UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Endangerment And Cause Or Contribute	)	
Findings For Greenhouse Gases	)	Docket No.
under Section 202(a) of the Clean Air Act	)	EPA-HQ-OAR-2009-0171

PETITION FOR DATA CORRECTION OF PEABODY ENERGY COMPANY

Peabody Energy Company respectfully requests that the United States Environmental Protection Agency ("EPA" or "Agency") correct the temperature data that underpinned its *Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act*, published at 74 Fed. Reg. 66496 (Dec. 15, 2009) ("Endangerment Finding"). Peabody's petition is submitted pursuant to the Information Quality Act, 44 U.S.C. §3516 ("IQA" or "the Act"), implementing guidelines of the Office of Management and Budget ("OMB") published at 67 Fed. Reg. 8460 (Feb. 22, 2002) and implementing guidelines of EPA.[1]

The Endangerment Finding is based to a large extent on EPA's interpretation of 20th century global temperature trends, and in particular temperature trends in the last three decades of the 20th century. EPA concluded that these trends were of such magnitude that they can only be explained by an anthropogenic influence.[2]

As EPA is aware, significant questions arose in the course of the Endangerment Finding rulemaking proceeding concerning the accuracy and reliability of the temperature records on which EPA relies. For instance, both before and after the release of the so-called climategate material, questions arose as to the lost or missing raw datasets on which the United Kingdom's Hadley Centre and University of East Anglia's Climate Research Unit ("HadCRUT")

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[1] *Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by the Environmental Protection Agency* ("EPA Guidelines"), October 2002.

[2] *See, e.g.*, *Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act* ("Endangerment Finding"), 74 Fed. Reg. 66496, 66518/1 (Dec. 15, 2009).

temperature record was based and the inability, therefore, to reproduce that record. Moreover, issues were brought to EPA's attention regarding possible flaws and biases in the HadCRUT record, as well as the temperature records maintained by the National Aeronautics and Space Administration ("NASA") and the National Oceanic and Atmospheric Administration ("NOAA").[3]

EPA made a number of responses to these issues, but a central part of EPA's justification for its reliance on these three temperature records was that each is produced independently yet yield very similar results. According to the Agency, the fact that each record produced similar trends means that the trends must be real and any defects in any one record must not be significant.[4]

New information has become available that challenges EPA's conclusion in this regard and the efficacy of the Agency's reliance on these temperature records for the conclusions that EPA reached in the Endangerment Finding. We attach a paper recently produced by Dr. Ross McKitrick of the University of Guelph that provides a critical assessment of the three temperature records on which EPA relies.[5] Dr. McKitrick concludes as follows:

1. The three records are not in fact independent of each other. They all draw from the Global Historical Climatology Network ("GHCN"), and the adjustments they make to this data are relatively similar to each other. Thus, the fact that the three records produce similar results does not show that the records are reliable for the purposes for which EPA uses them. To

[3] Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act: EPA's Response to Public Comments ("Response to Comments"), Vol. 2 at § 2.2 (Docket ID EPA-HQ-OAR-2009-0171-11638).

[4] *Id.* at Resp. 2-38 ("As noted above, the HadCRUT data show similar trends to the NOAA and NASA records, undercutting any implication that examination of the raw data would show a meaningful discrepancy."); Resp. 39 ("In fact, as discussed in response 2-28, the three widely used global surface temperature records show similar trends. Even if EPA and the assessment literature were to completely disregard the HadCRUT record, it would not meaningfully alter our understanding of surface temperature trends."); Resp. 2-40 ("The assessment literature is clear that additional confidence in the global surface temperature record is attained by virtue of the fact that there is very high level of agreement between the three major datasets which are developed using different techniques…").

[5] *An Overview of Surface Temperature Data Products*, July 26, 2010 ("McKitrick"). This is a preliminary version of a report to be published in fall 2010 by the Global Warming Policy Foundation (http://thegwpf.org/) London, UK. Given the pendency of EPA regulation, we wanted to bring this report to EPA's attention immediately.

the extent the GHCN has errors, those errors would be expected to be perpetuated in each of the three temperature records.

2. In fact, there are significant data problems with the GHCN, and these problems are of sufficient magnitude as to invalidate claims to have identified trends in the three temperature records with the precision on which EPA relies in its Endangerment Finding. Any one of the shortcomings described below introduces a margin of error in observed temperature trends that is comparable to, if not greater than, the very trend that EPA claims to perceive. Illustrative, but by no means exhaustive, examples of data deficiencies include the following:

- Significant gaps in geographic and temporal coverage exist that invalidate claims of continuity and render any attempt to infer worldwide long-term climate trends an exercise in sheer speculation.

- Changes over time in the methods of measuring sea surface temperature have yielded substantial swings in observed temperatures that may or may not reflect changes in actual temperature. What are essentially different data sets have been spliced together to create a long-term record. The combination of different data sets into a single temperature record, however, has required the use of adjustment factors to make the different data sets compatible, and the uncertainty in these adjustment factors is of a magnitude comparable to the trend in the long-term data itself.

- The number of land-based sampling stations used in the temperature records on which EPA relies has declined dramatically in the past 30 years. The drop in the number of sampling stations means that, as with the sea surface temperature record, different records are essentially being spliced together, again introducing a margin of error larger than the trend line on which EPA relies. Moreover the drop in sample size has led to a bias towards fewer and fewer suitable measurement sites, such as urban airports.

These deficiencies and the others described below significantly undermine the Endangerment Finding. In particular, the temperature trend on which EPA relies to show endangerment is a mere ~ 0.1 degrees C or less per decade, particularly if satellite data are used rather than surface records.[6] Indeed, according to EPA, the temperature trend for the last three decades of the 20th century, which EPA says was of such magnitude as to be unequivocally caused by anthropogenic GHGs, was 0.30 degrees F.[7] This compares with warming rates of 0.25 degrees F "during a number of 30-year periods spanning the 1910s to the 1940s," which EPA

[6] Endangerment Finding, 74 Fed. Reg. at 66522/3.
[7] Response to Comments, Vol. 2, Resp. 2-45. *See also* Technical Support Document for Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act ("TSD") (Docket ID EPA-HQ-OAR-2009-0171-11645) at 29.

says were not caused by anthropogenic GHGs.[8] Thus, temperature increases of a mere 0.05 degrees F per decade are given decisive weight by EPA in concluding that anthropogenic GHGs from fossil fuel combustion caused warming during the 20th century.

Given the measurement problems identified by McKitrick, however, the temperature records are not sufficiently reliable to confidently identify such small trends nor do they justify the expansive conclusions that EPA draws from such small temperature differences. This should perhaps not be surprising because the temperature monitors historically used in the land records, and the methods historically used for measuring sea surface temperature, were not designed to identify long-term global trends. Instead, they were designed to produce local data, and were not part of a systematic and standardized program to produce comparable data that could be used to produce a long-term global record. Producing a long-term record from such divergent data sources requires assumptions and adjustments, which in turn introduces uncertainty and a large margin of error compared with the very small temperature increases that EPA finds decisive.

As Peabody stated in its comments on the Endangerment Finding and in its Petition for Reconsideration of the Endangerment Finding, Peabody does not here take a position on whether or not anthropogenic greenhouse gas ("GHG") emissions are or are not affecting global climate.[9] Peabody does, however, believe, along with virtually the entire industrial and manufacturing sector of the United States, that regulation of GHGs under the Clean Air Act is a terrible idea that is likely to impose extremely high costs on the economy while making no meaningful impact on global concentrations of GHGs in the atmosphere.

Having initiated regulation with such far-reaching consequences, EPA remains under an obligation to continuously reassess the bases of its Endangerment Finding and, given new

[8] TSD at 29; s*ee also* Response to Comments, Vol. 3 at Resp. 3-57.
[9] *See* Docket ID EPA-HQ-OAR-2009-0171-11696.

information, to modify or withdraw that finding and the regulation that resulted from that finding as appropriate. In particular, EPA must understand and fully disclose all of the uncertainties underlying the data on which it relies, and where, as here, EPA has relied on data that is not reliable for the purposes used, EPA must correct it. The IQA requires no less.

I. EPA's Obligations Under the Information Quality Act

A. Statutory Requirements

Enacted in December 2000, the IQA requires the Office of Management and Budget ("OMB") and federal agencies to issue guidelines to "ensur[e] and maximiz[e] the quality, objectivity, utility, and integrity of information (including statistical information) disseminated" to the public.[10] Agencies must also "establish administrative mechanisms allowing affected persons to seek and obtain correction of information" that the agencies maintain and disseminate if such information does not comply with these guidelines.[11]

B. OMB Guidelines

In February 2002, OMB issued the government-wide guidelines required by the IQA, and directed agencies to issue their own guidelines by October 1, 2002.[12] OMB's guidelines require agencies to adopt a basic standard of quality that maximizes the objectivity, utility and integrity of information the agency disseminates.[13] Agencies must incorporate these information quality criteria into their dissemination practices, and develop a process for reviewing the quality of information before it is disseminated.[14]

OMB designed its guidelines with the overall goal of ensuring that agencies do not

[10] 44 U.S.C. §3516(a).
[11] 44 U.S.C. §3516(b)(2)(B).
[12] *Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by Federal Agencies* ("OMB Data Quality Guidelines"), 67 Fed. Reg. 8452 (Feb. 22, 2002).
[13] 67 Fed. Reg. at 8459.
[14] *Id*. at 8458-59.

disseminate substantive information if it does not meet a basic level of quality.[15] Agencies must hold more important information to higher quality standards before the agency can disseminate that information, especially in situations involving ''influential scientific, financial, or statistical information.''[16] Information is "influential" in the context of this phrase when dissemination of the information "will have or does have a clear and substantial impact (i.e., potential change or effect) on important public policies or private sector decisions."[17] If an agency is responsible for disseminating influential scientific information, agency guidelines are required to have a high degree of transparency about data and methods, so that third parties may use the data and attempt to reproduce the methods and findings.[18] OMB makes clear that each agency should define what information is ''influential'' in ways appropriate for it given the types of issues for which the agency is responsible.[19]

The OMB guidelines provide definitions of the terms utility, objectivity and integrity, which together collectively comprise OMB's overall concept of information quality.[20] Utility refers to the usefulness of the information to its intended recipients and users, including the public as well as the agency itself.[21] Integrity refers to the security of the information. To ensure integrity, an agency must protect information from corruption or falsification arising from unauthorized access or revision.[22]

OMB looked at several factors in calling for the "objectivity" of information. The term objectivity, as used in the OMB guidelines, does not refer to a requirement of impartiality, but rather that agencies must present information in an accurate, complete, reliable and unbiased

[15] *Id*. at 8452/3.
[16] *Id*. at 8452-53.
[17] *Id*. at 8455/2.
[18] *Id*. at 8460/1.
[19] *Id*. at 8460/3.
[20] *Id*. at 8459/2.
[21] *Id*. at 8459/2-3.

fashion and within a proper context.[23]

Information must be objective in both presentation and substance. With respect to information presentation, in the context of scientific findings, agencies must use sound statistical and research methods for original data and for the analysis of that data.[24] Independent and external review of data and results give the information a presumption of objectivity, but petitioners can rebut that presumption with a persuasive showing.[25]

With respect to the objectivity of the substance of scientific information, OMB's guidelines require agencies to identify supporting data and models "so that the public can assess for itself whether there may be some reason to question the objectivity of the sources."[26] This includes not only that the agency provide "full, accurate, [and] transparent documentation," but also that the agency identify any "error sources affecting data quality."[27]

C. EPA Guidelines

EPA issued its set of IQA guidelines in October of 2002, and elaborated on many of the requirements set out in the IQA and in OMB's guidelines, specifically in the area of "influential" information. Among the classes of information that EPA considers to be influential are those issues that are "highly controversial."[28] EPA also requires any scientific, financial, or statistical information disseminated with respect to those issues to "adhere to a rigorous standard of quality" (such as transparency about data and methods) as compared to information that may not have as great an impact on important public policy or private sector decisions.[29] Specifically, EPA requires a very high level of transparency for influential original and supporting data and

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[22] *Id*. at 8460/2.
[23] *Id*. at 8459/3.
[24] *Id*.
[25] *Id*.
[26] *Id*.
[27] *Id*.
[28] *Id*. at 20.

analytic results:

> It is important that analytic results for influential information have a higher degree of transparency regarding (1) the source of the data used, (2) the various assumptions employed, (3) the analytic methods applied, and (4) the statistical procedures employed. It is also important that the degree of rigor with which each of these factors is presented and discussed be scaled as appropriate, and that all factors be presented and discussed.[30]

EPA guidelines require that the substance of any scientific information is "accurate, reliable and unbiased."[31] Underlying data used in any scientific findings must be collected through "best available methods," and then only "if the reliability of the method and the nature of the decision justifies the use of the data."[32]

II. The Critical Role Of Temperature Data In The Endangerment Finding

The temperature data that are the subject of this petition are a critical component of the support marshaled by EPA for its conclusion, in issuing the Endangerment Finding, that anthropogenic greenhouse gases ("GHGs") have caused or contributed to observed changes in climate. According to EPA, "[a]ir temperature is a main property of climate and the most easily measured, directly observable, and geographically consistent indictor of climate change."[33] The agency itself has duly noted its reliance on "three global surface temperature records:" HadCRUT; NOAA's global land-ocean surface temperature dataset, and NASA's global surface temperature analysis. Indeed, EPA refers to these as "the three primary global surface temperature records."[34]

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[29] *Id*. at 20-21.
[30] *Id*. at 21.
[31] *Id*. at 22.
[32] *Id*.
[33] TSD at 26.
[34] Response to Comments, Vol. 2 at Resp. 2-29.

The temperature records extant today go back to approximately 1850, and in the ensuing 160 years there have been two periods of notable temperature increases, 1910-45 and 1977-98. EPA has acknowledged that "[a]s noted by the commenters, the 30-year rate of warming for the period from the 1910s to the 1940s is very similar to the rate of warming for the 1970s to the 2000s."[35] EPA has further acknowledged that the earlier warming period did not result from the combustion of fossil fuels, as there was little increase in carbon dioxide during that time.[36] As for the later period, however, the agency is firm in the view that anthropogenic GHGs were the primary cause. It believes that a temperature increase that has occurred in the face of a diminution in solar activity and an upswing in aerosols, which should have caused a cooling trend, must be explained by anthropogenic GHG emissions.[37]

As discussed above, EPA gives decisive weight to very small temperature changes – for instance, the difference between a trend of 0.30 degrees F for the last three decades of the 20th century (which EPA says was caused by anthropogenic GHGs) and a trend of 0.25 degrees F "during a number of 30-year periods spanning the 1910s to the 1940s" (which EPA says were not caused by anthropogenic GHGs).[38] In discussing satellite data, EPA refers to trend lines for the period 1979-1997 of 0.07 degrees F per decade in one record and 0.21 degrees F per decade in another.[39]

Going further, EPA has teased out of the data what it believes to be an unmistakable warming trend in the United States from 1930 to 2005: 0.83 degrees F per century using the NOAA U.S. dataset and 0.18 degrees F using the NASA U.S. dataset (a difference of 0.65

[35] *Id*. at Resp. 2-45.
[36] Response to Comments, Vol. 3 at Resp. 3-57.
[37] TSD at 50.
[38] Response to Comments, Vol. 2 at Resp. 2-45.
[39] *Id*. at Resp. 2-48.

degrees F per century).[40] Slicing the data somewhat differently, EPA finds that "[c]omparing the trends for the entire period of record for both U.S. datasets (from 1901 to 2008 – the NOAA dataset begins in 1901, the NASA dataset begins in 1880), the difference in trends is about 0.49 degrees F per century (1.28 degrees F/century trend for the NOAA and 0.79 degrees F/century for NASA)."[41]

Thus, EPA has used the temperature records to derive trends expressed in tenths or even hundredths of degrees on the Farenheit scale. The accuracy and reliability of those temperature trends at that level of detail are therefore essential to the validity of the Finding itself. Yet, as demonstrated below, the data contain multiple discontinuities any one of which potentially can yield errors of a size comparable to or larger than the very trend that EPA is trying to discern. These discontinuities are not made clear to the public in typical presentations of the data, so the public has not had the information necessary to "assess for itself whether there may be some reason to question the objectivity of the sources."[42]

Concerns have previously been expressed by commenters about these data. Several comments submitted to the agency noted multiple problems with U.S. surface temperature records.[43] Proximity to highly localized sources of heat (buildings, parking lots, etc.), and a survey showing that most U.S. weather stations did not conform to NOAA's site selection and installation standards were among the potential sources of error identified. EPA disagreed, citing NOAA website announcements and other statements to the effect that raw data could be, and had been, adjusted to account for any possible bias arising from locational problems.[44] EPA also noted NOAA's assertion that, even assuming locational or other bias in the absolute temperatures

[40] *Id*. at Resp. 2-28.
[41] *Id.*
[42] OMB Data Quality Guidelines, 67 Fed. Reg. at 8459/3.
[43] Response to Comments, Vol. 2 at Resp. 2-27.

recorded at a particular site at any given time, the more relevant question for purposes of assessing climate change was the trend in temperature over time, for even readings from a biased measuring station could reveal an increase from month to month, year to year, etc.[45]

Another commenter noted that no adjustments were made (except in NASA's temperature records) for urbanization, and that the possibility existed that most if not all of the 20th century warming was attributable to urban heat island ("UHI") effects.[46] Disagreeing with this comment as well, EPA stated that "[t]he different surface temperature datasets shown or cited in the TSD all account for urbanization, either directly or indirectly."[47] After explaining the adjustments made to each dataset to try to account for urbanization, EPA quotes Vose et al., 2005, in concluding that "[w]hile there are fundamental differences in the methodology used to create the surface data sets, the differing techniques with the same data produce almost the same results."[48]

Still other comments expressed concern about the sparsity of data for certain time periods and geographic areas. Records from earlier time periods are notably thin, and thus, these commenters noted, there are significant gaps in scientific understanding of temperature for that era.[49] EPA responded by agreeing that early records were of poorer quality and that there were sizable regions, "especially in the tropics and the Southern Hemisphere," where substantial gaps in data coverage persist.[50] The agency nevertheless concluded that "advanced interpolation and averaging techniques" took sufficient account of these chronological and geographic gaps, "and

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[44] *Id.* (citations omitted).
[45] *Id.*
[46] Response to Comments, Vol. 2 at Resp. 2-28.
[47] *Id.*
[48] *Id*. (quoting Vose et al. 2005).
[49] Response to Comments, Vol. 2 at Resp. 2-31.
[50] *Id.*

the associated uncertainty has been accounted for in the assessment literature, which finds warming of the climate system unequivocal."[51]

Commenters also noted that the destruction of HadCRUT data rendered it impossible to attempt to replicate any analysis, and violated scientific standards. Consequently, EPA's reliance upon CRU data or analysis performed thereon violated the IQA.[52] In response, EPA stated that "the three widely used global surface temperature records show similar trends."[53] Therefore, "[e]ven if EPA and the assessment literature were to completely disregard the HadCRUT record, it would not meaningfully alter our understanding of surface temperature trends."[54] Moreover, EPA asserted, "[t]he administrative record [underlying the Endangerment Finding] was based on the assessment reports, which rely on the three major peer-reviewed global temperature records as processed, not on the raw data . . . ."[55]

Thus, EPA has been presented with substantial questions surrounding the accuracy and quality of the raw temperature data. EPA has turned aside those questions in issuing its Endangerment Finding, first because it believes that any bias, gaps or other errors in the data are duly taken into account in the assessment reports, and second because, in any event, EPA perceives that there are three independent datasets that all point to the same conclusions.

However, as demonstrated by McKitrick in *A Critical Overview of Surface Temperature Data Products* (July 26, 2010), filed herewith, and explained in more detail below, both of these conclusions are unsupportable. The biases, gaps and discontinuities have been, in some cases, discussed in the assessment literature, but not rectified in any demonstrable way, and in most cases not even acknowledged in the Intergovernmental Panel on Climate Change's Fourth

[51] *Id.*
[52] Response to Comments, Vol. 2 at Resp. 2-39.
[53] *Id.*
[54] *Id.*

Assessment Report on Climate Change ("AR4").[56] And the three records cannot constitute verification of one another since they largely rely on the same input data. In continuing to stand by their conclusions, EPA has disseminated data that fall far short of the standards of quality, objectivity, integrity and utility that the IQA and the agency's own guidelines require for matters that are highly controversial.

III. Land And Sea Global Temperature Data Bases Relied Upon By EPA Include Discontinuities And Other Deficiencies That Reduce Their Utility For Measuring Climate Trends

The global temperature databases upon which EPA has relied contain numerous common errors that render them noncompliant with the requirements of the IQA. The errors and their commonality among the databases are explained below.

A. Land Temperature Records Are Deficient

The starting point for understanding the nature and consequences of the data quality problems that necessitate this Petition is the Global Historical Climatology Network ("GHCN"). All global temperature data compilations rely upon this archive of weather station data, which was first released in 1992 on an "as-is" basis with no corrections for inhomogeneities.[57] Later editions include both raw and adjusted data. The adjustments, the effects of which are described below, were designed to remove discontinuities arising from changes in equipment and in the position of monitoring stations, and involved evaluation of the quality of the source data, manual examination of each data series for conformity (or not) to expected values based on the local climatology, and, for those stations with at least 20 years of data, comparison of each data series

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[55] *Id.*

[56] Climate Change 2007: The Fourth Assessment Report of the United Nations Intergovernmental Panel on Climate Change ("AR4"), *available at* http://www.ipcc.ch/ipccreports/ar4-wg1.htm.

[57] McKitrick at 5. "Inhomogeneities" means discontinuities in measurement due to changes in equipment, changes in time of observation, relocation of an observation station and similar events. McKitrick's references to "correcting for discontinuities" include correction for measurement discontinuities, but not necessarily to discontinuities resulting from non-climatic effects. *Id.*

to regional reference series by regression analysis of data constructed from neighboring stations over five-year periods.[58] These "reference series" were assumed to represent the climate of the area around the station. If these reference series could not be constructed, either because data for 20 years did not exist or there were an insufficient number of neighboring stations, the station was not included in the homogeneity-adjusted group, resulting in a drop in the number of source records from roughly 8000 to just under 5000.[59]

A prominent feature of the GHCN data is the drop in the number of available weather station records since the 1990 – that is, the number of raw data sources, not simply the number that are eliminated through the adjustment process described above.[60] World-wide coverage is almost non-existent for maximum-minimum data back to 1900, and after 1997, only a small number of stations in the archive were updated on a regular basis. Since 1997, in fact, only three sources have been updated monthly.[61] The drop in the number of reporting stations, which has occurred on a global basis, became even more dramatic after 2005, with airport sites representing an increasing percentage of the total.[62] The sample size has fallen by about 75 percent since the early 1970s. Indeed, GHCN now samples fewer temperature records than it did in the 1920's and 30's—a period for which the EPA has agreed the temperature sample was of poor quality.[63] Thus, the GHCN record reflects data drawn from a shrinking number of sampling locations, a growing percentage of which are ill-suited to the task of climate monitoring. For instance, in the 1930's, just over 20 percent of GHCN data were taken from airports, but since 1990 the fraction

[58] *Id.* at 6.
[59] *Id.*
[60] *Id.* at 6-7.
[61] *Id.* at 7.
[62] *Id.* at 7-9. Airport sites are not suitable for climatic monitoring purposes because they are typically found in suburban locations that have experienced substantial growth in recent decades. Additionally, the airports themselves have experienced an increase in air and ground traffic, more pavement and buildings, all of which are difficult to remove from the temperature record. *Id.* at 10.
[63] *Id.* at 8.

has jumped sharply and is currently just under 50 percent globally and nearly 60 percent in the Southern Hemisphere.

Adjustments made to account for changes in equipment and the location of monitoring stations, discussed above, have introduced discontinuities of their own. Prior to approximately 1940, the adjustments were essentially negative, and thereafter they were positive up until roughly 1990, thus cooling the early part of the record and warming the latter part.[64] Even more significant, the adjustments became quite volatile after 1990, fluctuating +/- 0.5 degrees C year to year. This fluctuation dwarfs the actual perceived warming "signal."[65] Moreover, there is no objective methodology available to assess whether the adjustments bring the data closer to the "true" temperature, or simply add to the biases.

B. These Deficiencies Are Common To All Three Principal Land Temperature Datasets

As noted above, EPA has looked to the HadCRUT, NOAA and NASA datasets as the three principal temperature data products upon which it has relied in the Endangerment Finding. CRU officials, responding to a Freedom of Information request in 2007, stated that the station data they used were obtained from GHCN and the United States National Center for Atmospheric Research ("NCAR").[66] But a review of the NCAR website reveals that its data is just "a mirror" of GHCN.[67] More specifically, the University of East Anglia's Freedom of Information officer stated on April 12, 2007 that

> the CRU's monthly mean surface temperature dataset has been constructed principally from data available on the two websites

[64] *Id.* at 15.
[65] *Id.*
[66] *Id.* at 16.
[67] *Id.*

> [GHCN and NCAR]. Our estimate is that more than 98% of the CRU data are on these sites.[68]

Thus, the HadCRUT data are drawn from GHCN. So too are the NOAA data; its website states unequivocally that the land record is taken from GHCN, with no other archives listed.[69] The NASA data are maintained by the Goddard Institute for Space Studies ("GISS"), which uses three archives: GHCN for the world outside the U.S. and Antarctica; the U.S. Historical Climatology Network and an archive of Antarctic stations from the Scientific Committee on Antarctic Research.[70]

These common origins mean that any flaws in the data infect all three of the principal datasets. EPA therefore cannot point to the similarity of results obtained from analyses of HadCRUT, NOAA and GISS data as substantiation for its overall conclusion that a warming trend is underway. To suggest, as EPA has, that studies performed using various of the three datasets "verify" each other is to ignore the congruence of the raw materials from which these datasets are constructed, and the inevitable resulting similarity in processing outcomes.[71]

C. Discontinuities In Sea Surface Temperature Data Arise From Discrepancies And Gaps In Sources

Sea Surface Temperature ("SST") data are characterized by discontinuities arising from the sources of the data and from substantial gaps in coverage.[72] All historical SST data are derived from the International Comprehensive Ocean-Atmosphere Data Set ("ICOADS") or its predecessors. ICOADS combines approximately 125 million SST records from surface ships, and an additional 60 million from buoys and other sources.[73] Until the 1930s, most of the data were obtained from ships operating in established shipping lanes, so little or no data was

[68] *Id.* at 17 (citation to correspondence omitted).
[69] *Id.* (website citation omitted).
[70] *Id.*
[71] *See also* the discussion in Part IV, below.

available for the South Pacific. The situation improved by the 1970s, with near-global coverage except for ocean areas south of Australia, South America and Africa.[74] Coverage today is almost complete except for the poles.[75]

Sampling techniques have varied substantially over the time period covered by existing records. In the early days of sailing ships, temperature measurements were taken by dropping a bucket over the side of the ship, hoisting it aboard and placing a thermometer in it.[76] The construction (e.g. wood v. canvas) of the bucket, amount of water taken in, and other factors all affected the readings, and often introduced a cool bias relative to actual temperature.[77] When steam and other forms of motive power began to overtake wind as the source of ship propulsion, changes occurred in temperature measuring techniques.[78] The ships had sensors to monitor water drawn into the engine cooling systems, and these became the source of temperature readings. These readings tended to exhibit a warm bias compared to actual temperature.[79] Ships of different nations, moreover, made the change to the engine-cooling monitors at different rates, with U.S.-flag vessels changing over more quickly than those of the United Kingdom. A more recent trend has seen adoption of hull sensors in place of the cooling water variety, and changes in hull shapes may have introduced artificial trends in the ICOADS data.[80]

Attempts to take account of the changes in source data from buckets to engine inlets have themselves introduced additional uncertainties in the data. Folland and Parker, for example, attempted an adjustment based on their assumption that around December 1941, with the U.S.

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[72] *Id.* at 18.
[73] *Id.*
[74] *Id.*
[75] *Id.*
[76] *Id.* at 20.
[77] *Id.*
[78] *Id.*
[79] *Id.*
[80] *Id.*

entry into World War II, there was an "abrupt transition from the use of uninsulated or partially insulated buckets to the use of engine inlets."[81] The Folland-Parker estimating factor, adopted by the Hadley Centre, rises from approximately 0.1 to 0.4 degrees C from 1850 to 1940, touching the 0.4 level initially in 1910 and remaining there from 1930 to 1941, at which point it drops to zero.[82] When it is remembered that EPA discerned an overall warming trend in the 20th century of ~ 0.1 degrees C, this Folland-Parker factor looms very large indeed.

Moreover, despite the assumption that the bucket method disappeared in 1941, it is now known that as of 1980 bucket measurements still accounted for nearly half of the ship-derived ICOADS data.[83] And there was an indisputable increase in the percentage of SST data coming from engine inlet sensors from 1970 to 1990. Insofar as any studies assumed that this percentage remained steady over that period, the actual increase implies another potential source of upward bias.[84]

Other analyses of the SST data revealed a discontinuity around 1945 that coincided with an increase in data coming from ships of the United Kingdom and a decrease in data from U.S vessels.[85] An abrupt "step" occurs in the data. If that step is resolved by raising post-1945 data to make it continuous with that from prior to 1945, the entire series is rendered flat, implying a lack of warming. On the other hand, if the pre-1945 data is lowered to join the post-1945 data, the resulting warming trend becomes much larger than previously supposed.[86] In either case, dramatic apparent trends in climate are produced, or as McKitrick notes: "Either way, a massive

[81] *Id.*, *quoting* Folland and Parker (1995).
[82] *Id*. at 21 and Fig. 3-5, *citing* Folland and Parker (1995) at Fig. 19.
[83] *Id*. at 21.
[84] *Id.*
[85] *Id*. at 22-23, *citing* Thompson et al. 2008 and Kent et al. 2007.
[86] *Id*. at 23.

revision to the current understanding on global warming comes down to a largely arbitrary decision about how to fix an odd, recently-discovered discontinuity in a shaky data series."[87]

Prominent climate scientists debated the meaning of this blip and a similar one in land data. McKitrick notes an email discussion among Tom Wigley, Phil Jones and Ben Santer in September 2009, in which they discuss possible adjustments and their consequences.[88] The important point is that, as recently as last September, large and arbitrary changes to global SST series were being debated, any of which could fundamentally alter the mid-20th century temperature picture and even create new discrepancies in current climate models.

Finally, as was the case with land temperature stations, the number of ships providing SST data has been declining steadily.[89] Buoys and satellites have helped to maintain data coverage to an extent, but there are problems with each. Most buoys are in fixed locations near coasts. The new, globally-dispersed Argo drifting buoys do not measure sea surface temperature, but instead develop a profile beginning at a depth of 10 meters below sea level and dropping up to two kilometers below that.[90] Sea ice also affects SST data, for the hazards it poses meant that little data was obtained by ships in those areas in which sea ice was present. Satellites have to some degree helped to fill the gap, but adjustments to satellite readings were necessary to make them compatible with older, sparsely-sampled ship data.[91]

Taken as a whole, then, the SST data contain numerous discontinuities and sources of potential error that have not been sufficiently considered by EPA. As with the land temperature records, the margins of error may well exceed the very trend that EPA claims to have divined in

[87] *Id.*
[88] *Id.* at 24, *quoting* email from Tom Wigley to Phil Jones and Ben Santer, 1254108338.txt (Sept. 29, 2009) and email from Phil Jones to Tom Wigley, 1254147614.txt (Sept. 30, 2009).
[89] *Id.* at 25.
[90] *Id.*
[91] *Id.*

issuing its Endangerment Finding, and the problems in the data have not been sufficiently disclosed to allow the public to understand the objectivity of the data sources.

D. Uncertainty Persists About The Relationship Of Sea Surface To Air Temperature

SST data is combined with GHCN data to produce global temperature records. Implicit in this method is an assumption that the two together create an average of near-surface temperatures.[92] The CRU acknowledges that this approach "assumes" that anomalies in SST data mirror those in marine air temperatures ("MAT").[93] A study of 1979-99 SST and MAT data, however, revealed that the tropical ocean has been warming relative to the air, indicating that the SST data has been overstating air temperature trends.[94] Subsequent studies appear to confirm the trend of SST warming in relation to the air in the Southern Hemisphere, and at a minimum confirm the need for further investigation of the relationship between SST and MAT.[95]

IV. The Quality Limitations Inherent In The GHCN And ICOADS Datasets Make It Impossible For Any Subsequent Data Processing Efforts To Be Truly Independent

The limitations of the land and sea surface temperature records discussed above inexorably destroy the independence of subsequent analyses performed upon them. In recent months several independent efforts have been undertaken, including by the Muir Russell Review Team, to produce independent globally-averaged land temperature anomaly series from the GHCN. McKitrick reproduces a graph depicting the results for the global land average from various bloggers as well as traditional sources.[96] The similarities in results of the various studies

[92] *Id.*
[93] *Id.* at 25-26, *quoting* CRU Frequently Asked Questions, available at http://www.cru.uea.ac.uk/cru/data/temperature/.
[94] Christy et al. (2001), *cited in* McKitrick at 26.
[95] Rayner et al. (2003), *cited in* McKitrick at 26.
[96] McKitrick at 29, *citing* http://nonconsensus.wordpress.com/2010/07/14/gridded-global-temperature/.

are readily apparent and strongly suggest that, given the input data (GHCN), subsequent processing or analytical steps do not make much difference to the global average.[97]

McKitrick has reviewed the methodology employed by GISS, CRU and NOAA to analyze the GHCN and ICOADS data.[98] He notes specific variations in the approaches taken by each organization to compute anomalies, grid the data, average up to the zone and hemisphere levels, combine land and sea data and interpolate for missing regions.[99] He concludes that "[t]he different teams do not introduce any major differences as a result of their processing steps, although there are small but important differences in some decades."[100]

The similarities in outcomes—notwithstanding differences in methodology—noted by McKitrick are not unlike the observation of the Muir Russell Inquiry, which sought to demonstrate that the CRU global land-based record could be readily replicated. By downloading some data and performing fairly straightforward averaging, the Muir Russell team was able to produce global average temperature series that strongly resembled the CRU series.[101] The Muir Russell Inquiry concluded, based on this experience, that the major features of the CRU global average temperature series could be replicated by anyone who sought to do so. McKitrick draws a more significant conclusion, however:

> *The processing steps make little difference, once the series data (GHCN and ICOADS) have been chosen. Quality limitations in those data sets put boundaries on the quality of any resulting global average.*[102]

[97] *Id*. at 30.
[98] It bears reiteration that "[a]ll temperature products rely on GHCN (land) and ICOADS (ocean)." *Id.* at 31.
[99] *Id.* at 31-33.
[100] *Id.* at 33.
[101] *Id.*
[102] *Id.* (emphasis in original).

Thus, there is in the end little real measurement independence across the various global temperature products. The similarity of these data products does not provide independent replication for any of them, since each is, at bottom, analyzing the same data.[103]

V. In Addition To Quality Problems Due To The Changing Numbers And Location Of Measuring Points, The GHCN Data Contains Biases Due To Urbanization And Other Land Use Changes

It was explained in Part III, above, that the GHCN and ICOADS data are affected by changes in the number and location of measuring stations, as well as changes in certain aspects of the measuring process, e.g. the shift from buckets of water to engine inlet temperature readings for the SST data. Another source of bias that directly affects the quality of GHCN data, however, derives from the urbanization of an area surrounding a particular measuring station, and other changes in land use over time. These non-climatic influences must be removed from the temperature record in order to discern the climatic record.[104] The need for such an adjustment has been recognized by climate scientists and institutions, but corrective efforts have fallen short and left the major datasets, including those relied on in the very reports on which the Endangerment Finding is based, infected with error. Indeed, as with other data discontinuities, the magnitude of the error induced by these urbanization and land use influences is greater than the overall warming trend discerned by EPA.

A. Attempts At Adjusting Data For Non-climatic Influences Have Been Ineffective

For example, in AR4 (as well as its three predecessors) the IPCC acknowledged contaminating influences on temperature data, but claimed that adjustments had been made to remove them. As McKitrick notes, "[t]his forms an essential assumption behind all the key

[103] *Id.*
[104] *Id.* at 34.

IPCC conclusions."[105] The Summary for Policymakers accompanying AR4, for example, stated that "Urban heat island effects are real but local, and have a negligible influence (less than 0.006 degrees C per decade over land and zero over the oceans) on these values."[106] But this 0.006 figure is taken from Brohan et al. (2006), where it is simply an assumption about the standard error, not a statement of the size of the trend itself.[107] Elsewhere in AR4, similarly dismissive comments are made about the problem of surface data contamination, but the cited authorities that are claimed to have addressed the effects of urbanization in fact did not do so.[108]

The CRU cautions that its unadjusted temperature data products are not suitable for climatic analysis, and refers users instead to the CRUTEM products. The documentation accompanying those latter products, however, does not explain what adjustments were made or the grounds on which the CRUTEM products are claimed to be reliable for climate research.[109] What is clear about the CRU's data, however, is that it relies on subjective, largely undocumented methods to remove non-climatic influences from its temperature data. For example, the Brohan study cited in AR4 does not explain actual adjustments to CRU data, and instead simply focuses on the claim that any biases are small.[110] Original CRU records pertinent to the adjustments were not retained, so it is no longer possible to determine the size of these adjustments.[111]

Proper adjustment for urbanization bias would, as noted by Brohan et al., require a global comparison of urban versus rural records, but such a classification is impossible, so they resort to

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[105] *Id.* at 35.
[106] *Id*. at 35, *quoting* IPCC, 2007: Summary for Policymakers, in Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf.
[107] *Id*. at 35.
[108] *Id.* at 36.
[109] *Id.* at 37.
[110] *Id*. at 36, *citing* Brohan et al. (2006).
[111] *Id.* (internal Brohan et al. citations omitted).

the assumption noted above that the bias is no larger than 0.006 degrees C per century.[112] Another study of the CRU data, by Jones and Moberg (2003), emphasizes the need to correct for non-climatic influences.[113] But the procedures used to make their adjustments are never explained; they are described as "subjective interstation comparisons" and readers are then referred to two reports that only cover data sets ending in the early 1980s, though the data under dispute are in the post-1979 period.[114]

GISS fares no better than CRU in its attempts to account for urbanization. It classifies temperature stations as urban or rural based on population data, then derives a comparison for urban stations by averaging three or more rural stations in the vicinity, drawing circles of up to 1000 km if needed to encompass three such stations.[115] The problems with GISS's approach are first, that the method requires a dense sample of rural-urban pairs, which are largely unavailable outside the United States; second, that it fails to account for the relatively more rapid bias that occurs in the early stages of urbanization; and third, that it ignores the fact that stations in rural areas are commonly connected to agriculture, which generates warm bias effects of its own.[116]

These problems warrant closer scrutiny given the magnitude of the adjustments they engender. Addressing first the rate of growth issue, the standard model of urban heating, developed by Oke (1973), is logarithmic, implying the largest rates of change occur as small populations expand. If a town were to grow from 500 to 1000 persons over the time period of the calculation, it would still be considered "rural" under the GISS analysis and would therefore not be adjusted, but would record a 0.22 degree C false warming according to the standard model.[117]

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[112] *Id.*
[113] *Id., citing* Jones and Moberg (2003) at 174.
[114] *Id.*
[115] *Id.* at 37.
[116] *Id.* at 37-38.
[117] *Id.* at 38.

A town that grew from 240,000 to 250,000 would add only 0.014 degrees C of false warming, yet it would be adjusted to have the same rate as the small town, thereby increasing its apparent warming rate.[118]

The heat effects of agriculture were studied by Chagnon (1999). He described a temperature series collected from 1889 to 1952 at an Illinois agricultural research station. The collection instrument was moved twice as the university expanded, in an effort to maintain the "rural" character of the immediately surrounding land.[119] Air temperatures were also collected, at a station above ground that was gradually encroached upon by the university, and in two nearby towns. The U.S. Historical Climatology Network estimated a warming of 0.6 degrees C over the time period, deeming that figure to be free of any urbanization bias, but Chagnon found that the soil temperature increased only by 0.4 degrees C, leading him to conclude that even smaller communities and university campuses can have larger urban heating effects.[120] Likewise, Christy et al. (2006) showed that warming trends measured in a California valley, where agriculture had been introduced, were not supported by temperatures measured on nearby mountainsides where no agriculture had been introduced.[121]

Brohan et al. emphasize that urbanization adjustments should always yield temperature reductions: "recent temperatures may be too high due to urbanization, but they will not be too low."[122] Yet the GISS method manages to "routinely" yield urbanization adjustments that increase the estimated trend: about 42 percent of the time in US data.[123] Most U.S. stations have enough nearby rural data to support estimation of an adjustment, though a much smaller

[118] *Id*.
[119] Chagnon (1999), *cited in* McKitrick at 38.
[120] *Id*.
[121] Christy et al. (2006), *cited in* McKitrick at 38-39.
[122] Brohan et al. (2006) at 11, *quoted in* McKitrick at 38.
[123] McKitrick at 38.

percentage of those outside the U.S. do.[124] Hansen et al. (2001) estimated that the overall effect of the adjustments is to reduce 20th century warming in the U.S. by approximately 0.15 degrees C. They estimate warming from 1900 to 1999 at 0.51 degrees C globally, as compared to 0.32 degrees C in the U.S.[125] Again, the margins of error reflected in these adjustments are of a magnitude comparable to the very trend that EPA claims to have established.

B. Recent Studies Confirm That Data Adjustments Have Not Removed The Effects Of Urbanization And Other Land Use Changes

The foregoing discussion focuses on the attempts that have been made to describe the particular components of adjustments to temperature data to account for urbanization—what McKitrick calls an *ex ante* test.[126] Less attention has been paid in the scientific community to *ex post* tests: those tests that would facilitate a determination of how effective, or accurate, the adjustments were. One such *ex post* test was presented by Kalnay and Cai, who compared surface temperature data to "reanalysis" data from 6-hour ahead weather forecasts. The reanalysis data contained surface forecasts generated using atmospheric (but not surface) observations of wind and temperature taken from weather balloons and satellites.[127] These data, Kalnay and Cai contended, closely emulate the surface data but are free from the latter's contamination by land use changes or urbanization.[128] They found a difference of +0.27 degrees C over a century in minimum temperature trends at the surface versus their reanalysis data, implying a substantial warming bias in temperature records.[129]

The IPCC contends that a subsequent analysis by Vose et al. (2004) did not support Kalnay and Cai's methods. But as McKitrick notes, they actually reinforced Kalnay and Cai's

[124] *Id*. at 39 (citation omitted).
[125] Hansen et al. (2001), *cited in* McKitrick at 39.
[126] McKitrick at 39.
[127] Kalnay and Cai (2003), *cited in* McKitrick at 39-40.
[128] *Id.*

findings; their claim that the results were implausible was merely their opinion.[130] Another study by Simmons et al. (2004) suggested that Kalnay and Cai's results may have been a function of poor quality reanalysis data, a position adopted by the IPCC in AR4.[131] The dataset used for the Simmons study relies on CRU data as an input to its own forecast scheme, so there is a lack of complete independence between the Simmons inputs and the data being tested.[132] In addition, Phil Jones served as a second author on the Simmons paper, as well as Coordinating Lead Author of Chapter 3 of the IPCC report, so the latter's endorsement of the former amounts to Jones embracing his own work.[133] An email from Jones to Mann, quoted by McKitrick, reveals Jones's satisfaction that "[t]he main results are great for CRU . . . ."[134]

In short, the use of reanalysis data as a workable *ex post* test of temperature data is an ongoing effort. The short shrift it was given by the IPCC calls into question that body's adherence to sound scientific methods and casts substantial doubt on the quality of its analysis.

The IPCC's treatment of urbanization effects also relied upon studies by David Parker (2004, 2006), which the IPCC cited in support of the organization's conclusion that the UHI effect did not bias global temperature trends over land.[135] Parker's study was based on the contention that windy conditions mitigate the UHI effect, and therefore the strength of that effect could be measured by comparing temperatures on calm and windy nights.[136] His analysis revealed that while temperatures were lower on windy nights, the warming trends discernible on

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[129] *Id.*
[130] McKitrick at 40, *citing* Vose et al. (2004).
[131] AR4 at 245, *quoted in* McKitrick at 40.
[132] McKitrick at 41.
[133] *Id.*
[134] Email from Phil Jones to Michael Mann dated July 8, 2004 (1089318616.txt), *quoted in* McKitrick at 41.
[135] McKitrick at 43.
[136] Parker (2004, 2006), *cited in* McKitrick at 42-43.

windy and calm nights were essentially the same. Hence, he concluded that the UHI effect on temperature records was minimal.[137]

The problem with the Parker study is that it rests on a premise, or an assumption, not proven by his source or his analysis. Parker cited Johnson et al. (1991) for the basic notion that wind mitigates the UHI effect.[138] Johnson, however, had contended only that calm, clear conditions were optimal for the formation of the UHI effect, not that windy conditions prevented it.[139] Consequently, the results obtained by Parker are equally explainable by the possibility that the UHI effect is present on windy nights as well as calm nights.[140] The IPCC has therefore read too much into Parker's study. Further, Parker himself was a Lead Author of the section of the IPCC report that dealt with his own material, so as was the case with the debate over the Kalnay and Cai study, the IPCC's judgment lacks independence.[141]

A third possible *ex post* test of temperature data involves assessment of the relationship between the spatial pattern of warming over land and the pattern of industrialization. If climate data have been properly adjusted to remove the influence of industrialization, urbanization and other land use changes, then no correlation should be observable. But de Laat and Maurellis (2004, 2006) found a strong correlation, as did McKitrick and Michaels (2004a, 2007).[142] Two studies, one by Benestad (2004) and another by Schmidt (2009), attempted to challenge these findings. The first was not itself peer reviewed, and it was refuted by McKitrick and Michaels (2004b and 2007). The second was refuted by McKitrick and Nierenberg (2010), which showed that the original results were replicated across a large number of different data combinations,

[137] *Id.*
[138] McKitrick at 42, *citing* Johnson et al. (1991).
[139] *Id.*
[140] McKitrick at 43.
[141] *Id.* at 44.
[142] *Id.* at 44, *citing* de Laat and Maurellis (2004) *and* McKitrick and Michaels (2004a, 2007).

including three versions of the CRU data and different satellite data sets, and was robust to treatment for spatial autocorrelation, whereas Schmidt's own results were not.[143]

In responding to the Muir Russell inquiry, the University of East Anglia relied upon the Benestad and Schmidt papers. Yet Phil Jones of the University's CRU was the reviewer of Schmidt's paper for the journal in which it appeared, so its approval for publication was not independent support for Jones' data.[144]

Thus, two independent teams publishing in multiple climate journals found correlations in climate data between land use and warming trends, undercutting the contention that these patterns have been removed. Papers challenging these findings have been refuted, but the refutations have not been factored into more recent inquiries into the efficacy of the scientific processes employed by the CRU or incorporated into the work of the IPCC.

CONCLUSION

For all of the foregoing reasons, Peabody respectfully requests that this Petition for Correction be granted.

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[143] *Id.* at 44, *citing* McKitrick and Nierenberg (2010).
[144] *Id.* at 45, *citing* http://www.climate-gate.org/cru/documents/review_schmidt.doc.