R.Gurney
https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={9CECAE52-1921-408B-98B8-A4D0BD95ED11}&documentTitle=20159-114195-01
REBUTTALS TO Bezdek, Lindzen. Happer
SURREBUTALS BY: Bezdek, Lindzen. Happer
Bezdek:
p7 "However, the question of relevance to an assessment of the SCC should not be centered on whether or not there is a CO2 fertilization effect. The question should be centered on assessing the total net impact on plants, particularly food crops, from anthropogenic climate change."
p.9 "The results of the review performed in the IPCC 5th Assessment Report find that there is a net negative impact on crop yields, inclusive of the CO2 fertilization effect."
.
Lindzen:
pp.11-12 "I rebut the suggestion by Dr. Lindzen in Peabody Ex. ___ at 6 (Lindzen Direct); Peabody Ex. ___ RSL-2, lines 488-540) that there is an ambiguous relationship between emissions and atmospheric CO2 concentration. Dr. Lindzen suggests that:
"Even the connection of fossil fuel emission to atmospheric CO2 levels is open to question."
"This instrumental support precludes the notion that something other than fossil fuel CO2 emissions are driving the secular trend in atmospheric CO2 levels."
.
Happer:
pp.12-13 "The Happer testimony is centered around four somewhat interrelated claims which I rebut:"
(1) That recent observations show no warming ...
(2) that models used as the calibration to the IAMs (and their subsequent SCC results) do not agree with observations ...
(3) that a doubling sensitivity of IPCC models is too large and that a lower doubling sensitivity would require centuries to achieve a temperature rise of 2°C ...
(4) that warming and additional CO2 are beneficial."
p.21 has copy of IPCC summaries of ECS
p.32-48 is CV

On behalf of the Minnesota Department of Commerce, Division of Energy Resources, and the Minnesota Pollution Control Agency (the Agencies), enclosed for filing in the above docket, please find the second corrected Rebuttal Testimony and Attachments of Dr. Kevin Gurney.

The sole purpose of this second corrected Rebuttal Testimony is to correct the first Corrected Rebuttal Testimony filed September 21, 2015 (by repairing accidentally damaged tables on several pages). As with the first corrected Gurney Rebuttal Testimony, this second corrected Rebuttal Testimony provides an updated *curriculum vitae* for Dr. Gurney (DOC Ex. ___ KG-R-1) and a table of corrections to Gurney Rebuttal (DOC Ex. ___ KG-R-2).

The Agencies apologize for any confusion these corrections may have caused.

Sincerely,

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IN THE MATTER OF THE FURTHER INVESTIGATION INTO ENVIRONMENTAL AND SOCIOECONOMIC COSTS UNDER MINNESOTA STATUTE 216B.2422, SUBDIVISION 3	MPUC Docket No. E999/CI-14-643 OAH Docket No. 80-2500-31888

REBUTTAL TESTIMONY AND ATTACHMENTS OF KEVIN GURNEY

ON BEHALF OF

THE DIVISION OF ENERGY RESOURCES OF
THE MINNESOTA DEPARTMENT OF COMMERCE
and
MINNESOTA POLLUTION CONTROL AGENCY

AUGUST 12, 2015

REBUTTAL TESTIMONY AND ATTACHMENT OF KEVIN GURNEY
IN THE MATTER OF THE FURTHER INVESTIGATION INTO ENVIRONMENTAL AND SOCIOECONOMIC COSTS UNDER MINNESOTA STATUTE 216B.2422, SUBDIVISION 3

DOCKET NO. E999/CI-14-643
OAH DOCKET NO. 80-2500-31888

TABLE OF CONTENTS

I. INTRODUCTION AND QUALIFICATIONS

Q. Please state your name, employer and business address

A. My name is Kevin Gurney. I am employed by the Arizona State University, P.O. Box 874501, Tempe, AZ 85287-4501.

Q. On whose behalf are you testifying in this proceeding?

A. I am testifying at the request of the Minnesota Department of Commerce, Division of Energy Resources (Department).

Q. Dr. Gurney, please summarize your education and work experience as it relates to this proceeding.

A. I have a BA in environmental physics with a concentration in climate change from UC Berkeley, a Master of Science in atmospheric science from MIT, a Master in public policy from UC Berkeley and a Ph.D. in Ecology from Colorado State University.I have worked in climate change research for 30 years. I have performed research in think tanks and academia, focusing during the last 15 years on the global carbon cycle. My research on the global carbon cycle is performed through the use of observations and modeling to better understand how carbon flows through the Earth System and ultimately impacts the Earth's climate.

Q. Have you ever provided testimony in the State of Minnesota?

A. No, I have not.

II. PURPOSE OF TESTIMONY

Q. What is the purpose of your Rebuttal Testimony?

A. I review and provide expert judgment on specific issues raised in direct testimonies of Dr. Bezdek, Dr. Lindzen, and Dr. Happer, and I discuss the importance of relying upon peer-reviewed literature and the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment report.

Specifically, as to the Direct Testimony of Dr. Bezdek I address his arguments regarding the potential effect of CO2 fertilization. As to the Direct Testimony of Dr. Lindzen, I address his arguments regarding the relative roles of temperature v. emissions in determining increases in atmospheric CO2. As to the Direct Testimony of Dr. Happer, I address four somewhat interrelated claims: that recent observations show no warming; that models used as the calibration to the IAMs (and their subsequent SCC results) do not agree with observations; that doubling sensitivity of IPCC models is too large (a lower doubling sensitivity would require centuries to achieve a temperature rise of 2°C), and; that warming and additional CO2 are beneficial.

In my testimony, I also discuss the importance of referencing peer-reviewed research papers, and the importance of the IPCC 5th Assessment Report.

III. REBUTTAL OF DR. BEZDEK'S TESTIMONY

Q. What claims by Dr. Bezdek regarding CO2 fertilization do you address?

A. The Bezdek Direct centers on two main claims. First, I address Dr. Bezdek's statements in Peabody Ex. __ at 9-10 (Bezdek Direct) and in Peabody Ex.___RHB-2, pages 49-52 (Bezdek Direct) as to whether there is a CO2 fertilization effect and if so,

how big might it be. Second, I address Dr. Bezdek's limited assessment of the net impact of CO2 fertilization within the context of climate change.

Q. Is there a CO2 fertilization effect and if so, how big might that effect be?

A. All available scientific evidence supports the general concept of a CO2 fertilization effect. It is well understood and quantified at the individual leaf/plant scale in controlled or laboratory conditions. However, studies in real-world applications (in the field) and those that attempt to quantify CO2 fertilization at the population to ecosystem scale, arrive at much more variable and conflicting results. The magnitude of CO2 fertilization in real-world conditions is therefore extremely variable and dependent upon a wide array of factors such as nutrient availability, water availability, species, soil type/condition, light levels, etc.

Q. What support does Dr. Bezdek provide for his claims regarding CO2 fertilization?

A. Dr. Bezdek's testimony relies on a non-peer-reviewed report representing a compilation of individual responses of plants to CO2 increases, the majority of which are under controlled or laboratory conditions. I consider this an unreliable assessment of the impact of increasing CO2 concentration on plants in real-world conditions.

Furthermore, in Peabody Ex. ___ at 10 (Bezdek Direct) Dr. Bezdek refers to the testimony of Dr. Happer (a non-peer-reviewed source) to support the assertion that the planet has already experienced "greening" as a result of CO2 fertilization. Dr. Bezdek reproduces a Figure from Dr. Happer's testimony with the title "Figure 17-1: Global Greening from CO2 Fertilization: 1982-2010" in Peabody Ex. ___ at 10

(Bezdek Direct). As explained in my rebuttal to Dr. Happer's testimony, this figure was incorrectly cited and described in Dr. Happer's testimony. Dr. Bezdek's testimony furthers the misrepresentation of this figure by suggesting it represents "Greening from CO2 Fertilization". This is factually incorrect and a misleading representation of the CO2 fertilization effect. In my judgment this represents a fundamental misunderstanding regarding the role of CO2 fertilization within the wider topic of planetary greening.

Q. What do recent studies show about this effect?

A. A recent peer-reviewed study reviewed the CO2 fertilization effect for the specific case of food crops (particularly relevant for the question of SCC assessment) in order to quantify the regional impact expected from a 100 parts per million (ppm) increase in atmospheric CO2 concentration (equivalent to a 25% increase over current levels).[1] Model results found a crop yield response ranging from 5% to 17% at the regional level for a 100 ppm increase in atmospheric CO2 concentration. There was greater variation in the CO2 fertilization response within the regions and among various crop types and this variation (along with the variation across the regions) was dependent upon a wide variety of factors such as those noted above (nutrient availability, species, water availability, etc). However, the question of relevance to an assessment of the SCC should not be centered on whether or not there is a CO2 fertilization effect. The question should be centered on assessing the total net impact on plants, particularly food crops, from anthropogenic climate change. The

[1] McGrath, J.M and D.B. Lobell (2013) Regional disparities in the CO_2 fertilization effect and implications for crop yields, *Env. Res. Lett.* 8, doi:10.1088/1748-9326/8/1/014054

assessment should include the CO2 fertilization effect, along with other climate change impacts.

Q. What is your opinion of Dr. Bezdek's testimony regarding CO2 fertilization within the context of anthropogenic climate change?

A. In addition to my concerns, noted above, regarding the information sources and presentation of that information by Dr. Bezdek, isolation of the CO2 fertilization effect within the larger issue of climate change impacts on plants, particularly food crops, as presented by Dr. Bezdek in Peabody Ex. ___ at 16 (Bezdek Direct), results in an incomplete and misleading assessment.

The question is not whether there is a CO2 fertilization effect, but rather, is it accurately included in the assessment of impacts routinely undertaken in scientific study and included in institutional reviews of climate change impacts? In my judgment, the CO2 fertilization effect is included appropriately in reviews of climate change impacts on plants, and food crops in particular.

The Intergovernmental Panel on Climate Change has performed extensive review of the impact of climate change on crop productivity with CO2 fertilization effects considered:[2]

[2] IPCC 5th Assessment Report, Working Group II, chapter 7, page 506.

https://www.ipcc.ch/report/ar5/wg2/
It is well worth reading the pages around this.

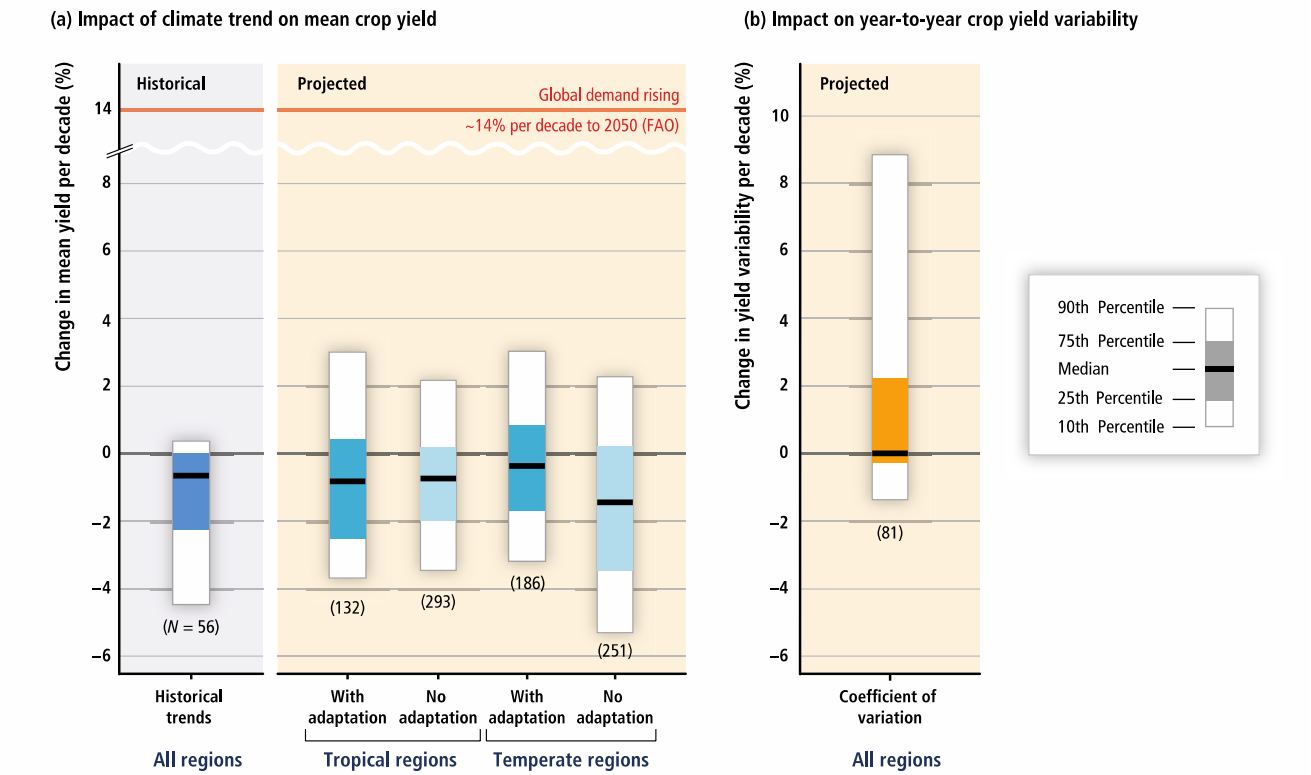


Figure 7-7 | Boxplot summary of studies that quantify impact of climate and CO_2 changes on crop yields, including historical and projected impacts, mean and variability of yields, and for all available crops in temperate and tropical regions. All impacts are expressed as average impact per decade (a 10% total impact from a 50-year period of climate change would be represented as 2% per decade). References for historical impacts are given in Figure 7-2, for projected mean yields in Figure 7-5, and for yield variability in Figure 7-6. *N* indicates the number of estimates, with some studies providing multiple estimates. In general, decreases in mean yields and increases in yield variability are considered negative outcomes for food security. Also indicated in the figure is the expected increase in crop demand of 14% per decade (Alexandratos and Bruinsma, 2012), which represents a target for productivity improvements to keep pace with demand.

As outlined in the IPCC review main text and noted in the figure caption, "….summary of studies that quantify the impact of climate and CO2 changes on crop yields…" the CO2 fertilization effect is included in the IPCC review results.

In order to understand and quantify the impact of climate change on crop productivity, all known negative and positive impacts must be included. The results of the review performed in the IPCC 5th Assessment Report find that there is a net negative impact on crop yields, inclusive of the CO2 fertilization effect. he net effect of climate and CO2 changes on crop productivity is negative at the global scale and the regional scale. In addition to the long-term mean impact, the variability of crop yields are projected to increase. It is worth noting, however, that the uncertainty is large. Though this area of research remains very active and the current assessment

Any farmer knows yield variability is not a plus.

acknowledges the need for additional research, the IPCC review represents the most comprehensive assessment of research on this topic, to date.

In summary, yes, the academic community has properly accounted for the CO2 fertilization effect (discussed by Dr. Bezdek in Peabody Ex. ___ RHB-2 (Bezdek Direct)) in their assessment of anthropogenic climate change impact on plants, particularly food crops in real world conditions. They find that the CO2 fertilization effect is highly variable and dependent upon a number of complicating factors that cannot be represented adequately by experiments carried out in small scale, controlled conditions. Assessments that reflect real-world environments and incorporate a more comprehensive treatment of the impacts of climate change on food crops (including CO2 fertilization), find a net negative response of crop yields to anthropogenic climate change.

Q. Has Dr. Bezdek published within the peer-reviewed literature on topic of CO2 fertilization or the impact of climate change on Food crops or agricultural productivity?

A. No, not to my knowledge.

IV. REBUTTAL OF DR. LINDZEN'S TESTIMONY

Q. What claims by Dr. Lindzen to you rebut?

A. I rebut the suggestion by Dr. Lindzen in Peabody Ex. ___ at 6 (Lindzen Direct); Peabody Ex. ___ RSL-2, lines 488-540) that there is an ambiguous relationship between emissions and atmospheric CO2 concentration. Dr. Lindzen suggests that:

> "Even the connection of fossil fuel emission to atmospheric CO2 levels is open to question."

The increase in atmospheric CO2 during the instrumental record is due to the increase in the combustion of fossil fuels and the alteration of vegetation at large scales (e.g. tropical deforestation). This has been conclusively established through the measurement of 14CO2 –a small amount of atmospheric CO2 for which the CO2 molecule has a slightly heavier carbon atom. Fossil fuel derived CO2 contains none of this rare CO2 due to its natural radioactive decay and the fact that it's half-life (the time it takes to decay) is far less than the time required for carbon to transition to fossilized form. By contrast, the atmosphere has a well-measured amount of CO2 in the 14CO2 form. The dilution of this well-known amount of 14CO2 can be quantitatively tied to the emission of fossil fuel CO2 into the Earth's atmosphere at levels consistent with the records of coal, oil, and natural gas consumption worldwide.[3] This is referred to as the "Suess" effect and is well established.

Roughly one-half of the emissions due to fossil fuel combustion and deforestation are removed from the atmosphere on an average basis and the removal processes in the ocean and land biosphere are relatively well quantified. The short-term (year-to-year) modulation of global emissions remains an area of active research.

However, it is well established through multiple lines of evidence that the long-term secular rise of CO2 concentration in the Earth's atmosphere is driven by the combustion of fossil fuels.

[3] See Tans et al., *Nature*, 280, pp 826-828, 1979.

Q. Is the relationship between emissions and atmospheric CO2 concentration based on a model?

A. No. In Peabody Ex. ___ RSL-2, lines 523-528 (Lindzen Direct), Dr. Lindzen states:

> "The usual rule of thumb that half of emitted CO2 appears as atmospheric CO2 based on the Bern model for CO2 geochemistry."

This is not true. The "rule of thumb" refers to something called the "airborne fraction" – the fact that when averaged over decade timescales, slightly over ½ of the fossil fuel CO2 emitted to the Earth's atmosphere is removed by processes in the ocean and land biosphere. This is not the outcome of a model but an observed quantity with decades of instrumental support. This instrumental support precludes the notion that something other than fossil fuel CO2 emissions are driving the secular trend in atmospheric CO2 levels.

V. REBUTTAL OF DR. HAPPER'S TESTIMONY

Q. What claims by Dr. Happer do you rebut?

A. The Happer testimony is centered around four somewhat interrelated claims which I rebut:

(1) That recent observations show no warming (Peabody Ex. __ at 8 (Happer Direct));

(2) that models used as the calibration to the IAMs (and their subsequent SCC results) do not agree with observations (Peabody Ex. __ at 8-9 (Happer Direct));

(3) that a doubling sensitivity of IPCC models is too large and that a lower doubling sensitivity would require centuries to achieve a temperature rise of 2°C (Peabody Ex. ___ at 7-8 (Happer Direct); and

(4) that warming and additional CO2 are beneficial. (Peabody Ex. ___ at 9-11 (Happer Direct)).

Q. What does Dr. Happer's Direct Testimony state about the lack of a warming trend?

A. The key assertions in Peabody Ex. ___ at 8 (Happer Direct) are:

> "Global warming basically stopped about the time of the last large El Nino event in 1998. There has been no significant warming since."
>
> "Ground-based observations show virtually no warming since 1998."

This is further elaborated in Peabody Ex. ___ at 6 (Happer Direct) where he states:

> "….satellite measurements indicate that the lower atmosphere has had no warming for at least 20 years."

First, it must be noted that the last of these assertions (the only one with a citation to support the statement) cites, and appears to be based upon, information published on a website rather than a peer-reviewed scientific paper. I will return below to this topic, when I discuss the importance of reliance upon peer-reviewed scientific literature as opposed to information on Internet websites or other grey literature sources that have not undergone the critical review process associated with academically respected literature.

Q. What opinion do academic organizations or peer-reviewed literature have on this subject?

A. First, it is important to note the particular time period being referred to in the Happer Testimony ("since 1998", "20 years"). This time period refers to the span starting in 1998 and ending presumably in 2014 (the last year for which an entire annual temperature data record would be available). This is a span of 17 years and begins, curiously, at a very large El Nino year (1998) which saw an unusually high global mean temperature (noted in Figure 3 in Peabody Ex. ___ WH-2, page 5 (Happer Direct)). This time period in the observed temperature record has been discussed regularly in the peer-reviewed literature and in the most recent IPCC 5th Assessment Report (so much so, this time period is often referred to as a warming "hiatus"). Because of the timing of the production and review process involved in all IPCC reports, this period is described in the most recent IPCC 5th Assessment Report as a 15-year timespan (1998 – 2012). The global mean surface temperature record shows a decadel trend of 0.04 °C per decade during this period.[4] When compared to the trend estimate for the time period 1951-2012 (a more appropriate climatological span): 0.106 ± 0.027 °C per decade, this is a much reduced temperature trend. This reduced trend in the much shorter and more recent time period is discussed and analyzed extensively in the peer-reviewed literature and within the IPCC 5th Assessment Report.

[4] IPCC 5th Assessment Report, Working Group I, Technical Summary, page 61

The following presents the IPCC 5th Assessment Report presentation of the global mean surface temperature trends from three different temperature databases, each of which represents an exhaustive, bias corrected review of the data:[5]

Table 2.7 | Same as Table 2.4, but for global mean surface temperature (GMST) over five common periods.

Data Set	Trends in °C per decade				
	1880–2012	1901–2012	1901–1950	1951–2012	1979–2012
HadCRUT4 (Morice et al., 2012)	0.062 ± 0.012	0.075 ± 0.013	0.107 ± 0.026	0.106 ± 0.027	0.155 ± 0.033
NCDC MLOST (Vose et al., 2012b)	0.064 ± 0.015	0.081 ± 0.013	0.097 ± 0.040	0.118 ± 0.021	0.151 ± 0.037
GISS (Hansen et al., 2010)	0.065 ± 0.015	0.083 ± 0.013	0.090 ± 0.034	0.124 ± 0.020	0.161 ± 0.033

Here is the graphical representation of this same information:[6]

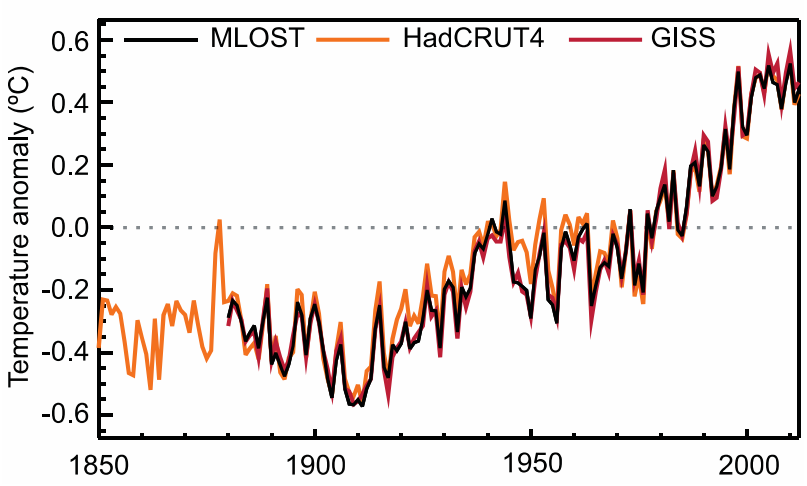


Figure 2.20 | Annual global mean surface temperature (GMST) anomalies relative to a 1961–1990 climatology from the latest version of the three combined land-surface air temperature (LSAT) and sea surface temperature (SST) data sets (HadCRUT4, GISS and NCDC MLOST). Published data set uncertainties are not included for reasons discussed in Box 2.1.

The temperature trend records shown in the table and graph represent statistically significant trends greater than that claimed for the short, recent warming "hiatus". The short time period emphasized in the Happer Testimony is the portion of the 162-year record at the end for which the general trend behavior slows.

[5] IPCC 5th Assessment Report, Working Group I, Chapter 2, page 193.
[6] IPCC 5th Assessment Report, Working Group I, Chapter 2, page 193.

Q. Are trends over short periods considered reliable?

A. Trends over periods as short as 15 years are neither reliable nor a reflection of long-term change in climate. As stated in the IPCC 5th Assessment Report:[7]

> Owing to natural variability, trends based on short records are very sensitive to the beginning and end dates and do not in general reflect long-term climate trends. As one example, the rate of warming over the past 15 years (1998 – 2012; 0.05 [–0.05 to +0.15] °C per decade), which begins with a strong El Niño, is smaller than the rate calculated since 1951 (1951 – 2012; 0.12 [0.08 to 0.14] °C per decade)Trends for 15-year periods starting in 1995, 1996, and 1997 are 0.13 [0.02 to 0.24], 0.14 [0.03 to 0.24] and 0.07 [–0.02 to 0.18], respectively.

Hence, the reference in Peabody Ex. ___ at 8 (Happer Direct) to trends in this short time period is not relevant to an assessment of the observational evidence for anthropogenic climate change, nor is it sufficient grounds to make a statement regarding the long term trend of the climate in one direction or another.

Q. Has any peer-reviewed journal published work of Dr. Happer in which he argues that there has been no warming trend over the past 15 years?

A. No, not to my knowledge.

VI. MODEL CALIBRATION

Q. Do models used as the calibration to the IAMs (and their subsequent SCC results) agree with observations?

A. The key assertions made by Dr. Happer on this issue in Peabody Ex.__ at 6 (Happer Direct)) are:

[7] IPCC 5th Assessment Report, Working Group I, page 194.

> Nearly all of the IPCC climate models have predicted several hundred percent more warming over the past twenty years than has actually been observed.[8]
>
> No, climate models do not agree with observed temperatures. Climate models predicted far more warming than has actually been observed.[9]

Similarly Dr. Happer states in Peabody Ex. ___ WH-2, page 6 (Happer Direct):

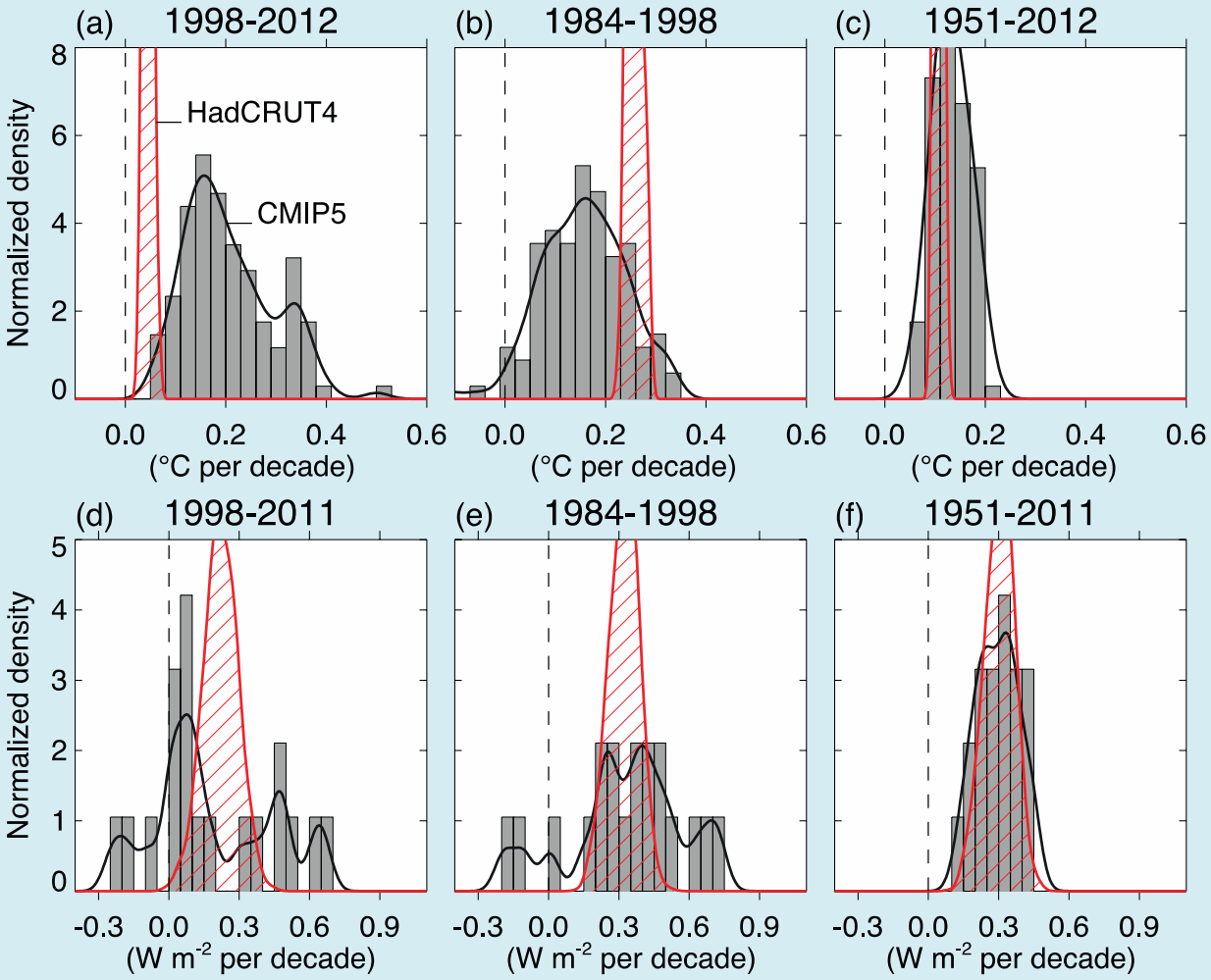
> Models predict that the lower atmosphere (the troposphere) should warm more rapidly than the Earth's surface, the opposite of what has been observed.

Technical support for these assertions is presented by Dr. Happer in Figures 4 and 5 in Peabody Ex. ___ WH-2, pages 6-7 (Happer Direct). Figure 4, it should be noted, is from congressional testimony – which is not peer-reviewed scientific content. Hence, it is difficult to comment on the content of this figure as there are many questions of clarification and context that would be needed to establish scientific reliability before one could consider this as support.Figure 5 is from a peer-reviewed study but provides an incomplete assessment of the difference between the observations and climate models. I provide a more comprehensive, balanced explanation below.

The discrepancy between the IPCC models and observed global mean temperature occurs over the previously discussed 15-year period and has received considerable analysis and description in the latest IPCC 5th Assessment Report.[10] A more complete view of the topic represented by Figure 5, presented in Peabody Ex.___ WH-2, page 7

[8] Happer direct testimony, page 7
[9] Happer direct testimony, page 9.
[10] For example, see IPCC 5th Assessment Report, Working Group I, Technical Summary, Box TS.3; Working Group I, Chapter 9, Section 9.4; Working Group I, Chapter 9, Box 9.2

(Happer Direct), is shown by the following figure from the IPCC 5th Assessment Report, which shows that there is little discrepancy between the model and observed temperature trends when comparison is performed over appropriately long time periods (panel c: 1951-2012 time period) as opposed to shorter time periods (panels a and b: 1998-2012 and 1984-1998, respectively).[11],[12]:



Box 9.2, Figure 1 | (Top) Observed and simulated global mean surface temperature (GMST) trends in degrees Celsius per decade, over the periods 1998–2012 (a), 1984–1998 (b), and 1951–2012 (c). For the observations, 100 realizations of the Hadley Centre/Climatic Research Unit gridded surface temperature data set 4 (HadCRUT4) ensemble are shown (red, hatched: Morice et al., 2012). The uncertainty displayed by the ensemble width is that of the statistical construction of the global average only, in contrast to the trend uncertainties quoted in Section 2.4.3, which include an estimate of internal climate variability. Here, by contrast, internal variability is characterized through the width of the model ensemble. For the models, all 114 available CMIP5 historical realizations are shown, extended after 2005 with the RCP4.5 scenario and through 2012 (grey, shaded: after Fyfe et al., 2010). (Bottom) Trends in effective radiative forcing (ERF, in W m^{-2} per decade) over the periods 1998–2011 (d), 1984–1998 (e), and 1951–2011 (f). The figure shows AR5 best-estimate ERF trends (red, hatched; Section 8.5.2, Figure 8.18) and CMIP5 ERF (grey, shaded: from Forster et al., 2013). Black lines are smoothed versions of the histograms. Each histogram is normalized so that its area sums up to one.

[11] IPCC 5th Assessment Report, Working Group I, Technical Summary, page 63.
[12] Note that panels d-f are not relevant to the current discussion but included so as not to cut the original figure.

Dr. Happer's Testimony does not show panel c. The panel c figure repeats (please refer to the quote in response to the question above: "Are trends over short periods considered reliable?") the importance of considering sufficiently long periods of time in order to establish climate trends and/or the ability of models to simulate long-term climate trends. Shorter periods (< 3 decades) are not long enough to assess climate trends or model veracity. Even though short periods cannot establish long-term trends, the discrepancy noted in this figure is a topic of active research within the climate science community, for which a complete discussion can be found in the IPCC 5th Assessment Report.[13]

Speculation as to the source of the discrepancy has been given some further attention, for example, in the recent paper by Dai et al.(2015) and is broadly attributed to the difficulty of large-scale atmospheric models to capture internal climate variability, particularly in regions such as the tropical Pacific (and hence, associated with El Nino activity).[14]

As I stated above, anthropogenic climate change, and the simulation of anthropogenic climate change must be assessed over sufficiently long time periods to avoid misinterpretations due to short-term variability such as concluded in Dr. Happer's Testimony.

The fact that the IPCC models perform well over the longer, climate-relevant time period, must be prioritized over discrepancies in shorter-term variability.

[13] IPCC 5th Assessment Report, Technical Summary, pages 61-63.
[14] Dai, A. J.C. Fyfe, S-P.Xie, and X. Dai (2015) Decadal modulation of global surface temperature by internal climate variability, *Nat. Clim Change*, **5**, 555-559.

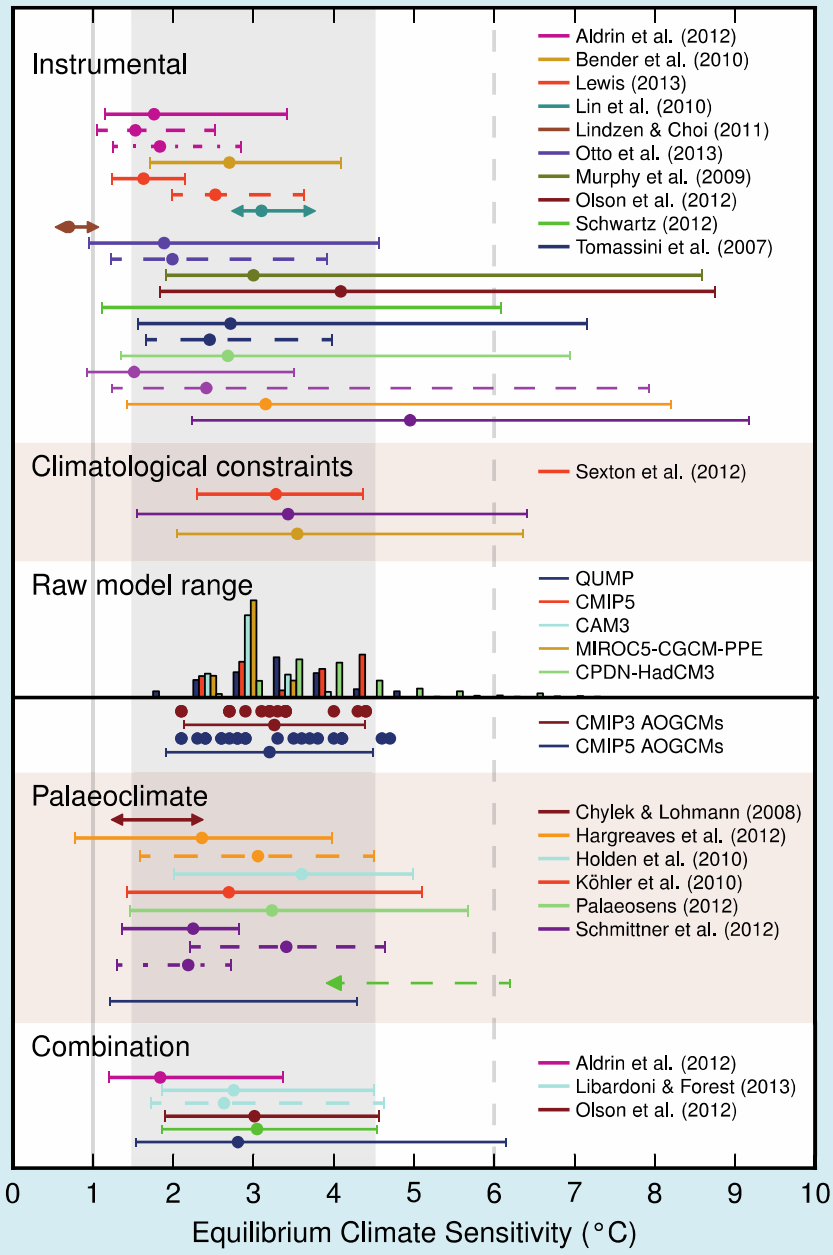
Q. Is a doubling sensitivity of IPCC models too large?

A. In Peabody Ex. ___ at 8 (Happer Direct), Dr. Happer asserts that the models reviewed by the IPCC 5th Assessment Report have climate sensitivity values that are too large. His opinion is that a mean value of S = 1 K is the correct value. His testimony in Peabody Ex. ___ WH-2, page 7 (Happer Direct) relies on the assertion that the ECS is most accurately assessed without any climate feedbacks.

> If one assumes negligible feedback, that is, that other properties of the atmosphere change little in response to additions of CO2, the doubling efficiency can be estimated to be about S = 1 K. The much larger doubling sensitivities claimed by the IPCC,which look increasingly dubious with each passing year, come from large positive feedbacks.

First, it must be pointed out that the IPCC does not "make claims". The IPCC is a group of scientists who volunteer to review,synthesize, and summarize the peer-reviewed research. Hence, the doubling sensitivity range reported in the IPCC 5th Assessment Report (1.5 °C – 4.5 °C) is a range of values representative of the large body of peer-reviewed scientific literature on the topic. The IPCC 5th Assessment Report has a thorough and comprehensive review of this important metric of the climate system (different aspects are discussed in at least three different chapters). The range of ECS values are based on multiple lines of evidence (e.g. paleoclimate, model simulations, and instrumental measurements), best represented in the following figure:[15]

[15] IPCC 5th Assessment Report, Working Group I, Chapter 12, box 12.2, Figure 1, page 1110.



Box 12.2, Figure 1 | Probability density functions, distributions and ranges for equilibrium climate sensitivity, based on Figure 10.20b plus climatological constraints shown in IPCC AR4 (Meehl et al., 2007b; Box 10.2, Figure 1), and results from CMIP5 (Table 9.5). The grey shaded range marks the *likely* 1.5°C to 4.5°C range, and the grey solid line the *extremely unlikely* less than 1°C, the grey dashed line the *very unlikely* greater than 6°C. See Figure 10.20b and Chapter 10 Supplementary Material for full caption and details. Labels refer to studies since AR4. Full references are given in Section 10.8.

Though the appeal made in the Happer testimony for a simple representation of the ECS is attractive, the available evidence as represented by the IPCC assessment report does not support such a conclusion.

VII. CARBON FERTILIZATION

Q. In your opinion, will additional CO2 be beneficial to plant growth and drought tolerance.

A. There is evidence in controlled environments that additional CO2 will enhance plant growth and potentially increase plant drought tolerance. However, research suggests that these effects are much more variable in real world application and that other impacts from climate change may negate any gains derived from additional atmospheric CO2 concentration.

The key assertion made in Peabody Ex. ___ at 10 (Happer Direct)) is that

> "More atmospheric CO2 will substantially increase plant growth rates and drought resistance."

As I state above, CO2 fertilization and the potential for increased CO2 to increase drought tolerance is theoretically well-understood. However, quantification of these effects is uncertain, particularly outside of controlled laboratory conditions. The IPCC 5th Assessment Report provides a thorough review of CO2 fertilization and the role of CO2 fertilization within climate change. The IPCC 5th Assessment Report states:[16]

> Elevated atmospheric CO2 concentrations lead to higher leaf photosynthesis and reduced canopy transpiration……The increase in leaf photosynthesis with rising CO2, the so-called CO2 fertilization effect, plays a dominant role in terrestrial biogeochemical models……These physiological changes translate into a broad range of higher plant carbon accumulation in more than two-thirds of the experiments….However, FACE experiments also show the dimishing or lack of CO2 fertilization effect in some ecosystems and for some plant species…… Nutrient limitation is hypothesized as primary cause for reduced or lack of

[16] IPCC 5th Assessment Report, Working Group I, Chapter 6, page 502.

CO2 fertilization effect observed on NPP in some experiments.

Furthermore, the impact of climate change on plants must necessarily include the entire suite of impacts in order to understand how plants will respond. If one were to isolate one element within this larger suite of impacts, results would be incomplete and potentially misleading.

Since the issue of plant productivity is of particular relevance to crop productivity, I repeat here the statement I provided in rebuttal to the Bezdek testimony on this topic:

The Intergovernmental Panel on Climate Change has performed extensive review of the impact of climate change on crop productivity with CO2 fertilization effects considered:[17]

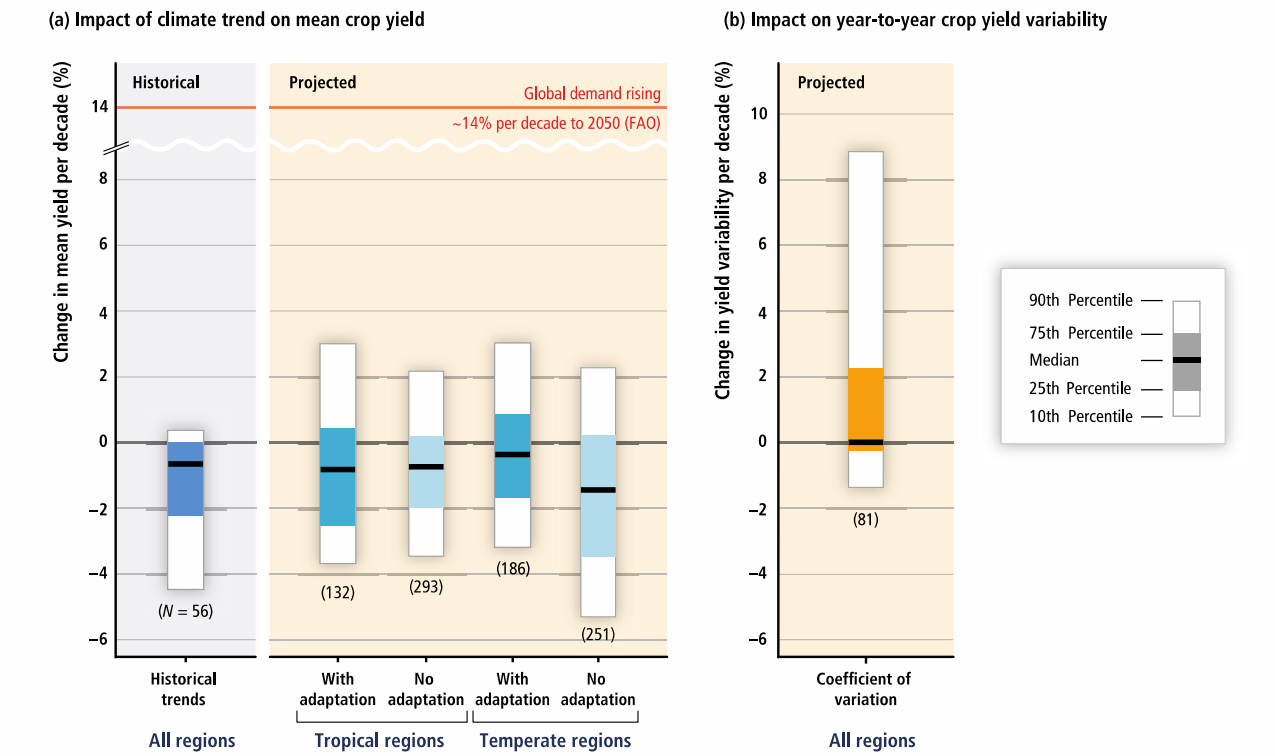


Figure 7-7 | Boxplot summary of studies that quantify impact of climate and CO_2 changes on crop yields, including historical and projected impacts, mean and variability of yields, and for all available crops in temperate and tropical regions. All impacts are expressed as average impact per decade (a 10% total impact from a 50-year period of climate change would be represented as 2% per decade). References for historical impacts are given in Figure 7-2, for projected mean yields in Figure 7-5, and for yield variability in Figure 7-6. *N* indicates the number of estimates, with some studies providing multiple estimates. In general, decreases in mean yields and increases in yield variability are considered negative outcomes for food security. Also indicated in the figure is the expected increase in crop demand of 14% per decade (Alexandratos and Bruinsma, 2012), which represents a target for productivity improvements to keep pace with demand.

[17] IPCC 5th Assessment Report, Working Group II, chapter 7, page 506.

As outlined in the IPCC review main text and noted in the figure caption ("….summary of studies that quantify the impact of climate and CO2 changes on crop yields…"), the CO2 fertilization effect is included in the IPCC review results.

In order to understand and quantify the impact of climate change on crop productivity, all known negative and positive impacts must be included. The results of the review performed in the IPCC 5th Assessment Report find that there is a net negative impact on crop yields, inclusive of the CO2 fertilization effect. The net effect of climate and CO2 changes on crop productivity is negative at the global scale and the regional scale. In addition to the long-term mean impact, the variability of crop yields are projected to increase. It is worth noting, however, that the uncertainty is large. Though this area of research remains very active and the current assessment acknowledges the need for additional research,the IPCC review represents the most comprehensive assessment of research on this topic, to date.

As evidence for the growth stimulation of additional CO2 on plants in Peabody Ex. ___ WH-2, page 11 (Happer Direct) includes a Figure (Figure 8: Greening of the Earth as observed by satellites") referenced to a peer-reviewed paper:

> "Satellite observations like those of Fig. 8 from R.J. Donohue [19] have shown a very pronounced "greening of the Earth ….."

The figure presented in the Happer Testimony is the following:

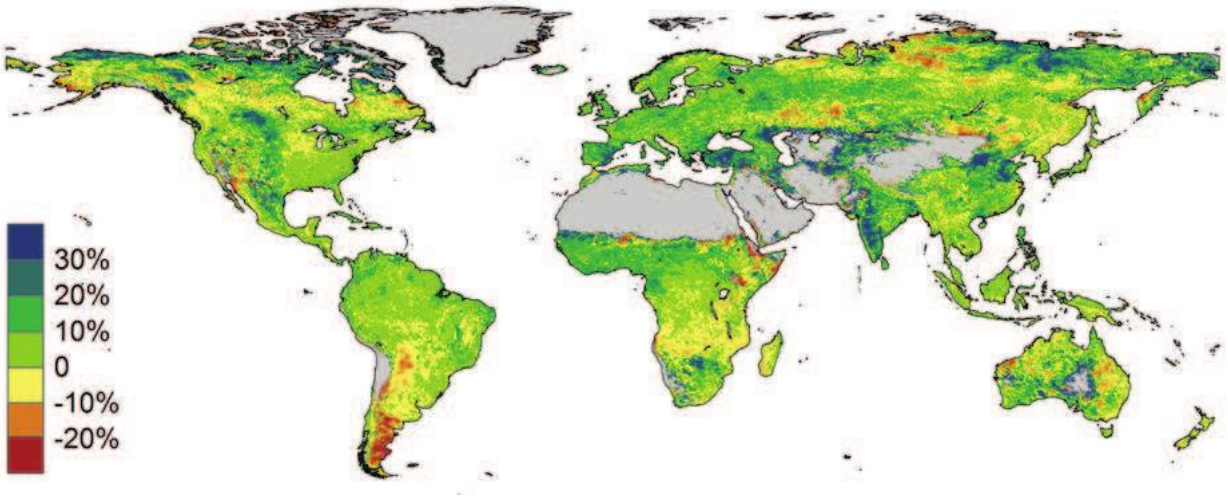


Figure 8: Greening of the Earth as observed by satellites.

However, the referenced paper - Donohue et al (2013)[18] - contains no such figure. Furthermore the Donohue et al. paper arrives at a far narrower set of conclusions regarding CO2 fertilization concluding that a "….14% increase in atmospheric CO2 (1982-2010) led to a 5 to 10% increase in green foliage cover in warm, arid environments."

Hence, the claim in Dr. Happer's testimony of worldwide greening due to CO2 fertilization is not supported by his chosen citation nor the IPCC review on the topic.

See annotations of S.Happer, pp.20-21 and 27- Happer tries to explain his use of a poorly-sourced image, which does not mean what he claims, i.e., greening does not imply vast net improvement in agriculture around the world.

Q. Do you know then, from what literature Dr. Happer drew his Figure 8?

A. In my opinion, Dr. Happer reproduced Figure 8 in Peabody Ex. ___ WH-2, page 11 (Happer Direct) from data consisting of satellite observations of the change in a metric of vegetation cover (the most common is the Normalized Difference Vegetation Index metric ("NDVI")).

[18] R. J. Donohue, M. L. Roderick, T. R. McVicar, and G. D. Farquhar, Impact of CO2 fertilization on maximum foliage cover across the globe's warm, arid environments, Geo-physical Research Letters 40, 3031-3035 (2013).

The image does not appear at that source, or in its supplementary materials. A variant appears in the press release, which however makes clear the bounds of applicability. Happer's claims contradict the published material, which carefully bounds applicability.

Q. On what do you base that conclusion?

A. The mechanisms driving the well-established "greening" of the planet over the last few decades remains a topic of research in which CO2 fertilization is considered one contributing factor. The following passage from the IPCC 5th Assessment Report provides a reasonable overview of the processes hypothesized to remove CO2 from the Earth's atmosphere into the land (referred to as "increased storage"):[19]

> This increased storage in terrestrial ecosystems not affected by land-use change is likely to be caused by enhanced photosynthesis at higher CO2 levels and nitrogen deposition, and changes in climate favouring carbon sinks such as longer growing seasons in mid-to-high latitudes. Forest area expansion and increased biomass density of forests that result from changes in land-use change are also carbon sinks, and they are accounted in Table 6.1 as part of the net flux from land use change.

Hence, CO2 fertilization is only one contributor to the global "greening" observed from satellites and inferred from other measurement and modeling approaches.

The confusion over the presented figure, its citation, and the general misinterpretation of the CO2 fertilization effect raise serious questions about the reliability of Dr. Happer's Testimony on the topic of CO2 fertilization and its relationship to anthropogenic climate change.

See annotations of S.Happer, pp.20-21 and 27-

[19] IPCC 5th Assessment Report, Working Group I, Chapter 6, pages 487-488.

VIII. USE OF PEER REVIEWED LITERATURE

Q. Earlier in your testimony, you noted that Dr. Bezdek's Direct testimony cited information published on the Internet, rather than research that had been subject to peer-review prior to publication. What is peer review?

A. The communication and dissemination of scientific research advance is performed through a process referred to as scholarly peer-review. This process subjects an authored work to the scrutiny of others who are expert in the particular subject matter under consideration. Scholarly peer-review is considered mandatory in most academic journals which are the primary means of communicating research results and advancing the scientific body of knowledge.

Q. How does the process of peer-review typically work?

A. In practice, academics submit a written record of scientific work (a manuscript) to a peer-reviewed journal. The work is scrutinized by typically 2-4 experts within the manuscript's specialized area of research. The reviewers may choose to remain anonymous.

Though the exact metrics used to judge the work vary somewhat between journals, the generally accepted metrics are scientific originality, integrity, accuracy and clarity of communication. Reviewers can reject the manuscript (with detailed reasoning and supporting information when necessary) or request revisions of a minor or major caliber. The author(s) of the manuscript have the opportunity to respond, make corrections, withdraw, etc. This can proceed through multiple rounds of review with the same set of reviewers. The goal is to remain impartial and to generate a process of self-correcting advance of knowledge and information.

An essential component of higher education within academia typically includes learning the peer-review process and the importance of maintaining impartiality, high quality, and adherence to strict scientific principles (hypothesis generation, experimentation, etc).

Q. Why is peer review important, and why should peer-reviewed sources, citations, and publications be given greater weight than those that have not been peer-reviewed?

Given the importance of peer review within scientific research, it is considered an expected standard when assessing what is known scientifically. Hence, when communicating to the scientific community or the public on scientific topics, the use of peer-reviewed literature as support is considered essential. Reliance on literature that has not gone through the peer-review process is considered of unknown reliability and in practice, handled with suspicion.

Q. Have the witnesses in this proceeding relied upon peer-reviewed literature in their testimony?

In examining Peabody Ex. ___ at 37 (Bezdek Direct), I found that out of 54 citations, one was peer-reviewed research, one was a national academy report. All other sources were either federal agency reports, grey literature or popular literature.

Q. What is the importance of the IPCC 5th Assessment Report?

A. The IPCC is an international collective of scientists with acknowledged expertise in the broad topical umbrella of climate change. During the nearly 3 decades during

which the IPCC has functioned, it has had the voluntary involvement of thousands of experts within the climate change discipline.

The most important function of this large international collective, and its founding intent, was

> to prepare a comprehensive review and recommendations with respect to the state of knowledge of the science of climate change; the social and economic impact of climate change, and possible response strategies and elements for inclusion in a possible future international convention on climate.

(see www.ipcc.ch/organization/organization_history.shtml). IPCC Assessment reports have been produced roughly every six years and now include multiple volumes, technical summaries, and a summary for policymakers.

Q. What literature is relied upon in the IPCC reports and is the IPCC 5th Assessment Report peer-reviewed?

A. The assessment reports aim to comprehensively examine every aspect of climate change. To that end, the authors review primarily peer-reviewed material to arrive at a complete, balanced assessment of the most likely state of knowledge. All research across the world is scoured for relevant material. It is critical to note on any topic within the multivolume assessments, there are often 10s to 100s of peer-reviewed papers. Papers can often have conflicting or incomplete results. Rather than "cherry-picking" a result by selecting a particular subset of papers, the assessments strive to synthesize all research, identifying those areas that remain uncertain or for which conflicting results exist, to arrive at an objective, unbiased assessment of what is known and not-known on the climate change topic.

The reports themselves are reviewed by experts and the reports reports synthesize primarily peer-reviewed research. This synthesis of the peer-reviewed research is itself, subject to peer-review. Therefore, the assessment reports have two layers of peer-review.

Finally, the assessment reports contain an attempt at assigning different levels of confidence and likelihood to key conclusions in the assessment. Page 138 of the IPCC 5th Assessment report best states these two metrics:

> All three IPCC Working Groups in the AR5 have agreed to use two metrics for communicating the degree of certainty in key findings (Mastrandrea et al., 2010):
>
> - Confidence in the validity of a finding, based on the type, amount, quality, and consistency of evidence (e.g., data, mechanistic understanding, theory, models, expert judgment) and the degree of agreement. Confidence is expressed qualitatively.
>
> - Quantified measures of uncertainty in a finding expressed probabilistically (based on statistical analysis of observations or model results, or expert judgement).

IPCC 5th Assessment Report (Working Group I, Chapter 1, Figure 1.11 and Table 1.2, page 142) provide specific guidance on the assignment of these metrics:

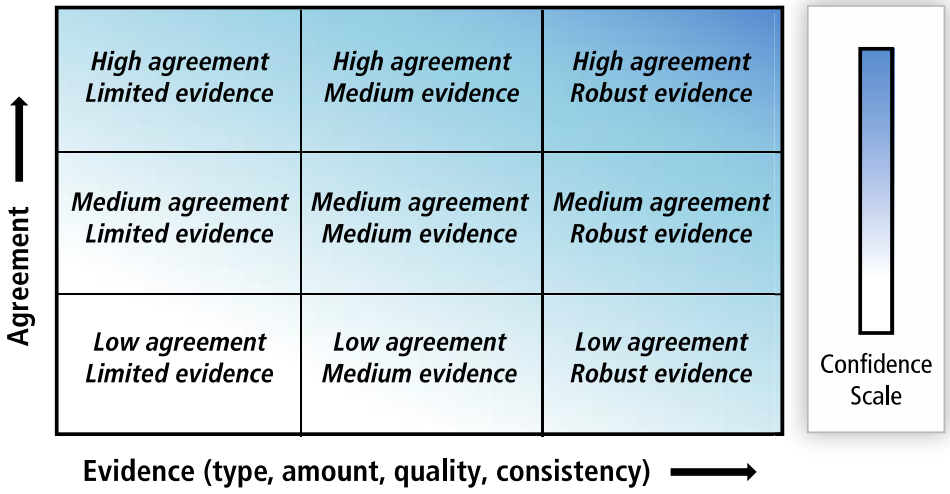


Figure 1.11 | The basis for the confidence level is given as a combination of evidence (limited, medium, robust) and agreement (low, medium and high) (Mastrandrea et al., 2010).

Table 1.2 | Likelihood terms associated with outcomes used in the AR5.

Term	Likelihood of the Outcome
Virtually certain	99–100% probability
Very likely	90–100% probability
Likely	66–100% probability
About as likely as not	33–66% probability
Unlikely	0–33% probability
Very unlikely	0–10% probability
Exceptionally unlikely	0–1% probability

Notes:
Additional terms that were used in limited circumstances in the AR4 (*extremely likely* = 95–100% probability, *more likely than not* = >50–100% probability, and *extremely unlikely* = 0–5% probability) may also be used in the AR5 when appropriate.

As a result, the IPCC assessments are the best resource for providing a comprehensive syntheses of what is known and not known on the topic of climate change. It provides an extensive bibliography citing the 1000s of papers reviewed for the report. All authors, contributing authors, editors, reviewers are publicly listed and the reports go through extensive editing to ensure readability, accuracy, and objectivity.

The only weakness to the assessment reports is the time it takes to write, process, and review the 3-volume set. This means that new research in the peer-reviewed literature, often available at the time of the report release, cannot have been included in the reports due to the need to cut off the review effort 2-3 years prior to final publication. However, with commitment to a particular element of the report, the newly published material can be synthesized by researchers with little additional effort.

Q. Does this conclude your Rebuttal Testimony?

A. Yes it does.

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EDUCATION

Ph.D. 2004 – Ecology, Colorado State University
M.P.P 1996 – Public Policy, University of California, Berkeley
S.M. 1990 – Meteorology, Massachusetts Institute of Technology
B.A. 1986 – Environmental Physics, University of California, Berkeley

PROFESSIONAL EXPERIENCE

Associate Professor, School of Life Sciences, Arizona State University, Aug 2010 – present
Affiliated Faculty, School of Geographical Sciences and Urban Planning, Mar 2013 - present
Graduate Faculty, School of Sustainability, Arizona State University, Jan 2013 - present
Senior Sustainability Scientist, Global Institute of Sustainability, Arizona State Univ, Aug 2010 – present
Associate Professor, Dept of Earth and Atmos Sci & Dept of Agronomy, Purdue University, Aug 2009 – Aug 2010
Assistant Professor, Dept of Earth and Atmos Sci & Dept of Agronomy, Purdue University, Aug 2005 – Aug 2009
Associate Director, Purdue Climate Change Research Center, Purdue University, Aug 2005 – Aug 2008
Research Scientist I, Department of Atmospheric Science, Colorado State University, July 1998 – August 2005
Staff Research Associate, Bren School of Env. Sci and Mngmnt, Univ of Ca, Santa Barbara, Apr 97 – June 98
Senior Scientist, Institute for Energy and Environmental Research, September 1992 – January 1997
Research Associate, Atmospheric and Environmental Research, Inc., February 1992 – September 1992
Research Associate, Tellus Institute, February 1990 - October 1991
Research Assistant, National Oceanic and Atmospheric Administration, Summer 1988
Research Intern, Environmental Sciences Division, Lawrence Livermore National Laboratory, Nov 1986 - Sept 1987
Student Assistant, Atmospheric Aerosol Research Group, Lawrence Berkeley National Lab, Feb 1985-Oct 1986

HONORS AND AWARDS

Nominated for AGU's Macelwane Medal 2014
Sigma Xi Young Investigator's Award 2010
NSF CAREER Award 2009
IPCC contributing author and reviewer (IPCC was organizational co-recipient of the 2007 Nobel Peace Prize)
Named 2007 "Air Conservationist of the Year", from the Indiana Wildlife Federation

UNIVERSITY SERVICE

Graduate Degree Program in Ecology executive committee 1999-2000
Graduate Degree Program in Ecology, Front Range Student Ecology Symposium Chairman 1999-2000
Undergraduate programs committee: 2013 - present
Safety committee: 2010 – 2013
Diversity Committee, Purdue University, Aug 2005 – Aug 2010

PROFESSIONAL SOCIETY SERVICE

American Geophysical Union member since 1990
Sigma Xi member since 2000
Phi Kappa Phi member since 2004
Ecological Society of America member since 2004

OTHER NATIONAL OR INTERNATIONAL PROFESSIONAL SERVICE

Carbon science steering working group (CCSWG) to the Carbon science interagency working group (CCIWG)
Global Carbon Program Science Steering Committee: 2008 - 2013

NASA review panel member, Instrument Incubator Program 2001

Larimer County Environmental Advisory Board 2000-2002

NOAA Review Panel, Global Carbon Cycle Program 2005

NOAA Global Carbon Cycle Scientific Steering Committee, 2006 - present

NASA Review Panel, New Investigator Program, April 2006

Carbon Management, Editorial Board, 2009 - present

MCI Task Force Committee member, 2005 – present

Carbon Balance and Management, Editorial Board member, 2006 - present

Carbon Dioxide Information Analysis Center, external advisory committee member, 2007 - present

United Nations Framework Convention on Climate Change attendee/advisor since 1996

PEER-REVIEWED PUBLICATIONS

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Guest lecturer in numerous courses, School of Life Sciences, School of Sustainability

Collated all climate change related courses currently offered at ASU in order to centralize a cliate change course offering – upcoming.

BIO 320: Fundamentals of Ecology (undergraduate)

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EAS 113/NRES 290/AGRY 290: Introduction to Environmental Sciences (undergraduate)

EAS 425: Carbon neutrality at Purdue (undergraduate/graduate)

EAS 591T: Principals of Terrestrial Ecosystem Ecology (graduate)

EAS 591A: Anthropogenic Climate Change (graduate)

Guest lecturer, Department of Atmospheric Science, Colorado State University, 1999 - 2005

UNIVERSITY AND PROFESSIONAL SERVICE

Commencement speaker, UC Berkeley School of Public Policy, 1996

Graduate Degree Program in Ecology, executive committee 1999-2000

Graduate Degree Program in Ecology, Front Range Student Ecology Symposium Chairman 1999-2000

NASA review panel member, Instrument Incubator Program 2001

Larimer County Environmental Advisory Board 2000-2002

United Nations Framework Convention on Climate Change attendee/advisor since 1996 (significant involvement advising both NGOs and nation-states on aspects of the UNFCCC/Kyoto Protocol related to carbon cycling)

Associate Director, Purdue Climate Change Research Center, 2005 – 2009 (part of 3-person leadership to grow the climate change center and the topic of climate change at Purdue University and regionally. Led student group to Copenhagen negotiations from the PCCRC, represented Center to University leadership, guided research focus)

NOAA Review Panel, Global Carbon Cycle Program 2005

NOAA Global Carbon Cycle Scientific Steering Committee, 2006 - 2009

NASA Review Panel, New Investigator Program, April 2006

IPCC contributing author and reviewer (IPCC was organizational co-recipient of the 2007 Nobel Peace Prize)

MCI Task Force Committee member, 2005 – 2008

Carbon Dioxide Information Analysis Center, external advisory committee member, 2007 - present

Carbon Balance and Management, Editorial Board member, 2006 - present

Diversity Committee, Purdue University, Aug 2005 – 2010

Global Carbon Project, Scientific Steering Committee member, 2008 – Feb, 2014 (meet 1-2 times per year, integrate and synthesize carbon cycle research across the international community, produce publications, coordinate with UN agenices)

Carbon Management, Editorial Board, 2009 – present (2 invited publications, near-annual meetings)

U.S. Carbon Cycle Science Steering Group, 2010 – present (2 meetings per year. Advise and inform 12 Federal Agenices on the state of carbon cycle science research in the US. Taken leadership on an effort proposing and urban-carbon theme witihin the Federal Agencies, supported by the CCIWG. Held independent workshop – 10/2013)

Greenhouse Gas Measurement and Management, Editorial Board, 9/2010 – present

Oak Ridge National Laboratory, Climate Change Science Institute, Scientific Advisory Board, 4/2010 – 4/2012 (annual 2-day meetings)

ASU SOLS Safety committee, 9/1/2011 – 5/1/2013

ASU SOLS undergraduate program committee, 1/1/2014 – present

North American Carbon Program AIM5 Planning committee, April 2014 - present

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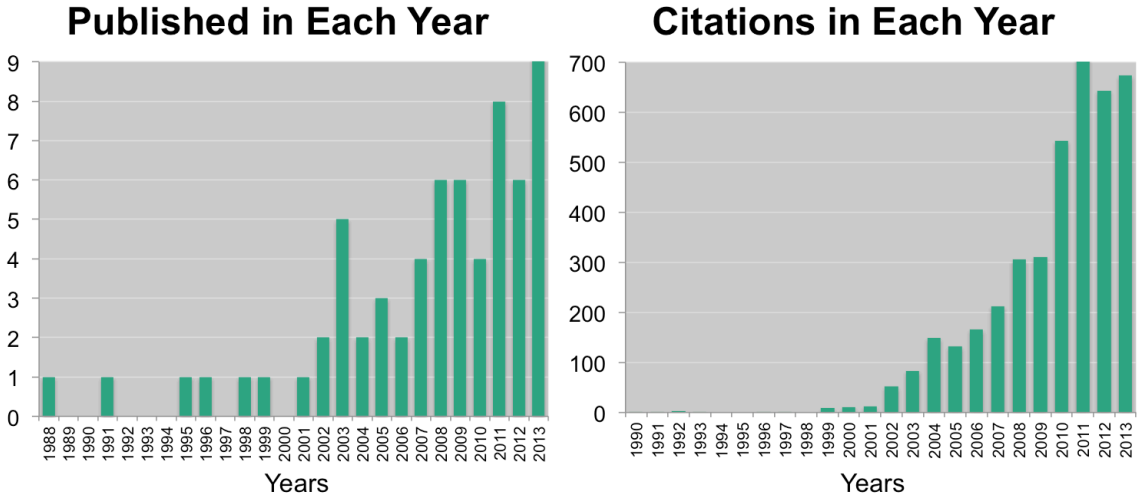

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Corrections to DOC Ex. ___ (Gurney Rebuttal)	
Page 3, Line 1	Second, I address Dr. Bezdek's limited assessment <u>of</u> the net impact of CO2 fertilization within the context of climate change.
Page 8, Line 10	Fossil fuel derived CO2 contains none of this rare CO2 due to its natural radioactive decay and the fact that it's half-life (the time it ~~take~~ <u>takes</u> to decay) is far less than the time required for carbon to transition to fossilized form.
Page 8, Line 15	This is referred to as the "~~Seuss~~ <u>Suess</u>" effect and is well established.
Page 8, Line 18	Roughly one-half of the emissions due to fossil fuel combustion and deforestation are removed from the atmosphere on an average basis and the removal processes in the ocean and land biosphere are relatively well ~~characterized~~ <u>quantified</u>.
Page 8, Line 22	However, it is well established through multiple lines of evidence that the long-term secular rise ~~in~~ <u>of</u> CO2 concentration in the Earth's atmosphere is driven by
Page 10, Line 22	First, it must be noted that the last of these assertions (the only one with a citation to support the statement) cites, and appears to be based upon<u>,</u> information published on a website rather than a peer-reviewed scientific paper.
Page 11, Line 16	When compared to the trend estimate for the time period 1951-2012 (a ~~standard meteorological~~ <u>more appropriate climatological</u> span): 0.106 ± 0.027 °C per decade, this is a much reduced temperature trend.
Page 14, Line 27	A more complete view of the <u>topic represented by</u> Figure 5, presented in Peabody Ex. ___ WH-2, page 7 (Happer Direct), is shown by the following figure from the IPCC 5th Assessment Report, which shows that there is little discrepancy between the model and observed temperature trends when comparison is performed over appropriately long time periods (panel c: 1951-2012 time period) as opposed to shorter time periods (panels a and b: 1998-2012 and 1984-1998, respectively).
Page 16, Line 5	Shorter periods (< ~~2~~ <u>3</u> decades) are not long enough to assess climate trends or model veracity.
Page 16, Line 11	Speculation as to the source of the discrepancy has been given some further attention<u>, for example,</u> in the recent paper by Dai et al. (2015) and is broadly attributed to the difficulty of large-scale atmospheric models to capture internal climate variability, particularly in regions such as the tropical Pacific (and hence, associated with El Nino activity).
Page 17, Lines 7 - 11 (format as quote)	~~If one assumes negligible feedback, that is, that other properties of the atmosphere change little in response to additions of CO2, the doubling efficiency can be estimated to be about S = 1 K. The much larger doubling sensitivities claimed by the IPCC,which look increasingly dubious with each passing year, come from large positive feedbacks.~~

	If one assumes negligible feedback, that is, that other properties of the atmosphere change little in response to additions of CO2, the doubling efficiency can be estimated to be about S = 1 K. The much larger doubling sensitivities claimed by the IPCC, which look increasingly dubious with each passing year, come from large positive feedbacks.
Page 26, Line 19	To that end, the authors review ~~all~~ primarily peer-reviewed material to arrive at a complete, balanced assessment of the most likely state of knowledge.
Page 27, Lines 1 and 2	The reports themselves are reviewed by experts and the reports ~~only~~ synthesize primarily peer-reviewed research.
Page 27, Line 2	~~Hence, opinions are not included.~~
Page 27, Line 4	Therefore, the assessment reports have two ~~stringent~~ layers of peer-review.
Page 28, Line 3	As a result, the IPCC assessments are the best resource for providing a comprehensive syntheses of what is known and not ~~know~~ known on the topic of climate change.

CERTIFICATE OF SERVICE

I, Sharon Ferguson, hereby certify that I have this day, served copies of the following document on the attached list of persons by electronic filing, certified mail, e-mail, or by depositing a true and correct copy thereof properly enveloped with postage paid in the United States Mail at St. Paul, Minnesota.

Minnesota Department of Commerce
Second Corrected Rebuttal Testimony and Attachments of Dr. Kevin Gurney

Docket No. E999/CI-14-643

Dated this 22nd day of September 2015

/s/Sharon Ferguson

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