<u>NOAA Response to Congressional Questions Regarding Climate Change</u>
The Honorable Joe Barton and the Honorable Fred Upton

Questions for the Record from the March 25, 2009 Hearing on Climate Adaptation
Response Updated November 2009 to Include Additional Graphic

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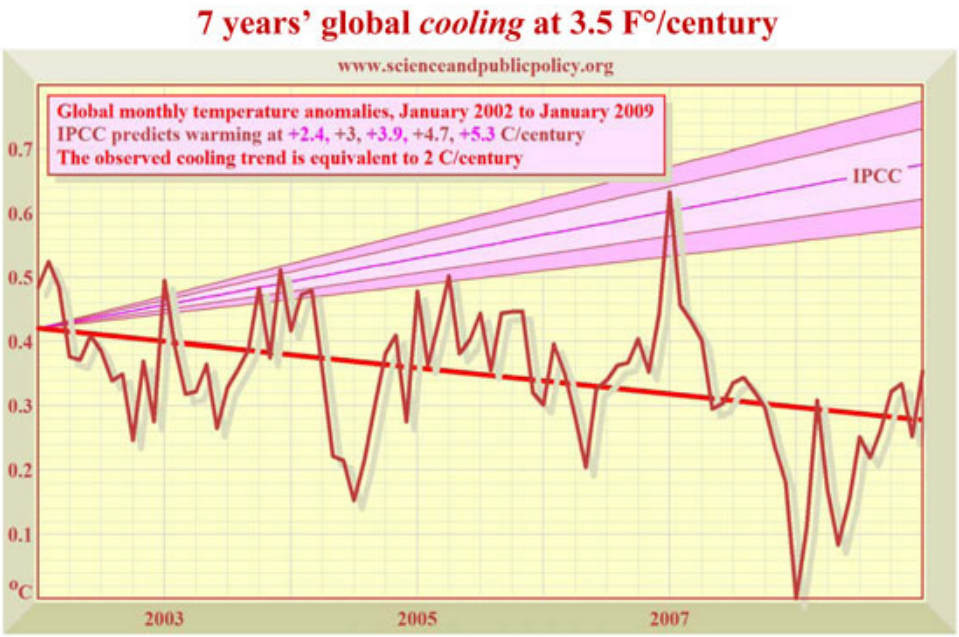
1. In response to a question from Representative Barton, you agreed during the hearing to research and assess whether the information presented in Lord Monckton's testimony (and as conveyed in the first three charts in his testimony) is factually correct, and to supply a report to the Committee. Committee Staff has supplied this testimony to you under separate cover. Among the information in your report responding to Representative Barton's request, please assess the following and provide sufficient citations and references to supporting documentation in your report and discussion to allow independent evaluation of both your and Lord Monckton's reports:

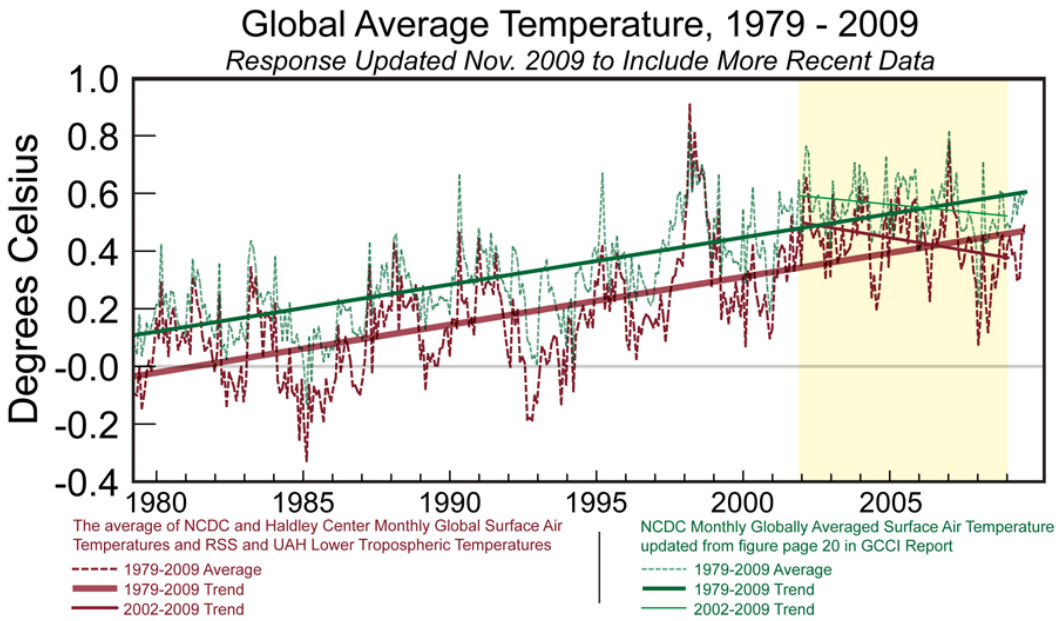
Question 1, Part (1): The testimony and related chart deriving information from the Hadley and NCDC monthly terrestrial global datasets and the RSS and UAH satellite lower-troposphere datasets, which showed a global cooling over the past seven years at a rate of 3.5 degrees Fahrenheit per century. The chart compared this apparent cooling with an IPCC central estimate prediction of a warming over this period at a rate of about 7 degrees Fahrenheit per century.

From Lord Monckton's Testimony: "There has been global cooling for seven years"



What "global warming"? *The mean of the Hadley and NCDC monthly terrestrial global-temperature datasets and the RSS and UAH satellite lower-troposphere datasets shows a (largely-unreported) cooling for seven years at a rate equivalent to 3.5 F°/century. The pink region shows the UN's projected range of warming rates: the pale pink region is 1 standard deviation either side of the UN's central estimate of 7 F° warming to 2100.*

NOAA Response: The fact that globally averaged surface air temperature has shown no trend or even slight cooling over the last 7 years is not an accurate reflection of long-term general trends. In fact, calculation of a trend over the last seven years is a gross mischaracterization of the longer term trend. The last seven years have been part of a strong warming trend that began in the 1970s, which is attributable to human influences (IPCC, 2007). During the last seven years six of the seven warmest years on record have been all been observed based on NOAA's global land and ocean data. Deducing long-term trends over such a short period of time is comparable to estimating the height of a sea swell by looking at the short period waves on top of the swell.



In addition to warming caused by greenhouse gases, the climate system also has natural variability, which is why one year's temperature is different from the next. This natural variability also can result in the climate having short periods of cooling or no trend, even with strong overall warming due to increasing greenhouse gases. The table below, based on the analysis by Easterling and Wehner[1], shows the probability that any ten year period will include negative trends of various magnitudes. Since 1975 there have been similar and longer periods of time where the globally averaged surface air temperature showed a slight cooling (1977-1985 and 1981-1989), yet the climate has warmed more in the past 33 years than any other time in our instrumental record. The results of Easterling and Wehner's analysis are consistent with the model simulations used by the Intergovernmental Panel on Climate Change (IPCC), and show that during the 21st century climate can and likely will experience decadal periods where the globally averaged surface air temperature show no trend or even cooling in the presence of a longer-term warming signal. Multiple decadal records are necessary in order to detect and attribute the effect of greenhouse gas increases in the climate system. These kinds of analyses have been performed extensively and reported on by the IPCC 2007 Assessments.

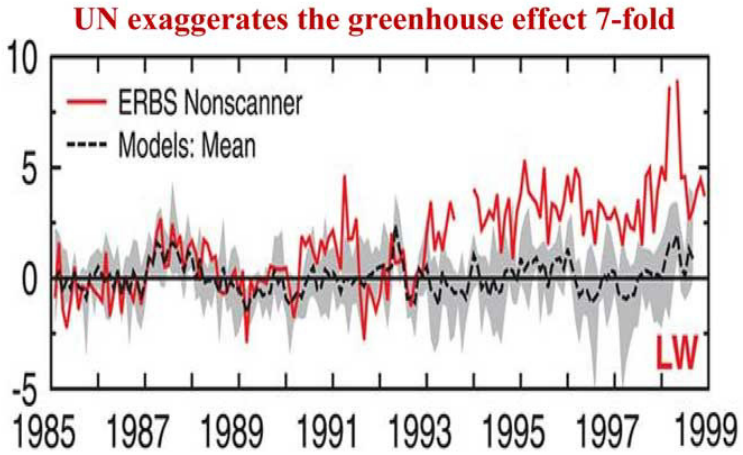
[1] *Easterling, D. R., and M. F. Wehner (2009), Is the climate warming or cooling?, Geophys. Res. Lett., 36, L08706, doi:10.1029/2009GL037810.*

		Trend °C/Decade	
	Any Negative Trend (<0.0°C)	**-0.1°C or less**	**-0.2°C or less**
Observed 1901-2008	21%	9%	8%
20th Century Model	18%	12%	8%
2000-2050 Model	9%	5%	1%
2000-2099 Model	5%	2.5%	0.5%

Probability that any 10 year period will have a negative trend of various magnitudes in the globally averaged surface air temperature from the observed record and climate model simulations for the 20th and 21st centuries.

Question 1, Part (2): **The testimony and related chart comparing 14 years' model-predicted and ERBE satellite-observed changes in outgoing long-wave radiation.**

From Lord Monckton's Testimony:
"The UN's climate panel has exaggerated carbon dioxide's effect on temperature sevenfold, verified by satellite observation that the diminution over time in outgoing long-wave radiation is one-seventh of that which the UN's computer games were told to predict"



Smoking gun: *14 years'* ***model-predicted (black)*** *and* ***ERBE satellite-observed (red)*** *change in outgoing long-wave radiation from the Earth's surface. Seven times as much long-wave radiation as the models predict continues to escape to space, demonstrating conclusively that the greenhouse effect has only one-seventh the effect on global temperature that the UN's models predict.* ***Source:*** *Professor Richard Lindzen.*

<u>NOAA Response:</u> We are unsure of the identified source of Richard Lindzen's diagram reported by Lord Monckton, because a citation was not provided in Lord Monckton's testimony. We note, however, that the figure above has a striking similarity to the top curve of the figure below:

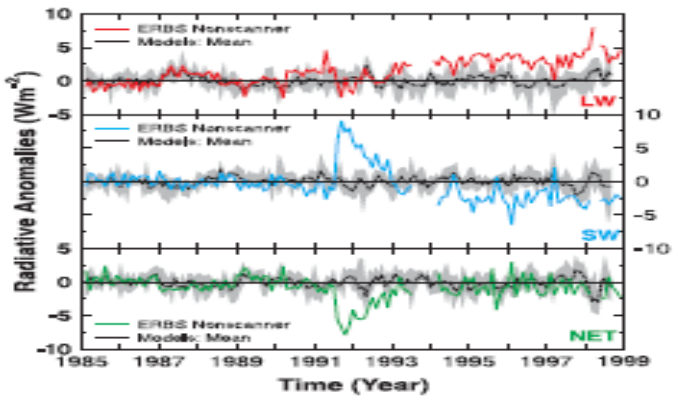
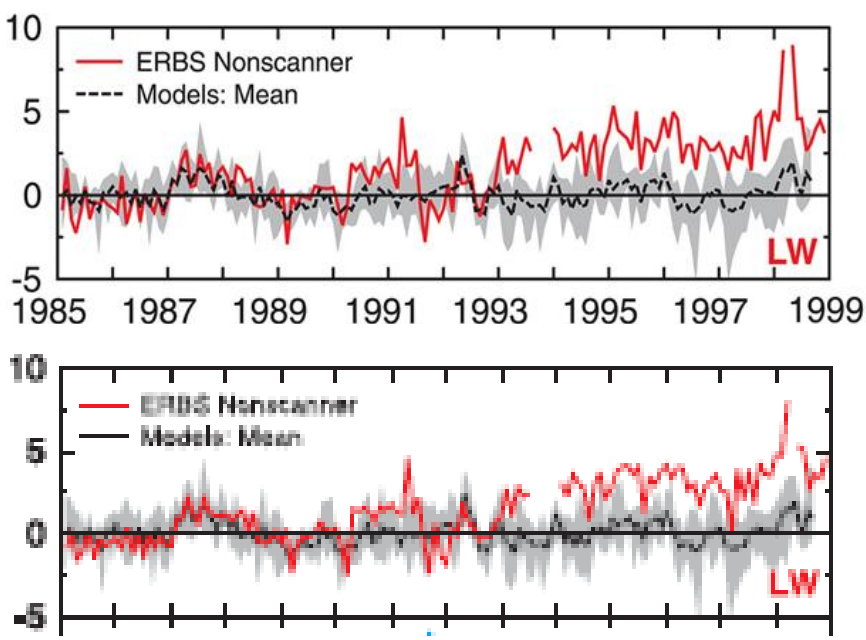


Fig. 2. ERBS satellite 36-day precession cycle averages are used for tropical mean SW, LW, and net radiation anomalies in comparison to climate model simulations. Compare with figure 4 of (*1*). Elimination of the diurnal-cycle aliasing signal results in a clearer decadal radiation signal in SW and net fluxes, although some increased variability in the 1990s remains.

Figure 2 is from Wielicki et al. (2002a) and is a response to a technical comment by Trenberth (2002) in response to the original article of Wielicki et al (2002b), all in the peer reviewed publication, *Science* magazine.

To facilitate the intercomparison of these two figures, below we have cropped the two figures (Monckton-Lindzen on top; Wielicki et al Figure 2, 2002a; bottom) and placed them side-by-side:

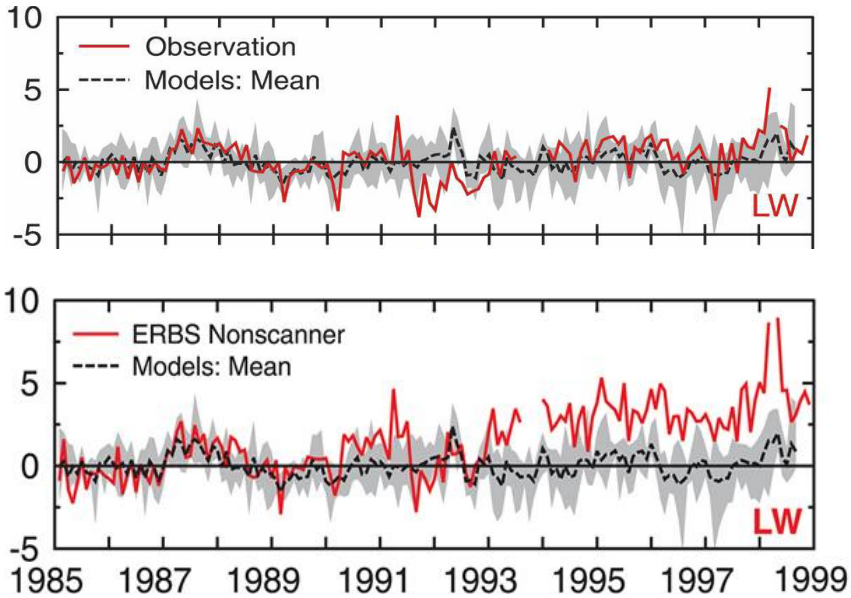


From this comparison, it can be safely concluded that the model means (black line) are precisely the same and that the ERBS Nonscanner data (red line) are largely, but not precisely, the same. Given the striking similarity, and the fact that Wielicki is the principal scientist on the ERBS mission and not

Lindzen, we assume for the purposes of this response that the source of Lindzen's ERBS Nonscanner data is Wielicki's group.

After this controversy in 2002 in *Science*, Wielicki and his colleagues revisited all aspects of how those data were processed. They found that there was an error in the processing of the ERBS Nonscanner data. Specifically, a flag in the computer code, used in ERBS instrument testing pre-launch that turns ON/OFF the altitude correction for the ERBS spacecraft altitude, was accidentally left in the OFF position. This code error did not matter the first 6 years or so of ERBS orbits since the spacecraft altitude was carefully controlled and did not change. Later in its life, the ERBS orbit was allowed to drift to a lower altitude and no one realized that the altitude flag was still in the OFF position, when it should have been in the ON position all along. This error in the software processing code was corrected and this correction was published in 2006 (Wong et al., 2006).

Below is plotted the revised figure from Wong et al (2006) with the software processing error for the ERBS Nonscanner data corrected (top) and the figure from Monckton-Lindzen that contains the software processing error (bottom).

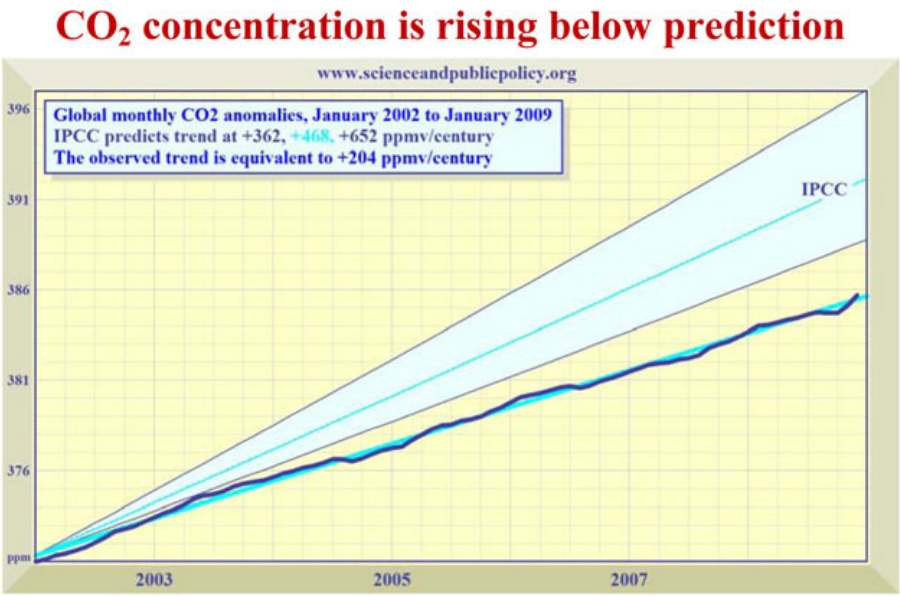


It is very clear that when the identified software processing error is corrected (top figure from Wong et al., 2006), the observed ERBS Nonscanner data compares very well with the model data. The Monckton-Lindzen figure is clearly in error, an error which has been corrected in the scientific peer reviewed literature by the scientists who produced the ERBS Nonscanner data.
Clearly, the upper graph shows that after corrections, the long-wave radiation as measured from satellites, falls squarely within the gray uncertainty band as calculated from a set of models used by IPCC to simulate the earth's outgoing longwave radiation.
References:

B. A. Wielicki *et al.*, *Science* **295**, 841 (2002b)
B.A. Wielicki *et al., Science*, **296**, 2095a (2002a)
K.E. Trenberth, *Science*, **296**, 2095a (2002)
T. Wong *et al., J. Climate*, **19**, 4028 (2006)

Question 1, Part (3): The testimony and related chart comparing the predicted rate of increase of atmospheric concentrations of carbon dioxide with the observed rate of increase of carbon dioxide.

From Lord Monckton's Testimony:
"Carbon dioxide is accumulating in the air at less than half the rate the UN had imagined"



Observed and predicted CO_2 concentration, 2000-2100: *The pale-blue region, bounded by exponential curves, is the UN's predicted path for CO_2 concentration over the present century. The observed, deseasonalized CO_2 concentration change calculated by NOAA from January 2000 to November 2008* ***(dark blue)*** *is near-coincident with the least-squares linear-regression trend* ***(solid, pale-blue line)*** *on the data. CO_2 concentration is no longer rising ever more rapidly, but only in a straight line, even though CO_2 emissions are rising ever more rapidly.*

NOAA Response: The figure Monckton provided and information contained in it is not found in the IPCC Fourth Assessment and the source of the figure he provided is unknown. It does appear that the smoothed CO_2 data has been derived from NOAA measurements, which is the only data in the figure that reflects observed measurements. In his figure on the carbon dioxide increase, he shows a line (the one in the middle) labeled "IPCC" that has CO_2 increasing at the rate of 3.0 parts per million by volume (ppmv), per year. Chapter 10 of the Fourth Assessment shows projections for several emissions scenarios. In the near-term, the projections do not differ significantly between scenarios because it takes time for policies to take a hold. Specifically, the rate of increase projected by the IPCC for 2000-2010 is ~1.7-1.8 ppmv/year, not 3.0 ppmv/year as the graph suggests, which is actually below what has been observed so far (2.0 ppmv/year) by NOAA. Also, the rates projected by the IPCC accelerate or decelerate over time depending on the scenario, but that is not noted in Monckton's plot. NOAA's data (2.0 ppmv/year) shows that Monckton's plot is erroneous, and the IPCC estimates have actually been shown to be too conservative in its near-term projections. In other words, CO_2 is increasing at a faster rate than was projected by the IPCC.

Question 2: The U.S. emits about 5.5 billion tons of energy-based CO_2 each year. The developing world today produces about 14 billion tons. By 2030, the U.S. and Western Europe, Canada, other developed countries will add about 2 billion tons annually by official estimates. The developing world - China, India, the Middle East, and Africa - will produce another 12.8 billion tons of energy-based Co_z over this time. How will the United States' cutting its emissions affect global warming and public health if the developing world does not cut its emissions to half of today's emissions?

Response: Though it is true that large reductions in carbon dioxide emissions are required on a global scale to halt the increase in carbon dioxide concentration in the atmosphere any reduction in emissions, anywhere in the world, helps slow the rate of increase and lessen the corresponding impacts of climate change. The rate of temperature increase is a key element related to the severity of climate change impacts.

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Question 3: Are we currently able to put together regional climate models that can reliably project potential climate change impacts? If so, please name and provide references to these models.

Response: Yes, we have considerable confidence in our ability to predict regional changes in average temperature for example, in contrast to regional changes in precipitation, especially in areas that do not have strong responses to increases in greenhouse gas forcing. This is described in detail in the State of Knowledge report on Global Climate Change Impacts in the United States (2009)[2].

Global climate models, including world-leading models from NOAA scientists, remain the primary source of regional information for determining the range of possible future climates at continental to sub-continental scales. The science of climate modeling has matured through finer spatial resolution, the inclusion of a greater number of physical processes, and comparison to a rapidly expanding array of observations. These models have important strengths and limitations. Dynamic downscaling techniques are limited by high uncertainty in initial conditions for the models; these require a representative set of global model simulations and only a limited number of these studies are currently available due to the large computational capacity needed. Statistical downscaling, which can better utilize multimodel ensembles using less computational power, are completely dependent on the accuracy of regional circulation patterns produced by global models (see the recent Synthesis and Assessment Product 3.1 Climate Models: An Assessment of Strengths and Limitations, for a more detailed assessment of regional model downscaling techniques).

A clearer picture of regional impacts and a higher level of confidence would be attained by improving model resolution, incorporating processes important to regional climate into climate models, and an expanding set of simulations using a larger ensemble of different models. . In the recent Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4), NOAA and other U.S. government agencies used a climate model with ocean resolution of 100 km and atmospheric resolution of 200 km. Since then, U.S. government scientists have developed and are validating models with much finer resolution (e.g., 50 km resolution in the atmosphere and 10-25 km resolution in the

[2] Global Climate Change Impacts in the United States, A State of Knowledge Report by the United States Global Change Research Program, Cambridge University Press, 198pp.

ocean). However, replacing current models with these new, finer resolution models to produce comprehensive climate projections for reports such as the IPCC Fifth Assessment Report (due out in 2013) we estimate would require approximately a 100-fold increase in computer capacity. The American Recovery and Reinvestment Act provides $170 million to support climate modeling, including computing, and represents nearly a tripling of NOAA's climate computing over a five year period. This will permit NOAA to run a limited number of IPCC-relevant experiments with these high-resolution models and advance the development of operational climate prediction systems at regional scales. Additionally, NOAA has signed a Memorandum of Agreement (MOA) with DOE to collaboratively address High Performance Computing requirements, which we discuss in more detail below. The computational power provided by the MOA increases current computing capability by about 10 percent. This interagency approach to meeting the Nation's computing needs is highlighted in the 2004 Federal Plan for High-End Computing: Report of the High-End Computing Revitalization Task Force (http://www.nitrd.gov/pubs/2004_hecrtf/20040702_hecrtf.pdf)."

Question 4: Are we currently able to put together a global integrated picture of climate at a scale that is useful for policymakers?

Response: The answer to this question is not uniform, since it depends on the types of questions being asked by policymakers. We believe the current resolution of many climate models, which provide information about continental scale changes in extremes of temperature, drought, rainfall, and changes in sea level and arctic ice extent, is already adequate to address important policy issues. For others, particularly those at regional scales relevant to their constituents, policymakers have requested regional climate models with resolutions of 50 kilometers and finer to be most useful for informing additional policy decisions.

NOAA has signed a Memorandum of Agreement (MOA) with DOE to collaboratively address High Performance Computing requirements. This MOA would allow NOAA to use DOE computing for prototyping models for climate research and for transitioning these prototype models into operational use. Additionally, NOAA climate computing has been substantially enhanced with funds from the American Recovery and Reinvestment Act. Together, these new computational resources will support a limited set of climate change projections that will better resolve the climate at regional scales. Additional improvements to model resolution and the representation of smaller-scale processes active at these higher resolutions, along with greater computing resources, will be needed to have confidence in climate projections at *local* scales.

Question 5: Here is what the IPCC says about its emissions scenarios: "There is no single most likely, 'central,' or 'best-guess' scenario….None of the [IPCC] scenarios represents an estimate of a central tendency for all driving forces or emission, such as a mean or median, and none should be interpreted as such. The distribution of the scenarios…does not represent the likelihood of occurrence." (IPCC SRES, 2000). How does the IPCC derive climate impact forecasts from emission scenarios that it says cannot be used to make forecasts?

Response: In characterizing the future, the IPCC draws on literature that employs a variety of approaches and methods to estimate climate change impacts, adaptation and vulnerability. The scenarios

used by IPCC are based on well-considered plausible futures. None of which can be considered more likely than others. For example, the scenarios consider a wide range of possibilities for population growth, economic growth, technological development, improvements in energy efficiency, among others. None of the scenarios incorporate specific policy decisions related to curbing the growth of atmospheric greenhouse gases. .

The standard approach to assessment has been a climate scenario-driven 'impact approach' developed from the seven-step assessment framework of the IPCC. The seven steps are: (1) define problem; (2) select method; (3) test method/sensitivity; (4) select scenarios; (5) assess biophysical/socio-economic impacts; (6) assess autonomous adjustments; and (7) evaluate adaptation strategies. This approach aims to evaluate the likely impacts under a given scenario and to assess the need for adaptation and/or mitigation to reduce vulnerability to climate risks. The fact that the IPCC cannot state which scenario is most likely is reflected in the uncertainty projections provided by IPCC.

Question 6: Dr. James Hansen and former Vice President Al Gore both are on record saying the IPCC is wrong and sea levels may rise upwards of 20 feet by the end of the century; do you subscribe to this view? If so, why? If not, why not?

Response: The models used to project sea level rise reflect a fairly robust scientific understanding of the contributions of thermal expansion and glacier melting to sea level rise. The complex processes that determine past and potential contributions to sea level rise from changes in ice sheets, however, are less well understood. The scientific literature used in preparing the 2007 assessment by IPCC reflected the inability of the scientific community at the time to quantify the contributions to sea level rise due to changes in ice sheet dynamics, and thus projected rise in the world's oceans of between 8 inches and two feet by the end of this century. More recent research[3] has provided additional insights into the potential contributions to sea level rise from the accelerated flow of ice sheets to the sea and to estimate sea level based on the observed relationship between sea level and temperature. Estimates of sea level rise based on these new scientific insights exceed those of the IPCC with the average estimates for sea level rise under higher emission scenarios at between 3 and 4 feet.

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Meier, M.F., M.B. Dyurgerov, U.K. Rick, S. O'Neel, W.T. Pfeffer, R.S. Anderson, S.P. Anderson, and A.F. Glazovsky, 2007: Glaciers dominate eustatic sea-level rise in the 21st century. *Science*, 317(5841), 1064-1067.

Pfeffer, W.T., J.T. Harper, and S. O'Neel, 2008: Kinematic constraints on glacier contributions to 21st-century sea-level rise. *Science*, 321(5894), 1340-1343.

Rahmstorf, S., 2007: A semi-empirical approach to projecting future sea-level rise. *Science,* 315(5810), 368-370.