attribution’ studies of climate change. Attribution studies model the effects that can alter climate, e.g. changes to solar radiance, atmospheric injection of volcanic aerosols, etc.). Differences between the model results and the observed changes to MGT are usually attributed to anthropogenic climate change (AGW). Any errors in the MGT data sets will clearly affect the results of attribution studies which use those data sets.

There are significant variations between the results of MGT calculated by the different teams that compile them. The teams each provide 95% confidence limits for their results. However, the results of the teams differ by more than double those limits in several years, and the data sets provided by the teams have different trends. Since all three data sets are compiled from the same available source data (i.e. the measurements mostly made at weather stations using thermometers), and purport to be the same metric (i.e. MGT anomaly), this is surprising. Clearly, the methods of compilation of MGT time
series can generate spurious trends (where 'spurious' means different from reality), and such spurious trends must exist in all but at most one of the data sets.

The three MGT time series are shown in Figure 1.

**Figure 1.** Mean global temperature anomalies and trends normalized to a common start value as indicated by three teams (after Jones et al., GISS and GHCN).

In this figure, the trends (in °C/decade) and the 2SD trend error are

- GHCN: 0.076 ± 0.010
- Jones: 0.064 ± 0.007
- GISS: 0.048 ± 0.006

The Jones trend is significantly different from the GISS trend (p<0.05), and the GHCN trend is very significantly different from the GISS trend (p<0.01).

The data sets in Figure 1 are derived from the same available source data and, therefore, the differences between the data sets in Figure 1 demonstrate either:

(a) that they are monitoring different climate effects;

or

(b) that at least two of the data sets provide wrong results (they differ in annual change by more than double their stated 95% confidence limits in each of several years).

Each team claims to provide a true MGT, but their results differ. Each uses a unique method to derive an indication of some changes to the lower atmosphere, and these methods clearly each provide a different indication of the changes. Therefore, the minimum required amendment to MGT usage is for each team, and others who refer to their data, to use a unique title for the metric that they provide (e.g. 'GISS Surface Temperature Index' and 'GHCN World Warmth Index').

In addition, and noting the importance of MGT time series for bodies such as the IPCC, other changes to the determination of these time series are warranted also, against two different understandings of MGT. Either:

(i) MGT is a physical parameter that - at least in principle - can be measured;

or

(ii) MGT is a 'statistic'; i.e. an indicator derived from physical measurements.

These two understandings derive from alternative considerations of the nature of MGT:

1. If the MGT is assumed to be the mean temperature of the volume of air near the Earth's surface over a period of time, then MGT is a physical parameter indicated by the thermometers (mostly) at weather stations that is calculated using the method of mixtures (assuming unity volume, specific heat, density etc).

Alternatively:
2. If the thermometers (mostly) at weather stations are each considered to indicate the air temperature at each measurement site and time, then MGT is a statistic that is computed as being an average of the total number of thermometer indications.

The following discussions consider MGT according to each of these alternative understandings.

2. Consideration of MGT as a physical parameter with a unique value for each year

The MGT data sets provided by the various teams are often presented on the same graph (e.g. by IPCC) under the same heading, and there has been no public objection to this by any of these teams. This suggests that the teams agree MGT is a physical parameter that indicates a unique value for the average temperature of the air near the surface of the Earth for each year. But, the data sets provide significantly different trends, and in each of several pairs of years the annual change to MGT differs between the data sets by more than double the calculated 95% confidence limits of each data set. This paradox can be explained by application of measurement theory.

When the measurement sites are considered as being the measurement equipment, then the non-uniform distribution of these sites is an imperfection in the measurement equipment. Some measurement sites show warming trends and others cooling trends and, therefore, the non-uniform distribution of measurement sites may provide a preponderance of measurement sites in warming (or cooling) regions. Also, large areas of the Earth's surface contain no measurement sites, and temperatures for these areas require interpolation.

Accordingly, the measurement procedure to obtain the MGT for a year requires compensation for the imperfections in the measurement equipment. A model of the imperfections is needed to enable the compensation, and the teams who provide values of MGT each use a different model for the imperfections (i.e. they make different selections of which points to use, they provide different weightings for e.g. effects over ocean and land, and so on). So, though each team provides a compensation to correct for the imperfection in the measurement equipment, each also uses a different and unique compensation model.

The large differences between the results generated by each team demonstrates that the compensation models used - by all except at most one of the teams - must contain large errors that generate:
(A) spurious trends to MGT with time, and

(B) errors to MGT that are more than double the calculated 95% confidence limits

But the fact that all the teams calculate their errors demonstrates that each of the teams thinks that its particular model is correct.

Use of an analogy may assist understanding of the problem posed by use of an imperfect compensation model. Figure 2 shows that an area to be measured by an optical system will have a distorted image if viewed at the wrong angle. But - if the viewing angle is known - then the true shape of the image can be calculated so it can be measured. However, a distorted image will still be measured if the compensation applies a wrong correction for the angle. In terms of MGT, the non-uniformity in results between the teams is analogous to different "wrong correction angles". Perhaps most important, the magnitude of
the errors to MGT resulting from imperfect compensation models cannot be known, because there is no independent calibration for MGT.

**Figure 2. Use of a compensation model in image analysis.**

MGT time series are often used to address the question, "Is the average temperature of the Earth's surface increasing or decreasing, and at what rate?"
If MGT is considered to be a physical parameter that is measured then these data sets cannot give a valid answer to this question, because they contain errors of unknown magnitude that are generated by the imperfect compensation models.

We know that the different compensation models create significantly different results for MGT. Importantly, we also know that the imperfect compensation models provide spurious trends of unknown magnitude and sign in the MGT data sets. And finally we know that the MSU data sets indicate strong warming trends that do not occur in the available MSU satellite (e.g. Christy - full reference needed) and weather balloon radiosonde (e.g. Angell - full reference needed) data sets for lower atmosphere temperature.

A result that is a function of its construction is a serious error. If MGT is considered as a physical parameter that is measured, then the data sets of MGT are functions of their construction. Attributing AGW - or anything else - to a change that is a function of the construction of MGT is inadmissible.

**3. Consideration of MGT as a statistic with a variety of possible useful values**

The issues raised in Section 2 (above) might be resolved by considering MGT as a statistic (as described in Section 1 above) which does not have a unique value. According to this consideration MGT is not measured - it is calculated from measurements - and, therefore, it is not correct to use measurement theory when considering MGT. Thereby, the arguments advanced in Section 2 (above) become invalid because they are based on measurement theory.

However, if MGT is considered to be a statistic then it can be computed in several ways to provide a variety of results, each of different use to climatologists. In such a way, the MGT is similar in nature to a Retail Price Index, which is a statistic that can be computed in different ways to provide a variety of results, each of which has proved useful to economists. If MGT is considered to be a statistic of this type, then MGT is a form of average. In which case, the word 'mean' in 'mean global temperature' is a misnomer, because although there are many types of average, a set of measurements can only have one mean.

Importantly, if MGT is considered to be an indicative statistic then the differences between the values and trends of the data sets from different teams indicate that the teams are monitoring different climate effects. In this case, there is no reason why the data sets should agree with each other, and the 95% confidence limits applied to the MGT data sets by their compilers may be correct for each data set. Similarly, the different trends indicated by the MGT data sets and the MSU and radiosonde data sets could indicate that they are also monitoring different climate effects.

To treat the MGT as an indicative statistic has serious implications. The different teams each provide a data set termed mean global temperature, MGT. But if the teams are each monitoring different climate
effects then each should provide a unique title for their data set that is indicative of what is being monitored. Also, each team should state explicitly what its data set of MGT purports to be monitoring. The data sets of MGT cannot address the question "Is the average temperature of the Earth's surface increasing or decreasing, and at what rate?" until the climate effects they are monitoring are explicitly stated and understood. Finally, the application of any of these data sets in attribution studies needs to be revised in the light of knowledge of what each data set is monitoring.

4. Additional considerations

Clearly, the issues in Sections 2 and 3 (above) need to be properly evaluated. However, all the above issues assume the source data (mostly obtained from weather stations) used to obtain MGT are correct. Though there are in fact serious reasons to doubt the quality of much of this source data, their consideration is outside the scope of this paper.

Another important consideration is that it is not self-evident that MGT is the most useful or even a valid indicator of global climate change. Doubts exist, because it can be argued that a temperature reading is not sufficient to define the quantities of heat stored in a volume of air. What needs to be resolved is the difference between:
(a) the amount of energy the Earth has received from the Sun; and
(b) the amount of heat retained in the atmosphere by the greenhouse gases.

A minimum of three parameters is required to determine the amount of heat stored as a result of the greenhouse gases, namely temperature, pressure and humidity. Global climate change is the average of local climate changes, and significant local climate changes may often occur without any change to the local mean temperature. Indeed, the above minimum three parameters are not sufficient to indicate the heat stored in some cases: for example, a local temperature may remain constant when additional heat added to a region melts ice in that region so heat is stored as latent heat of melting. Furthermore, alterations to precipitation or wind speeds may not be indicated by changes in MGT although the amount of energy stored in the air mass can vary considerably.

We conclude that the use of time-series of temperature change alone has the potential to be a strongly misleading indicator of global climate change.

5. Summary and Conclusions

We have discussed the validity of the ways in which MGT is reconstructed and interpreted. However, we are also concerned about the uses to which MGT time series are put in the public discussion about possible human-caused global warming.

Whatever the interpretation placed on the reconstruction of MGT over the last ~100 years, the following seminal points remain true:
The three most-cited data sets (CRU, GISS, GHCN) differ significantly in the temperature trends that they portray;

For the late 20th century warming period between 1972 and 2000, the trends are +0.61 C/century, + 0.48 C/century and 0.76 C/century, respectively;
These rates of temperature change are significantly higher than the rates for the lower atmosphere measured by satellite MSUs (insert rate) and weather balloon radiosondes (insert rate).

These discrepancies notwithstanding, all these rates of change, even the highest, lie well within the variability displayed by the long term (Holocene) record of temperature change as captured in polar ice-cores and deep sea cores; and

The pattern of all three MGT estimates between 1900 and 2005 signally fails to correlate with the pattern of human production of CO2. In contrast, more than 60% of the variance in the MGT temperature signal correlates with solar variability.

In the face of these facts, the degree to which the debate on global warming is being influenced by the publicizing of alarmist temperature scenarios - based on unverified, deterministic computer models - and by the encouragement of public hysteria about atmospheric CO2, is of great concern to us. That concern is deepened by the fact that senior governmental science advisors, once-influential science journals and distinguished science academies all currently continue to fuel such public alarmism.

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