On Challenges to EPA's Climate Change Endangerment Finding

Michael MacCracken

June 2017

A Climate Institute Publication
1400 16th Street, Suite 430, Washington DC 20036

On April 2, 2007, so just over ten years ago, the U.S. Supreme Court ruled 5 to 4 that the Environmental Protection Agency had the authority under the Clean Air Act to limit emissions of carbon dioxide (CO_2). The majority opinion in Massachusetts versus EPA (549 U.S. 497, 2007) was written by Justice Stevens.[1] As described in an early commentary by Climate Institute president John Topping,[2] Justice Stevens granted standing to Massachusetts based in part on a declaration prepared by Dr. Michael MacCracken, the Climate Institute's Chief Scientist for Climate Change Programs. Among other impacts, MacCracken's brief described how sea level rise being caused by the warming of ocean waters and the melting of land-based glaciers and ice sheets was going to be taking the land of the Commonwealth of Massachusetts, and the state had turned over responsibility for defending its boundaries when it joined the Union.[3]

As a result of the decision, the Environmental Protection Agency was required to move forward in considering whether there was a basis for regulating CO_2 rather than, as it had been doing, choosing not to move forward in even considering the issue. The process of developing the required document, called an Endangerment Finding, took over two and a half years and involved expert preparation of a review of the scientific literature, the legal basis for making a finding, and then an extensive public review process that led to over 380,000 comments, each of which was considered in preparation of the eventual finding. Finally, on December 7, 2009, the Administrator of EPA signed the Endangerment Finding,[4] and, following it publication in the Federal Register on December 15, 2009,[5] EPA began the process of preparing regulations that would limit the emissions of CO_2 and a number of other greenhouse gases from the transportation, electric utility and other sectors.

With the inauguration of Donald Trump as President and the appointment and confirmation of Scott Pruitt as Administrator of the EPA, past actions of the EPA are being reconsidered. As one aspect of this reconsideration, two petitions have been filed seeking a new rule-making proceeding to consider the effects of CO_2 and other greenhouse gases on public health and welfare. The first petition has been submitted by the "Competitive Enterprise Institute, the Science and Environmental Policy Project, and four individual members of the latter's Board of Directors",[6] hereafter referred to as CEI/SEPP, and the second has been submitted by "Concerned Household Electricity Consumers Council, consisting of Joseph D'Aleo, Clement Dwyer, Jr., Russell C. Slanover, Scott Univer, James P. Wallace III, Robin D. Weaver, and Douglas S. Springer",[7] hereafter referred to as CHECC.

In support of their request for EPA reconsideration, the petitioners assert that new scientific findings (indeed, so new they have not been published in a reputable journal nor confirmed by independent scientific studies by those most widely published in the field) justify a new look being taken at the understandings of climate change science and impacts that have been confirmed in five international scientific assessments conducted by the Intergovernmental Panel on Climate Change and been affirmed by international academies of science and professional societies around the world and utilized, after careful review, by three national assessments of climate change impacts on the United States.

While the international and national consensus on the important role that human-caused emissions of CO_2 and other greenhouse gases are having now and will have in the future is a reason for suspicion regarding the validity of the new science cited in the two petitions, new ideas do merit consideration and evaluation in their own right. As an initial step, Dr. MacCracken, who wrote the declaration for the Supreme Court, has reviewed the two petitions and provided comments on a section-by-section basis regarding both the CEI/SEPP and the CHECC petitions.

Overall, he finds both petitions seriously deficient and in no sense sufficient to justify a reconsideration of any of the findings in EPA's Endangerment Finding. Indeed, since that Finding was written the intensity and understanding of the seriousness of many of the impacts has significantly increased. As just one example, the rate of sea level rise, which was the basis of the Supreme Court finding on standing, has been confirmed to be accelerating at a faster rate than over most of the 20th century and the rise in sea level during the 21st century are now, due to the accelerating loss of ice from the Greenland and Antarctic ice sheets is now projected to be roughly double the rate projected in 2004 when the MacCracken's legal declaration was written. The draft Climate Science Special Report prepared under the auspices of the U.S. Global Change Research Program and now being revised after public comments and consideration by the National Academy of Sciences provides a thorough examination of recent scientific findings and how they have modified, indeed generally amplified, the projected impacts of human-induced climate change on the United States.[8]

Based on available scientific literature and new findings, there is no scientific basis for reconsidering EPA's 2009 Endangerment Finding or that it overstates the seriousness of the situation that humanity faces.

Section-by-Section Analysis of CEI/SEPP Filing

The "Petition of the Competitive Enterprise Institute and the Science and Environmental Policy Project for Rulemaking on the Subject of Greenhouse Gases and Their Impact on Public Health and Welfare, in Connection with EPA's 2009 Endangerment Finding, 74 FR 66,496 (Dec. 15, 2009)" (hereafter CEI/SEPP), in calling for initiation of a new rule-making procedure regarding the threat of human-induced climate change, makes a number of statements that are incomplete and/or misleading based on my experience and the state of understanding as reported on in major, widely peer-reviewed national and international scientific assessment reports (which can be referred to for access to the international scientific literature).

Page 1, second paragraph: The statement that "since that finding was issued, evidence has continued to mount that directly contradicts it" is extremely misleading. Since the Endangerment Finding was approved in 2009, not only has there been very extensive additional research reported in peer-review publications that confirms and amplifies the seriousness of the findings within the Endangerment Finding, but the Intergovernmental Panel on Climate Change (IPCC) has also issued its Fifth Assessment Report (FAR), which has been agreed to unanimously by the roughly 190 countries that participate in the IPCC process. The most recent IPCC assessment makes clear, among other findings reported in its Summary for Policymakers for Working Group I, that:

- "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia."
- "The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia (*high confidence*)."
- "The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years," this being the period for which ice core data are available.

- "Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system."
- "Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes. This evidence has grown since [IPCC's Fourth Assessment Report]. It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century."
- Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions."
- "Cumulative emissions of CO_2 largely determine global mean surface warming by the late 21st century and beyond. Most aspects of climate change will persist for many centuries even if emissions of CO_2 are stopped. This represents a substantial multi-century climate change commitment created by past, present and future emissions of CO_2."

The Synthesis Report from the IPCC's Fifth Assessment Report reiterates the IPCC WG I findings and adds additional key findings, including:

- "Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks."
- "Climate change will amplify existing risks and create new risks for natural and human systems. Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development."
- "Without additional mitigation efforts beyond those in place today, and even with adaptation, warming by the end of the 21st century will lead to high to very high risk of severe, widespread and irreversible impacts globally (*high confidence*)."

- "Adaptation can reduce the risks of climate change impacts, but there are limits to its effectiveness, especially with greater magnitudes and rates of climate change."

In addition to these international reports, the U.S. Global Change Research has a report updating the findings of the IPCC FAR with a focus on the United States. It is this report, widely authored and peer-reviewed, including by the National Academy of Sciences (NAS), that is considering the latest research relevant to climate change impacts on the United States, including evidence both supporting and modifying previous understanding. The draft report reviewed by the NAS, invited experts, and the public provided no support for reconsidering the Endangerment Finding because of an overstatement of the seriousness of the issue; if anything, recent research indicates that the evolving situation is more serious than earlier concluded.

Page 1, third paragraph, Procedural Background: CEI/SEPP's petition suggests that "[a] rulemaking proceeding is appropriate when new developments demonstrate that an existing rule or finding rests on erroneous factual premises...." As indicated in response to the statement in the second paragraph above, there is ample evidence to suggest that the Endangerment Finding is confirmed and not based on "erroneous factual premises." There is thus no basis for undertaking a rulemaking to re-examine the Endangerment Finding.

Page 1, bottom paragraph and page 2, first paragraph: The basis for standing asserted by the CEI and SEPP provides no indication, for example by citation of published peer-reviewed papers, of the petitioners having expertise in the area of climate change science, generally or specifically, on which the Endangerment Finding is based. The Endangerment Finding does not mandate particular policy actions, but simply finds that climate change resulting from ongoing activities is occurring and will create serious impacts and risks for the environment and society that would justify rule-making.

Pages 2-3, Claim I. "There Has Been No Statistically Significant Atmospheric Warming Despite a Continued Increase in Atmospheric Carbon Dioxide Levels; This Seriously Undercuts the Endangerment Finding's First Line of Evidence Regarding an Adequate Understanding of Climate"

Claim I of the petitioners asserts, essentially, that, because 1998 and 2016 had essentially the same global average atmospheric temperature even though the CO_2 concentration has risen by about 37

ppm, "serious question" is merited regarding "EPA's contention that we have an adequate 'physical understanding of the effects of changing concentrations of GHGs ... on the climate system.'" This claim fails on several grounds:

1. The Endangerment Finding is focused on changes in the "climate." As defined by NOAA, "climate" is the state of the system compiled over three decades (including averages and other statistical measures). This multi-decadal period is used in order to ensure that there is no unusual influence resulting from the natural variability that results from one year to the next as the weather fluctuates due to such factors as the occurrence of an El Niño or La Niña event, volcanic eruptions, and various internal air-sea and other fluctuations. Comparing the trend from one year to another single year is a scientifically improper way to determine a trend in the climate. When the observations are properly grouped to look at trends in the averaged conditions over decadal and longer periods, the warming trend is very clear.
2. The petitioners appear to have chosen to look at the trend in the tropospheric temperature rather than the surface temperature. The multi-decadal temperature record for the troposphere (roughly the lowest 6 to 10 kilometers of the atmosphere) is generated by back-calculating from satellite observations of microwave emissions at wavelengths near the oxygen bands. This record provides an estimate for several-kilometer thick layers of the atmosphere rather than an observation at some specific altitude. The resulting record has had to go through several revisions and corrections over the past few decades due to a number of well-documented problems and it is not yet proven that all such problems have been resolved (e.g., that the tropospheric warming record due to the rising concentrations of GHGs is not anywhere influenced by the cooling of the stratosphere that is also an expected result of the rising concentrations of GHGs). In addition, because the satellite record is suggested to mainly result from changes in the mid-troposphere, the record does not record the significant amplification of surface temperature warming that is occurring in high latitudes below a strong near-surface inversion is being broken nor does the mid-tropospheric temperature record account for the greater increase in nighttime minimum land surface temperatures that is observed because convection is not mixing near-surface air up through the troposphere through the nighttime hours.
3. The petitioners are inappropriately comparing apples and oranges. On the one hand, they are

drawing a trend from observations that include the effects of all external factors that are affecting the climate, so, in addition to the warming influence of the increase in GHG concentrations, the observations include influences from changes in solar radiation, changes due to volcanic eruptions, changes in the locations and amounts of the emissions of SO_2 that would rapidly alter the intensity and location of sulfate cooling, and so on. In addition, they are comparing their record to the expected rate of change calculated in model simulations that are only considering the changes in the CO_2 concentration assuming that the influences of all other factors are held constant, which has clearly not been the case (especially when the time constants of the response are accounted for). In contrast to this improper comparison of observations with model results intended to simulate only the effects of the rising CO_2 concentration, the scientific community has carried out very detailed detection-attribution studies that, in comparing to observations, do account for all of the other influential factors in addition to the changing CO_2 concentration, and these studies make clear that the very important influence of the rising CO_2 concentration is present to the extent that was documented in the Endangerment Finding.

In summary regarding this claim, the petitioners also assert that there has been a hiatus in the warming over the period from 1998-2016. Careful study makes clear that this was not the case and warming of the climate system was continuing. In addition, trends in other measures of the state of the climate also make clear that human-induced climate change was ongoing, including retreat and thinning of Arctic sea ice, rising sea level, increases in atmospheric moisture, shifting ranges of fishes, birds and other species, and much more. Cherry-picking two particular years that are relatively close together (18 years apart when the definition of climate focuses on changes in the average over periods of three decades) and that were also influenced by factors other than just the rising CO_2 concentration is not a proper scientific analysis or provide credible evidence favoring the purported claim.

Pages 3-4, Claim II: "Contrary to the Endangerment Finding's Second Line of Evidence, Changes in Global Temperatures in Recent Decades Are Far From Unusual."

In making the argument in support of this claim, the petitioners put forth a number of very

misleading statements:

1. "Over recent geological time, Earth's temperature has fluctuated naturally between about +4°C and -6°C with respect to twentieth century temperature. A warming of 2°C above today, should it occur, falls within the bounds of natural variability." Geological data suggest that the last time global average surface temperature was 4ºC above its 20th century value was tens of millions of years ago (a time when there was no Greenland Ice Sheet and likely only a very small ice sheet in Antarctica, a situation that today would likely result in sea level being 50-60 meters, so about 160-200 feet, above its present level!). Based on paleoclimatic evidence, including quite definitive results recorded in ice cores from Greenland and Antarctica, the last time global average temperature was 6ºC below its 20th century value was nearly 20,000 years ago, a time when massive ice sheets covered much of North America and Europe and sea level was about 120 meters, so about 400 feet, below its present level. While I can agree that human factors were not active in those times, the changes were not just natural fluctuations or variations. Changes recorded in ocean sediment cores and other geological and paleoclimatic evidence make clear that glacial-interglacial cycling and other large changes in the Earth's climate have been driven largely by identifiable and explainable changes in the global energy balance and in the locations continents and oceans. Very warm periods of the distant past, for example, were due in part to a considerably higher atmospheric CO_2 concentration as well as significantly different continental locations, mountainous extent, and ocean circulation. Accumulated paleoclimatic evidence also makes clear that the glacial-interglacial cycling of the last million years has been driven by significant changes in the latitude-season distribution of incoming solar radiation caused by the shape of the Earth's orbit. In particular, periods of glacial accumulation generally occurred when incoming Northern Hemisphere summer radiation was reduced by several percent and wintertime solar radiation was a bit higher than at present so that there was energy enough to evaporate ocean waters that could later fall as snow, and periods associated with glacial melting were a result of greater than average solar radiation in summer and less than average in winter. The most dominant time scale of glacial-interglacial cycling has been about 100,000 years, so over times quite long compared to the several thousand year, fortuitously stable climatic period during which civilization developed. Thus, as for much warmer periods of the much more distant past, the changes are being forced by seasonal and

latitudinal cycles in radiative forcing and long-term feedbacks; they are not a result of random fluctuations of the natural climate system.

The variations in multi-decadal global average surface temperature over the few millennia prior to the Industrial Revolution when cities and communities developed and that has determined global vegetation cover have relatively slowly varied, reaching only about plus and minus 0.5ºC from the several-thousand year average. By contrast, the global average surface temperature has risen a bit over 1ºC since the late 19th century and is projected to go up another few degrees Celsius by 2100 unless there is an early and sharp reduction in the emissions of CO_2 and other greenhouse gases. The projected warming, if allowed to happen will in a century or two return the Earth's global average temperature to the very warm conditions that last occurred tens of millions of years ago, so at a rate roughly five orders of magnitude faster (assuming no air resistance, a passenger jumping from a jet plane without a parachute would impact the surface less than two orders of magnitude faster than a normally descending softly aircraft lands). The rate of human-induced climate change is just far faster and larger than has occurred in the past other than when a very large asteroid has hit the Earth and wiped out most species—it is not "within the bounds of natural variability" that civilization has experienced and survived.

2. "At the current level of ~400 ppm we still live in a CO_2-starved world. Atmospheric levels 15 times greater existed during the Cambrian Period (about 550 million years ago) without known adverse effects." Human-induced climate change may not be a threat to the planet, but what matters for humans and society is what the situation has been during the period of human existence, which, even going back to the earliest time of man, is only about 0.5% of the time the CEI-SEPP petition is referring to. 550 million years ago was about the time that the most basic plants and animals were first appearing on Earth; dinosaurs did not appear until about 230 million years ago. Even if plants did evolve during periods when the CO_2 concentration was considerably higher than at present, the biosphere was very different, with what is now tropical vegetation at high latitudes because the world was much, much warmer. It is a real stretch of logic to reach back that far, especially as Homo sapiens did not appear until ~250,000 years ago when the CO_2 concentration was fluctuating between about 200 and 300 ppm as a result of glacial cycling. While scientists are not suggesting that the rising

CO_2 concentration is going to wipe out life on Earth, the altered climatic conditions, the rising sea level, and the intensifying ocean acidification are projected to very significantly alter the environment in which plants and animals (including humans) will be trying to exist. Scientific projections suggest that the induced changes in climate will cause a few tens of percent of plant and animal species to go extinct because there will be no suitable environmental niche for them to occupy. Were humans not able to use energy to create suitable artificial environments (e.g., air-conditioned spaces so they would not need to migrate with the season or hibernate as many other species do), the global population would be unlikely to persist in such numbers. Extensive scientific studies have made clear that a rapid transition to a world with a much higher CO_2 concentration would lead to disastrous consequences for the environment and the ecological services that are provided as well as for coastlines, water resources, communities, society in general.

3. "The overall warming since about 1860 corresponds to a recovery from the Little Ice Age modulated by natural multidecadal cycles driven by ocean-atmosphere oscillations, or by solar variations at the de Vries (~208 year) and Gleissberg (~80 year) and shorter periodicities." This is pure speculation (i.e., wishful thinking) that is in many ways inconsistent with the scientific evidence. Prior to the 19th century, there appears to have been a slow global cooling from the peak post-glacial warmth that occurred roughly 5000 to 7000 years ago when the Earth's orbit took it closest to the Sun during the Northern Hemisphere summer. Subsequent cooling was coincident with a slow change in the time of year when the Earth was closest to the Sun, with closest approach going roughly from late summer in the Northern Hemisphere into fall and then winter (recall, the relatively rapid deglaciation occurred during the period when the Earth was closest to the Sun during Northern Hemisphere spring into summer). While total annual solar radiation reaching the top of the atmosphere integrated over the Earth is not changed by the cyclic orbital changes, the reduction of solar radiation during the Northern Hemisphere's warm months tends to reduce the average temperature more than the Southern Hemisphere temperature increases because the Northern Hemisphere is mainly land, which is much more sensitive to changes in the seasonal variations in solar radiation than the Southern Hemisphere, which is mainly ocean.

During this several-thousand year period of global cooling, there were some variations, both warmer and cooler. These changes were most intensive in the land areas around the North Atlantic Ocean, but also occurred in other areas, although not always simultaneously. Contributing factors to the quite cool period several hundred years ago in the North Atlantic (often referred to as the Little Ice Age) likely included not only the changing orbital configuration, but also a higher than average rate of large volcanic eruptions, postulated reductions in the absolute amount of solar radiation, and perhaps also changes in land cover and other factors that affected surface reflectivity and other factors. The petitioners assert that the late 19th and early 20th century warming was a recovery from this colder than typical situation due mainly to changes in the intensity of solar radiation (which have been estimated based mainly on changes in the number of sunspots, even though present satellite observations indicate that the relationship of sunspot number to solar radiation is too weak to explain the entire change). Based on more comprehensive scientific studies, the postulated changes in solar radiation were simply not large enough to explain the warming that has occurred and that, in the absence of the well-reconstructed increases in greenhouse gas concentrations, the climate would have remained cool or even become cooler because of the ongoing orbital changes. The detection-attribution studies that have been done make very clear that if the inferred solar changes were able to cause the warming suggested by the petitioners, then consistency would require that the warming influence of the rising concentrations of greenhouse gases be substantially more than has been observed.

4. "The causes of historic global warming remain uncertain, but significant correlations exist between climate patterning and multidecadal variation and solar activity over the past few hundred years." While there have been a number of studies that suggest a relationship between changes in incoming solar radiation and climate, careful scientific studies simply do not confirm this assertion. Critical to the studies to which the petitioners refer is that the observed global average temperature was especially high during World War II when sunspot cycle analysis suggests that solar radiation may have peaked. However, the uncorrected observations over the ocean during World War II have been found to be quite biased due to the changing methods of observation to reduce manpower needs and avoid giving away ship location, to the changing mix of ships by country and type making the measurements, to the changing routes of ships, and so on. Attempts to correct the observations for such biases

have required quite large adjustments. Despite these efforts, an examination of the ocean temperature record still shows a significant positive bump in ocean temperatures during World War II for which there is no explanation other than remaining bias (e.g., the land temperature record shows no similar bump). Without the then consequent artificial bump in combined land-ocean temperature, the analyses suggesting that variations in solar radiation have been a major contributor to recent warming are significantly undermined, placing the role of solar variations well below the increase in greenhouse gas concentration as a contributor to warming since the mid-19th century.

5. "Similarly, a comprehensive new study of 13 complete temperature data sets (nine in the tropics, one in the U.S. and three global) found that 'once just the ENSO [El Nino Southern Oscillation] impacts on temperature data are accounted for, there is no "record setting" warming to be concerned about.'" The report by Wallace et al.[11] that the petitioners cite has apparently not been published or peer-reviewed outside of the set of individuals who put it together, which is not surprising in that the study makes unjustified presumptions and astounding claims that make it so inconsistent with fundamental understanding of how the climate system works that its conclusions cannot possibly be valid. These problems include:
    a. The study finds that the increasing CO_2 concentration has made no contribution to the warming since the mid-20th century. If the CO_2 does not make any difference, then this would undermine the explanation of the underlying greenhouse effect itself that makes the climate of the Earth different than the climate of the Moon (not to mention the explanations for the surface temperatures of Venus and Mars), that underpins the scientific explanation for glacial-interglacial cycling, and that explains the different climates over the history of the Earth. No consideration is given to this illogical finding and no alternative explanation for how the climate system works is provided.
    b. The study postulates that there are only four possible causes of climate change, namely the El Niño/La Niña (ENSO-driven) fluctuations, cyclic solar variations, volcanic eruptions, and the changing CO_2 concentration. In actuality, there are many more factors that can and very likely have influenced (or are influencing) the climate, including the CFC emissions that influence the stratospheric ozone layer as well as being greenhouse gases, SO_2 emissions that contribute to the Earth's reflective

sulfate layer, tropospheric ozone created by human-generated emissions of hydrocarbons and nitrogen oxides, land cover change, and more. The Wallace et al. study is simply incomplete in this regard.

c. The Wallace et al. study fails to provide a basis for explaining why ENSO-driven fluctuations are having an effect now at just the time fossil fuel emissions are raising the atmospheric CO_2 concentration and that there is no evidence that such ENSO-driven fluctuations have caused similar warming in the past (or, conversely, caused compensating cooling).

d. The analysis is apparently done by only considering qualitative correlations and not quantitative analyses of the physical relationships that take account of such issues as time delays caused by the thermal heat capacity of the oceans, the requirement for consistency of response to forcings of the same magnitude, etc.

e. By starting in 1959 for some of their analyses and in 1979 for other analyses, the study leaves out consideration of the ongoing climatic influences that occurred before the beginning of the data sets used in the analyses.

f. The study appears to have neglected that the transfer of CO_2 across the air-sea interface is dependent not only on the temperature of the ocean, but also on the rising CO_2 concentration in the atmosphere resulting from the increasing amounts of fossil fuel emissions. There is also no analysis of carbon isotopes that the international scientific community uses to differentiate among sources causing the change in the atmospheric concentration.

g. The study fails to explain how this analysis gets such a very different result than the myriad of studies that have been done on the subject and reported on by the Intergovernmental Panel on Climate Change. All published studies that argue that they have a new explanation are expected to very carefully explain the causes of differences from the prevailing paradigm. As Carl Sagan said: "Extraordinary claims require extraordinary evidence" and the analysis here provides no explanation at all of why it is getting such a different result.

h. The study asserts (page 49) that climate scientists have been clinging "to fitting linear trends to temperature time series." This is simply not the case—both particular research studies and the detection-attribution studies conducted by the international

scientific community consider multiple factors influencing the climate and treat the different time and space scales of each of the various factors that have the potential to influence the climate. Indeed, what is astounding about the Wallace et al. study's approach is that using an accumulating measure of the ENSO index is like applying a low pass filter that, in essence, ends up creating a linear trend that is then claimed to explain the observed rise in the temperature even though there is no physical basis at all for using the accumulating measure. If instead they had made the correlation to the time-varying ENSO index itself in order to subtract out the role of ENSO variations, which many others have done and makes physical sense, then the trend in temperature remains, and the rising CO_2 concentration would be the only plausible explanation. Basically, by choosing an analysis approach that is not justified and does not make sense, they incorrectly and misleadingly attribute the warming trend to ENSO rather than the ongoing increase in the concentration of CO_2 and other greenhouse gases.

i. The study fails to explain how all of the other changes in climate that have been observed and that confirm global warming can be related to the ENSO-driven changes that they assert explains everything. For example, the stratosphere has been cooling, and this result can only be explained if the additional CO_2 has increased the capacity for the lower stratosphere to radiate energy from this layer of the atmosphere (so CO_2 is apparently radiating energy in the stratosphere but not in the troposphere).

Pages 4-5, Claim III: "The Growing Accumulation and Refinement of Balloon and Satellite Data Demonstrates that the Atmosphere Is Far Less Sensitive to CO_2 Forcing than Predicted by the Climate Models; As a Result, EPA's Third Line of Evidence Is No Longer Valid"

This claim in the CEI/SEPP petition is justified primarily by questionable and unscientific assertions made in the February 2016 testimony of Prof. John Christy to the U.S. House Committee on Science, Space and Technology; many of these assertions have not been published or subjected to the rigorous scientific review and comment associated with publication in leading journals. A number of the points have also been presented in the testimony of Prof. Christy to the same committee in March 2017. There has been substantial criticism of that testimony, much of it

collected from the scientific community by Representative Don Beyer (D-VA) and entered into the Congressional Record.[9] Skeptical Science, a Web site that has been widely recognized for presenting authoritative analyses of incomplete and biased presentations of the science, has also carried out an analysis.[10] Numerous serious issues have been raised.

Prof. Christy's main claim that climate that model simulations do not provide a reasonable representation of reality is simply untrue. As Dr. John Abraham's note explains [see compilation of comments by Rep. Beyer], the analysis of Dr. Christy is contradicted by numerous other studies. Indeed, rather than over-predicting the warming from the changing concentrations of greenhouse gases as Dr. Christy suggests using a graph of one particular location in the atmosphere, careful analyses indicate that the model projections are lagging behind the changes evident in observations over much of the Earth. To generate his graph for this one relatively small region of the atmosphere, Dr. Christy violates a couple of scientific norms for creating such graphs: (1) he compares model results from simulations that considered changes expected when allowing for only a change in the CO_2 concentration with observational results that are responding to changes in all factors that can affect the climate; and (2) he artificially normalizes the time sequence of all of the model results and the observations for what happened in a single year, which, in effect, improperly subtracts out the presence of natural variability in the system for that year, while leaving it in for all other years. Looking into the supposed disagreement that Christy raises, other scientists have found that a proper analysis shows very good agreement between model simulations and observations.

Prof. Christy has a long history of making claims that have proven to be wrong, particularly relating to the data set of tropospheric temperatures that he considers more appropriate and accurate than surface temperature measurements. In particular, the MSU data set that he has championed has had to be revised several times over the past two decades due to failures to account properly for various factors that others have identified (e.g., the changing altitude of the satellite, the changing time of day of the measurement, instrument calibrations from satellite to satellite, problems with the radiosonde data set used for calibration, etc.). With each of these changes the slope of his purported trend changed, actually going from negative to positive over this time period. Normally, if a scientist publishes a paper with data that is determined to be incorrect due to processing errors, the paper and its conclusions would be withdrawn. To my knowledge, however, Dr. Christy and his co-authors have not taken this step, allowing the flawed publications to remain available and publishing no

specific rejection or set of qualifications regarding use and interpretation of these papers. Given this situation, extreme caution should be used in relying on results from his papers, and especially from testimony that has not been passed through rigorous peer review (particularly given the unanswered criticisms regarding his testimony that have been made, as mentioned above).

Pages 5 and 6, Supplication: "Given the Mounting Evidence that EPA's Greenhouse Gas Regulations Will Have No Discernible Climate Impact, the Rationale for Its Endangerment Finding Requires Reexamination"

In support of this supplication, the petitioners cite results that are presented on pages 14 and 15 of the 2016 Congressional testimony of Prof. Christy. While these results are based on calculations using a model that has been calibrated to simulations reported on by IPCC, the set up of the simulation had several shortcomings, including:

1. Prof. Christy specified a climate sensitivity (that is, the temperature response of the climate to a change in the CO_2 concentration) that is at the low end of the scale that has emerged from both model simulations of the recent climate and from paleoclimatic analyses and model simulations of various periods in Earth's climate history. In particular, Prof. Christy used a value of 1.8ºC per CO_2 doubling where the IPCC-agreed-upon range is 1.5 to 4.5ºC and his assertion that the actual climate sensitivity may be even less is considered to be very unlikely.
2. Prof. Christy's simulation with the model ran for only 50 years. Because of the ongoing effects of past emissions and of emissions by countries outside the US, significant warming will of course occur. Simulations reported on by IPCC do make clear that, because of those factors, it is quite challenging to reduce near-term warming, but these simulations also make clear that the effect becomes quite important over a longer period.
3. Prof. Christy's analysis appears to fail to consider the contributions to warming of U.S. emissions of the full set of greenhouse gas emissions, most of which are coupled to the U.S. emission of CO_2. Thus, to address the overall impact of the U.S. cutting its emissions of CO_2 to zero, Christy appears to fail to consider the effects of the associated reductions that would occur for methane, black carbon, and the precursors of tropospheric ozone. Because these substances all have short atmospheric lifetimes compared to the 50-year analysis period, there would be a quite significant additional reduction in the global average temperature

resulting from cutbacks in their emissions.

4. It is correct that this is a global problem that needs to be addressed by actions of all nations. If the U.S. chooses to abdicate its traditional world leadership role, other countries might well follow or at least make less intense efforts, whereas if the U.S. jumps forward by taking aggressive action, other countries are very likely to join in. Prof. Christy's analysis completely fails to consider this coupled effect and the U.S. responsibility to be a responsible member of the global community. That the petitioners seek to consider the U.S. contribution separate from the contribution and efforts of all nations creates a very misleading impression.
5. Prof. Christy's simulation cites the U.S. share of global emissions as being 14-17% of global emissions. While this may be a reflection of the current share, in the past the share has been considerably higher. In that past emissions have led to an increase, so far, of over 1ºC and their continuing influence will cause further warming due to the very long atmospheric lifetime of the CO_2 increase that has been created by past U.S. emissions, it is very misleading to infer that the U.S. share of global warming has been and will be only 14-17%.
6. In that the likelihood of occurrence of weather and climate conditions is roughly bell-shaped around the mean condition, even small changes in the mean can have very large effects on the likelihood of occurrence of extreme conditions. For example, Hansen et al. (2012)[12] compiled observations of Northern Hemisphere summertime land-surface temperature anomalies on a five-degree latitude-longitude grid, and plotted the shifting distributions of the anomalies over three-decade periods since the mid-20th century. He found that the likelihood of the summer time average temperature exceeding what had only 0.1% of the time in the period 1951-80 had increased to about 10% for the period 1981-2010, even though the average summertime temperature had increased by a relatively small amount. This result made very clear that, as enumerated in the Endangerment Finding, even seemingly small changes in the large-scale multi-decadal average temperature can lead to large changes in the likelihood of extreme conditions and, therefore, that even quite modest reductions in the increase in the global average temperature can have quite beneficial implications for society and the environment.

The CEI/SEPP petitioners' assertion that the Clean Power Plan will not have a noticeable global effect further amplifies one of the misimpressions resulting from Christy's analysis, Indeed, the

Clean Power Plan, which needs to be seen as only the first phase of cutting CO_2 emissions from the power sector to zero (or necessarily to below that level if prompt action is not taken), is dealing with only about 1% of global emissions. Implying that this is a meaningless amount is equivalent to saying that the emissions of all but ~15 nations out of the 190+ nations in the world are meaningless, and so the question arises why any of the nations with less than 1% emissions should take any action at all to reduce emissions, even though, their cumulative emissions total about 25% of global emissions. Basically, the argument being made totally fails to understand the inherent international character of the issue and that a very large collection of relatively small actions must be taken to have a significant global effect. Suggesting that an alternative approach to taking many, many comparatively small steps is needed to get to zero emissions is simply misleading and not at all a way to responsibly address the risks raised in EPA's Endangerment Finding.

Summary of Analysis of the CEI/SEPP Petition: Given the failings in each of the three Claims made in the petition filed by the Competitive Enterprise Institute and the Science and Environmental Policy Project, there is simply no basis for reconsidering EPA's Endangerment Finding as requested by the petitioners. Indeed, with the accelerating pace of impacts such as sea level rise, plant and animal diebacks, increasing occurrence of extreme weather, and more, the Endangerment Finding, if revised, would seem likely to be the basis for even more aggressive actions to limit emissions than is called for by the 8-year old Endangerment Finding.

Section-by-Section Analysis of CHECC Filing

The "Petition for Reconsideration of 'Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act' filed by the Concerned Household Electricity Consumers Council consisting of Joseph D'Aleo, Clement Dwyer, Jr., Russell C. Slanover, Scott Univer, James P. Wallace III, Robin D. Weaver, and Douglas S. Springer" (hereafter CHECC), in my opinion, makes a number of statements that are incomplete and/or misleading based on my experience and the state of understanding as reported on in major, widely peer-reviewed national and international scientific assessment reports (which can be referred to for access to the international scientific literature).

Page 1, second paragraph: The paper by Wallace et al.,[13] which this petition indicates it primarily relies on, is very seriously flawed. That it is posted on the Web does not mean that the paper has been published in the traditional sense; that is, there is no indication that it has gone through the high-quality peer review that a leading journal would conduct before acceptance and publication, particularly for a paper that makes so many claims of differences with existing understanding. In contrast, EPA's Endangerment Finding is based on results presented in an extensive set of peer-reviewed research articles and assessments. Given the overwhelming evidence presented in support of the Endangerment Finding, this paper simply does not, in my opinion, present a basis for reconsideration of the Endangerment Finding.

To be more specific regarding the report by Wallace et al., it makes unjustified presumptions and astounding claims that make it so inconsistent with fundamental understanding of how the climate system works that its conclusions cannot possibly be valid. These problems include:

j. The study finds that the increasing CO_2 concentration has made no contribution to the warming since the mid-20th century. If the CO_2 concentration does not make any difference, then this would undermine the explanation of the underlying greenhouse effect itself that makes the climate of the Earth different than the climate of the Moon (not to mention the explanations for the surface temperatures of Venus and Mars), that underpins the scientific explanation for glacial-interglacial cycling, and that explains the different climates over the history of the Earth. The paper provides no convincing justification for this illogical finding nor an alternative explanation for all the various phenomena that are based on the traditional understanding relied upon in all major national and international assessments.

k. The study postulates that there are only four possible causes of climate change, namely the El Niño/La Niña (ENSO-driven) fluctuations, cyclic solar variations, volcanic eruptions, and the changing CO_2 concentration. In actuality, there are many more factors that have the potential to altering the climate, including the chlorofluorocarbon (CFC) emissions that influence the stratospheric ozone layer as well as being greenhouse gases, SO_2 emissions that contribute to the Earth's sulfate layer, tropospheric ozone created by human-generated emissions of hydrocarbons and nitrogen oxides, land cover change, and more. The Wallace et al. study is simply incomplete in this regard.

l. The study fails to provide a basis for explaining why ENSO-driven fluctuations are having an effect now at just the time fossil fuel emissions are raising the atmospheric CO_2 concentration while there is no evidence that such ENSO-driven fluctuations have caused similar warming in the past (or, conversely, caused compensating cooling).

m. The analysis is apparently done by only considering qualitative correlations and not quantitative analyses of the physical relationships that take account of such issues as time delays caused by the thermal heat capacity of the oceans, the requirement for consistency of response to forcings of the same magnitude, etc.

n. By starting in 1959 for some of their analyses and in 1979 for other analyses, the study leaves out consideration of the ongoing climatic influences that occurred before the beginning of the data sets used in the analyses.

o. The study appears to have neglected to consider that the transfer of CO_2 across the air-sea interface is dependent not only on the temperature of the ocean, but also on the rising CO_2 concentration in the atmosphere resulting from the increasing amounts of fossil fuel emissions. There is also no use of carbon isotope analyses that can be used to differentiate among sources causing the change in the atmospheric concentration.

p. The study fails to explain how this analysis gets such very different results than the myriad of studies that have been done on the subject and reported on by the Intergovernmental Panel on Climate Change. All published studies that argue that they have a new explanation are expected to very carefully explain the causes of the differences. As Carl Sagan said: "Extraordinary claims require extraordinary evidence" and the analysis here provides no explanation at all for the reasons that it is getting such a non-traditional result.

q. The Wallace et al. study asserts (page 49) that climate scientists have been clinging "to fitting linear trends to temperature time series." This is simply not the case—both particular research studies and the detection-attribution studies, for example, consider multiple factors influencing the climate and treat the different time scales of each of the various factors that have the potential to exert an influence. Indeed, what is astounding about the study's approach is that using an accumulating measure of the ENSO index, as they do, is like applying a low pass filter that, in essence, ends up creating a linear trend that is then claimed to explain the observed rise in the temperature even though there is no physical basis at all for using the accumulating measure. If instead they had made the

correlation to the time varying ENSO index itself in order to subtract out the role of ENSO variations, which many others have done and makes physical sense, then the trend in temperature remains in the observational data set, and the rising CO_2 concentration would be the only plausible explanation. Basically, by choosing an analysis approach that is not justified and does not make sense, they mistakenly attribute the warming trend to ENSO rather than the ongoing increase in the CO_2 concentration.

r. The study fails to explain how all of the other changes in climate that have been observed and that confirm global warming can be related to the ENSO-driven changes that they assert explains everything. For example, the stratosphere has been cooling, and this result can only be explained if the additional CO_2 has increased the capacity for the lower stratosphere to radiate energy from this region of the atmosphere (so, by their reasoning, CO_2 is apparently radiating energy in the stratosphere but not in the troposphere).

Page 1, third paragraph: The assertion that "regulations that are based on the Endangerment Finding have resulted in much ongoing activity in the economy that looks to shut down existing sources of electricity and replace them with other much more expensive sources" is simply not the case. The closure of coal-fired power plants that has been occurring has been primarily a result of the increasing availability of low-cost natural gas as a result of advanced drilling and fracking techniques and secondarily a result of the ongoing decrease in the cost of producing renewable energy from wind and solar installations. An additional factor has perhaps been the EPA regulations forcing reductions in the emission of mercury, but those regulations were not based on the Endangerment Finding regarding climate change. Expert studies do not project that proposed regulations "will impose massive new burdens on consumers of electricity" as the petitioners insist, especially when one considers the very significant benefits for present and future generations in and outside the U.S. associated with moderating the pace of climate change. A lower bound estimate of the potential benefits of reducing emissions can be derived by using the official estimate for the Social Cost of Carbon (SCC); as made clear in scientific papers about what is left out of the official SCC estimate, the correct estimated environmental and societal costs are likely several times greater.

Page 2, top three paragraphs: The seriously flawed Wallace et al. paper would, in my opinion, not have been considered of high enough scientific credibility to have had any effect on preparation of the Endangerment Finding. As enumerated above, the analysis described in the Wallace et al. paper

leads to conclusions that appear to be seriously flawed as a result of failing to consider the actual physics of the climate system. Given the inconsistencies between the paper's findings and the well-established understanding of the factors affecting atmospheric conditions described in reports prepared by the Intergovernmental Panel on Climate Change (IPCC), the United States Global Change Research Program (USGCRP), the National Academy of Sciences, and more, the Wallace et al. paper should not serve as the basis for convening a proceeding for reconsideration of the Endangerment Finding.

Page 2, bottom paragraph through page 5, top two paragraphs: Based on the flawed content of the Wallace et al. paper, the EPA should deny the petition. Doing so, EPA would have plenty of grounds for explaining its decision given the many shortcomings and implausible claims made in the Wallace et al. paper, especially as compared to the extensively documented and reviewed evaluation made in its Endangerment Finding.

Page 5, second paragraph of Section III: The assertion of the petitioners that the regulation of CO_2 emissions based on the Endangerment Finding will lead to an increase in cost of electricity around the nation "by a factor of five or likely a lot more" is simply not supported by what is happening in energy markets across the nation. In the states where there is an opportunity for companies to compete to be the source of a customer's electricity, the variations in rate across energy technologies have tended to be quite small, and with a real commitment to moving forward, ongoing technological developments and other actions would likely be taken that would actually make the incoming renewable sources of energy even less expensive. And this in the absence of accounting for the very significant environmental and societal consequences being caused by existing fossil-fuel based sources of energy.

Page 5, bottom paragraph through page 8, end of section III: When electric systems are not tied together over wide enough areas by the electric grid, the problem of intermittency that is raised can indeed require steps to deal with periods when the Sun is not shining and the wind is not blowing. These solutions can include, among others and implemented singly or in combination: limiting the share of generation from intermittent renewables, promoting energy efficiency to reduce demand and energy management to shift the demand curve, overbuilding renewable systems and building storage to carry a system through times of inadequate generation, maintaining backup

generation systems based on fossil-fuel powered or other generating technologies, and enhancing grid connectivity, particularly via high-voltage/direct-current (HV/DC) transmission lines (which can be installed below ground) so that energy can be efficiently transmitted across the country (or at least across distances larger than the dimensions of weather systems) at low cost.[i] Thus, the assertions that the cost of electricity will increase is only the case if the rather dynamic U.S. economy fails to take any of quite a range of possible actions, and there is no indication that this will be the case, especially if a price for releasing carbon dioxide is imposed that covers even the lower bound estimates of the detrimental costs imposed by use of fossil fuels.

Pages 8-13, Section IV: Much of the reasoning used in the CHECC petition to question global warming is very similar to the reasoning in the CEI/SEPP petition, with similar serious flaws. The responses to the misleading arguments included in the CHECC petition should thus be read in conjunction with the explanations and criticisms of the same arguments made in the CEI/SEPP petition.

Page 8, bottom paragraph continuing on to the top two lines on page 9: First, it is simply not the case that global warming results from the projected tropical "Hot Spot" as is suggested in the CHECC criticisms. The increase in the atmospheric CO_2 concentration resulting from combustion of fossil fuels occurs globally and calculations of the warming influence that results from the higher concentration (i.e., the radiative forcing) indicates that the warming influence is relatively uniform over the whole planet.

Second, the amount of warming that is induced around the globe results from the interaction of many processes and the additional warming influences resulting from positive feedbacks that are created as the world warms in response to the radiative forcing (e.g., the atmosphere holds more water vapor as it warms, enhancing the greenhouse effect; snow and ice melt back in high latitudes, leading to increased absorption of solar radiation in high latitudes; etc.).

Third, careful statistical analyses of the latitude-altitude atmospheric warming pattern that the

[i] A recent paper by MacDonald et al. (Nature Climate Change, 2016 DOI: 10.1038/NCLIMATE2921), suggests that a national network of HV/DC lines (roughly equivalent to an interstate highway system for electricity) could be constructed for roughly a penny per kilowatt-hour, so a small fraction of the electric rate in areas across the country, and in so doing, this would allow of order 80% reliance on renewables (and a higher rate with storage) and actually likely bring down electric rates in regions where energy is now particularly expensive.

petitioners raise as an issue indicate that the observed response of the global system to changes in greenhouse gas concentrations and aerosol loadings is within the range that is generated by model simulations when comparisons are made that account for the set of climate-inducing factors being considered.

Page 9, first full paragraph: The Endangerment Finding indicates that increases in global average temperature over the last several decades are consistent with the explanation that the increase in the concentrations of CO_2 and other greenhouse gases is the primary cause of the warming and that the continued rise in the concentrations of these gases will lead to very severe environmental and societal consequences that require action under the provisions of the Clean Air Act. The language filed by the petitioners is very loose here in asserting that EPA said "global average temperatures have been rising in a dangerous fashion over the last fifty years." Since the Endangerment Finding was published in 2009, the global average temperature has continued to rise, with additional heat building up in the oceans, greater melting back of snow and sea ice cover, ongoing shifts in the ranges of species, etc.

Page 9, second full paragraph: The assertion that climate model simulations of past time periods are not evidence is equivalent to saying that the storyline of a crime constructed from all the information and physical evidence gained in a criminal investigation is not evidence. Indeed, the model results are not the direct observations themselves, but the model results provide an analysis that can be used to explain in a physically and internally consistent manner what is being observed and what is causing the changes. Using the model simulations and careful statistical analyses, postulated explanations for what is happening and why can be tested and evaluated, ruling out attributions where contradictions of basic physical laws would have to be occurring for an explanation to fit observations (e.g., if warming is occurring and the intensity of solar radiation is not increasing or is decreasing, that would rule out that postulated cause). Analytic studies going back over 100 years and model simulations carried out over the past 50 years all make clear that the increasing concentrations of CO_2 and other greenhouse gases will lead to global warming, and modeling and analytic studies have determined (within a range of confidence levels) the relationship between the increase in the CO_2 concentration and the amount of global warming. Together, these results provide the basis for EPA to propose emissions limits that must be imposed to limit warming to levels that would be expected to lead to temperature changes resulting in unacceptable impacts for

society and the environment (situations that would be, under the law, endangering the interests of the citizens of the United States).

Page 9, third full paragraph through page 10, top bullet: The 2016 research report of Wallace et al. is not a report that has gone through the traditional review processes of the scientific community (much less the review requirements of the Federal Data Quality Act that is mandated for reports that would have a large effect on government actions). As noted in earlier comments, the research report leads to all sorts of inconsistent conclusions that violate fundamental understanding of the way in which atmospheric conditions and the climate are determined (e.g., if changes in the CO_2 concentration do not affect the radiative balance and global average temperature, then this would also negate scientific understanding of natural variations in Earth's climatic history, explanations for the observed climates of Venus and Mars, how CO_2 lasers and various military systems work, and more). With respect to the bulleted points:

- Careful, peer-reviewed scientific studies published in leading journals (e.g., by Santer et al.) make clear that a proper statistical analysis shows that the observations and models are not in conflict,[ii] as is asserted by the report. When findings are in conflict with widely accepted findings, it is the obligation of authors to explain why their results are so different, and this is not even attempted in Wallace et al.
- As noted in response to the first point, the suggested invalidation has simply not been done. For it to be accepted, publication in a leading journal with a rigorous review process would be needed, and the Wallace et al. report is not near to passing this requirement. Indeed, model simulations, while admittedly not perfect, do, as expected, reproduce the main features of the climate system. Models are not like a house of cards where one slightly unsatisfactory result means the models are of no use—they are carefully constructed from the fundamental laws of physics and chemistry, incorporating representations of all the processes that have been identified as important, with the ability to represent each process tested individually as well as can be accomplished given the vast range of time and space scales needing to be represented and the integrated set of processes making up the whole model being tested against past climatic periods and

[ii] This phrasing is used because statistical analyses are designed to rule out false explanations.

situations to the limits to available computer resources. By contrast, the Wallace et al. paper constructs a series of relationships based on mathematical correlations that do not assure that physical relationships are being maintained in a manner consistent with the fundamental physical equations and that have not been tested for an independent period of time or physical system (e.g., to explain the range of climatic conditions that occurred over Earth history and the very different temperatures of Venus and Mars).

- If one has a flawed approach, it should not be surprising that it gives flawed results. The careful detection-attribution studies reported on in the IPCC assessments provide an authoritative review and summary of how such analyses should be done. While the El Nino/La Nina variations are an internal fluctuation of the system that moves energy around, they are simply not capable of causing the very large observed build up of heat in the ocean and the energy to melt sea ice and initiate accelerating loss of mass of the Greenland and Antarctic ice sheets.
- The claims that virtually no general change has been occurring in the climate is strongly contradicted by a very large set of changes going on around the world that the ENSO variations simply could not have caused—there is simply not enough energy involved in these internal variations to be causing the changes around the globe that are occurring.

Page 10, top paragraph: For the petitioner's claim "that the climate sensitivity parameter's estimate is not statistically significant" to be true, the entire scientific understanding of what determines atmospheric structure and Earth's climatic history that has been meticulously worked out over the last two centuries would have to be tossed out, for they are arguing that atmospheric composition does not affect the climate. The Wallace et al. paper offers no alternative explanation for how the Earth's climate system works now or has worked in the past, much less for all the other technological achievements that are also dependent on the understanding of physical processes that is built into our understanding of atmospheric behavior and on which climate models are based, including the atmospheric radiation model used to reconstruct changes in the tropospheric temperature from satellite data and co-author John Christy has focused his career on.

The follow-on assertions in the next two sentences are therefore unsupported. Indeed, as

documented in the Endangerment Finding, there are significant adverse consequences to the climate, sea level and ocean chemistry that fully justify setting a significant positive value for the Social Cost of Carbon (indeed, a number of academic studies identify impacts and risks not accounted for adequately in the Social Cost of Carbon, suggesting that the value being used by the federal government is several times too low).

Page 10, second paragraph through the second paragraph on page 13: This focus on the "Tropical Hot Spot" is mistaken and shows both a serious lack of understanding of the reasons that a greater warming would be expected in this region of the atmosphere and an unfamiliarity with (or intentional decision to ignore) the scientific literature on this subject, which makes very clear that a proper statistical analysis shows there not to be the significant difference claimed by the petitioners. A more detailed response on this point is provided.[14]

Page 13, last paragraph of Section IV: As noted in this analysis, each of the three claims of petitioners regarding shortcomings in the Endangerment Finding and a conflict with current understanding are without scientific basis. Consequently, the claims and assertions of the petitioners simply do not justify the need for reconsideration of the Endangerment Finding or of the Social Cost of Carbon. Indeed, although not presented in this critique of the arguments of the petitioners, both the research done and the longer set of observations available since the Endangerment Finding was promulgated in 2009 indicate that there is now an even stronger basis for the Endangerment Finding and that even stronger actions will be needed to meet the policy objectives associated with limiting climate change, sea level rise, ocean acidification and the full set of consequences of these changes for society and the environment.

Pages 13 and 14, Section V: The main conclusion of the petitioners, namely that "[n]o scientists have yet devised an empirically validated theory proving that higher atmospheric CO_2 levels will lead to higher global average surface temperatures," demonstrates a fundamental misunderstanding of the approach that has been used to conclude that there is no quantitatively consistent alternative explanation for the observed changes in temperature, sea level, and ocean acidification that is more scientifically consistent with the cause being human activities, primarily the release of CO_2 as a result of combustion of fossil fuels, deforestation, and agricultural activities.

What scientists have done in their analyses is to first assemble the available observations for temperature and a range of other climatic variables and then analyze the available records to detect the statistically significant changes and trends. Second, researchers have identified all of the potential factors that it is suggested could have caused or contributed to the changes and trends that have been detected, assembling records of their changing intensities over the past two centuries. Third, researchers have then developed estimates of the temporal and spatial responses that would be expected to result from the each of the postulated causal factors. Fourth, the researchers have determined the optimal combination of factors that, in a quantitatively consistent and optimal sense, explain the observed changes and trends in the climate. And finally, the researchers have carried out these analyses for a number of climate variables and found consistency across their analyses, with all of the factors for which records of satisfactory length and quality confirming that there is no other plausible explanation for than the human-caused emissions of CO_2. The series of assessments reports produced by the IPCC provide a detailed description of the development of this field of study over the past few decades, and they link empirical analyses very tightly to the model results, which the petitioners seem to consider as theoretical even though they are based on the fundamental conservation laws of mass, energy, and momentum that are closely tied to experiments and other empirical evidence.

This detection-attribution approach to identifying the cause of the changes is very much like what goes on in other fields of analysis, such as criminal investigations, medical determinations, etc. Basically, during the detection phase of the investigation, detailed records are assembled of what happened and analyzed to determine if a crime occurred or a person has a medical problem, and then, during the attribution phase, all possible causative factors are identified, their modus operandi and time history of location or impact are developed and considered, and then the postulated culprits are considered in order to distinguish those that are consistent with what has happened with those that are not. So, for example, despite satellite observations showing very little change in solar radiation, were a brightening Sun causing the surface warming, one would expect to be seeing warming not only at the surface and in the atmosphere, but also in the stratosphere; records, however, indicate that the stratosphere is cooling, in direct contradiction to what would be expected were solar brightening the cause of climate change over the last several decades. On the other hand, the rising concentration of CO_2 due to human activities is expected to cause warming of the surface

and of the troposphere, but cooling of the stratosphere, just as observations indicate, and at rates consistent with the rising atmospheric concentration of CO_2 over time. Yes, having fewer volcanic eruptions could lead to warming of the surface-troposphere system and cooling of the stratosphere, but the observed changes have occurred despite large volcanic eruptions and when there are periods with essentially no volcanic eruptions. More generally, were any natural factors the cause of the observed warming since the mid-20th century, why might it be that such rapid and strong warmings have not been observed in the past and that it is instead happening at exactly the same time that human activities are modifying atmospheric composition. Occam's Razor, an adage calling on an analyst to not give up the most obvious and simplest explanation for more complex ones not as strongly supported by the evidence, is overwhelming in its favoring of the rising atmospheric CO_2 concentration as the dominant cause of the observed warming, there not even being a competing explanation.

Summary: The entire argument put forth in the petitioner's brief is totally flawed and without support. There is simply no scientific basis for pulling back from the understanding presented in the Endangerment Finding and its supporting Technical Support Document. And the petitioners claims that the Social Cost of Carbon is "flawed and dangerous" is similarly unjustified—real impacts are occurring around the world today, with much more serious impacts inevitable because it will take at least a few decades to very seriously reduce the very large emissions of CO_2 in the U.S. and around the world. Numerous studies make clear that the cost of changing our energy system will be far less than the costs and consequences of not doing so, and indeed, that the transition effort will create many new jobs while at the same time reducing the damaging impacts on human health of ongoing fossil fuel pollution.

The international community of nations has developed the IPCC assessment process for making the very detailed and rigorous scientific analysis that the petitioners call for, and the U.S. has a supporting assessment process. Over the past 27 years, the IPCC reports have been unanimously accepted by the nations of the world, with their summaries for policymakers unanimously approved on a word-for-word basis, all after extensive opportunities for review by each nation, by hundreds of the scientific and technical experts, and by hundreds of environmental, professional, industrial and other organizations. That the petitioners offer such a weak and flawed critique of the well-developed scientific consensus is simply not a sufficient basis for reconsidering the Endangerment Finding.

[Dr. MacCracken is the chief scientist at the Climate Institute, a fellow of the American Association for the Advancement of Science (AAAS), and a member of the American Meteorological Society, the Oceanography Society and the American Geophysical Union]

Notes

1. Massachusetts v. EPA. 549 U.S. 497 (2007)

2. Topping, John, Jr. "Massachusetts v. EPA: A Turning Point for the US on Climate Change?" Massachusetts versus EPA on climate change. http://climate.org/archive/topics/national-action/massachusetts-vs-epa.html.

3. MacCracken, Michael C. Exhibit 20 - Declaration of Michael C. MacCracken, Massachusetts v. EPA. https://www.scribd.com/document/252040637/Exhibit-20-Declaration-of-Michael-C-MacCracken-Massachusetts-v-EPA.

4. "Endangerment and Cause or Contribute Findings for Greenhouse Gases under the Section 202(a) of the Clean Air Act." EPA. April 28, 2017. https://www.epa.gov/ghgemissions/endangerment-and-cause-or-contribute-findings-greenhouse-gases-under-section-202a-clean.

5. 74 Fed. Reg. 66,496 (Dec. 15, 2009)

6. Petition of the Competitive Enterprise Institute and the Science and Environmental Policy Project for Rulemaking on the Subject of Greenhouse Gases and Their Impact on Public Health and Welfare, in Connection with EPA's 2009 Endangerment Finding, 74 FR 66,496 (Dec. 15, 2009). Environmental Protection Agency

7. PETITION FOR RECONSIDERATION OF "ENDANGERMENT AND CAUSE OR CONTRIBUTE FINDINGS FOR GREENHOUSE GASES UNDER SECTION 202(a) OF THE CLEAN AIR ACT". Concerned Household Electricity Consumers Council, consisting of Joseph D'Aleo, Clement Dwyer, Jr., Russell C. Slanover, Scott Univer, James P. Wallace III, Robin D. Weaver, and Douglas S. Springer

8. Review of the Draft Climate Science Special Report (2017). Committee to Review the Draft Climate Science Special Report. Committee to Review the Draft Climate Science Special Report. National Academics Press. https://www.nap.edu/read/24712/chapter/1.

9. Donald Breyer. Congress of the United States. House of Representatives. Washington, DC 20515-4608 https://beyer.house.gov/uploadedfiles/rep_beyer_factcheck_project_binder_1__submitted_april_11.pdf.

10. Dana1981. "Climate Science Glossary." Skeptical Science. March 10, 2011. https://skepticalscience.com/christy-testimony.html.

11. Wallace, James P., John R. Christy, and Joseph S. D'Aleo, 2016: On the Existence of a "Tropical Hot Spot" & The Validity of EPA's CO_2 Endangerment Finding, https://thsresearch.files.wordpress.com/2016/09/wwww-ths-rr-091716.pdf

12. Hansen et al., 2012: Perception of Change, PNAS, 109(37), E2415–E2423, doi: 10.1073/pnas.1205276109.

13. Wallace, James P., John R. Christy, and Joseph S. D'Aleo, 2016: On the Existence of a "Tropical Hot Spot" & The Validity of EPA's CO_2 Endangerment Finding, https://thsresearch.files.wordpress.com/2016/09/wwww-ths-rr-091716.pdf

14. Nuccitelli, Dana. "Climate contrarians want to endanger the EPA climate endangerment finding The Guardian. May 02, 2017. https://www.theguardian.com/environment/climate-consensus-97-per-cent/2017/may/02/climate-contrarians-want-to-endanger-the-epa-climate-endangerment-finding.