

**AN UPDATE ON THE SCIENCE OF GLOBAL
WARMING AND ITS IMPLICATIONS**

HEARING
BEFORE THE
**COMMITTEE ON ENVIRONMENT AND
PUBLIC WORKS**
UNITED STATES SENATE
ONE HUNDRED TENTH CONGRESS
SECOND SESSION

—————
JULY 22, 2008
—————

Printed for the use of the Committee on Environment and Public Works



Available via the World Wide Web: <http://www.access.gpo.gov/congress.senate>

—————
U.S. GOVERNMENT PUBLISHING OFFICE

88-902 PDF

WASHINGTON : 2015

For sale by the Superintendent of Documents, U.S. Government Publishing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512-1800; DC area (202) 512-1800
Fax: (202) 512-2104 Mail: Stop IDCC, Washington, DC 20402-0001

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

ONE HUNDRED TENTH CONGRESS
SECOND SESSION

BARBARA BOXER, California, *Chairman*

MAX BAUCUS, Montana	JAMES M. INHOFE, Oklahoma
JOSEPH I. LIEBERMAN, Connecticut	JOHN W. WARNER, Virginia
THOMAS R. CARPER, Delaware	GEORGE V. VOINOVICH, Ohio
HILLARY RODHAM CLINTON, New York	JOHNNY ISAKSON, Georgia
FRANK R. LAUTENBERG, New Jersey	DAVID VITTER, Louisiana
BENJAMIN L. CARDIN, Maryland	JOHN BARRASSO, Wyoming
BERNARD SANDERS, Vermont	LARRY E. CRAIG, Idaho
AMY KLOBUCHAR, Minnesota	LAMAR ALEXANDER, Tennessee
SHELDON WHITEHOUSE, Rhode Island	CHRISTOPHER S. BOND, Missouri

BETTINA POIRIER, *Majority Staff Director and Chief Counsel*
ANDREW WHEELER, *Minority Staff Director*

C O N T E N T S

Page

TUESDAY JULY 22, 2008

OPENING STATEMENTS

Boxer, Hon. Barbara, U.S. Senator from the State of California	1
Bond, Hon. Christopher S., U.S. Senator from the State of Missouri	3
Lautenberg, Hon. Frank R., U.S. Senator from the State of New Jersey	5
Cardin, Hon. Benjamin L., U.S. Senator from the State of Maryland	7
Klobuchar, Hon. Amy, U.S. Senator from the State of Minnesota	9
Inhofe, Hon. James M., U.S. Senator from the State of Oklahoma	85

WITNESSES

Burnett, Jason, Private Citizen, Former Associate Deputy Administrator, Environmental Protection Agency	10
Prepared statement	13
Responses to additional questions from Senator Cardin	27
Trenberth, Kevin E., Head, Climate Analysis Section, National Center For Atmospheric Research, Climate And Global Dynamics Division	30
Prepared statement	32
Response to an additional question from Senator Boxer	45
Response to additional questions from Senator Cardin	45
Spencer, Roy W., Principal Research Scientist, Earth System Science Center, University of Alabama, Huntsville	50
Prepared statement	52
Response to additional questions from Senator Cardin	59

AN UPDATE ON THE SCIENCE OF GLOBAL WARMING AND ITS IMPLICATIONS

TUESDAY JULY 22, 2008

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
Washington, DC.

U.S. Senate Tuesday, July 22, 2008 Committee on Environment and Public Works, Washington, DC.

The full committee met, pursuant to notice, at 10 a.m. in room 406, Dirksen Senate Office Building, Hon. Barbara Boxer (chairman of the full committee) presiding.

Present: Senators Boxer, Craig, Lautenberg, Cardin, Sanders, Klobuchar, Whitehouse, Bond.

OPENING STATEMENT OF HON. BARBARA BOXER, U.S. SENATOR FROM THE STATE OF CALIFORNIA

Senator BOXER. Good morning. Today's hearing will focus on global warming science and its implications. We are going to be backed up against an early vote around 11:15, 11:30, so we are going to move quickly. And I am going to limit the opening statements to whoever shows up before our witnesses start, then those who don't can put it in the record.

Today's hearing, again, is focusing on global warming science, its implications. The evidence has been overwhelming that global warming poses a serious threat to the American people, and that we must act now to prevent devastating consequences. In dozens of hearings and briefings in this Committee and this room, we have heard presentations from Nobel prize-winning scientists of the Intergovernmental Panel on Climate Change, the IPCC, we heard repeatedly that global warming endangers public health and welfare. We heard that from the Bush administration's own CDC.

The IPCC found that global warming is unequivocal, and that most of the recent warming is due to human activity. In North America, the IPCC warned of risks to public health, including increased frequency and duration of heat waves and heat-related illness and death; increased water-borne disease from degraded water quality; and increased respiratory disease, including asthma and other lung diseases from increased smog. Children and the elderly will be especially vulnerable to these impacts.

It is interesting, the recent document we received from the EPA basically said all that, right out there, and showed the enormous impact global warming will have all across our Country. In the U.S., there will be reduced snow pack in the western mountains, critically reducing access to water. There will be prolonged

droughts and insect invasions that will kill crops and damage forests, leaving them more susceptible to fire. I want to say to my colleagues, we are having a taste in California of fires that are caused by what they call dry lightning. At one point we had more than a thousand fires burning.

Coastal communities and habitats will be battered by intensified storms. Leading scientists every week sound the warning. Let's look at a few headlines over the last several weeks: "Warming West is Ground Zero for Wildfires;" "Wetlands Could Unleash Carbon Bombs;" "Climate Change May Muddy Better-than-Bottled New York Tap Water;" "Global Warming Depletes Great Lakes Even More."

We are fortunate to be joined today by an IPCC scientist who will share some of the latest information with us on the dangers posed by global warming. I would also like to place in the record a statement from Dr. Pachauri, chairman of the IPCC, whom I have met with and who graciously briefed colleagues on both sides of the aisle months ago.

[The referenced information was not received at time of print.]

Senator BOXER. Despite the scientific consensus, despite the danger, the Bush administration has failed to take any meaningful action. In fact, rather than addressing the problem, recent investigations by the press and congressional committees have documented an effort by the White House and the Office of the VP to cover up the threat posed by global warming. We know they have censored documents including CDC testimony, they have muzzled scientists. They have ignored unanimous recommendations from agency experts to act.

The Bush administration's actions threaten the health and welfare of the American people, but it is true that their lack of action benefits a narrow group of special interests. Nevertheless, we have the tools to begin to act now. The Supreme Court *Massachusetts v. EPA*, decided last April, made absolutely clear that our Clean Air Act applies to global warming emissions. Unfortunately, the Bush administration has defied the Supreme Court's ruling and has pushed off action. In our hearing today, we will hear more about how that happened.

Not only has the Bush administration itself failed to act, but they are blocking the actions of States like California, and as many as 19 other States that are waiting to follow suit. To me, it is one thing to say, I am in charge and we are not doing one thing about global warming, despite the laws, despite everything else. It is another thing to stop the States who want to play a role in solving this problem.

So I am committed to continuing to press for action at the earliest opportunity. We won't let up in this Committee. We cannot afford to. We have the opportunity to solve the problem, it lies in the Clean Air Act, it lies in legislation we should be able to agree to across parties. We are going to solve the problem, it is a question of when, and it is going to be soon. I look forward to hearing from the witnesses today.

With that, I will call on Senator Bond.

**OPENING STATEMENT OF HON. CHRISTOPHER S. BOND,
U.S. SENATOR FROM THE STATE OF MISSOURI**

Senator BOND. Thank you very much, Madam Chair. Thank you for holding this hearing today on regulating carbon dioxide.

I am sure we will be treated to many breathless statements, questions and answers about who said what and when regarding EPA's plans to regulate carbon dioxide. But while that is going on, I hope those who may be listening and those who are here will remember these remarks about what really is going on here. You might have thought that I would launch into a statement of condemnation about the naked political goals of this hearing. That certainly is the case.

But something even more important is at stake with this issue. It threatens every family, every worker, every farmer, and every driver in this Nation. Each of these groups are already suffering. Families are struggling with record high gas prices. This summer will bring high power bills to pay for air conditioning. We are hearing that families will pay high heating bills this winter. Workers are suffering as their good-paying manufacturing jobs are going overseas to countries with cheaper energy. Huge segments of the American economy are shutting down and going abroad. Fertilizers, plastics and chemical operations are all fleeing America's high prices for places like Asia and the Middle East.

I might add that they are going to countries with weaker environmental laws and will pollute more and certainly not control for carbon dioxide or energy efficiency. And I would share the goal with the Chair that we are going to reduce carbon. We are going to promote energy efficiency. We have a wide range of actions that we may take to get things done in a responsible manner.

But what is the real threat to the people of America? That threat is even higher energy prices and more lost jobs. On top of record gas prices, even higher prices for gas, on top of higher power bills, even higher prices for power, on top of lost manufacturing jobs, even more jobs lost.

Just last month, advocates attempted to push through Congress a plan to oppose a \$6.7 trillion, that is trillion with a T, \$6.7 trillion in high energy costs. Those energy costs resulting from a price on carbon would be passed on to American families and workers. Additionally, a carbon cap bill would increase gas prices by \$1.40 per gallon. That would be on top of our record high prices.

My constituents are already fed up with \$4.00 gasoline. There is no way I can convince them to pay \$5.50 or more a gallon for gasoline. There is no way that they should. Some have said it just went up too quickly. Well, I disagree: it just went up too high.

But that would be the unavoidable result of impossible carbon reduction targets set to levels and on time lines that technology cannot meet. Without provisions to control costs as well as carbon, the American people will face sky-high energy costs and lost jobs.

Now we have the advocates back. They could not impose their plans through the Senate floor. Today we will examine why they could not impose their plans through Federal regulation. The tools may be different, existing legislation instead of new legislation; command and control regulation instead of cap and trade. But no

doubt, the results would be the same, pain and suffering for the American people already suffering the pain of high energy prices.

And for those under new Clean Air Act carbon regulations, it would be a complete disaster. The Clean Air Act was never intended to regulate carbon dioxide. Congressman John Dingle wrote the Clean Air Act. He said he never intended it to cover carbon dioxide. It was a law rightfully intended to reduce pollution from major sources such as power plants, refineries and chemical plants. And I was a co-sponsor of the Bond-Byrd Acid Trading Compromise that helped pass the Clean Air Act.

But now, this law is being applied to suck in tens of thousands of small businesses, farms, commercial buildings, hospitals and schools. They would be forced to spend tens of thousands of dollars each to submit cumbersome and complicated air permits to the States and EPA, and that regulatory nightmare would be accompanied by a litigation nightmare as dozens of questions and legal issues will be litigated in the courts.

Now, that may be the agenda of some, but it is not my agenda. It is not the agenda of the people of Missouri. I am very glad that the Administrator had the good, adult judgment and the courage to stop, take a breath and ask what in the world we are getting ourselves into. We saw the Senate wanted no part of what we would get into; I am confident the American people feel the same.

Senator BOXER. This hearing is about not refighting the Global Warming Bill, the Boxer-Lieberman-Warner, but since you brought it up, I want to make a point. You misspoke on it, I am sure you believe what you said. But the fact is, the vast majority of the funds coming in, which would come from the cap and trade system, goes directly to consumers to make sure that they are helped during the energy transition. Then once we get the alternatives, which a lot of other funds are used for, to develop those alternatives, prices will actually go down and others.

So there is a large chunk of that \$6 trillion that goes to researching alternative energies and encouraging those. A lot of funds go to the States for that. And then the last traunch of big dollars goes to deficit reduction. My friend may have noticed that we have a real deficit problem.

So that is what our bill did. We 54 Senators expressed themselves, 48 on the floor of the Senate, 6 with letters to us saying they were for moving this bill forward. Today we are looking at the science.

The other point I want to make about gas prices is, I so agree with my friend on this. That is why our leader is bringing to the floor and anti-speculation bill. Because experts have told us that some people think that as high as 45 percent of the price for a barrel of oil has to do with people speculating in the futures market. I really look forward to taking that bill up. If our friends want to offer an amendment on drilling in moratoria of pristine coastal areas, we have a solution to that. We say to the oil companies, you have 68 million acres, use it or lose it. You have another 28 million acres available in the Alaska naval reserve, go for it. We believe we need a policy that is not driven by the oil companies but is driven by what is right.

And my friend says that Mr. Johnson has the courage, had the courage to say let's take a deep breath, he has been taking a deep breath for many years now on global warming. We are the last person at the party to understand this as an issue, whether you look at our allies around the world or you look at our States that are doing so much already.

Senator BOND. Madam Chair, may I respond?

Senator BOXER. Yes, you may.

Senator BOND. I thank the Chair. I am sorry I am not going to be able to continue this discussion. I would note that under the Warner-Lieberman bill, \$6.7 trillion would be taken away from workers in America, only \$900 million would come back in tax relief.

I would point out that speculation driving up the price is not just speculators on Wall Street. I saw last week that CalPERS, the California Public Employees Retirement System, had invested billions of dollars in the high future cost of energy. The reason they bet on energy going up, as long as we keep all of the land that potentially has oil and gas out of production and 97 percent of offshore, 94 percent of Federal lands are out of production, then that gas price will go up. So we will look forward to discussing this further.

Senator BOXER. Yes, and I totally, let the record show, those numbers make no sense at all to me. So we will get in the record our response to Senator Bond, and again, his misstatement of taking money away from America's workers. That is really extraordinary.

So we are going to go forward now and we are going to turn to Senator Lautenberg.

**OPENING STATEMENT OF HON. FRANK R. LAUTENBERG,
U.S. SENATOR FROM THE STATE OF NEW JERSEY**

Senator LAUTENBERG. Thank you, Madam Chairman, for the leadership on so many issues that we face here and your unwillingness to let casual dismissal of reality take place. I compliment you for that.

When we look at the world out in front of us, I have to tell you that while high prices for gas and the resultant services, heat and light, is drowning our society, to use the expression, the fact is that ahead of that concern is whether or not our children are able to grow up healthfully. That to me is the principal mission that we have here. Yes, we have to keep it in some kind of financial order, absolutely. And my heart breaks for those who are dependent on gasoline for commuting or for getting kids to school and mom to the doctors and so forth. It is awful, and we ought to take care of that. Energy has to be more available from renewable sources.

But if the first thing we start with is costs that are developed with a skew to them, that we become dissuaded from doing the best we can for the health of our families, then we are on terribly different wavelengths here. Floods have turned some of Iowa's fields and roads into rivers. Fire has turned California's mountains to black ash. And heat waves have killed tens of thousands of people in Europe. These disasters will only become more common as we feel the effects of global warming.

And as a result of global warming, drastic changes in our climate and the dramatic events that they cause are on the rise. Several weeks ago, EPA scientists mapped out the consequences of the threat posed by global warming. I point to it, it is a fairly concise, I think very dramatic presentation of what the effects are of global warming, distributed regionally. I note with interest that even a place like Texas, Oklahoma, Arkansas, Louisiana, will have degraded air quality, urban heat islands, wildfires, and it goes on. Heat waves, drought, tropical storms, extra rainfall with flooding, and wherever they have water boundaries, sea levels rising.

The chart spells out very clearly the increased risk to each region of our Country as a result of global warming. This is done by scientists at EPA. We are not talking about minor shifts in the weather. We are talking about heat waves. We are talking about drought, fire and flooding. Major threats to our Country and our world. Even with more storms and the possibility of more destruction, some of our colleagues are still arguing that global warming is a farce. And even among those who agree that global warming is a fact, some argue, we have heard it, that taking action is too expensive. These arguments are not acceptable in my family, and as a consequence, it is not acceptable in any family.

When we have bad air days, whatever the cause may be, my grandson is watched so carefully by my daughter. He is 14 years old. When he starts to wheeze, her knees start to shake. It happens more frequently all the time. And I want everybody's children to be free of that kind of threat.

These arguments are not acceptable. Fighting global warming is not a choice, it is a necessity. It is the single greatest environmental threat to our planet. And our children cannot afford a failure for us to act promptly, boldly and decisively. Yet the Bush administration has had 8 years to show the kind of leadership that takes that kind of action. And for 8 years, they have sat on their hands. The Administration denied 15 States, including my State of New Jersey, the right to cut greenhouse gases, wanted to preempt our rules and regulation, the right to cut greenhouse gas emissions from cars, trucks and buses.

Last year, the Supreme Court ruled that EPA must consider regulating greenhouse gas emissions to fight global warming. EPA was moving in the right direction to start the process of regulating these gases. But ExxonMobil and other big oil companies pushed back, and instead of siding with our children, the Bush administration chose to side with big oil, decided not to fight global warming.

Madam Chairman, I appreciate the fact that I have run over. It seems to be—OK. Wrapping up, I commend you for your leadership on this issue, so critical when we have a White House that undermines our efforts at every turn.

Senator BOXER. I usually am much more generous, but we do have a vote in there. So, Senator Craig, if everyone could stick to the 5-minutes, preferably 4 minutes and 30 seconds. Go ahead.

Senator CRAIG. Frank has used my five, I will yield, thank you.

Senator BOXER. All right. Senator Cardin.

**OPENING STATEMENT OF HON. BENJAMIN L. CARDIN,
U.S. SENATOR FROM THE STATE OF MARYLAND**

Senator CARDIN. Madam Chair, first let me comment very briefly on the exchange between you and Senator Bond. There is a lot of frustration, not only among the members of the U.S. Senate, but among the people of this Country.

And it is because of the failure of our Country to have an energy policy. We haven't had an energy policy. We have seen during this term of Congress the consequences. We saw that in the fact that we are not secure, we need to commit our military internationally because of the need for imported oil. We have seen that in regard to the large increase in the cost of energy, not only with the use of our automobiles and gasoline, but utility bills in our homes have caused extreme hardship due to the large increase in cost.

And we see it in our environment. And I thank you for having this hearing. I think we have a common answer to all three of the problems, and that is legislation that will get us off of oil and develop alternative fuels that are going to be friendly toward our environment and dealing with conservation in a way that we use energy more efficiently. All that will help us solve all three of the consequences of our current failure to have an energy policy.

So I thank you for holding this hearing so we can take a look at the continued evidence of the impact of global climate change. To me, it has been clear that it has affected not just our environment, and Madam Chair, you know of my interest in the ecosystems, like the Chesapeake Bay and the impact that global climate change is having on that national resource. On our human welfare, we see that with the rising sea level and the effect it is having on those near our waters, but also the impact of extreme weather, the impact on agriculture. And I could go on and on and on.

That is why I particularly appreciate this hearing, because we will be getting an update on the good scientific information which I think we need to base our decisions, on good science, on what will make sense. And yes, the Lieberman-Warner bill, which I am a proud co-sponsor of and believe it is an extremely important bill to get done, will allow us to take the necessary steps to deal with the consequences of global climate change and be an international leader. But we want to make sure we have good science information, good technical information.

One of the things that I would urge, Madam Chair, that as we go through this process, let's make sure we have a robust provision that will allow us to continue to get the best scientific information to be able to monitor our actions to make sure that we not only pass the best legislation on the science available, but that we have also the collection of information continuing to make sure we make the necessary adjustments, that we achieve the objectives we set out to do.

We all know about corn ethanol and the consequences of that decision, it was not exactly as we intended when we first went forward with that proposal. So I hope as part of the hearing process that we are going forward with that we will incorporate in legislation that we ultimately pass the type of support for the people that are witnesses today to be able to make available not only to us but

to the American people the information necessary to make sure we achieve the objectives that will be good not only for our environment but good for our economy and good for our national security.

Thank you, Madam Chair.

[The prepared statement of Senator Cardin follows:]

STATEMENT OF HON. BENJAMIN L. CARDIN, U.S. SENATOR
FROM THE STATE OF MARYLAND

Madame Chairman, thank you.

Over the last year we have heard testimony from a number of individuals on the State of the global climate system, the projections on how the climate system is changing, and the likely impacts these changes will have on health and human welfare, agriculture, transportation systems, and important ecosystems like the Chesapeake Bay. Much of the testimony has been informed by the latest, peer-reviewed science and represents a consensus of the scientific community on the nature of the climate system's warming, the causes for that warming, and the degree to which this warming will continue.

We know that a significant contribution to climate change comes from our burning carbon-based fuels. We also know that climate change is not only manifest as an increase in the globally averaged temperature, but that climate change will likely be manifest by increasing variability in weather and will be experienced as non-uniform changes around the globe. Some areas will warm more rapidly than others, some will be wetter, others considerably drier. The projected increase in the risk of significant rains over a short period of time means that flooding risks will also increase. In Baltimore, the EPA projects that a three degree Fahrenheit overall air temperature increase in air temperature could increase the heat-related death toll by 50 percent from 85 to 130 people annually.

Climate change will likely have an impact on our Nation's treasure, the Chesapeake Bay. Possible impacts for the Chesapeake include increased sea-levels, lower dissolved oxygen levels, more precipitation, and changes in various species' abundance and migration patterns. Many species will deal with the interaction of several climate change effects, which could impact their ability to survive in the Bay region.

It is not only wildlife that are threatened by climate change—the EPA has found that increasing greenhouse gas concentrations poses a threat to human health due to a number of factors including more deaths attributed to heat and the increase in vector-borne diseases.

The research upon which these findings are based is rooted in an extensive, careful analysis of past and present observations of the atmosphere and ocean coupled with advanced numerical predictive models. As we will see today, there are some uncertainties in climate projections, however scientists are continually decreasing these uncertainties as more observational data is analyzed and the numerical models the scientists use are improved. What is important, is that we recognize the magnitude of these uncertainties and determine whether these uncertainties are relevant to our understanding of climate change impacts. Enhanced monitoring and analysis of climate data will help with this effort.

Unfortunately, over the last several years, there has been a degradation of our Nation's climate monitoring capabilities.

There have been funding cuts in NASA's and NOAA's capabilities to monitor the Earth's climate system—particularly satellite platforms. Our historical record of climate data at fixed locations is gradually being eroded as budget constraints force the re-sighting or elimination of observational platforms.

A suite of observations ranging from surface-based measurements to satellites are required to assess the State of Earth's climate systems so that we cannot only reduce uncertainties in our climate projections, but also enhance our abilities to better understand what will be necessary to mitigate and adapt to changing conditions.

These observations are not only vital to our understanding of climatic changes decades out, but are also important for much shorter-term needs including daily weather prediction and the associated issuance of timely warnings to protect lives and property. As I noted earlier, climate scientists project that climate changes will be potentially associated with increasing variability in weather, including perhaps more high-impact weather events like stronger hurricanes and heat waves. An enhanced global environmental monitoring system is essential for us to provide the information necessary for emergency managers and longer-term decisionmakers to deal with the impacts of these phenomena.

For these reasons, last month I filed an amendment to S. 3036 that used the proceeds of auctioned allowances to fund climate science monitoring, research, and op-

erations. The amendment provided funds to upgrade and maintain an effective observing system to monitor the State of the global climate including the atmosphere and oceans. Additionally, funding was made available to ensure that the data provided from these observations is put to greatest use in operational weather and climate prediction.

I look forward to hearing from all of today's witnesses and learning more about the latest climate science research results and what these results suggest about the actions our government should be taking to confront this important issue.

Thank you to Madame Chairman.

Senator BOXER. Thank you, Senator.

Senator KLOBUCHAR.

**OPENING STATEMENT OF HON. AMY KLOBUCHAR,
U.S. SENATOR FROM THE STATE OF MINNESOTA**

Senator KLOBUCHAR. Thank you very much, Madam Chair, for holding this important hearing, and to our witnesses for being here.

I started my day yesterday with a 14-year old girl from Minneapolis named Liza who rode her bike 1,500 miles across the Country with a group of petitions signed by 1,200 kids from across the Country asking for more research and technology and encouragement of fuel-efficient vehicles, specifically electric and hybrid cars. She came up with this idea in April, got a bike, she got her family to follow behind her in a car, and she did this all by herself. It made me think once again how about a lot of times the kids are leading the way on this and trying to push some of the people here in Washington to get something done.

I can tell you that in our State of Minnesota we believe in science. I have often told my fellow Committee members here that we brought the world everything from the pacemaker to the post-it note. We are the home of the Mayo Clinic. That is why, Dr. Trenberth, I am specifically interested in some of your testimony about the science, about the heavy rainfalls and what some of the warming, the increased levels of warm, moist air coming out of the Gulf of Mexico are doing to the environment.

I have been surprised, not at just kids on bicycles, but at the number of adults that have brought up the issue of climate change to me after we had the flooding in southern Minnesota and in Iowa, we have had an increase in tornadoes. Again, they know that it may not just be due to climate change, or it may not be because of climate change. But they want to know the facts. And it is starting to get into their heads that this may have something to do with what is going on, storms that maybe were once every 500 years suddenly seem that they are happening 2 years in a row.

The second reason I am so interested in this is just as a former prosecutor, I have always believed in evidence. And it appears that the Administration, Mr. Burnett, has been living in an evidence-free zone. I have just been interested in following the stories about your e-mails and how they have been somehow contained, about the lengths that have been taken by the Administration to squash any kind of an endangerment finding.

It seems to me that what keeps happening is that when they don't like the answer, they try to squash the science. We had this happen when the head of the Centers for Disease Control testified, and her testimony seemed rather limited and stilted. Then it turned out a whistleblower came out and gave us the right testi-

mony, and here it had been redacted. One of the most interesting facts and one of the things redacted was that climate change, while it wouldn't cause wildfires, could lead to increased and more vociferous wildfires on the Pacific Coast. And the same week it was redacted was when the wildfires were raging in California a year ago, and of course, we have had that happen again.

But it just seems like time and time again, in closing, what we have heard of what happened with you, Mr. Burnett, they don't like the answer, so they squash the science. They don't like the answer about the wildfires, they squash the testimony. They don't like the answer about what is in your e-mails, they squash the e-mails. I think the American people and that little 14-year old girl are really owed an answer here, and that is what I hope we will hear from this hearing.

Thank you very much, Madam Chair.

Senator BOXER. Thank you, Senator Klobuchar.

Senator WHITEHOUSE.

Senator WHITEHOUSE. Well, I can't top Liza, and I would like to get to the witnesses, so I will withhold any opening statement.

Senator BOXER. Thank you.

Senator LAUTENBERG. Madam Chairman, I want the record to reflect that the time that I took, 55 seconds, it was nice of Larry to sacrifice all of his time.

Senator CRAIG. Thank you, Frank.

[Laughter.]

Senator BOXER. Let me say this. Because this is an oversight investigation, where we will be doing fact-finding, we will be swearing in all of our witnesses today. Therefore, please stand, raise your right hand and take the following oath.

Do you solemnly swear that the testimony you are about to give will be the truth, the whole truth and nothing but the truth, so help you, God?

[Witnesses respond in the affirmative.]

Senator BOXER. Let the record reflect that everyone said, I do.

We will begin with Mr. Burnett. We are going to try to hold you to 5 minutes, because I know there are many, many questions. Let me introduce to everybody who we have here.

Jason Burnett, private citizen, former Associate Deputy Administrator, U.S. Environmental Protection Agency. We have then Dr. Kevin E. Trenberth, head of the Climate Analysis Section, National Center for Atmospheric Research, Climate and Global Dynamics Division; and Dr. Roy Spencer, Principal Research Scientist, Earth Systems Science Center, University of Alabama in Huntsville.

We will begin with you, Mr. Burnett.

STATEMENT OF JASON BURNETT, PRIVATE CITIZEN, FORMER ASSOCIATE DEPUTY ADMINISTRATOR, ENVIRONMENTAL PROTECTION AGENCY

Mr. BURNETT. Madam Chairman, Senator Craig, members of the Committee, thank you for the opportunity to testify on the science of climate change and its implications. My name is Jason Burnett, I recently resigned my position as Associate Deputy Administrator of the Environmental Protection Agency, where I helped lead the

effort to respond to the Massachusetts v. EPA Supreme Court decision and to help design the resulting greenhouse gas regulations.

I am appearing before this Committee as a private citizen and my opinions for how the Country should respond to climate change are mine alone. The scientific information I present, however, is not my opinion. It is the conclusion of peer-reviewed reports produced or endorsed by the U.S. Government. As the saying goes, you are entitled to your own opinion, but not your own facts.

A central point I would like to make this morning: we can and must do a better job of differentiating between the facts of a problem and the opinions about how to address the problem.

The first question in the climate debate is primarily in the realm of science: what is the nature and extent of the problem. The U.S. Government relies on a wealth of information produced by thousands of scientists resulting in reports by dozens of Government authors and reviewers. The second question is primarily one of policy judgment: what should be done to address the problem, given the scientific assessment. Ultimately, this is the charge of our elected officials and the people they appoint to administer our laws.

Both the process of scientific inquiry and the policy process have uncertainties and legitimate differences of opinion. But we should not allow the desire for a particular policy outcome to cloud our assessment or presentation of the problem at hand. In this regard, I feel I made a key contribution in the climate change debate in helping the Government draw a clear line between science and policy. As recent news reports have suggested, this assignment was not always easy in this Administration.

What we should expect from our Government is a fair and honest presentation of the facts, and then have a public debate about what solutions to offer, given those facts. Allow me to set the stage. The April 2d, 2007 Massachusetts v. EPA Supreme Court decision fundamentally, profoundly and permanently changed the regulatory landscape by finding that greenhouse gases are air pollutants within the Clean Air Act. Under that decision, EPA must determine if greenhouse gases endanger the public. And if so, EPA must regulate emissions from cars and trucks if those emissions contribute to the problem. The law is straightforward. If the public is endangered, the Government must act.

In June 2007, EPA Administrator Steve Johnson asked if I would return to the agency to help him lead the effort to respond to the Supreme Court decision and develop the first Federal greenhouse gas regulations. Having left EPA less than a year before caused me to be cautious and view with skepticism any suggestion that the Administration had decided to take regulatory action. However, it was a unique opportunity to help with a profound policy challenge. I accepted the invitation.

The initial matter before EPA was how to make an endangerment finding. Working with other expert agencies across the Government, EPA produced a science assessment to inform that finding. These are among the key conclusions of that assessment. Climate warming may increase the possibility of large, abrupt and unwelcome regional or global climactic events such as the disintegration of the Greenland ice sheet or collapse of the west Antarctic ice sheet. Severe heat waves are projected to intensify in

magnitude and duration over portions of the U.S. where these events already occur, with likely increases in mortality and morbidity, especially among the elderly, the young and the frail.

To be balanced, I will add that climate change is also projected to bring some benefits, such as fewer deaths from cold exposure. To my knowledge, EPA successfully defended any efforts to delete sections of this assessment, which was made public as a sixth order draft earlier this month.

The science is clear on this point. The U.S. will experience serious human health and Environmental consequences from climate change. The science assessment provided the support for answering the Supreme Court and making it an endangerment finding. Given the profound consequences of such a finding, we worked to ensure that we had agreement across the Federal Government.

Senator BOXER. I will give you, and each of you, two more minutes.

Go ahead.

Mr. BURNETT. Thank you, Senator.

Policy process culminated in a Cabinet level meeting in November 2007, where agreement was reached that greenhouse gases did endanger the public and therefore, require regulation. The Administration also accepted that a finding of endangerment would have deep consequences and the initial decisions for how to apply the Clean Air Act would set the stage for years to come.

Lacking a desire to implement the existing law, the Administration left the important decisions about how best to move forward to the next Administration and the next Congress. In the end, the only way to avoid making a positive endangerment finding was to avoid making any finding at all. That is what this Administration has decided to do. Intent on not using the Clean Air Act, the White House could only find a way to delay its use.

That should signal everyone that it is simply a matter of time before a positive endangerment finding is made, and regulation under the Clean Air Act is triggered. That is, unless Congress passes a new, better law.

In closing, I think that we are at the end of the debate about whether greenhouse gases endanger the public. They clearly do so. I look forward to the next phase of the debate about how we should respond. There are no easy answers, and a serious response will require hard work, compromise and sacrifice.

Thank you for the opportunity to testify, and I ask that my written testimony be submitted for the record. I will be happy to answer any questions. Thank you.

[The prepared statement of Mr. Burnett follows:]

Testimony of

Jason Burnett

Private Citizen

**Former Associate Deputy Administrator,
Environmental Protection Agency**

Before the

Committee on Environment and Public Works

U.S. Senate

Hearing:

**“An Update on the Science of Global Warming and its
Implications”**

July 22, 2008

Testimony of

**Jason Burnett
Private Citizen**

Former Associate Deputy Administrator, Environmental Protection Agency

Before the

**Committee on Environment and Public Works
U.S. Senate**

July 22, 2008

Thank you for the opportunity to testify before this committee on the science of climate change and its implications. I will briefly summarize the peer-reviewed, synthesis scientific reports produced or endorsed by the US government and then will focus my remarks on why this body of science compels action under current law. In particular, the Supreme Court's interpretation of the Clean Air Act, combined with the science of climate change, will require regulations of greenhouse gases for a range of mobile and stationary sources. However any action should be tempered by the recognition that regulation of greenhouse gases under the current Clean Air Act poses unnecessary challenges because the law was not specifically designed for greenhouse gas regulation. Congress can and should design and pass new legislation that simultaneously addresses the challenges of the current law and sets in place a more comprehensive, equitable, and efficient national program.

Background:

I worked at the Environmental Protection Agency (EPA) in two positions. In 2004 I came to EPA to work in the Office of Air and Radiation as a senior advisor to the Assistant Administrator. In that position I helped develop a suite of regulations to

reduce air pollution. I also worked closely with Administrator Johnson in EPA's review of the air quality standards for fine particles, commonly called "soot." Fine particles are the most deadly type of air pollution in the US, killing tens of thousands of Americans every year. A tighter standard would have reduced this toll and done so cost-effectively. I left EPA in the fall of 2006 after the decision to not provide increased protection from fine particles through a tighter annual standard. I also wanted to work on climate change policy and thought the most productive work would be done outside EPA.

One event many observers did not foresee was the April 2nd, 2007 Supreme Court decision in *Massachusetts v EPA*. In that decision, the Supreme Court fundamentally, profoundly and permanently changed the regulatory landscape by finding that "greenhouse gases fit well within the Clean Air Act's capacious definition of 'air pollutant.'" According to the Court's logic, greenhouse gases from vehicles must be regulated if they meet the two-part endangerment test provided by the Clean Air Act. The first part of that test requires the Administrator to judge whether the air pollution in question "may reasonably be anticipated to endanger public health or welfare." The second part of the test requires the Administrator to judge whether "the emission of any air pollutant" is found to "cause, or contribute to" the air pollution problem. If so, "[t]he Administrator shall by regulation prescribe ... standards applicable" to those emissions. The basic logic of the law is straightforward; if the public is endangered, the government must act.

Administrator Johnson asked if I would return to EPA to help him lead the effort to respond to the Supreme Court decision and develop the first federal greenhouse gas regulations. Having just left EPA less than a year before caused me to be cautious and view with skepticism any suggestion that the Administration had decided to take regulatory action designed to reduce greenhouse gases. However there were two things that caused me to believe action would be taken. First, President Bush made an announcement on May 14, 2007 directing EPA and others to “take the first steps towards regulations that would cut gasoline consumption and greenhouse gas emissions from motor vehicles...” The President’s announcement seemed to indicate that the policy direction had been settled. Second, in conversations with EPA Administrator Johnson and others familiar with the internal process I came to believe that this Administration would want to lay down its mark on how the Clean Air Act should and should not be used.

I therefore accepted the invitation to return to EPA as Associate Deputy Administrator with the charge of coordinating energy and climate change policy and helping to lead the effort to respond to the Supreme Court.

Climate Change Science

The initial matter before EPA was how to make the endangerment finding, and what body of scientific information would be used to support the finding. The scientific information is presented in the recently released “Technical Support Document for Endangerment Analysis for Greenhouse Gas Emissions under the Clean Air Act, Sixth Order Draft” (Endangerment TSD) dated June 21, 2008. EPA developed this

Endangerment TSD by relying primarily on existing peer-reviewed synthesis reports with a focus on the Intergovernmental Panel on Climate Change (IPCC), US Climate Change Science Program (CCSP), and National Research Council of the US National Academy of Sciences (NRC) reports. As stated in the Endangerment TSD (page 4):

EPA is relying most heavily on these synthesis reports because they 1) are very recent and represent the current state of knowledge on climate change science, vulnerabilities and potential impacts; 2) have assessed numerous individual studies in order to draw general conclusions about the state of science; 3) have been reviewed and formally accepted by, commissioned by, or in some cases authored by, US government agencies and individual government scientists and provide EPA with assurances that this material has been well vetted by both the climate change research community and by the U.S. government; and 4) in many cases, they reflect and convey the consensus conclusions of expert authors.

Since it was natural to interpret endangerment to *public* health or welfare as most clearly applying to the American public, the Endangerment TSD synthesized the impacts, vulnerabilities and risks within the US or impacts abroad that will indirectly affect the US such as threats to national security.

The authors of the Endangerment TSD summarized not just the central estimates of impacts but also the possibility that climate change will be more benign or more catastrophic than those central estimates. The motivation for doing so was that if

climate change is more catastrophic than there would be huge benefits of addressing that possibility and we would be glad we began putting in place “insurance policies.” Our public institutions, EPA included, are reasonably good at dealing with risks of high probability events with known societal impact. We have a reasonably good understanding of the societal risks posed by future levels of smog and soot since we have decades of experience with air pollution higher than today’s levels. But climate change is different than most other risks that EPA regulates for the simple reason that, unlike air pollution problems such as smog and soot, we do not have historical experience with climate change of the magnitude we will likely experience this century. The risk is unbounded because the possible extent of climate change is unbounded; it is more likely we will experience a 2 degree Celsius increase in mean temperature than a 10 or 20 degree Celsius increase but we are not able to rule out the possibility of higher temperature changes leading to more catastrophic climate change.

The Endangerment TSD discusses these possibilities. For example, the report states that “[r]isk increases with increases in both the rate and magnitude of climate change. Climate warming may increase the possibility of large, abrupt, and unwelcome regional or global climatic events (e.g., disintegration of the Greenland Ice Sheet or collapse of the West Antarctic Ice Sheet). The majority of the impacts literature assesses the effects of warming for climate sensitivities within the most likely range, not at the tails of the distribution. Consideration of outlier information is crucial for risk- management analysis even if potential impacts are of low probability or low confidence. The abrupt climate changes of the past are not fully

explained yet, and climate models typically underestimate the size, speed, and extent of those changes. Hence, future abrupt changes cannot be predicted with confidence. Environmental changes that are more extreme or persistent than society's experience with natural climatic variability can lead to vulnerabilities, especially if the changes are not foreseen and/or if capacities for adaptation are limited." (Endangerment TSD at ES-3)

Of course change is not all bad; we expect a number of benefits of a warmer, wetter climate. The Endangerment TSD identifies eight sectors in the US that are impacted by climate change ranging from health and air quality to forestry, ecosystems and wildlife. For each sector, the report identifies any positive, negative and uncertain impacts. For example, the report states that "[s]evere heat waves are projected to intensify in magnitude and duration over the portions of the U.S. where these events already occur, with likely increases in mortality and morbidity, especially among the elderly, young and frail. Climate change is projected to bring some benefits, such as fewer deaths from cold exposure. Ranges of vector-borne and tick-borne diseases in North America may expand but with modulation by public health measures and other factors." (Endangerment TSD at ES-3)

Of particular concern is the likely increase in extreme weather events and the consequences of a less predictable climatic system. Individuals, businesses and our communities benefit from our ability to plan for the future. By making our future less certain, climate change impedes that ability. For example the Endangerment TSD states that "[i]ntensity of precipitation events is projected to increase in the U.S.

and other regions of the world, increasing the risk of flooding, greater runoff and erosion, and thus the potential for adverse water quality effects. Increases in the amount of precipitation are very likely in higher latitudes, while decreases are likely in most subtropical, more southern regions, continuing observed patterns in recent trends in observations. The mid-continental area is expected to experience drying during summer, indicating a greater risk of drought. It is likely that hurricanes will become more intense, with stronger peak winds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures.”

(Endangerment TSD at ES-2)

Throughout the process of developing and reviewing the Endangerment TSD, EPA received and incorporated literally hundreds of comments. This is a healthy part of the review process and ensured that the document reflected the best information available. For example, the Office of Management and Budget was interested in how adaptation may affect the nature and extent of impacts. This led to the development of a section providing a “preliminary review of the state of knowledge pertaining to adaptation” (Endangerment TSD at 118). In other examples, theories were advanced that did not have scientific support and they were rejected or dismissed. To my knowledge, EPA successfully defended any efforts to delete sections of the Endangerment TSD and the full Sixth Order Draft was made public earlier this month.

Public Endangerment

The science contained in the Endangerment TSD provided the support for answering the Supreme Court and making an endangerment finding but the Endangerment TSD itself or, for that matter, any amount of science does not substitute for the judgment of the Administrator as required by the Clean Air Act. Given the profound consequences of making an endangerment finding we worked to ensure we had agreement across the federal government. The policy process culminated in a cabinet-level meeting in November 2007 where agreement was reached that greenhouse gases endangered the public and therefore that regulation was required.

This conclusion was reached despite various efforts made over the past year to develop theories for how another answer could be reached. For example, some advanced the idea that EPA could only consider in an endangerment analysis impacts that could be quantified or monetized, ruling out consideration, for example, of “non-market damages, the effects of climate variability, risks of potential extreme weather (e.g., droughts, heavy rains and wind), socially contingent effects (such as violent conflict), and potential long-term catastrophic events.” (Technical Support Document on Benefits of Reducing GHG Emissions, U.S. Environmental Protection Agency, June 12, 2008 at 15). Others advanced the idea that the endangerment test was limited to current impacts and could not consider the future projected and likely more serious impacts.

After the passage of the Energy Independence and Security Act of 2007 (EISA) other theories came forward. One theory was that motor vehicles no longer “contributed”

greenhouse gases to the atmosphere because of the increased fuel economy required by EISA. Another theory was that EISA could be used to argue that the Supreme Court decision no longer applied. Despite these various theories, the Administration recognized that the only supportable answer to the Supreme Court was to find that greenhouse gases endanger the public. They also recognized that a finding of endangerment would have profound consequences and the initial decisions for how to apply the Clean Air Act would set the stage for years to come.

On April 16, 2008 President Bush called on Congress to pass new legislation and to amend the Clean Air Act so that it did not need to be used to regulate greenhouse gases. This strategy of calling for a legislative “fix” to the Supreme Court decision had been tried just four months earlier as Congress was debating EISA. The legislative strategy did not work when coupled with EISA and it was even less likely to work coupled with comprehensive climate change legislation that does not have serious prospects this year. Without a realistic legislative strategy for amending the Clean Air Act or a regulatory strategy to deal with the profound consequences of an endangerment finding, the Administration just left the important decisions about how to best move forward to the next Administration and the next Congress.

In the end, the only way to avoid making a positive endangerment finding was to avoid making any finding at all and that is what this Administration has decided to do. By issuing the Advanced Notice of Proposed Rulemaking, they have left the next Administration with the challenge of actually responding to the Supreme Court. The fact that an Administration intent on not using the Clean Air Act could only find a

way to delay its use should signal to everyone that it is only a matter of time before a positive endangerment finding is made and regulation under the Clean Air Act is triggered.

Regulation under the Clean Air Act

The most direct regulatory consequence of issuing a positive endangerment finding for greenhouse gas emissions from motor vehicles is that the “Administrator shall by regulation prescribe ... standards applicable” to those emissions.

Carbon dioxide is the primary greenhouse gas from motor vehicles and most but certainly not all of the greenhouse gas reductions would come from reducing carbon dioxide emissions. The only real way to reduce carbon dioxide emissions is to reduce the amount of carbon being put in the gas tank; greenhouse gas regulations for cars and trucks would force manufacturers to build and sell vehicles with higher fuel economy. The EISA already stipulates that the Department of Transportation (DOT) set mileage standards to require higher fuel economy “[b]ut that DOT sets mileage standards in no way licenses EPA to shirk its environmental responsibilities,” to quote the Supreme Court. Reducing the risk of climate change is a different but similar societal challenge than improving our energy security.

Climate change is a long-term issue resulting from the accumulation of greenhouse gases over many decades. Mirroring the timeframe of the environmental concern, EPA regulations designed to reduce greenhouse gases could also be phased in over the course of many years. In this way EPA regulations could provide more lead-time for manufacturers to design and phase in new vehicle models than the shorter 5-

year time horizon that DOT uses in its fuel economy regulations. The flexibility of the mobile source sections of the Clean Air Act can also be used to design more efficient regulations, saving both money and leading to greater fuel savings. The analysis performed over the past year provides strong evidence that EPA greenhouse gas regulations for cars and trucks could lead to much higher fuel economy and enable Americans to save a substantial amount of money at the gas pump than DOT's proposed fuel economy rule. Moving forward with Clean Air Act regulation of motor vehicles would reduce greenhouse gases, improve energy security, and make Americans better off in large part by reducing the amount they spend on gasoline. Although the effect would be modest, the price of oil would also likely decline as demand was reduced.

The Clean Air Act is structured such that one regulation often triggers additional regulation. When EPA starts regulating greenhouse gases from cars and trucks, the law requires that the best available greenhouse gas control technology be used on a variety of other new sources such as oil refineries, power plants, and many smaller sources. While the prospect of requiring the best technology for new sources may sound reasonable and could be administered in a way that would phase in over time, it is not without its challenges. For example, it is not clear to what degree, if at all, regulation of greenhouse gases should differentiate between new sources and existing sources. New sources are generally more efficient than existing sources simply because they use new, better technology. A sensible program may actually want to encourage these new, more efficient sources relative to older sources. If a regulatory program for new sources is not carefully designed it could counter-

productively retard the turnover of capital and actually extend the economic life of the existing, less efficient sources.

Another concern with the Clean Air Act is that it may eventually require very small sources to obtain an air permit and install the best available control technology for greenhouse gases. EPA's recently released Advanced Notice of Proposed Rulemaking offers several options for mitigating this concern but there is no question that this section of the Clean Air Act demonstrates that Congress did not design the act specifically for greenhouse gases.

New Legislation

Unlike the Clean Air Act, new legislation could be specifically designed for the challenges of greenhouse gas regulation. For example, new legislation can more clearly define what types and sizes of sources are subject to regulation. New legislation can also more explicitly provide authority for comprehensive, economy-wide, flexible programs that allow the market, not government, to determine how best to achieve reductions in emissions. Perhaps most importantly, Congress can design a program that discourages greenhouse gas emissions through either a cap and trade system or a carbon tax. Under either approach, Congress would need to decide how best to use the value of carbon allowances or the tax revenue and could significantly improve the efficiency of any such program by using the revenues to reduce payroll or capital gains taxes. This tax shift would discourage things we don't want--like greenhouse gas emissions--while promoting things we do want--like work and investment.

In closing, I think that we are at the end of the debate about whether greenhouse gases endanger the public. They clearly do. I look forward to the next phase in the debate about how government should respond. There are no easy answers and a serious response will require hard work, compromise and sacrifice. But we are better off confronting the challenge now rather than allowing it to grow.

Question 1 from Senator Cardin:

In your testimony, you refer to "a cabinet-level meeting in November 2007 where agreement was reached that greenhouse gases endangered the public and therefore that regulation was required." Did you participate in this meeting? Do you know which cabinet members did? Who were they?

Answer:

As part of the team at EPA working on a response to the *Massachusetts v EPA* Supreme Court decision I participated in a number of interagency meetings leading up to and immediately following the cabinet-level meeting in November 2007. I prepared Administrator Johnson for the cabinet-level meeting but did not attend the meeting myself.

The agencies, departments and offices generally represented at the many interagency meetings held to develop a response to the Supreme Court decision include the Department of Energy, the Department of Transportation, the Department of Agriculture, the Department of the Treasury, the Office of Management and Budget, Council of Economic Advisers, the Office of the Vice President, the Council on Environmental Quality, and others in the Executive Office of the President. However, as I did not attend cabinet-level meeting, I do not know the full attendee list.

Question 2 from Senator Cardin:

While the science clearly indicates that the global climate is warming, there are uncertainties which remain on the extent to the degree of warming and the geographic distribution of climate change. Could you explain how these uncertainties in climate projections were considered when preparing the endangerment finding?

Answer:

The Clean Air Act requires the Administrator to determine, in his "judgment," whether air pollution "may reasonably be anticipated to endanger public health or welfare." EPA considered this statutory language, the legislative history of the development of this language, and past EPA practice for interpreting this language as we prepared the endangerment finding for greenhouse gases. It is the nature of scientific inquiry, especially for something as complicated as climate change, that some level of uncertainty will always remain. The statutory language reflects Congress's recognition of this part of the scientific process and its desire that EPA consider and incorporate uncertainty rather than perpetually pointing to ever diminishing uncertainty as a justification for inaction.

The Clean Air Act addresses uncertainty in three basic ways. First, the endangerment test of section 202 is an "or" test meaning that regulation required if either public health or welfare is endangered. It is not necessary to find that both

public health and welfare are endangered. The Administrator provisionally concluded that public welfare was endangered and declined to form a judgment regarding public health.

Second, the phrase “reasonably be anticipated” allows for the Administrator to consider events or effects that are projected to occur in the future, even if they are not occurring today and even if it is not certain they will occur. This reflects Congress’s desire that EPA have the authority and obligation to work to prevent public endangerment before it occurs rather than waiting until after the public is harmed before taking action. Such a statutory construct is especially important for climate change given that most greenhouse gases have long residence times in the atmosphere and therefore will continue contributing to climate change for decades. The Administrator considered both current observed climate change and future projected climate change in forming his provisional conclusion.

Third, the statute requires the Administrator to form a “judgment.” This recognizes the general lack of bright lines in making a finding including what level of scientific certainty or uncertainty is allowed by the phrase “reasonably be anticipated” and what level of risk or harm is meant by endangerment to public health or welfare.

EPA considered this statutory language along with the scientific information on climate change. The basic scientific information that the Administrator used in forming his provisional judgment of public endangerment is presented in the “Technical Support Document for Endangerment Analysis for Greenhouse Gas Emissions under the Clean Air Act, 6th Order Draft, June 21st, 2008” (Endangerment TSD). As the Endangerment TSD makes clear, scientific uncertainties remain for a number of issues including the two referenced in your question.

The first scientific uncertainty you identify is the degree of warming. The projected warming depends on the projected emissions growth, represented by various scenarios such as B1 (low emissions growth) and A2 (high emissions growth), and the amount of warming caused by any level of emissions, called climate sensitivity. The Endangerment TSD concludes that “[b]y the end of the century, projected average global warming (compared to average temperature around 1990) varies significantly by emissions scenario, ranging from 1.8 to 4.0°C (3.2 to 7.2°F), with an uncertainty range of 1.1 to 6.4°C (2.0 to 11.5°F), according to the Intergovernmental Panel on Climate Change (IPCC).” When considering scientific uncertainty regarding the degree of warming, it is important to consider both the scenario that warming will be less than the central estimates and the scenario that warming will be more than the central estimates. In the case of climate change for which we do not have extensive historical experience, we cannot rule out the possibility that warming and therefore the damage will be far greater than the central estimates. This is one example of where scientific uncertainty should cause greater concern and swifter action. EPA’s consideration of this scientific uncertainty contributed to the case that the public was endangered.

The second scientific uncertainty you identify is the geographic distribution of climate change. The climate models used by the IPCC can be used to project regional changes in precipitation and temperature although with less certainty than for the global averages. The Endangerment TSD concludes that “[a]ll of the U.S. is very likely to warm during this century, and most areas of the U.S. are expected to warm by more than the global average.” Further refinement of these regional models will assist in planning adaptation efforts but was not necessary for making an endangerment finding because EPA did not need to determine precisely what parts of the country are most endangered by climate change to find that the public is endangered.

Senator BOXER. Thank you very much, Mr. Burnett.
Dr. Trenberth, you will be given 7 minutes. Go ahead.

STATEMENT OF KEVIN E. TRENBERTH, HEAD, CLIMATE ANALYSIS SECTION, NATIONAL CENTER FOR ATMOSPHERIC RESEARCH, CLIMATE AND GLOBAL DYNAMICS DIVISION

Dr. TRENBERTH. Good morning, Madam Chair, distinguished members of the Committee.

I am pleased to appear before you today to provide an update on climate change. My name is Kevin Trenberth. I was the coordinating lead author of Chapter 3 of the Fourth Assessment Report of the IPCC, the same body that received the Nobel Peace Prize in 2007 with Al Gore.

I am happy to answer any questions you have about the IPCC, but I will simply note that it is a very open and thorough process, and it is inherently conservative in its findings because of the nature of the process. My main message today is that climate change from human influences is a real problem today. And it could have major consequences beyond those already seen. In fact, rather than slowing down, the problem is accelerating.

Carbon dioxide emissions are increasing and raise the specter of future climate changes that could be much larger and come much sooner than the IPCC suggests. The problem is that carbon dioxide has a long lifetime in the atmosphere, so it builds up, and it presently is 36 percent above pre-industrial levels. Half of that increase has occurred since 1970.

The climate system, especially the oceans and the land ice, the major glaciers, has a lot of inertia. It responds slowly. So with what we have already done to now, we are guaranteed to have at least another degree Fahrenheit warming in the global mean temperatures. Also, there is inertia in the infrastructure, so that even if we take actions now, we will have more warming in the pipeline. This means that long lead times are essential for actions to address climate change, something which is not widely appreciated by the general public.

In my written testimony, I outlined the evidence for global warming with several updates on post-IPCC developments, and I would like to run through some of those right now. To paraphrase the IPCC report, warming of the climate system is unequivocal, and it is very likely due to human activities. This word unequivocal was passed by all of the governments that were present, including the U.S., in the Paris meeting.

Also, the observed changes in recent decades are reproduced in climate models and are projected to increase in the future with substantial impacts. Nature continues to provide evidence that it is under duress, and the impacts are affecting people and animals.

My interpretation of the recent events is in the context of the IPCC findings. It includes first, six out of the ten warmest years in the contiguous United States have occurred since 1998. Globally, the past 7 years are among the eight warmest on record. Second, the most dramatic climate event recently has been the huge loss of Arctic sea ice in 2007. This affects permafrost and surrounding areas as well as polar bears and other native species.

Sea level rise I think is the best single indicator of a warming planet. It continues at the rate of a foot a century. Changes in ocean acidity accompany the buildup in carbon dioxide in the atmosphere, with consequences for sea creatures and bleaching of corals occurs in association with the warming.

In the first 6 months of 2008, record heavy rains and flooding in Iowa, Ohio and Missouri led to over-topped levees that have occurred along the Cedar River in Iowa and in the Mississippi. They point to the increases in intensity of rains that has been observed around the world, and especially across the United States, in association with more water vapor in the atmosphere that is a direct consequence of warming.

The record-breaking numbers of tornadoes and deaths in the United States in 2008 probably also has a global warming component from the warm, moist air coming in out of the Gulf of Mexico into the Midwest.

Longer dry spells also accompany warming, as the extra heat that is available goes into evaporating moisture, drying and wilting vegetation. The risk of wildfire increases enormously. Wildfires in California earlier this year and again this summer are examples of the impacts.

In 2007, for the first time, two Category Five hurricanes made landfall in the Americas. They both were in Central America they didn't get much attention in the U.S. as a result. Recent devastation in Typhoon Nargis in Myanmar, Burma and also the Typhoon Fengshen in the Philippines are signs of lack of adequate preparation for the consequences that are already going on of global warming.

In the Atlantic in 2008, in July, Hurricane Bertha has broken several records on how early and how far east it formed, and it is the longest lasting July hurricane on record. We should not be misled by short-term natural climate variations, such as the La Nina, the cold sea temperatures that developed in the tropical Pacific, that has dominated patterns over this past year.

Global warming is not just a threat for the future, it is already happening, and at rates faster than the IPCC projects. It is affecting people and ecosystems and public health. Our predictions at NCAR, my institution, and in the IPCC, are for substantial climate changes into the future, to the point where the Earth could become a different planet by 2100.

I believe there is a crisis of inaction in addressing and preparing for climate change. Global warming is happening, as I often say in my talks, coming, ready or not.

I appreciate the opportunity to address the Committee concerning the science of global climate change, and I look forward to answering any questions you may have today or in the future.

[The prepared statement of Dr. Trenberth follows:]

An update on human-induced climate change

Testimony of

Dr. Kevin E. Trenberth*
National Center for Atmospheric Research **

before

The U. S. Senate Committee on Environment and Public Works
The United States Senate
Room 406 of the Dirksen Senate Building
Committee on Science and Technology
10:00 a.m., July 22, 2008

* Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author and do not necessarily reflect those of the National Science Foundation.

** The National Center for Atmospheric Research (NCAR) is sponsored by the National Science Foundation.

Summary

In 2007 the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), known as AR4, clearly stated that “Warming of the climate system is unequivocal” and it is “very likely” due to human activities. Since the IPCC report, nature continues to provide evidence that it is under duress with impacts affecting people and animals. Increasing rates of carbon dioxide emissions raise the specter that future climate changes could be much larger and come much quicker than IPCC suggests.

The AR4 found that warming of the climate system is unequivocal based on an increasing body of evidence showing discernible physically consistent changes. These include increases in global average surface air temperature; atmospheric temperatures above the surface, surface and sub-surface ocean water temperature; widespread melting of snow; decreases in Arctic sea-ice extent and thickness; decreases in glacier and small ice cap extent and mass; and rising global mean sea level. The observed surface warming at global and continental scales is also consistent with reduced duration of freeze seasons; increased heat waves; increased atmospheric water vapor content and heavier precipitation events; changes in patterns of precipitation; increased drought; increases in intensity of hurricane activity, and changes in atmospheric winds. This wide variety of observations gives a very high degree of confidence to the overall findings. Because these changes are now simulated in climate models for the past 100 years to a reasonable degree, there is added confidence in future projections for more warming and increased impacts. Moreover, these changes in physical variables are reflected in changes in ecosystems and human health.

Carbon dioxide concentrations are increasing at rates beyond the highest of the IPCC scenarios, suggesting even bigger and faster climate change than IPCC projected. Warming is manifested in multiple ways, not just increases in temperatures. Most dramatic is the loss of Arctic sea ice in 2007, which affects surrounding areas and promotes changes in permafrost, as well as polar bears and other native species. Distinctive patterns of temperature and precipitation anomalies in the winter of 2007-08 were characteristic of the strong La Niña that had a signature over most of the world. In the first 6 months of 2008, record heavy rains and flooding in Iowa, Ohio, and Missouri, led to overtopped levees along the Cedar River in Iowa and the Mississippi, and point to the increases in intensity of rains associated with more water vapor in the atmosphere: a direct consequence of warming. The record breaking numbers of tornadoes and deaths in the U.S. in 2008 probably also have a global warming component from the warm moist air coming out of the Gulf of Mexico adding to instability of the atmosphere. Longer dry spells also accompany warming, as heat goes into evaporating moisture, drying and wilting vegetation, and thus increasing the risk of wild fire enormously. Wild fires in California early in 2008 and again this summer are evidence of the impacts. In 2007, for the first time, two category 5 hurricanes made landfall in Central America. Recent devastation from typhoon Nargis in Myanmar and typhoon Fengshen that hit the Philippines are signs of lack of adequate planning for consequences. In the Atlantic in July 2008, hurricane Bertha has broken several records for how early and how far east it formed, and it is the longest lasting July hurricane. Sea level rise, perhaps the best single indicator of a warming planet, continues at a rate of over a foot a century. Changes in ocean acidity accompany the buildup in carbon dioxide in the atmosphere with consequences for sea creatures, and bleaching of corals occurs in association with warming oceans. Melting permafrost exposes huge potential sources of methane and carbon dioxide that can amplify future climate change. Global warming is not just a threat for the future, it is already happening, endangering the health and welfare of the planet. There is a crisis of inaction in addressing and preparing for climate change.

Introduction

Thank you for the opportunity to appear before the Committee. My name is Kevin Trenberth. I am a senior scientist and the Head of the Climate Analysis Section at NCAR, the National Center for Atmospheric Research. I have authored over 400 publications in the area of climate, many highly cited, and given hundreds of talks on the subject. I am especially interested in global-scale climate dynamics; the observations, processes and modeling of climate changes from interannual to centennial time scales. I have particular expertise in El Niño, the hydrological and energy cycles, and hurricanes and climate change. I have served on many national and international committees including National Research Council/National

Academy of Science committees, panels and/or boards. I co-chaired the international Climate Variability and Predictability (CLIVAR) Scientific Steering Group of the World Climate Research Programme (WCRP) from 1996 to 1999 and I have served as a member and officer of the Joint Scientific Committee that oversees the WCRP as a whole from 1998 to 2006. I chair the WCRP Observations and Assimilation Panel. I have been extensively involved in the Intergovernmental Panel on Climate Change (IPCC) scientific assessment activity as a lead author of individual chapters, the Technical Summary, and Summary for Policy Makers (SPM) of Working Group (WG) I for the Second, Third and Fourth Assessment Reports (SAR, TAR and AR4; IPCC 1996, 2001, 2007a,b). I was Coordinating Lead Author of Chapter 3 of WG I of AR4 that deals with observations of the surface and atmospheric climate change.

The IPCC is a body of scientists from around the world convened by the United Nations jointly under the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) and initiated in 1988. Its mandate is to provide policy makers with an objective assessment of the scientific and technical information available about climate change, its environmental and socio-economic impacts, and possible response options. The IPCC reports on the science of global climate and the effects of human activities on climate in particular. Major assessments were made in 1990, 1995, 2001, and 2007. Each new IPCC report reviews all the published literature over the previous 5 to 7 years, and assesses the state of knowledge, while trying to reconcile disparate claims and resolve discrepancies, and document uncertainties.

WG I deals with how the climate has changed and the possible causes. It considers how the climate system responds to various agents of change and our ability to model the processes involved as well as the performance of the whole system. It further seeks to attribute recent changes to the possible various causes, including the human influences, and thus it goes on to make projections for the future. WG II deals with impacts of climate change, vulnerability, and options for adaptation to such changes, and WG III deals with options for mitigating and slowing the climate change, including possible policy options. Each WG is made up of participants from the United Nations countries, and for the 2007 assessment there were over 450 lead authors, 800 contributing authors, and over 2,500 reviewers from over 130 countries. The IPCC process is very open. Two major reviews were carried out in producing the report, and climate “skeptics” can and do participate, some as authors. All comments were responded to in writing and by changing the report. The process is overseen by two Review Editors for each chapter. The SPM were approved line by line by governments. The rationale is that the scientists determine what can be said, but the governments help determine how it can best be said. Negotiations occur over wording to ensure accuracy, balance, clarity of message, and relevance to understanding and policy. The strength is that it is a consensus report but the process also makes it a conservative report.

Observed Climate Change

The following includes a summary of aspects of the IPCC report, which mostly takes account of observations through 2005, but with updates on more recent changes and developments in the context of the IPCC findings.

Carbon dioxide concentrations in the atmosphere have increased such that current values of about 385 ppmv are over 36% higher than pre-industrial values of 280 ppmv and over half that increase has occurred since 1970 (Fig.1). Of particular note is the clear evidence that carbon dioxide concentrations are increasing at rates beyond the highest of the IPCC scenarios (Raupach et al., 2007) in spite of the Kyoto Protocol, suggesting that climate changes are apt to become larger than any IPCC projections. Although U.S. emissions continue to climb, large increases in emissions from China and India contribute to the acceleration, and in 2007 China supposedly surpassed the U.S. as leader in annual emissions. Carbon dioxide comes primarily from burning of fossil fuels in association with energy production and industrial activity (see the U.S. Energy Information Administration web pages for detailed data, e.g., <http://www.eia.doe.gov/iea/environment.html>.) There is no doubt that carbon dioxide is a greenhouse gas and causes warming, and it has a long lifetime which is why amounts are increasing in the atmosphere. Other greenhouse gases also contribute significantly to warming, while aerosols and dust more often cause cooling and regionalize some of the radiative forcing. A direct consequence of the escalating level of

carbon dioxide in the atmosphere is the world's ocean becoming more acidic, dramatically altering ocean chemistry and threatening corals and other marine organisms that secrete skeletal structures (e.g., Caldeira et al., 2007).

Since 1979, measurements from space have been made of changes in the sun and, as there are no changes of consequence during the period to date, changes in the sun are not responsible for the large changes observed in climate since the 1970s.

The iconic summary statement of the observations section of the IPCC (2007a) report is **“Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level.”** The language was carefully chosen to reinforce the view that

- 1) There are multiple lines of evidence from many variables
- 2) There is a wide body of evidence and multiple analyses of each variable
- 3) The variables and evidence are physically consistent with warming
- 4) The human signal has clearly emerged from noise of natural variability, i.e., it is large.

This finding fundamentally changes the way we think about and approach climate change. Previously, we have always supposed (scientists refer to it as a null hypothesis) that the climate is not changing and the onus has been to prove that global warming is having an effect. Now this should switch to an underlying hypothesis that global warming is affecting all aspects of weather and climate, and the onus is on showing this is not the case. We are often asked, “Is a particular event caused by global warming or natural variability?” The answer is that it is always both.

a. Temperature

Instrumental observations over the past 158 years show that temperatures at the surface (Fig. 1) have risen globally, with important regional variations. For the global average, warming in the last century occurred in two phases, from the 1910s to the 1940s (0.35°C or 0.63°F), and more strongly from the 1970s to the present (0.55°C or 1.0°F) at a rate of about 0.16°C (0.3°F) per decade. An increasing rate of warming has taken place over the last 25 years, and 12 of the 13 warmest years on record have occurred in the past 13 years. The total warming since the 1800s is about 0.76°C (1.4°F). Globally, 2006 ranks 6th and was the second warmest on record in the United States (behind 1998), while 2007 ranks as 8th warmest. Sea surface temperatures (SSTs) are also increasing, however land areas are warming much faster than the oceans since 1970.

Two possible issues with the surface temperature record – urban heat island effects, and discrepancies with balloon-based and satellite measurements – were extensively studied in the IPCC (2007a) report. The urban heat island effects are real but local, and have been found to have a negligible influence on the overall surface temperature record. New analyses of balloon-borne and satellite measurements of lower- and mid-tropospheric temperature show warming rates that are similar to the surface temperature record and consistent within their respective uncertainties. The 2007 IPCC report essentially removes these two issues as serious sources of uncertainty for the global surface temperature record.

Regional temperature observations do not always track the global average warming because of atmospheric wave patterns, as well as increased natural variability at smaller geographic scales. For example, the eastern half of the United States has not warmed as much as other areas, especially during the daytime, owing to increases in cloud and precipitation associated with changes in atmospheric circulation as the climate changes. On the other hand, average Arctic temperatures increased at almost twice the global average rate in the past 100 years and also since 1960. However, Arctic temperatures have high decadal variability and a warm period was observed from 1925 to 1945, but that was focused in the North Atlantic and not global as in the recent warming.

Since 1950, the number of heat waves globally has increased and widespread increases have occurred in the numbers of warm nights. Cold days, cold nights and frost have generally become rarer.

For the United States (Fig. 2), the temperatures feature an especially warm period in the 1930s and it is only in the past decade that these values have been exceeded. Six of the 10 warmest years for the contiguous U.S. have occurred since 1998. In the summer half year, there is a strong negative correlation

between temperature and precipitation: it is either hot and dry or cool and wet, but not other combinations. Hence, the record heat in the 1930s was associated with the drought of the Dust Bowl years (see also the precipitation in Fig. 2). In contrast, the warming over the U.S. since about 1970 has taken place in spite of the exceptionally wet conditions that have generally prevailed, even as the year-to-year variations still tend to reflect changing precipitation. It is important to recognize this aspect of local variability: wetter conditions mean more cloud and less sunshine, and more heat goes into evaporation of surface water instead of increasing temperature. The change in the 1970s to much wetter and cloudier conditions across the United States, especially east of the Rockies, corresponds to a change in the atmospheric circulation and more El Niño-like conditions. The eastern U.S. is unique around the world in not having warmed by day in some areas during the 20th century. In 2007, this pattern broke down in association with the development of a La Niña event, and a substantial drought in the Southeast ensued, with major water shortages as a result. The eastern U.S. would be exceedingly vulnerable to such events if the atmospheric circulation were to return to pre-1970 patterns. Because of the nature of the changes over the past four decades, the U.S. is more vulnerable to large future warming and drought than many other areas.

b. Temperature related

The average atmospheric water vapor content has increased over land and ocean as well as in the upper troposphere, and over the global oceans this is estimated to be 4% since 1970. The increase is broadly consistent with the extra moisture that warmer air can hold and amounts to a fairly constant relative humidity. The added water vapor also adds to the greenhouse effect and roughly doubles that due to carbon dioxide, providing a powerful positive feedback to climate change.

Decreases are found in the length of the freeze season of river and lake ice. Temperature at the top of the permafrost layer has increased by up to 3°C since the 1980s in the Arctic. The maximum area covered by seasonally frozen ground has decreased by about 7% in the Northern Hemisphere since 1900 and this value is up to 15% in spring.

The average temperature of global ocean water from the surface to a depth of 700 m increased significantly from 1961 to 2003, indicating that the ocean is absorbing most of the heat being added to the climate system. This causes seawater to expand and is estimated to have contributed 0.42 mm per yr to the average sea level rise from 1961 to 2003, and 1.8 mm per yr from 1993 to 2003.

Sea-ice extents have decreased in the Arctic since 1978, particularly in spring and summer (7.4% per decade through 2005), and patterns of the changes are consistent with regions showing a temperature increase, although changes in winds are also a major factor. The AR4 only included data through 2005 and sea-ice extents were at record low values in 2005, which was also the warmest year since records began in 1850 for the Arctic north of 65°N. This record has since been smashed in 2007 when Arctic sea ice dropped to over 20% below the 2005 value. There have also been decreases in sea-ice thickness. The result in 2008 is that there is an unprecedented amount of first year ice in the Arctic that is very vulnerable to melting.

In contrast to the Arctic, Antarctic sea ice did not exhibit any significant trend from the end of the 1970s through 2006, which is consistent with the lack of trend in surface temperature south of 65°S over that period. However, along the Antarctic Peninsula, where significant warming has occurred, progressive break up of ice shelves occurred beginning in the late 1980s, culminating in the break up of the Larsen-B ice shelf in 2002. In 2008 there was a marked expansion of Antarctic sea ice in association with changes in atmospheric winds.

The observed surface temperature increases are consistent with the observed nearly worldwide reduction in glacier and small ice cap mass and extent in the 20th century. In addition, flow speed has recently increased for some Greenland and Antarctic outlet glaciers, which drain ice from the interior, and melting of Greenland and West Antarctica has increased after about 2000. Critical changes (not well measured) are occurring in the ocean and ice shelves that buttress the flow of glaciers into the ocean. Glaciers and ice caps respond not only to temperatures but also to changes in precipitation, and both winter accumulation and summer melting have increased over the last half century in association with temperature increases. In some regions moderately increased accumulation observed in recent decades is consistent with changes in atmospheric circulation and associated increases in winter precipitation (e.g., southwestern Norway, parts of coastal Alaska, Patagonia, and the South Island of New Zealand) even though increased

ablation has led to marked declines in mass balances in Alaska and Patagonia. Tropical glacier changes are synchronous with higher latitude ones and all have shown declines in recent decades. Decreases in glaciers and ice caps contributed to sea level rise by 0.5 mm per yr from 1961 to 2003 and 0.8 mm per yr from 1993 to 2003. Taken together, shrinkage of the ice sheets of Greenland and Antarctica contributed 0.4 mm per yr to sea level rise over 1993 to 2003.

Global average sea level rose at an average rate of 1.8 mm per year from 1961 to 2003. The rate was faster after 1992 (Fig. 3), when truly global values have been measured from altimeters in space, at about 3.2 mm per yr from 1993 to early 2008. About 60% of this is from ocean warming and expansion, and 40% is from melting land ice, adding to the ocean volume. The observation of consistent sea level rise over several decades, and also an increasing rate of sea level rise in the last decade or so, is probably the single best metric of the cumulative global warming that we have experienced to date. There is really no explanation other than global warming for the observed sea level rise. A consequence is increasing risk of coral bleaching and coastal storm surge flooding.

In the northern winter of 2007-08, a strong La Niña event dominated the patterns of weather especially around the Pacific and had major influences across the United States. It also affected sea ice in the southern oceans. The cooling of the tropical Pacific Ocean amounts to a redistribution of heat within the ocean and it affects the jet stream and tracks of cyclones around the world. Only in northern Europe and Asia was the weather pattern not identified with La Niña, and the pattern called the North Atlantic Oscillation played a role there in making conditions much warmer than normal. The net result was a very snowy winter and above normal snow cover in North America, but much below normal snow cover for Eurasia, and much below for the hemisphere as a whole. Even sea level rise leveled off after mid-2007 (Fig. 3), suggesting a loss of heat from the ocean and/or a slowing of melting of glaciers and the ice sheets. This is exactly as expected and a counter example is in 1997/98 (Fig. 3) when a major El Niño occurred. Such natural variability is to be expected: global warming does not mean relentless warming at every place and time.

The observed surface warming at global and continental scales is consistent with observed changes in sub-surface ocean water temperature; decreases in sea-ice extent and thickness; decreases in glacier and small ice cap extent and mass; sea-level rise; reduced duration of freeze seasons, increased heat waves; and increased atmospheric water vapor content. Hence the Earth is warming, and major components of the Earth's climate system are already responding to that warming. This wide variety of observations gives a very high degree of confidence to the overall findings.

c. Precipitation and related

The IPCC (2007a) report finds that changes are occurring in the amount, intensity, frequency, and type of precipitation in ways that are also consistent with a warming planet. These aspects of precipitation generally exhibit large natural variability (compared to temperature trends), and El Niño and changes in atmospheric circulation patterns have a substantial influence, making it harder to detect trends in the observational record.

A key ingredient in changes in character of precipitation is the observed increase in water vapor and thus the supply of atmospheric moisture to all storms, increasing the intensity of precipitation events. Indeed, widespread increases in heavy precipitation events and risk of flooding have been observed, even in places where total amounts have decreased. Hence the frequency of heavy rain events has increased in most places but so too has episodic heavy snowfall events that are thus associated with warming. Snow cover has decreased in many Northern Hemisphere regions, particularly in spring, and more precipitation is falling as rain instead of snow. These changes are consistent with changes in permafrost, noted above.

Long-term trends from 1900 to 2005 have been observed in total precipitation amounts over many large regions. Significantly increased precipitation has been observed in eastern parts of North and South America, northern Europe and northern and central Asia. Drying has been observed in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. Precipitation is highly variable spatially and temporally. Robust long term trends have not been observed for other large regions. The pattern of precipitation change is one of increases generally at higher northern latitudes (because as the atmosphere warms it holds more moisture) and drying in the tropics and subtropics over land. Basin-scale changes in

ocean salinity provide further evidence of changes in the Earth's water cycle, with freshening at high latitudes and increased salinity in the subtropics. Continental U.S. changes are given in Fig. 2.

More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics. Increased drying due to higher temperatures and decreased precipitation have contributed to these changes, with the latter the dominant factor. The regions where droughts have occurred are determined largely by changes in SST, especially in the tropics (such as during El Niño), through changes in the atmospheric circulation and precipitation. In the western United States, diminishing snow pack and subsequent summer soil moisture reductions have also been a factor. In Australia and Europe, direct links to warming have been inferred through the extreme nature of high temperatures and heat waves accompanying drought.

Satellite records suggest a global trend towards more intense and longer lasting tropical cyclones (including hurricanes and typhoons) since about 1970, correlated with observed warming of tropical SSTs. There is no clear trend in the annual number of tropical cyclones globally although a substantial increase has occurred in the North Atlantic after 1994. There are concerns about the quality of tropical cyclone data, particularly before the satellite era. Further, strong multi-decadal variability is observed and complicates detection of long term trends in tropical cyclone activity. In the Atlantic, many records were broken in the 2004 and 2005 hurricane seasons, with unprecedented damage in Katrina. It has been estimated that heavy rains in tropical storms and hurricanes (including Katrina) have increased by 6 to 8% as a result of higher SSTs and more water vapor in the atmosphere (Trenberth et al., 2007). In 2007, a record number of two category 5 hurricanes made landfall in the Americas, both hitting Central America. Widespread damage was also occurred in 2008 from typhoons in Myanmar (Nargis) and Fengshen in the Philippines. In the Atlantic, Bertha has broken several records for how early and how far east it formed, and it has also been the longest-lasting July tropical storm.

In the U.S., not only are precipitation amounts generally up since the 1970s (Fig. 2), but heavy rains are up much more: the top 0.3% are up 27% in the 40 years from 1967 to 2006 (Groisman and Knight, 2008). The same study also shows that dry spells of one or two months have also increased in most places, as the warm season has increased by 5 to 6 days in length. Easterling et al. (2007) show that drought would have been much more common and widespread if it were not for the increases in precipitation after the 1970s (Fig. 2). Temperatures would also have been much higher and with more heat waves.

d. Synthesis across variables

In summary, global mean temperatures have increased since the 19th century, especially since the mid-1970s. Temperatures have increased nearly everywhere over land, and SSTs have also increased, reinforcing the evidence from land. However, global warming does not mean that temperatures increase steadily or uniformly, indeed temperatures have increased neither monotonically, nor in a spatially uniform manner, especially over shorter time intervals. The atmospheric circulation has also changed: in particular increasing westerly wind flow is observed in most seasons in both hemispheres. In the Northern Hemisphere this brought milder maritime air into Europe and much of high-latitude Asia from the North Atlantic in winter, enhancing warming there. In the Southern Hemisphere, where the ozone hole has played a role, it has resulted in cooling since 1971 for parts of the interior of Antarctica but large warming in the Antarctic Peninsula region and Patagonia. Temperatures generally have risen more than average where flow has become more poleward, and less than average or even cooled where flow has become more equatorward, reflecting atmospheric patterns of variability.

Over land in low latitudes and in summer more generally, there is a strong tendency for either hot and dry or cool and wet. Hence areas that have become wetter, such as the eastern United States and Argentina, have not warmed as much as other land areas. Increased precipitation is associated with increases in cloud and surface wetness. Thus more heat goes into increased evapotranspiration and less into raising temperature at the surface in wetter conditions.

The three main ocean basins are unique and contain very different wind systems, SST patterns and ocean currents, leading to vastly different variability associated, for instance, with El Niño/La Niña in the Pacific, and the ocean currents including the Gulf Stream in the Atlantic. Consequently the oceans have not warmed uniformly, especially at depth. SSTs in the tropics have warmed at different rates and help drive,

through coupling with tropical convection and winds, distinctive wave patterns known as teleconnections around the world. This has changed the atmospheric circulation and the monsoons. Another consequence is increases in ocean acidity that accompany the buildup in carbon dioxide in the atmosphere with consequences for sea creatures. Changes in precipitation and storm tracks are not as well documented but clearly respond to these changes on interannual and decadal timescales. When precipitation increases over the ocean, as it has in recent years in the tropics, it decreases over land, although it has increased over land at higher latitudes. Droughts have increased over many tropical and mid-latitude land areas, in part because of decreased precipitation over land since the 1970s but also from increased drying arising from increased atmospheric demand associated with warming.

Warming promotes increases in both drought and temperature. Changes in both come as the heat goes into raising temperature or drying (evaporation) and, as the temperatures increase, the water holding capacity of the atmosphere goes up at 4% per deg F. Hence warmer temperatures have the effect of drawing moisture out of plants and soils. In the U.S., even as rains have become heavier (more intense), so dry spells have also become longer. The two go hand in hand and relate to how precipitation changes: more intense but less frequent, and the amount changes less. After a certain point where the ground is dry and the plants have reached wilting point, all the heat goes into raising temperature and creating heat waves, and then wild fire risk goes up substantially. The West has warmed more than the East (east of Rockies) and the latter region has become noticeably wetter in general, while drought has become more common in the West. All of this indeed promotes wildfire risk, and "dry lightning" is disastrous, especially in areas where trees are damaged such as by bark beetle. Wild fires in California early in 2008 and again this summer are direct evidence of the impacts. As of June 30, more than 2.1 million acres have burned this year according to the National Interagency Fire Center, the third highest on record after 2006 and 2002. Of course the risk of wild fire does not necessarily translate into a wild fire if care has been taken in managing the risk by building wild fire breaks, cutting down on litter, removing diseased and dead trees and vegetation near buildings, etc. A key question in recognizing that global warming is happening, is whether adequate preparation for the changes (whether heavy rains, drought, or wild fire risk) has been made?

A consequence of these findings is that what were once 500 year flood events are now more like 30 or 50 year events. A particular example has been seen in the central U.S in the first 6 months of 2008 as record heavy rains have occurred in Iowa, Ohio, and Missouri, with associated flooding through overtopped levees along the Cedar River in Iowa and the Mississippi. This follows from similar flooding in 1993, just 15 years ago. The record breaking numbers of tornadoes and deaths in the U.S. in 2008 probably also has a modest global warming component. Tornadoes are most common in the spring and early summer in weather systems moving across the U.S. that bring warm moist low-level air flowing from the Gulf of Mexico into the storms, while drier westerly winds aloft create wind shear that leads to rotation and thus tornadic thunderstorms. Because the Gulf air is warmer and moister than it would otherwise have been 30 or more years ago, the instability of these storms is enhanced. The effect is not measurable owing to the nature of tornado statistics which mainly reflect increasing numbers of people in more places.

Consequences of the physical changes in climate in terms of public health are addressed extensively in WG II of IPCC (2007b), and see also Haines et al. (2007). Datasets are not as good or as long as for physical variables, and autonomous adaptation occurs to changing conditions to some degree. Climate change effects occur amidst increases in life expectancy in most places, and are thus hard to sort out. However, evidence already exists for changes in infectious disease vectors and allergenic pollens. Direct effects include those given above from changes in heat, cold, storms (including hurricanes and tornadoes), drought, and wild fires. In 2008 preliminary counts through June are that 119 people have died in tornadoes in the United States. The drought-related heat wave in Europe in summer 2003 killed as many as 35,000 people. On the other hand fewer cold waves reduce mortality. Safe drinking water is jeopardized by more intense rains and runoff which can lead to contamination and increased microbial loading, sometimes overwhelming water treatment plants (if they exist). Hence water-borne diseases have been observed to increase. Also drought and observed earlier snow melt and runoff jeopardize water supplies, especially in summer. Changes in temperatures, humidity and precipitation also affect the environment for pests and disease, and have increased risk of certain problems in plants, animals and humans. Changes in phenology, reproduction, and geographic range are occurring, disrupting predator-prey relationships. Some species have

become extinct. For instance, pine beetle that has devastated huge tracts of lodge-pine forest in the West has climate dependencies and flourishes and spreads in warmer temperatures. Evidence of climate change effects is also evident in fish, such as salmon. Air quality is also changing from pollution, and ground level ozone and particulate matter are increasing in most regions, with increased hospital admissions for respiratory disease. The capacity to adapt to these changes varies greatly regionally, but all of these problems or changes are evident in North America. Particular human health problems have occurred with spread of West Nile virus, which requires warmer temperatures to survive. Similarly, Lyme disease, borne by ticks, is associated with temperature and precipitation.

Modeling climate change and projections

Many of the above observed changes are now simulated in climate models run for the past 100 years, adding confidence to understanding of the relationship with the agents that alter the climate, and human-induced changes in atmospheric composition. In particular, when anthropogenic forcings are included, the models simulate the observed global and continental-scale temperature records with impressive fidelity. The models can then be used to simulate the record without anthropogenic forcings, and the results are similar up till about 1970, and it is only since then that the human influence has emerged above the levels of natural variability. Also, the models indicate that volcanic and anthropogenic aerosols have offset some of the additional warming that would have resulted from observed increases in greenhouse gas concentrations alone.

A climate model is a tool; often a very sophisticated tool that encapsulates much of our understanding about the complex climate system. But it is still a model that makes assumptions and approximations, and is a grossly simplified version of the real world. Faster computers that can permit much higher resolution are required, for one thing, to merely capture our current understanding about the role of currently unresolved phenomena such as hurricanes. Adding more processes and complexity could also allow progress to be made. The main way models have been used is to examine the change in response to some new forcing. This avoids worrying about specifying the initial state. But it means the result is not a prediction. It is referred to as a projection based on a “what-if” scenario of future emissions and forcing.

Climate models have crude representation of aerosols and their forcing, and clouds are the biggest source of uncertainty. Climate models have some systematic errors in placement of precipitation, in the diurnal cycle of precipitation, and in phenomena such as El Niño. George Box is credited with saying “*All models are wrong, some are useful*”. It applies to climate models especially well. No-one should base a decision on a climate model and its output without proper evaluation as to whether it is in the useful category. In fact models are used to guide decisions every day: weather forecasts, seasonal forecasts, and so on. But they should not be used as a “black box”. IPCC (2007a) evaluates the utility of climate models and uses them in their projections.

The climate is changing and the past is no longer a good guide to the future. So what should we use for guidance? Any decision involves a model: whether it is a model of no change (which is surely wrong), a back-of-the-envelope or heuristic model perhaps based on someone’s limited experience, a simple energy balance model, or a full blown global climate model that requires a super computer to run. At least the latter includes many of the feedbacks and nonlinearities that we know are so important. But it does not include them all. For instance, carbon cycle feedbacks are not included in models used by IPCC. Warming promotes permafrost melt and also decay of soil vegetable matter generating methane (if a wet anaerobic environment) or carbon dioxide (if a dry aerobic environment). It also promotes out-gassing of carbon dioxide from the oceans as the oceans warm. These are likely to amplify the climate changes that have been projected from IPCC in the decades ahead.

Some of the major results from AR4 models, with some updates and commentary, include:

- Owing to the long lifetime of carbon dioxide and other greenhouse gases, even if no further emissions occurred into the atmosphere we are guaranteed to have further warming of the planet, amounting to about 1°F according to IPCC, but possibly quite a bit larger if feedbacks not accounted for in models kick in (such as with the carbon cycle noted above).

- Over the next two decades, all models produce similar warming trends in global surface temperatures, regardless of the emissions scenario. The rate of the projected warming is near 0.2°C per decade.
- Decadal-average warming over each inhabited continent by 2030 is insensitive to the emission scenario; but by the middle of the 21st Century the choice of scenario becomes more important for the magnitude of surface warming, and by the end of the 21st Century there are clear consequences for which scenario is followed. The best estimate of the global surface temperature change from today to the end of the century is +1.8°C (with a likely range of +1.1°C to +2.9°C) for the low emission scenario (corresponding to a carbon dioxide equivalent concentration of 600 ppm by 2100) and +4.0°C (+2.4°C to +6.4°C) for the highest emission scenario (corresponding to 1,550 ppm). This result highlights the long lead times required before measures taken are effective in reducing the threat of global warming.
- Geographical patterns of warming show greatest temperature increases at high northern latitudes and over land, with less warming over the southern oceans and North Atlantic, as has been observed in recent decades. In spite of a slowdown of the meridional overturning circulation and changes in the Gulf Stream in the ocean across models, there is still warming over the North Atlantic and Europe due to the overwhelming effects of the increased concentrations of greenhouse gases.
- Sea ice coverage is projected to shrink in polar regions. In 2006 a model suggested that there are real prospects for the Arctic becoming ice free in late summer by about the 2040s (Holland et al., 2006) and the record low Arctic sea ice observed in 2007 suggest that this may be happening a lot faster than most models suggest. The IPCC models fail to capture these dramatic changes.
- Snow cover is projected to contract, with widespread increases in thaw depth over most permafrost regions. Another recent study (Lawrence et al, 2008) with a climate model suggests that permafrost may melt much faster than previously thought partly as a consequence of the diminishing sea ice, with consequences for the carbon cycle.
- It is very likely that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent.
- It is likely that tropical storms and hurricanes will become more intense and with much heavier rainfalls, and thus risk of flooding.
- The observed patterns of precipitation change in recent decades is projected to continue, with increases over northern continents but decreases over subtropical regions, increasing risk of drought. At the same time, dry spells are expected to increase everywhere. Water resources will be a major issue and perhaps the biggest source of stress on society.
- Projections of sea level rise by the end of the century in IPCC range from 30 to 40 cm, but do not include possible ice sheet collapse. These climate models have very primitive modeling of ice sheets and the role of buttressing ice shelves (e.g., Shepherd and Wingham, 2007; Rignot et al., 2008), leading to considerable uncertainty in possible future sea level rise. The IPCC estimates of future sea level rise could be low by a factor of 2 or more.
- Consequences of these physical changes in climate are addressed extensively in WG II of IPCC (2007b) (see above for observed changes), and projections are based on many case studies of relationships of impacts with weather and climate. Increasing risk occurs especially with direct effects of heat and extreme weather events (including tornadoes, hurricanes, thunderstorms, and extratropical cyclones), air quality, spread of water-, food- and vector-borne diseases, disruptions to forests and also agriculture, resulting in food scarcity, fresh water shortages, changes in biological systems and disruptions in predator-prey relationships, and public health effects (e.g., Haines et al., 2007). The effects and vulnerability vary greatly by region, but even the U.S. is at risk for adverse impacts in many of these areas.

Models can be exceedingly useful if used wisely. Observed climate changes are now sufficiently large, and models in IPCC have now improved to the point that they simulate many of the observed changes going on. As shown by recent sea ice and ice sheet changes, the IPCC conclusions are quite conservative. We very much need to improve models and have access to faster bigger computers.

Some implications

The scientific understanding of climate change is now sufficiently clear to show that specific global and regional changes resulting from global warming are already happening, possibly faster than IPCC has projected. Uncertainties remain, and new efforts at reprocessing past satellite records for phenomena such as hurricanes are required, but the 2007 IPCC report definitively shows that the climate is changing. "Warming is unequivocal" and it is "very likely" caused by human activities.

In my personal opinion as a climate scientist, there is a need for a three pronged approach of mitigation, adaptation, and maintaining and improving climate observing and information systems.

While there are uncertainties (although these cut both ways) and some changes arising from global warming may be benign or even beneficial, at least in some places and in the short run, the IPCC report shows that the rate of change as projected exceeds anything seen in nature in the past 10,000 years. Moreover, the inertia of the climate system and the long life of carbon dioxide in the atmosphere mean that we are already committed to a significant level of climate change. I believe that mitigation actions are certainly needed to significantly reduce the build-up of greenhouse gases in the atmosphere and lessen the magnitude and rate of climate change. Action taken now to reduce significantly the build-up of greenhouse gases in the atmosphere will lessen the magnitude and rates of climate change. In fact I believe there is a crisis of lack of adequate action in this regard.

At the same time, the 2007 IPCC report makes clear that even aggressive mitigation would yield benefits decades in the future, and that no amount of mitigation can avoid significant climate change. It is apt to be disruptive in many ways. Hence it is also vital to plan to cope with the changes, such as enhanced droughts, heat waves and wild fires, and stronger downpours and risk of flooding. Managing water resources will be a major challenge in the future. Adapting to climate change and reducing vulnerability is essential. This means that we should adapt to climate change by planning for it and making better predictions of likely outcomes on several time horizons.

Finally, although not reported by the IPCC, my experience in working with observations of climate change has led me to urge the Committee to address the considerable shortcomings in our observing systems. Weather observing systems are continually used for climate purposes for which they were not designed. Moreover, weather stations come and go and changes are made without regard to the effect on the climate record. Changes in observing systems, especially from satellites, as new satellites and instruments are launched, create artifacts in the climate record. Loss of Earth observing satellites is also of concern, as documented in the National Research Council (2007) decadal survey. Ground based observations are not being adequately kept up in many countries. Calibration of climate records is critical. Small changes over long times are characteristic of climate change but they occur in the midst of large variations associated with weather and natural climate variations such as El Niño. Yet the climate is changing and an imperative is to track the changes and the causes as they occur. We need to build a system based on these observations to inform decision makers on what is happening, and why, and what the predictions are for the future on several time horizons.

In summary, global warming is coming, ready or not.

I appreciate the opportunity to address the Committee concerning the science of global climate change, and look forward to answering any questions you may have today or in the future.

References and some bibliography

- Caldeira, K., et al. (2007), Comment on "Modern-age buildup of CO₂ and its effects on seawater acidity and salinity" by Hugo A. Loaiciga, *Geophys. Res. Lett.*, 34, L18608, doi:10.1029/2006GL027288.
- Easterling, D. R., T. W. R. Wallis, J. H. Lawrimore, and R. R. Heim Jr., 2007: Effects of temperature and precipitation trends on U.S. drought, *Geophys. Res. Lett.*, 34, L20709, doi:10.1029/2007GL031541.
- Groisman, P.Ya., and R. W. Knight, 2008: Prolonged dry episodes over the conterminous United States: New tendencies emerging during the last 40 years. *J. Climate*, 21, 1850-1862.
- Haines, A., R.S. Kovats, D. Campbell-Lendrum and C. Corvalan, 2007 : Climate change and human health : Impacts, vulnerability and public health. *Public Health*, 120, 585-596.
- Holland, M.M., C.M. Bitz, and B. Tremblay, 2006: Future abrupt reductions in the summer Arctic sea ice. *Geophysical Research Letters*, 33, L23503, doi:10.1029/2006GL028024

- IPCC (Intergovernmental Panel on Climate Change), 1996: *Climate Change 1995: The Science of Climate Change*. Eds. J. T. Houghton et al., Cambridge University Press, Cambridge, U.K. 572 pp.
- IPCC, 2001: *Climate Change 2001: The Scientific Basis*. Eds. J. T. Houghton, et al., Cambridge University Press, Cambridge, U.K. 881 pp.
- IPCC, 2007a: *Climate Change 2007. The Physical Science Basis*. S. Solomon, et al. Eds. Cambridge University Press, Cambridge, U. K., 996pp.
- IPCC, 2007b: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, M.L. Parry, et al., Eds., Cambridge University Press, Cambridge, UK, 976pp.
- Karl, T. R., and K. E. Trenberth, 2003: Modern global climate change. *Science*, **302**, 1719–1723.
- Karl, T. R., and K. E. Trenberth, 2006: Modern global climate change. *Science Magazine's State of the Planet*, Donald Kennedy and the editors of *Science* magazine, Eds., Island Press, 88–98.
- Lawrence, D. M., A. G. Slater, R. A. Tomas, M. M. Holland, and C. Deser, 2008: Accelerated Arctic land warming and permafrost degradation during rapid sea ice loss, *Geophys. Res. Lett.*, **35**, L11506, doi:10.1029/2008GL033985.
- National Research Council, 2007: *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*. The National Academies Press.
- Raupach, M. R., G. Marland, P. Ciais, C. Le Quééré, J. G. Canadell, G. Klepper, and C.B. Field, 2007: Global and regional drivers of accelerating CO₂ emissions. *PNAS*, doi:10.1073/pnas.0700609104.
- Rignot, E., J.L. Bamber, M. R. van den Broeke, C. Davis, Y. Li, W.J. van de Berg, E. van Meijgaard, 2008: Recent Antarctic ice mass loss from radar interferometry and regional climate modeling, – *Nature Geoscience*, doi:10.1038/ngeo102.
- Shepherd, A., and D. Wingham, 2007: Recent sea-level contributions of the Antarctic and Greenland Ice Sheets. *Science*, **315**, 1529–1532.
- Trenberth, K. E., 2001: Stronger evidence for human influences on climate: The 2001 IPCC Assessment. *Environment*, **43**, 4(May), 8–19.
- Trenberth, K. E., 2005: Uncertainty in hurricanes and global warming. *Science*, **308**, 1753–1754.
- Trenberth, K. E., 2007: Warmer oceans, stronger hurricanes. *Scientific American*, July, 2007, 45–51.
- Trenberth, K. E., 2008: The impact of climate change and variability on heavy precipitation, floods and droughts. *Encyclopedia of Hydrological Sciences*. M. H. Anderson (Ed.) J. Wiley and Sons, Ltd. Chichester, UK. Doi: 10.1002/0470848944.hsa211.
- Trenberth, K. E., and D. J. Shea, 2006: Atlantic hurricanes and natural variability in 2005. *Geophys. Res. Lett.*, **33**, L12704, doi:10.1029/2006GL026894.
- Trenberth, K. E., T. R. Karl and T. W. Spence, 2002: The need for a systems approach to climate observations. *Bull. Amer. Meteor. Soc.*, **83**, 1593–1602.
- Trenberth, K. E., C. A. Davis and J. Fasullo, 2007: Water and energy budgets of hurricanes: Case studies of Ivan and Katrina. *J. Geophys. Res.*, **112**, D23106, doi:10.1029/2006JD008303.

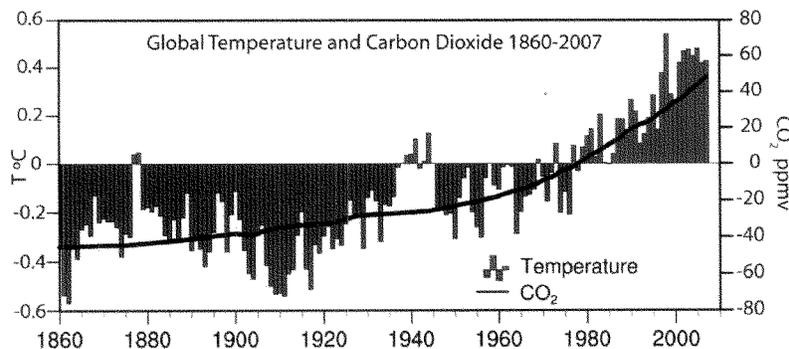


Figure 1. Time series of annual global mean temperature departures for 1861-2007 from a 1961-90 mean (bars), left scale, and the annual mean carbon dioxide from Mauna Loa after 1957 linked to values from bubbles of air in ice cores prior to then. The zero value for 1961-90 for temperature corresponds to 14°C and for carbon dioxide 334 parts per million by volume (ppmv). Updated from Karl and Trenberth (2003); original data from HADCRUV3 <http://www.cru.uea.ac.uk/cru/data/temperature/#datdow>, and <http://www.esrl.noaa.gov/gmd/ccgg/trends/>.

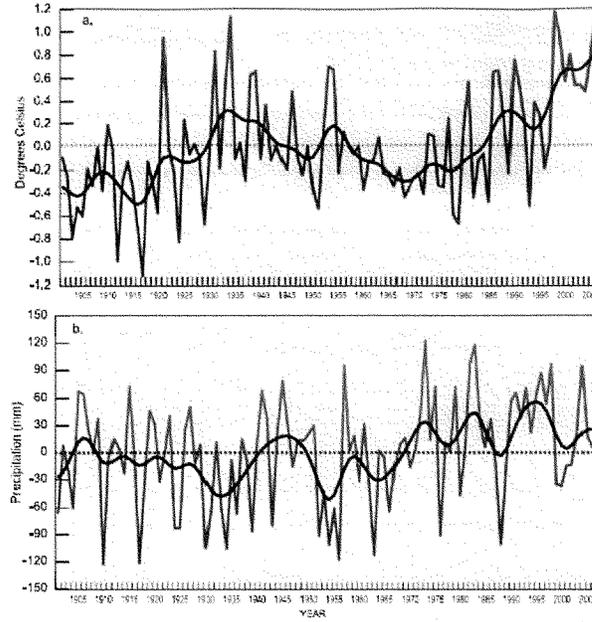


Figure 2. Changes from 1901 to 2006 in the continental US temperatures (top) and precipitation amounts (bottom): annual and smoothed decadal values; from Easterling et al. (2007)

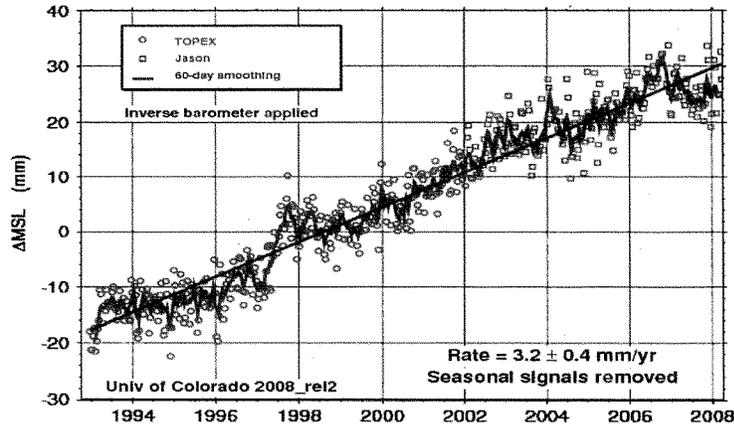


Figure 3. Sea level changes based on altimetry from space from the TOPEX/Poseidon and Jason measurements, processed to remove the mean annual cycle and with an inverse barometer correction applied (to account for changing sea level pressure over the oceans). From Univ. Colorado http://sealevel.colorado.edu/current/sl_ib_ns_global.jpg courtesy Steve Nerem.

**Environment and Public Works Hearing
July 22, 2008**

Follow-up questions and responses.

Kevin E Trenberth

Senator Barbara Boxer

On May 29, 2008, the U.S. Climate Change Science Program issued a final report on the scientific evidence of global warming. This report was reviewed and approved by President Bush's top science advisors and was signed off on by the Office of Management and Budget and White House officials. Key findings of the report include:

- *"It is well established through formal attribution studies that the global warming of the past 50 years is due primarily to human-induced increases in heat-trapping gases."*
- *"In the future, with continued global warming, heat waves and heavy downpours are very likely to further increase in frequency and intensity. Substantial areas of North America are likely to have more frequent droughts of greater severity. Hurricane wind speeds, rainfall intensity, and storm surge levels are likely to increase."*
- *"Climate change is currently impacting the nation's ecosystems and services in significant ways, and those alterations are very likely to accelerate in the future, in some cases dramatically."*

1) Are these findings consistent with the conclusions reached in the general body of scientific research and analyses of climate change?

Yes. The findings are consistent with the available scientific evidence including the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment report issued in 2007. In addition, a number of new Synthesis and Assessment Product (SAP) reports have either recently been completed or are underway that update the latest consensus information. The statements are actually taken from two of those. As a consensus view, these reports tend to be somewhat conservative and they rely on published literature, which often takes a year or more to come out. So they may not be right up to date. However, they represent sound science.

Senator Benjamin L. Cardin

1) Do you believe that climate models are now sufficiently well advanced or soon will be sufficiently advanced to be able to project differences in climate at regional scales –like the difference between the average July temperature here in D.C. vs. that in Salisbury, MD (about 100 miles to our southeast)?

This question requires a number of qualifications in the answer. Climate models continue to advance but are limited by their fairly coarse resolution that is imposed by computer limitations. Bigger faster computers would enable increases in resolution that would realize further improvements. At present the grid in the atmosphere does not distinguish between Salisbury and D.C. By recognizing the observed average differences under

various conditions, useful information can be provided on the differences between the two, but it does not come directly from the climate models. Use of higher resolution regional models can enable "downscaling" of results with finer detail. Indeed, one way forward is embedding higher resolution regional models within climate models to resolve important regional scale weather and climate processes, as well as account for the influence of those processes on the large-scale climate. This approach, being developed at NCAR, has the potential to improve the fidelity of climate change simulations and their utility for local and regional planning, although the reproducibility and reliability of the initial results needs further evaluation.

A key aspect of regional climate prediction is the need to actually do predictions rather than the more general projections. The latter, as done by/for IPCC, are based on certain emission scenarios and the models are not initialized. That is to say, they are not started from the observed state at any time, where the state includes that of the atmosphere, the oceans, the land surface (including vegetation, snow cover etc), and sea ice. A prediction would firstly have to step up to obtaining all the requisite observations and making global analyses that can be used to initialize the climate model. It should secondly make a forecast of the so-called forcings, including human emissions. The latter is likely to be probabilistic (effectively weighting the emissions scenarios and updating them with recent data).

The predictability depends on time scale. In the near term (decades), emissions make little difference (except for visible pollution (aerosols)), but skill is expected for perhaps a few decades based on recent changes and memory within the climate system, especially the oceans. El Niño has demonstrated predictability for 6 months to a year, but not much more.

In summary, the answer depends not just on models, but also how they are run, what data can be used to initialize them, and the computer power that can be marshaled to enable multiple runs (ensembles) which can document the reproducibility to small changes (predictability). The ability to do this properly is still partly a research topic.

2) If not, what tools can decisions makers within states use to begin planning their adaptation and mitigation strategies?

I believe the first step with regard to adaptation is a more comprehensive analysis and assessment of what is happening now and has happened recently. This means making full use of available observations of not just the state of the climate system, but also the forcings [the atmospheric composition (greenhouse gases and aerosols), the sun (across the electromagnetic spectrum (ultraviolet to infrared)), and the land surface (changes in vegetation and its health, changes in land use etc)]. It also means linking the observed changes to the forcings and fully understanding why recent climate anomalies have occurred (such as the role of the recent La Niña). This immediately informs the prospects for reliable predictions. However, we already have a lot of observations and analyses. Some are not processed as quickly as they might be (near real time) and it is only a first step to produce the information base. It is another step entirely to promulgate and dispense this information to decision makers and users through a full climate service, that

also seeks feedback from and informs users about prospects for new products. Some such information is already available, for example through the National Climate Data Center (of NOAA), either as routine products or by special request.

For mitigation, the issues relate to the changes in forcings, and especially how and why emissions of long-lived greenhouse gases are changing. The “why” relates to reporting and whether or not countries are being honest. This is especially an issue under any cap and trade scheme that sets quotas by country or by industry. Who is in violation and how this is managed is a key issue, and so it requires detailed monitoring of carbon dioxide and other greenhouse gases, their sources and sinks, and the ability to model the carbon cycle so that one can tell with confidence whether a source is missing or understated. At present the ability to do this is limited.

More generally, there is a strong argument in favor of doing everything possible and practicable to reduce emissions and slow down the rates of climate change. I believe a toolkit of incentives and penalties is needed, but it requires very careful design (to level the playing field and with proper credits for past as well as future actions). The implementation is perhaps more critical (especially the time scale) than what is actually done.

3) What is necessary to improve the resolution of these projections - improved computing resources, research into improving the modeling of physical processes, or some combination of these activities?

There was recently (6-9 May 2008) a “Climate Modelling Summit for Climate Prediction” sponsored by the World Climate Research Program and others that produced a consensus statement related to this question. It calls for a quantum jump increase in computing, perhaps organized into a world center (although many interpret this as a virtual center and a framework for collaboration among major centers in, say, the U.S., Europe, and Japan), but also a marked increase in a scientific workforce with the requisite skills and training.

Improved computing resources clearly help, but many problems remain to be solved, and so improved modeling of physical processes (especially clouds) is also needed. So too is how to utilize the available observations in a physical framework (a model) when the model is imperfect. This relates to the need to be able to initialize models and make predictions.

4) Do you believe the fundamental climate research results are being communicated effectively to those decisions makers at state and local levels?

For the most part, no. I have given many public lectures and interacted with people at the local level, and many are very pleased to have good information, but the disinformation available muddies the waters. Many decisions have a component of weather and climate, and often rote formulae are employed that do not account for information available that could lead to improved decisions. Sometimes this is for legal reasons to protect those who make decisions, because not all will be right (in hind-sight). Not only is

communication needed on climate research results, but also how to use that information and make decisions that pay off (this can relate to benefits of many good decisions versus one bad decision, for example). Many people in areas where they know information could make a difference are eager for information, but what they need is not available except perhaps as a probability, and with some uncertainty. Learning how to use what is possible is necessary. Unfortunately, there are some who are skeptical who do not listen to the scientific evidence with an open mind. In the long run, they will be losers, but maybe we can't afford to wait?

5) What would you say the most important remaining uncertainties are in climate projections?

Undoubtedly the role of clouds and how they change, as the climate changes, is the largest source of uncertainty. Clouds are affected by aerosols (pollution) directly, as well as by climate, and sorting out the different influences is one problem. Aerosols are often listed as being a major uncertainty, and they are for past climate but we cannot go back and make observations that were not made at the time. However, aerosols have a short lifetime as they get washed out of the atmosphere by rain, and so it is essential for aerosols to be linked to clouds and water vapor, perhaps more strongly than is currently the case. Aerosols are often incorrectly treated as a forcing, whereas they are interactive unless the aerosol is in the stratosphere above the clouds and rain processes. Other key issues include the carbon cycle, regional climate change and how "modes" of variability in the atmosphere and climate change. The latter include El Niño and preferred patterns of behavior in winds and storm tracks.

6) What are your recommendations for improving climate monitoring capabilities?

I offer the following ten points:

- 1) Restore lost observations, especially those from space, as given by the climate instruments demanifested from NPOESS, and more fully in the NRC "decadal survey" report, but also include in situ observations that are declining in number.
- 2) Make most, if not all, observations suitable for climate (satisfying the climate principles that are designed to ensure continuity of record). This especially includes those from space.
- 3) Reprocess all past observations with the latest algorithms, technology, and knowledge to produce as reliable and homogeneous climate record of the past as is possible. This is inherently an international project that requires U.S. leadership but with coordination with other space agencies and in situ agencies.
- 4) Reanalyze all those observations into global gridded fields to create a comprehensive climate record that can be continued into the future.
- 5) Make all of these data available in ways that they can be readily retrieved and with easy access and as low cost as possible.
- 6) Upgrade the ability to process observations in real time into global fields that can be compared with the past record and determine how anomalous current conditions are.

- 7) Implement an operational attribution activity that carries out studies and numerical experimentation in near real time to allow reliable statements to be made not only about what the state of the climate is, but also why it is the way it is.
- 8) Implement a system to track the state of (health of) the climate observing system and ways (resources) to fix it when something goes wrong.
- 9) Implement new monitoring systems based upon recent research platforms or experiments. This part of the program should enable more efficient and less costly observations to be made. This suggestion includes especially making the ARGO float observations in the ocean operational and ongoing (currently they are mainly funded out of research budgets).
- 10) Implement the Global Climate Observing System (GCOS) Implementation Plan for essential climate variables.

Senator BOXER. Thank you, Doctor.
And now, Dr. Roy Spencer.

STATEMENT OF ROY W. SPENCER, PRINCIPAL RESEARCH SCIENTIST, EARTH SYSTEM SCIENCE CENTER, UNIVERSITY OF ALABAMA, HUNTSVILLE

Mr. SPENCER. I would like to thank you, Madam Chair, for the opportunity to address the Committee.

There are two issues I want to talk about. First, I would like to address the role of the White House in policy-relevant research performed by Government employees, which this Committee is obviously concerned with today. As a NASA employee performing climate change research during the Clinton-Gore Administration, I was told what I could and could not say during congressional testimony. Since it was well-known that I was skeptical of the view that mankind's greenhouse gas emissions are mostly responsible for global warming, I just assumed that this advice was to help protect Vice President Gore's political agenda on the subject.

But this did not particularly bother me, since I knew that as an employee of an executive branch agency, NASA, my boss ultimately resided in the White House. To the extent that my work had policy relevance, it seemed entirely appropriate to me that the privilege of working for NASA included a responsibility to abide by direction from my superiors. But when I finally did tire of the limits on my interactions with Congress and the press, I resigned from NASA in 2001 and assumed my present position as a University employee, where I have more freedom to speak on climate issues.

Now, second today and more importantly, I would like to present some of the latest scientific research regarding the relative roles of mankind and nature in climate change. As you might know, there remains considerable uncertainty over just how sensitive the climate system is to our greenhouse gas emissions. But now we have peer reviewed and published evidence, both theoretical and observational, that climate sensitivity estimates previously diagnosed from satellite data have been too high. The two papers describing that work are referenced in my written testimony.

Furthermore, in recent weeks, I believe we have attained what has been called the holy grail of climate Research, which is a true measurement of climate sensitivity. We have discovered why previous sensitivity estimates have been so high and so uncertain. They have been contaminated by natural cloud variability. And we have even developed two methods of removing that contamination. An analysis of 6 years of our latest and most accurate NASA satellite data reveals evidence of very low climate sensitivity. When translated into an estimate of future global warming, it would be less than 1 degree Celsius by 2100, well below the range of the IPCC's estimates of future warming.

If this new evidence of low climate sensitivity is indeed true, it also means, and this is very important, if we have low climate sensitivity, that also means that the radiative forcing being caused by the CO₂ we put into the atmosphere is not nearly enough to explain the warming we have seen in the last 100 years. There must be also some sort of natural warming mechanism involved.

And this is where the IPCC process has failed us. The IPCC has been almost totally silent on potential natural explanations for global warming. They mention a couple of external influences, such as volcanic eruptions and small fluctuations in solar output as possible minor players. But they have totally ignored the 800 pound gorilla in the room: natural internal chaotic fluctuations in the climate system.

In my written testimony, I show with a simple climate model a simple example of how small cloud variations associated with two known modes of natural climate variability, the El Nino/La Nina phenomenon, and the Pacific decadal oscillation, might explain 70 percent of the global average warming in the last 100 years, as well as its basic character, the warming that was experienced until 1940, slight cooling or constant temperatures until about the 1970's, and then resumed warming up until recently, since the satellite data shows that warming stopped about 7 years ago. But as Dr. Trenberth mentioned, short-term results are no indication of future potential.

While these new results that I am talking about are not yet published, I did present them in a seminar to about 40 climate researchers at the University of Colorado last week, and I received no serious objections to my analysis. It seems that the IPCC leadership has a history of ignoring natural climate variability. I often wonder, what evidence for natural sources of warming might have been found if the same amount of money and manpower was put to the task as the IPCC has used over the years. After all, remember, the IPCC is tasked with dealing with the human influence on climate. So they don't have a whole lot of motivation for finding possible natural explanations.

There is a story I would like to relate to you, and I have never told it before. In the early days of the IPCC, I was visiting the head of the White House's Office of Science and Technology Policy, the Director, Dr. Robert Watson, who later became the first chairman of the IPCC. He informed me and a work associate with me, that since we now had started to regulate ozone-depleting substances under the 1987 Montreal Protocol, the next goal, in his mind, was to regulate carbon dioxide emissions from fossil fuel burning. This was nearly 20 years ago. There was no mention of the scientific basis for that goal.

So as you can see, from the beginning of the IPCC process, it has been guided by desired policy outcomes, not science. I believe that most of the scientists involved in the IPCC are indeed reputable and honest. But they have been used by politicians, bureaucrats and a handful of sympathetic and outspoken scientists.

In conclusion, I am predicting today that the theory that mankind is mostly responsible for global warming will slowly fade away in the coming years, as will the warming itself. I trust you would agree, Madam Chair, that such a result deserves to be greeted with relief.

That concludes my testimony and I would be willing to answer any questions.

[The prepared statement of Mr. Spencer follows:]

**Testimony of Roy W. Spencer before the
Senate Environment and Public Works Committee on 22 July 2008**

I would like to thank Senator Boxer and members of the Committee for allowing me to discuss my experiences as a NASA employee engaged in global warming research, as well as to provide my current views on the state of the science of global warming and climate change.

I have a PhD in Meteorology from the University of Wisconsin-Madison, and have been involved in global warming research for close to twenty years. I have numerous peer reviewed scientific articles dealing with the measurement and interpretation of climate variability and climate change. I am also the U.S. Science Team Leader for the AMSR-E instrument flying on NASA's Aqua satellite.

1. White House Involvement in the Reporting of Agency Employees' Work

On the subject of the Administration's involvement in policy-relevant scientific work performed by government employees in the EPA, NASA, and other agencies, I can provide some perspective based upon my previous experiences as a NASA employee. For example, during the Clinton-Gore Administration I was told what I could and could not say during congressional testimony. Since it was well known that I am skeptical of the view that mankind's greenhouse gas emissions are mostly responsible for global warming, I assumed that this advice was to help protect Vice President Gore's agenda on the subject.

This did not particularly bother me, though, since I knew that as an employee of an Executive Branch agency my ultimate boss resided in the White House. To the extent that my work had policy relevance, it seemed entirely appropriate to me that the privilege of working for NASA included a responsibility to abide by direction given by my superiors.

But I eventually tired of the restrictions I had to abide by as a government employee, and in the fall of 2001 I resigned from NASA and accepted my current position as a Principal Research Scientist at the University of Alabama in Huntsville. Despite my resignation from NASA, I continue to serve as Team Leader on the AMSR-E instrument flying on the NASA Aqua satellite, and maintain a good working relationship with other government researchers.

2. Global Warming Science: The Latest Research

Regarding the currently popular theory that mankind is responsible for global warming, I am very pleased to deliver good news from the front lines of climate change research. Our latest research results, which I am about to describe, could have an enormous impact on policy decisions regarding greenhouse gas emissions.

Despite decades of persistent uncertainty over how sensitive the climate system is to increasing concentrations of carbon dioxide from the burning of fossil fuels, we now have new satellite evidence which strongly suggests that the climate system is much less sensitive than is claimed by the U.N.'s Intergovernmental Panel on Climate Change

(IPCC). Another way of saying this is that the real climate system appears to be dominated by “negative feedbacks” -- instead of the “positive feedbacks” which are displayed by all twenty computerized climate models utilized by the IPCC. (Feedback parameters larger than 3.3 Watts per square meter per degree Kelvin ($\text{Wm}^{-2}\text{K}^{-1}$) indicate negative feedback, while feedback parameters smaller than 3.3 indicate positive feedback.)

If true, an insensitive climate system would mean that we have little to worry about in the way of manmade global warming and associated climate change. And, as we will see, it would also mean that the warming we have experienced in the last 100 years is mostly natural. Of course, if climate change is mostly natural then it is largely out of our control, and is likely to end -- if it has not ended already, since satellite-measured global temperatures have not warmed for at least seven years now.

2.1 Theoretical evidence that climate sensitivity has been overestimated

The support for my claim of low climate sensitivity (net negative feedback) for our climate system is two-fold. First, we have a new research article¹ in-press in the *Journal of Climate* which uses a simple climate model to show that previous estimates of the sensitivity of the climate system from satellite data were biased toward the high side by the neglect of natural cloud variability. It turns out that the failure to account for natural, chaotic cloud variability generated internal to the climate system will always lead to the illusion of a climate system which appears more sensitive than it really is.

Significantly, prior to its acceptance for publication, this paper was reviewed by two leading IPCC climate model experts - Piers Forster and Isaac Held-- both of whom agreed that we have raised a legitimate issue. Piers Forster, an IPCC report lead author and a leading expert on the estimation of climate sensitivity, even admitted in his review of our paper that other climate modelers need to be made aware of this important issue.

To be fair, in a follow-up communication Piers Forster stated to me his belief that the net effect of the new understanding on climate sensitivity estimates would likely be small. But as we shall see, the latest evidence now suggests otherwise.

2.2 Observational evidence that climate sensitivity has been overestimated

The second line of evidence in support of an insensitive climate system comes from the satellite data themselves. While our work in-press established the existence of an observational bias in estimates of climate sensitivity, it did not address just how large that bias might be.

But in the last several weeks, we have stumbled upon clear and convincing observational evidence of particularly strong negative feedback (low climate sensitivity) from our latest and best satellite instruments. That evidence includes our development of two new methods for extracting the feedback signal from either observational or climate model data, a goal which has been called the “holy grail”² of climate research.

The first method separates the true signature of feedback, wherein radiative flux variations are highly correlated to the temperature changes which *cause* them, from internally-generated radiative forcings, which are uncorrelated to the temperature

variations which *result* from them. *It is the latter signal which has been ignored in all previous studies, the neglect of which biases feedback diagnoses in the direction of positive feedback (high climate sensitivity).*

Based upon global oceanic climate variations measured by a variety of NASA and NOAA satellites during the period 2000 through 2005 we have found a signature of climate sensitivity so low that it would reduce future global warming projections to below 1 deg. C by the year 2100. As can be seen in Fig. 1, that estimate from satellite data is much less sensitive (a larger diagnosed feedback) than even the least sensitive of the 20 climate models which the IPCC summarizes in its report. It is also consistent with our previously published analysis of feedbacks associated with tropical intraseasonal oscillations³.

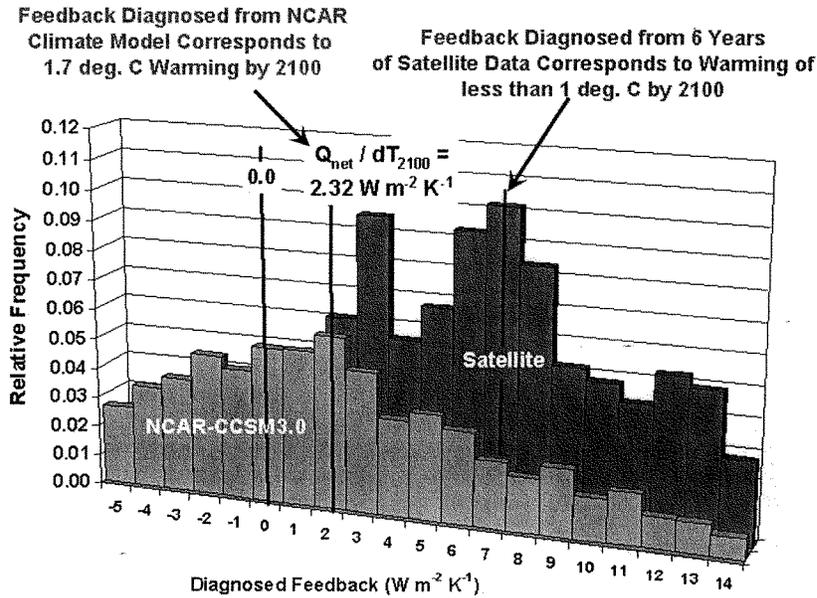
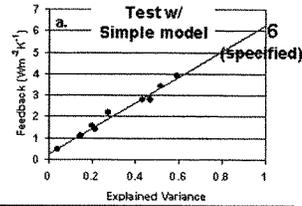


Fig. 1. Frequency distributions of feedback parameters (regression slopes) computed from three-month low-pass filtered time series of temperature (from channel 5 of the AMSU instrument flying on the NOAA-15 satellite) and top-of-atmosphere radiative flux variations for 6 years of global oceanic satellite data measured by the CERES instrument flying on NASA's Terra satellite; and from a 60 year integration of the NCAR-CCSM3.0 climate model forced by 1% per year CO₂ increase. Peaks in the frequency distributions indicate the dominant feedback operating. This NCAR model is the least sensitive (greatest feedback parameter value) of all 20 IPCC models.

A second method for extracting the true feedback signal takes advantage of the fact that during natural climate variability, there are varying levels of internally-generated radiative forcings (which are uncorrelated to temperature), versus non-radiative forcings

(which are highly correlated to temperature). If the feedbacks estimated for different periods of time involve different levels of correlation, then the “true” feedback can be estimated by extrapolating those results to 100% correlation. This can be seen in Fig. 2, which shows that even previously published⁴ estimates of positive feedback are, in reality, supportive of negative feedback (feedback parameters greater than $3.3 \text{ Wm}^{-2}\text{K}^{-1}$).

A Simple Climate Model forced with various amounts of radiative and non-radiative heat fluxes shows that the true feedback parameter can be estimated by extrapolating the different diagnosed feedback parameter estimates to 100% explained variance.



Reanalysis of the Feedback Parameters Diagnosed from 11 Years of Satellite Data by Forster and Gregory (2006) shows they are consistent with negative feedback, not positive feedback.

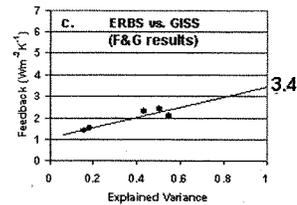
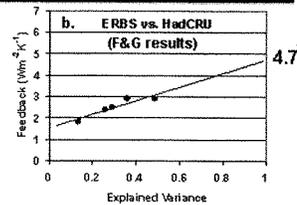


Fig. 2. Re-analysis of the satellite-based feedback parameter estimates of Forster and Gregory (2006) showing that they are consistent with negative feedback rather than positive feedback (low climate sensitivity rather than high climate sensitivity).

2.3 Why do climate models produce so much global warming?

The results just presented beg the following question: If the satellite data indicate an insensitive climate system, why do the climate models suggest just the opposite? I believe the answer is due to a misinterpretation of cloud behavior by climate modelers.

The cloud behaviors programmed into climate models (cloud “parameterizations”) are based upon researchers’ interpretation of cause and effect in the real climate system⁵. When cloud variations in the real climate system have been measured, it has been assumed that the cloud changes were the *result of* certain processes, which are ultimately tied to surface temperature changes. But since other, chaotic, internally generated mechanisms can also be the cause of cloud changes, the neglect of those processes leads to cloud parameterizations which are inherently biased toward high climate sensitivity.

The reason why the bias occurs only in the direction of high climate sensitivity is this: While surface warming could conceivably cause cloud changes which lead to either

positive or negative cloud feedback, causation in the opposite direction (cloud changes causing surface warming) can only work in one direction, which then “looks like” positive feedback. For example, decreasing low cloud cover can only produce warming, not cooling, and when that process is observed in the real climate system and assumed to be a feedback, it will always suggest a positive feedback.

2.4 So, what has caused global warming over the last century?

One necessary result of low climate sensitivity is that the radiative forcing from greenhouse gas emissions in the last century is not nearly enough to explain the upward trend of 0.7 deg. C in the last 100 years. This raises the question of whether there are natural processes at work which have caused most of that warming.

On this issue, it can be shown with a simple climate model that small cloud fluctuations assumed to occur with two modes of natural climate variability -- the El Nino/La Nina phenomenon (Southern Oscillation), and the Pacific Decadal Oscillation -- can explain 70% of the warming trend since 1900, as well as the nature of that trend: warming until the 1940s, no warming until the 1970s, and resumed warming since then. These results are shown in Fig. 3.

A Simple Climate Model Forced with Natural Cloud variations proportional to PDO and El Nino/La Nina (SOI)

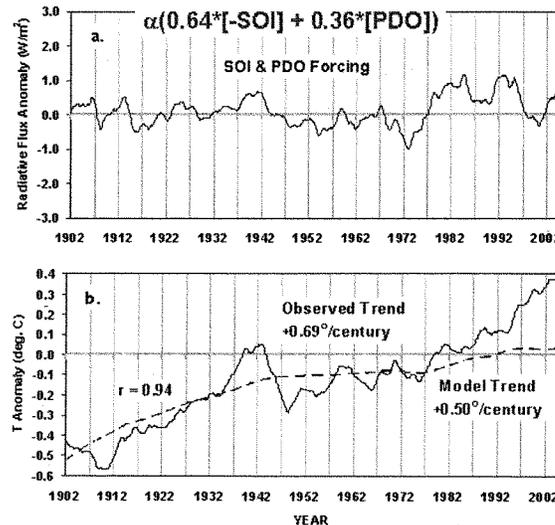


Fig. 3. A simple climate model forced with cloud cover variations assumed to be proportional to a linear combination of the Southern Oscillation Index (SOI) and Pacific Decadal Oscillation (PDO) index. The heat flux anomalies in (a), which then result in the modeled temperature response in (b), are assumed to be distributed over the top 27% of the global ocean (1,000 meters), and weak negative feedback has been assumed ($4 \text{ W m}^{-2} \text{ K}^{-1}$).

While this is not necessarily being presented as the only explanation for most of the warming in the last century, it does illustrate that there are potential explanations for recent warming other than just manmade greenhouse gas emissions. *Significantly, this is an issue on which the IPCC has remained almost entirely silent. There has been virtually no published work on the possible role of internal climate variations in the warming of the last century.*

3. Policy Implications

Obviously, what I am claiming today is of great importance to the global warming debate and related policy decisions, and it will surely be controversial. These results are not totally unprecedented, though, as other recently published research⁶ has also led to the conclusion that the real climate system does not exhibit net positive feedback.

While it will take some time for the research community to digest this new information, it must be mentioned that new research contradicting the latest IPCC report is entirely consistent with the normal course of scientific progress. I predict that in the coming years, there will be a growing realization among the global warming research community that most of the climate change we have observed is natural, and that mankind's role is relatively minor.

While other researchers need to further explore and validate my claims, I am heartened by the fact that my recent presentation of these results to an audience of approximately 40 weather and climate researchers at the University of Colorado in Boulder last week (on July 17, 2008) led to no substantial objections to either the data I presented, nor to my interpretation of those data.

And, curiously, despite its importance to climate modeling activities, no one from Dr. Kevin Trenberth's facility, the National Center for Atmospheric Research (NCAR), bothered to drive four miles down the road to attend my seminar, even though it was advertised at NCAR.

I hope that the Committee realizes that, if true, these new results mean that humanity will be largely spared the negative consequences of human-induced climate change. This would be good news that should be celebrated -- not attacked and maligned.

And given that virtually no research into possible natural explanations for global warming has been performed, it is time for scientific objectivity and integrity to be restored to the field of global warming research. This Committee could, at a minimum, make a statement that encourages that goal.

REFERENCES

1. Spencer, R.W., and W.D. Braswell, 2008: Potential biases in cloud feedback diagnosis: A simple model demonstration. *J. Climate*, in press.
2. Allen, M.R., and D.J. Frame, 2007: Call off the quest. *Science*, **318**, 582.
3. Spencer, R.W., W. D. Braswell, J. R. Christy, and J. Hnilo, 2007: Cloud and radiation

budget changes associated with tropical intraseasonal oscillations. *Geophys. Res. Lett.*, **34**, L15707, doi:10.1029/2007GL029698.

4. Forster, P. M., and J. M. Gregory, 2006: The climate sensitivity and its components diagnosed from Earth Radiation Budget data. *J. Climate*, **19**, 39-52.
5. Stephens, G. L., 2005: Clouds feedbacks in the climate system: A critical review. *J. Climate*, **18**, 237-273.
6. Schwartz, S. E., 2007: Heat capacity, time constant, and sensitivity of the Earth's climate system. *J. Geophys. Res.*, **112**, D24S05, doi:10.1029/2007JD008746.

Environment and Public Works Committee Hearing
July 22, 2008
Answers to Follow-Up Questions

Questions from: Senator Benjamin L. Cardin
Answers from: Roy W. Spencer

Question 1. In your opinion what are the most important remaining uncertainties in climate projections?

Answer to Question 1:

I believe there really is only one overriding uncertainty, and that is the sensitivity of the climate system. The strength of future manmade climate change entirely depends upon figuring out the climate sensitivity value, as does the answer to how much of the warming seen over the last century is natural versus manmade. There has not been enough work on this important question, which I believe will only be answered (if at all) through analysis of global satellite data from a number of sensors.

Question 2. Are the sensitivities (and related feedbacks) you estimate from satellite studies and which you believe to have been overestimated in climate models important on the timescales relevant to climate?

Answer to Question 2:

We don't know yet. We are currently analyzing climate model output from the IPCC models to see if any of the measures we have of short term feedbacks are related to long-term climate sensitivity in those models. Hopefully, we will find such short-term signatures of long-term climate sensitivity in the models which we can then test with the satellite data. This is my primary research goal at this time.

Senator BOXER. OK, we are going to, before you start my time, this is the list of how I am going to call on people. After I finish my questions, Senator Craig, then unless there is an objection, Senators Lautenberg, Cardin, Klobuchar, Whitehouse and Sanders. Is that acceptable to everybody? OK. And we are going to give each of us 6 minutes.

Mr. Spencer, did you quit NASA when Bill Clinton was President or George Bush was President?

Mr. SPENCER. I believe when George Bush was President.

Senator BOXER. I also want to point out that on your own blog, you said you never were told you couldn't speak about your scientific views. And I think that is really key. Because what we have happening now is the scientific views are being censored. Last, I guess there is a certain congratulations, Rush Limbaugh referred to you as the official climatologist of the Rush Limbaugh excellence in broadcasting network.

Mr. SPENCER. Yes, that is a tongue-in-cheek reference.

Senator BOXER. Right. But I just wanted to point that out for people to understand, we know that Mr. Burnett has been forthcoming about his problems and where he stands. I just want to make sure everybody knows what is really happening.

Mr. Burnett, one of the things I said in my opening is that we need to get started on this. And I said that since the President has decided not to, and obviously you confirmed that, saying they are just kicking this to the next Administration, one way we could get started is if they signed the waiver. That is why that waiver decision was so crucial. They are doing nothing. The States, almost 19 of them, want to act.

So I am going to ask you a few questions, mostly yes or noes, but I want to get the record clear. Because I am having trouble getting everything that was promised to me by Mr. Johnson. He promised e-mails, we are getting nothing. And we are going to talk about that, colleagues, on Thursday. We may have to subpoena these documents.

But let me ask you, did Administrator Johnson discuss with you his plan in December 2007 to inform the White House that he wanted to move forward with at least a partial waiver for California?

Mr. BURNETT. Yes. We had a two-part plan, if the Clean Air Act remained as is, specifically the relevant section of the Clean Air Act was not amended by Congress, the plan was to move forward with a partial grant of the waiver. However, if Congress chose to amend the Clean Air Act, then of course we would have to evaluate the new law.

Senator BOXER. OK. In order to support the plan to grant the partial waiver, did Administrator Johnson indicate that the compelling and extraordinary conditions needed to meet the test to grant California the waiver, and the other States, that test had been met?

Mr. BURNETT. As part of the plan to grant a partial waiver, certainly it was the case that all three criteria in the Clean Air Act would be met, including the criteria that California has compelling and extraordinary circumstances.

Senator BOXER. Did you prepare Administrator Johnson for a meeting at the White House on the California waiver, and did he communicate to you that he understood there was no reasonable defense of a denial of the California waiver, and that a denial was likely to lose in the courts?

Mr. BURNETT. First, on the issue of the legal vulnerability, I think that materials from our Office of General Counsel have stated that it is highly likely a denial will lose in court. That was certainly communicated in multiple form to Administrator Johnson.

Senator BOXER. OK. After returning from the White House, did Administrator Johnson inform you or were you aware for any other reason that the President of the United States had asserted the policy position that there should be only one emission standard applicable to vehicles, despite the requirements of the Clean Air Act?

Mr. BURNETT. Yes. President Bush had made it clear through a variety of mechanisms of his policy preference for a single standard and an approach that would not be consistent with Administrator Johnson granting the waiver. That was made clear in a variety of conversations and also was reiterated in the statement of Administration policy as part of the debate on the Energy Bill.

Senator BOXER. And just for the record, the Clean Air Act has always, well, since I think it is the 1970's said that this waiver process should be able to move forward, and that there wouldn't be a patchwork but there would be one Federal standard. And if California decided to move in a tougher direction, that would open the door for other States to follow. Is that correct?

Mr. BURNETT. Yes. The basic structure of the Clean Air Act is that California alone can design a different system from the Federal system, and then other States have a choice of either following California or continuing to use the Federal system.

Senator BOXER. OK. Did Administrator Johnson make it clear to you that the Energy Bill and its outcome were a consideration in his decision on the waiver?

Mr. BURNETT. The Energy Bill certainly was a consideration. It was provided as the policy context, if you will, for the denial of the waiver. That policy context was articulated in a letter from Administrator Johnson to Governor Schwarzenegger on December 19th, 2007.

Senator BOXER. And it was interesting to me because the Supreme Court clearly said, any action by DOT has nothing to do with the obligations of the EPA. So when he came before us and talked about that, we were very shocked.

Did the Administrator commission an analysis comparing the Energy Bill to the California waiver?

Mr. BURNETT. Yes. As the Energy Bill was moving its way through both Houses of Congress, there was a comparison done at Administrator Johnson's request of the fuel economy requirements of the Energy Bill compared with the effective fuel economy requirements of the California program.

Now, that comparison was difficult to make. And there are a number of complications in that comparison. The vehicle fleet is different in California. The years of the program are different. The California program phases in more quickly than the Federal program.

So we attempted to perform a comparison, but that comparison really ultimately was an apples to oranges comparison.

Senator BOXER. OK, my last question, and I am sorry, colleagues, for going a little over time here, did you recommend that the California waiver be granted, and did you as the chief climate advisor to the Administrator inform him that the waiver was supported by the law and the facts?

Mr. BURNETT. Yes. California had made, in my mind, a convincing case that it met all three criteria as required by the Clean Air Act. My advice, my recommendation, as well as the advice and recommendation of all other advisors within EPA that I am aware of was for Administrator Johnson to grant the waiver or at least grant the first few years of the waiver.

Senator BOXER. Thank you very much.

Senator CRAIG.

Senator CRAIG. Thank you very much, Madam Chairman.

Gentlemen, thank you for being with us today.

Dr. Spencer, let me only make comment and then ask you a brief question. Being politically incorrect in today's climate change debate is not necessarily popular. It isn't popular before this Committee sometimes, it isn't popular in the world of public opinion. So as an outsider, if you will, but a scientist, on climate change, what does the scientific community around climate change think of your findings and your expressions?

Mr. SPENCER. I receive really no negative direct input from the scientists that are qualified to cast judgment on my published Research. It is usually met with silence, which in the past I have found usually means that you are making good points that people don't want to address, since everybody is just silent on the evidence you have put forward.

Senator CRAIG. I thank you for that. I have been a fairly regular attendee of the climate change conferences around the world. I recognize that it is a thriving cottage industry at times. Thank you for your observation, and please, continue your work. There deserves to be reasonable counterpoint to this debate.

Mr. SPENCER. There are more like me out there, Senator.

Senator CRAIG. Thank you.

Dr. Trenberth, you gave passing comment as it relates to forest fires and climate change. I am frustrated, because I see that as an ingredient of tremendous importance in our Country. The skies of my State, Idaho, were filled with smoke this weekend, but the smoke wasn't from Idaho. It was from California. And we have seen the tremendous episode California has already had this year.

In 1991, a group of scientists met, they just happened to meet in Idaho, but they were forestry scientists, both forest managers and forest scientists. At that time, in 1991, they determined that there were millions of acres of forests in the Great Basin West and in the Sierras that were dead and dying. As a result, if there was less than any activity in managing these forests, they would result in massive wildfires over the decades to come.

Now, of course, because of the tremendous population and fuel buildup in our forests, and a slight change in temperature, we are seeing the consequences of that. Last year's forest fires produced about an equivalent of carbon into the atmosphere upwards of 12

million automobiles operating annually. Yet very little is said by scientists today as to natural emissions of carbon into the atmosphere. And this Congress denies the Forest Service an active management role in our forests to change the dynamics of forests, even if you accept warming as I do, and the consequence of that in the lower elevations in the Great Basin West and in the Sierras.

Why aren't scientists dealing more with the consequences, the vegetative consequences? And why aren't they advocating active management to reduce fuel loads and therefore reduce carbon?

Dr. TRENBERTH. Senator, in my own testimony, I actually comment on one way of dealing with the increased risk of wildfires is indeed to cut down on litter and to try to reduce the risk of wildfire. It is something that you do have control over.

There are of course a lot of natural variations. The things that have come into play in recent years in the West especially is the major drought in 2002 which weakened many of the trees, especially the lodgepole pine that has subsequently become infested with the bark beetle. And the bark beetle itself is affected by, can be affected by climate and can get killed off if there is a cold spell when the pupae goes into the tree in the beginning of the fall or when it comes out in the spring, if the temperatures are below about 10 degrees Fahrenheit. In the middle of winter, it can also be killed off with a very cold spell of about minus 30 degrees Fahrenheit. In recent times, we have not had those. So there is a warming component to the infestation that has occurred much more recently throughout the West and has increased the risk of wildfire over many other regions as well.

Senator CRAIG. I appreciate that comment. Lodgepole pine are of course a climatic species, and we understand their ebb and flow. It is interesting today the fires in California were not necessarily in the lodgepole areas. They serve obviously as ladders, sometimes, for fire. You are right about bug kill, and you are right about the bug itself. It is also possible to deter that if you interject the human into the process when you recognize it is happening, by taking out those bug kill areas so that they don't spread. We are being denied that. I guess that is my point, active management can help us.

Madam Chair, my time is up or nearly up. I thank you, Jason, thank you for being with us. I would ask unanimous consent that I enter into the record some additional information in relation to Jason Burnett.

Senator BOXER. Without objection.

[The referenced information follows:]

JASON K. BURNETT AND THE PACKARD FOUNDATION

Son of Nancy Burnett (officer on the board of trustees for the David and Lucille Packard foundation) and grandson of David and Lucille Packard

The David and Lucille Packard Foundation is the one of the wealthiest in the world.

2007 ANNUAL REPORT FOR THE DAVID AND LUCILLE PACKARD FOUNDATION

Total Awards amount for 2007—\$273,927,605
 Environmental Defense—\$1,219,500
 Natural Resources Defense Council—\$446,572
 World Wildlife Fund—\$3,555,250
 Sierra Club Foundation—\$300,000

Union of Concerned Scientists—\$125,000

JASON K. BURNETT CAMPAIGN CONTRIBUTIONS

Barack Obama—\$5900
 Al Gore—\$1000
 EMILY's List—\$15000
 Democrat Senatorial Committee—\$52,500
 Joseph Lieberman—\$2000
 Claire McCaskill—\$2100
 Jim Webb—\$2100
 Diane Feinstein—\$500
 Hilda Solis—\$500
 Debbie Stabenow—\$1000
 Sheldon Whitehouse—\$2100
 Robert Menendez—\$2100
 Jon Tester—\$2100

Senator CRAIG. Thank you.

Senator BOXER. Senator Lautenberg.

Senator LAUTENBERG. Thank you, Madam Chairman.

Mr. Spencer, since you ascribe the problems with changing climate to natural causes, is it then suggested that we just kind of throw up our hands and wait and let nature take its course and put our children in the position of the canaries in the coal mine and see if they drop and then decide that the weather has really—

Mr. SPENCER. First of all, I am of the strong professional opinion that most of the warming is due to nature, rather than mankind. I don't see how mankind can't have some influence. After all, the presence of trees on the planet changes the planet compared to if the trees were not there. It would probably be hard for the climate and the earth to not know that 6 billion people live here.

But to the extent that we do influence climate, then of course, you are into a policy issue. And you have to look at how difficult it would be to change what we are doing, business as usual. And as I have written before numerous places on this subject, the way out of this problem, to the extent there is a problem with carbon dioxide emissions, is through technology. It is going to take new technology that we don't currently have, and you cannot legislate new technology into existence. It is created by wealthy societies, wealthy countries, countries that have free market economies, that have the excess wealth to devote to those new technologies.

That is where I think the answer would be, to the extent that carbon dioxide is a problem.

Senator LAUTENBERG. So a poor country like ours would have to wait for those wealthy ones to get there?

Mr. SPENCER. Well, we already spend billions of dollars, Senator, on new alternative energy Research. I don't know why that is never mentioned. Maybe we could spend more, I don't know.

Senator LAUTENBERG. Thank you very much.

Mr. Burnett, you said in an interview with the House Select Committee on Global Warming that some oil companies, including ExxonMobil, told the Administration that moving forward with greenhouse gas emission regulations would "taint President Bush's legacy by having on his legacy an increase of regulations." Have you heard that?

Mr. BURNETT. The basic policy debate within the Administration was whether the Administration should move forward with the re-

sponse to a Supreme Court and most within the Administration believed that they would be able to better set the course for the inevitable regulation by moving forward.

However, the counter-argument was a concern that moving forward would lead to an increase in regulation. We are of course, talking about regulation of greenhouse gases.

Senator LAUTENBERG. Right.

Mr. BURNETT. And that is not something that this President wanted to have associated with him.

Senator LAUTENBERG. Right. The oil company's assertion that any regulation was unacceptable, even if it was necessary to protect the public's health, is that a proper view of what was taking place?

Mr. BURNETT. Well, the question was whether we would go public with a finding that there was endangerment to human health or welfare.

Senator LAUTENBERG. Keep it secret as an alternative.

Mr. BURNETT. Whether or not to go public, yes.

Senator LAUTENBERG. What is the position of career scientists at EPA? What is the position of the career scientists there?

Mr. BURNETT. Well, in fact it was the position of the Administration that the public is endangered by greenhouse gases. We had an extensive policy process within the Environmental Protection Agency and across the Federal Government that culminated in a Cabinet level meeting where there was agreement that the public was in danger. The question now is simply when that finding will be made public.

Senator LAUTENBERG. Dr. Trenberth, the EPA and other scientific agencies put out a report last week showing real impacts to the United States from global warming. We have this chart on display here, which I am sure you have seen. And if not, we will get you a copy, I promise.

Are the findings of this report consistent with the recent findings of the Intergovernmental Panel on Climate Change such that there shouldn't be any dispute over the reality of global warming and its effects?

Dr. TRENBERTH. I haven't read that report in detail. As far as I can judge, it was very heavily based upon the IPCC report. As a result, it is probably a couple of years out of date. So it is quite conservative in that regard.

Senator LAUTENBERG. Thank you. Are we approaching a point of no return where it will be too late to fully protect our people from the impacts of global warming?

Dr. TRENBERTH. Global warming consequences are already with us. They are certainly going to continue to happen in the future. We need to recognize that and therefore plan accordingly. I don't think we are doing that, and you can see the evidence of that from the devastation that occurred along the Mississippi with the floods that overtopped levees through, what scientists have recognized for at least 10–15 years, the much heavier rains. So what used to be a 500 year flood is now a 30-year flood.

Senator LAUTENBERG. Thank you very much.

Senator BOXER. Senator Lautenberg, thank you so much for that.

Senator CARDIN. I am going to run out for 1 minute, be right back.

Senator CARDIN. Thank you, Madam Chair.

Mr. Burnett, let me followup on this, if I might. Because I am reading from your testimony and from your statements here today in which you underscore, given the profound consequences of making an endangerment finding, we worked to ensure that we had agreement across the Federal Government. Your written statement then goes through some of the potential alternatives to making an endangerment, some theories that could be used, including actions already taken. And you come to the conclusion that despite these various theories, the Administration recognized that the only supportable answer to the Supreme Court was to find that greenhouse gases endanger the public.

Then as you pointed out in response to Senator Lautenberg's question, the policy process culminated in a Cabinet level meeting in November 2007, where agreement was reached that greenhouse gases endanger the public, and therefore, that regulation was required, from your statement.

Were you present at that Cabinet level meeting?

Mr. BURNETT. I was not present at the Cabinet level meeting. I was part of the senior team that coordinated the interagency process that began in the summer of 2007 and ran through in preparation for the Cabinet level meeting. Administrator Johnson represented, as the Cabinet level official of the EPA, represented the agency at that meeting.

Senator CARDIN. How were you apprised of the finding at the Cabinet level meeting? How did you find out about that?

Mr. BURNETT. I had helped prepare the briefing papers for members of the Cabinet in preparation for that meeting. And Administrator Johnson and Deputy Administrator Marcus Peacock returned from that meeting and asked for us to draft a regulatory finding that reflected the decisions reached in that meeting.

Now, to be extra cautious and certain that in fact the finding that we developed reflected those decisions, I took the extra steps of reading portions of that finding to the Office of Management and Budget before it was formally submitted. And then I checked with the head of the regulatory office of OMB to make sure that OMB was ready to receive that findings for formal review. Upon reaching agreement that it was ready for review, I sent it to OMB. So we took a number of steps to ensure that it was not simply EPA, but the entire Federal Government that was in agreement with moving forward with a finding that the public was endangered.

Senator CARDIN. Do you know who was at the Cabinet meeting?

Mr. BURNETT. I have an understanding from the report back from the meeting who was in attendance. And I certainly know the agencies and departments and offices of the White House that were centrally involved in the policy process throughout most of last year. We had meetings three times a week, generally at the Old Executive Office Building, hosted by OMB and attended by many individuals across the Federal Government.

Senator CARDIN. So you were confident that the Cabinet level meeting in November was an agreement that greenhouse gases en-

danger the public and therefore regulation was required was reached at that Cabinet level meeting?

Mr. BURNETT. Yes. In fact, Administrator Johnson has said he took the extra step of checking with the President's chief of staff office and the Deputy Chief of Staff, Joel Kaplan, to make sure that in fact that Cabinet level meeting was sufficient for Administrator Johnson to announce to staff at EPA that a decision had been made and to proceed with work in drafting the formal document that found that the public was endangered.

Senator CARDIN. And then what happened after that? Why were no regulations issued? Why didn't it go forward?

Mr. BURNETT. Well, the series of events over the course of December 5th were strange indeed. That morning, I had made sure that OMB was ready to receive the finding formally, for formal review. I had checked with my colleagues at EPA to make sure that there was agreement within EPA that it was ready to be sent over. I sent the document over, and we then received a phone call requesting that we not send the document. We informed the individual that the document had been sent, and we were asked to recall the document.

Senator CARDIN. Asked by whom?

Mr. BURNETT. By Deputy Chief of Staff Joel Kaplan, to recall the document or send a followup note stating that the document had been sent in error. I couldn't do that.

Senator CARDIN. So you were preparing the necessary paperwork to make the declaration, you were then asked to recall that document?

Mr. BURNETT. Yes, sir.

Senator CARDIN. Then what happened next? Did you recall it?

Mr. BURNETT. No, sir. It represented the culmination of our policy process, the response to the Supreme Court and our required action under the Clean Air Act. There was then a period of waiting while the Energy Bill moved through Congress and continued debate through early this year about whether this Administration wanted to answer the Supreme Court and release the finding, or whether it wanted to allow the next Administration to take that action.

Senator CARDIN. So the next thing you know, it was basically punted to the next Administration by not making a finding?

Mr. BURNETT. Ultimately, what the Administration has decided to do is issue an advance notice of proposed rulemaking, which is not a regulatory action. It is designed in part to solicit public input and in part to make sure that it is the next Administration, not this Administration, that makes the important decisions about how to move forward with the Clean Air Act.

Senator CARDIN. Thank you, Madam Chair.

Senator BOXER. Thank you so much, Senator.

Senator KLOBUCHAR.

Senator KLOBUCHAR. Thank you very much, Madam Chair.

I apologize for mispronouncing your name, Mr. Burnett. My daughter just returned from French camp, and will only speak to me in French. So it was in my head.

The issue that Senator Cardin was raising with you about you sending over this e-mail, it was an e-mail, is that correct, to the OMB?

Mr. BURNETT. Yes, Senator.

Senator KLOBUCHAR. And then this Deputy Chief of Staff, Joel Kaplan, called you and said, take it back or send a note that we didn't send it, is that right?

Mr. BURNETT. To clarify, he called the Administrator and the Administrator asked whether I would be able to send a follow-up note. Upon explaining that it had not been sent in error, there is agreement at EPA that it wouldn't be appropriate for me to send such a note.

Senator KLOBUCHAR. And do you know if someone from the White House or if someone told him to not open this? Was there someone outside of OMB? Do you know who that person is?

Mr. BURNETT. It is my understanding from conversations with individuals at OMB that they were directed not to open the e-mail, so that the e-mail would not be in receipt, so that OMB could say that they had not received a finding of public endangerment, and therefore, the public transparency provisions of the Clean Air Act and the Executive Order 12866 would not be triggered.

Senator KLOBUCHAR. And do you know who ordered them to not open it?

Mr. BURNETT. I do not know, since I was not part of that conversation.

Senator KLOBUCHAR. OK. Mr. Burnett, press accounts say that the White House instructed the EPA to change their calculations regarding the cost of greenhouse gas emissions to our society. Why do you think they wanted to minimize the net benefit to society of controlling carbon emissions?

Mr. BURNETT. Well, let me first say that the regulation that we were working to develop would have resulted in an increase in fuel economy of the Nation's cars and trucks. And that would have resulted in a number of benefits besides reducing greenhouse gases. Perhaps most importantly for the current debate about energy prices, it would have reduced the pain at the pump by reducing the quantity of gas that Americans need to put in their tanks.

There was a desire for a less aggressive regulation to be put forward by the Department of Transportation, rather than a more aggressive regulation that EPA thought, that EPA analysis would have been in the benefit of the American people.

Senator KLOBUCHAR. The New York Times has written that you went back and forth in memos to OMB over the definition of carbon dioxide molecules. Could you tell me about that debate?

Mr. BURNETT. As I stated previously, there was a robust inter-agency process. I was at almost all of those meetings hosted by OMB. A number of questions were raised during that process, given the profound ramifications of making an endangerment finding, including the definition of various terms within the Clean Air Act, such as air pollutant or air pollution or what exactly is meant by the cause and contribute test of the Clean Air Act.

All of these terms are important terms, and we wanted to make sure that we got it right, not only for the immediate regulations for cars and trucks, but also because we believed that it would lead to

regulations and set the precedent for how regulations were developed for a variety of stationary sources.

Over the course of that discussion, there was quite a bit of effort and interest to see whether the Supreme Court case itself and regulation of CO₂ and other greenhouse gases from automobiles could be restricted to just regulation of automobiles. How the Clean Air Act works is that after a pollutant is a regulated pollutant, controls are required on a variety of sources. So there is an interest to determine whether we could define CO₂ from automobiles as somehow different than CO₂ from power plants, for example. Clearly that—

Senator KLOBUCHAR. Do you think that is possible?

Mr. BURNETT. Clearly it wasn't supportable.

Senator KLOBUCHAR. And who was trying to argue for that?

Mr. BURNETT. Well, several individuals were trying to make that general case.

Senator KLOBUCHAR. People within OMB?

Mr. BURNETT. Jeff Rosen, as part of the General Counsel's Office at OMB, had raised that question multiple times. And I must say that it was sometimes somewhat embarrassing for me to return to EPA and ask for my colleagues to explain yet again that CO₂ is a molecule and there is no scientific way of differentiating between CO₂ from a car or a power plant.

Senator KLOBUCHAR. Thank you. That is what I was talking about earlier about believing in science. I appreciate what you have done to stand up for science. Hopefully in the end we will get this done based on science.

Dr. Trenberth, just a quick question to followup. Of course I am very interested in the flooding issue and these enormous rainfalls that we have had suddenly in the Midwest. We had them last year, we had eight people die in Southern Minnesota, and now we have another one where I stood in front of a huge stretch of road, yards and yards long that had just collapsed, and a man died trying to get a sump pump, the road collapsed out from under him because of the water. You talked about the fact that 500 year floods are not 30 to 50 year floods. Could you just expand on that for 1 minute about what we can expect in the future and why this is happening?

Dr. TRENBERTH. Over the past century, rains in the U.S. are up about 7 percent. But it is not really a linear trend. There was a jump around the 1970's, and the rainfall has been running on average that much higher. It is mainly east of the Rockies.

At the same time, the heavy rains, the top 5 percent are up 14 percent. And the very heavy rains, the top 1 percent are up 20 percent. The main reason is well understood, and it is because there is about 4 percent more water vapor in the atmosphere. That is a number which comes directly from about 1 degree Fahrenheit warming over the planet. So the air can hold more water at a rate of about 4 percent for every 1 degree Fahrenheit higher air temperature.

Senator KLOBUCHAR. So the warming causes more water in the atmosphere?

Dr. TRENBERTH. The weather systems reach out, grab that water vapor, concentrate it, dump it down and so the natural consequence is heavier rains.

Senator KLOBUCHAR. Very good for 1 minute. Thank you very much.

Senator BOXER. Thank you, Senator Klobuchar.

Before I call on Senator Whitehouse, I just was told that the Metropolitan Washington area is under a severe weather alert, 40 mile per hour winds, lightning and heavy downpours, just coincidentally. This has nothing to do with anything, but I thought I would throw that out.

Senator SANDERS. Barbara, you arrange these props extraordinarily well.

[Laughter.]

Senator BOXER. Thank you, sir.

Go ahead, Senator Whitehouse.

Senator WHITEHOUSE. Thank you, Chairman Boxer.

Mr. Burnett, were you at the EPA long enough or in a position adequate to get a sense of what the routine meetings and conversations were between the Administrator and the White House?

Mr. BURNETT. My focus was on climate and energy policy. I think that I am generally aware of the conversations and the policy process related to those issues. I can't say that I am personally and substantially familiar with other conversations regarding other issues before the agency.

Senator WHITEHOUSE. Were there routine meetings between the Administrator and the White House on the California waiver Clean Air Act issue?

Mr. BURNETT. There were a number of meetings that the Administrator had, a number of meetings that I and others had.

Senator WHITEHOUSE. Would you characterize them as routine?

Mr. BURNETT. I don't think that there was, well, this was the first vehicle waiver that I was substantially involved with. And so I want to be cautious about not suggesting that I had experience with other waivers.

But I was familiar with the general policy process for regulations.

Senator WHITEHOUSE. Were the meetings that we are talking about related to the California waiver, the Clean Air Act waiver, specific to that? Or were they part of a routine schedule that the Administrator had, going to the White House on a regular basis and this would be on the agenda, this particular time? Or were these meetings that were scheduled specifically to address this and not part of a routine, ongoing scheduled meeting process?

Mr. BURNETT. Both. There were some meetings that were specifically scheduled to talk about the California waiver, and other meetings to talk about a range of issues relating particularly to climate policy, including the response to the Supreme Court and the California waiver.

Senator WHITEHOUSE. And were there meetings specific to the California waiver that you would not characterize as routine, that were specifically scheduled for that purpose?

Mr. BURNETT. Well, there were meetings specifically scheduled for that purpose, as I said.

Senator WHITEHOUSE. Not just dropped in as an agenda point on a regularly scheduled meeting?

Mr. BURNETT. Yes, meetings that were specific to talk about the California waiver. But I am not sure if that means that they were routine or not. It certainly was the case that this issue of the California waiver received a great deal of attention from a number of people throughout the Administration.

Senator WHITEHOUSE. Would it be accurate to say that in those meetings Administrator Johnson's contribution was limited to an update on the status of the waiver action?

Mr. BURNETT. I—there was an effort that we were engaged in and that I was engaged in to make the case that it would be appropriate to issue at least a partial grant of the waiver. Ultimately, we were not successful in making that case, and ultimately the Administrator decided to deny the waiver.

Senator WHITEHOUSE. From your perspective, did the White House understand that the responsibility for addressing and making a decision on the waiver rests with the Administrator?

Mr. BURNETT. That is an interesting question that has been brought to light in a recent ozone decision, where the President reached a different conclusion than the Administrator. And the President's policy was ultimately followed.

Senator WHITEHOUSE. In the Clean Air Act waiver, after the White House was notified of the proposed decision that you put together, did the White House respond to that notice that you intended to partially grant the waiver?

Mr. BURNETT. The response was clearly articulating that the President had a policy preference for a single standard that would be inconsistent with granting the waiver.

Senator WHITEHOUSE. That was the response from the White House?

Mr. BURNETT. Yes.

Senator WHITEHOUSE. And it was a response to the Administrator?

Mr. BURNETT. That is my understanding of the conversations that the Administrator had, and that certainly is the, the statements that I received directly from individuals in the White House.

Senator WHITEHOUSE. Would they have made sense if the Administrator weren't aware of them? I mean, it was clearly implicit that this had been communicated to the Administrator, correct?

Mr. BURNETT. It was—

Senator WHITEHOUSE. If not directly, directly through staff?

Mr. BURNETT. It was well known and the Administrator certainly knew the President's policy preference for a single standard.

Senator WHITEHOUSE. Which had been communicated to him after he had heard the proposal to grant the partial waiver?

Mr. BURNETT. We had been working on a variety of options ranging from a grant to a denial. I thought that the option that had the most prospect of moving forward in this Administration was a partial grant of the waiver. We tried to argue that could be done in a way that was both legal, legally supportable and consistent with the general policy direction that we were receiving.

Senator WHITEHOUSE. But just in terms of the timing, that the White House response to that followed, that notification to the White House that was your intention? In terms of the order.

Mr. BURNETT. Well, there were multiple meetings. So I want to simply be cautious about the exact sequence, because there was back and forth. But we went forward with our plan, told the White House about our plan to have a partial grant of the waiver, and in response, we were reminded of the President's policy preference.

Senator WHITEHOUSE. Got you.

Madam Chair, will we have a second round? I have two more questions I would like to ask. And I would like to allow Senator Sanders to proceed with his. OK, thank you.

Senator BOXER. Senator Sanders.

Senator SANDERS. Thank you, Senator. And thank you, Senator Boxer, for holding this hearing, and I want to thank the panelists for being here.

Senator BOXER.

[Remarks off microphone.]

Senator SANDERS. We have a vote, we have to be out of here in about 10 minutes.

Senator BOXER.

[Remarks off microphone.]

Senator SANDERS. I want to thank the panelists. I am not going to ask Mr. Burnett any questions, because I think he has received enough questions. What he is doing today is important, because it only confirms, I think, what many of us have known for years, is that with the Bush-Cheney Administration, we have an administration that will go down in history as having the worst record that I can think of any administration in the history of our Country. But they have been especially bad and outrageous in environmental matters. And they stand uniquely alone. If you even compare the Bush administration to his father, who was a moderate on these issues, the decisions and actions of this Administration will cause incalculable harm for the future. It is going to take us many, many years, if ever, to recover and reverse what they have done.

What I want to do is ask Dr. Trenberth a question. If we do not reverse global warming and if the planet continues to warm up, and if we see more drought, if we see more flooding, if we see the loss of arable land, if we see mass migrations because people are unable to farm or grow the food that they need, if we see the result, more and more illnesses develop, what happens? Talk a little bit about the impact of human health and global warming.

Dr. TRENBERTH. Of course, what happens is that this doesn't happen everywhere all at once. Usually it happens episodically. So we see examples like what happened with Katrina in our Country, indicating that indeed a western country leading the world, the United States, was not up to and didn't have the infrastructure to deal with that kind of a disaster.

So this year there have been major disasters in Myanmar (Burma) and the Philippines as a result also of hurricanes. So these things happen from time to time and they affect different areas. And you read about them in the news. But they don't affect everywhere all at once. The same thing tends to happen with droughts. The droughts move around from 1 year to the next. It is easy to say, well, maybe this is natural variability, and natural variability is playing a role. The thing is that we have, in fact,

nowadays, global warming and natural variability going hand in hand.

Another really good example was what happened in Europe in 2003. The magnitude of the heat waves that occurred at that time was unprecedented there is no way that this, and in Europe they have records for centuries.

Senator SANDERS. How many people died? My recollection is that thousands of people died.

Dr. TRENBERTH. Yes, over 30,000 people. The IPCC suggests up to about 35,000 people died in that particular heat wave. And you cannot account for it by natural variability, you cannot account for it by global warming. It is a combination of both. So it was an extreme natural event on top of global warming that led to that particular event.

Senator SANDERS. But go beyond just the severe weather disturbances, whether it is a prolonged heat wave or whatever. If you see increased drought, people are not going to be able to grow food, and they are going to have to migrate and so forth.

Dr. TRENBERTH. Right.

Senator SANDERS. There are going to be more and more diseases developing for a variety of reasons. Can you say a few words on that?

Dr. TRENBERTH. Yes, that is correct. There are various kinds of diseases and pests, like wheat rust and cotton rust that tend to flourish in warmer and wetter conditions. Ironically, we often have droughts and floods at the same time but in different places. Then they move around from 1 year to the next. Where they occur gets determined by things like the El Nino phenomenon or the La Nina that we have had over the past year.

So these things gradually occur in different places. Everyone will be affected one way or the other, sooner or later and in different ways. The thing that has happened in the last 30 years in particular is that it has gotten a lot warmer in general in Europe and Asia. In the U.S., the main thing that has happened is that it has gotten wetter. There is a figure in my testimony which shows that. That has ameliorated the drought that we otherwise would have had. There has been some work done to illustrate that. Also, it has not become as hot as it otherwise would have been.

But we are extremely vulnerable to both of those things occurring much more in the future if the atmospheric circulation tends to revert to the conditions that occurred before about 1970. And we saw an example of that last year, for instance, in the Southeast with the drought, and the consequences of that and the arguments over water between States and so on. So you will see more examples of that kind of thing. I personally think that the biggest pressure point on society will actually be through water and water resources. That is especially true in other places around the world.

Senator SANDERS. Thank you, Madam Chair.

Senator BOXER. Thank you very much.

Here is what we are going to do. We are going to continue this hearing, because I have to followup on some things that were said. The information we have received so far raises serious concerns in my mind regarding the account of events that has been provided to this Committee, including statements by Administrator Johnson.

So when I come back, I want to further ask you, and I think it is so important, Mr. Burnett, the President himself, what I understand, you don't have to answer now, because I want you to think about it, the President himself wanted a single standard for automobiles. What I want you to think about is, that flies in the face of the law and the Supreme Court. So I want you to just think about that, because it is very, very important.

When Senator Whitehouse comes back, Bettina, if you could tell him to sit right here, reopen the hearing and I will be right back. We stand in recess just for about five or 10 minutes.

[Recess.]

Senator WHITEHOUSE.

[Presiding] The hearing will come to order.

First of all, let me just express for the record my appreciation to Chairman Boxer for allowing me the time to vote and return. I would like to continue the line of questioning that I had for a moment.

Mr. Burnett, you indicated in your earlier testimony that President made his policy preference for a single standard clear in a variety of conversations and a statement of Administration policy. Could you describe what more you know about those conversations and that statement? Is the statement a matter of public record? Is that an administrative document?

Mr. BURNETT. Yes, I believe it is.

Senator WHITEHOUSE. An OMB circular of some kind, something like that?

Mr. BURNETT. Yes. Statement of Administration policy generally, well, in that case were developed as the Energy Bill, the Energy Independence and Security Act of 2007 was moving through Congress. And that final document made it clear that there was a desire for, frankly, for clarity as to EPA's role and that was seen as an effort to push for a legislative fix, if you will, to the Clean Air Act, something that would legislative deny the California waiver.

Senator WHITEHOUSE. Was the statement of Administration policy developed in the context of the Energy Bill, though?

Mr. BURNETT. Yes.

Senator WHITEHOUSE. OK. With respect to the Cabinet meeting, is there any way that one could describe that Cabinet meeting as routine from the perspective of the Administrator of the Environmental Protection Agency?

Mr. BURNETT. For major policy decisions that EPA makes, we often would have what we call a principals meeting, which is the principal decisionmaker and the Cabinet level officials would get together and would look at the decision before the Administrator, and that occurred in this case.

Senator WHITEHOUSE. So it wasn't a full-blown Cabinet meeting, it was a Cabinet level meeting?

Mr. BURNETT. That is right. Cabinet level officials, the Administrator representing EPA.

Senator WHITEHOUSE. And you assisted the Administrator in preparing for that and you assisted him creating the agenda for it and so forth?

Mr. BURNETT. I both assisted the Administrator in preparing for it and I assisted OMB in preparing the briefing documents that went out to the other agencies and departments.

Senator WHITEHOUSE. Are you aware of any other such Cabinet level meetings on other issues that took place during your time at EPA?

Mr. BURNETT. Yes. There were at least three Cabinet level meetings related to the response to the Supreme Court. We had a meeting, the Administration had a meeting to make the policy decisions about the fuel economy standards and the greenhouse gas standards for cars and trucks, a meeting for the greenhouse gas standards for gasoline and other fuel for the transportation sector, and a Cabinet level meeting for the issue of public endangerment.

Senator WHITEHOUSE. Do you know who attended the meeting on the California waiver, the Cabinet level meeting?

Mr. BURNETT. I am sorry, I don't think I said that there was a Cabinet level meeting, at least that I am aware of, on the California waiver.

Senator WHITEHOUSE. It was on the endangerment recommendation?

Mr. BURNETT. Yes.

Senator WHITEHOUSE. OK. And do you know who attended that?

Mr. BURNETT. I know generally who attended, and certainly some of the individuals, as well as the offices, agencies and departments involved.

Senator WHITEHOUSE. It was the Administrator and Deputy Administrator Peacock on behalf of the EPA?

Mr. BURNETT. Yes, and Roger Martella, the General Counsel also attended that meeting for EPA.

Senator WHITEHOUSE. Without going into individual names, what other Cabinet agencies were represented, do you know?

Mr. BURNETT. I believe that CEQ, Counsel on Environmental Quality, the Office of Management and Budget, I believe the CEA, I believe that the Office of the Science Advisor, the Office of the Vice President, the Chief of Staff's Office to the President, I believe the Department of Transportation, Department of Energy, Department of Agriculture and that is neither necessarily a comprehensive list nor—I may be incorrect about certain offices. But those were the offices that were generally involved in the policy process, and I believe that all of those offices were at the Cabinet level meeting in November 2007.

Senator WHITEHOUSE. Department of Energy? Department of Transportation?

Mr. BURNETT. Yes. Yes.

Senator WHITEHOUSE. OK. And you indicated that the result coming out of that Cabinet level meeting was that you should prepare to go ahead with a finding that the public was in fact endangered?

Mr. BURNETT. Yes.

Senator WHITEHOUSE. Do you have any information that could help explain how that determination could have gotten out of that group with the Chief of Staff to the President, the Office of the Vice President and OMB all represented when they seem to be the enti-

ties opposed to at least the ramifications of that conclusion, if not that conclusion itself?

Mr. BURNETT. Things changed between November 2007 and December 2007. The primary thing that changed is that the Energy Bill was moving its way through Congress and the prospects for that bill being signed into law were looking better in early December than in November. And ultimately, one of the key reasons that the Administration was interested in moving forward with a response to the Supreme Court was to help accomplish the President's objective of reducing gas consumption by 20 percent over 10 years, the so-called 20 in 10 plan.

After it looked like the President could achieve that policy objective without responding to the Supreme Court, then effectively a lot of the support for responding to *Massachusetts v. EPA* evaporated. EPA still argued that it was in the best interests of the Country to move forward with a response, because in fact the science had not changed and the law had not changed. And the public was still endangered. Therefore, we were required to move forward sooner or later. The decision was simply to delay that response until the next Administration.

Senator WHITEHOUSE. And going back to the waiver determination, as I recall the timing, that was, the Administrator's decision, without any of the required background or support, was announced in a sort of explanation to follow the same day, if I am not mistaken, that the Energy Bill was signed into law, if I have my timing right.

Mr. BURNETT. Yes, you are correct.

Senator WHITEHOUSE. How did that timing happen to occur, to your knowledge?

Mr. BURNETT. On Monday December 17th, the Administrator came into my office and told me of his intent to deny the California waiver. I immediately asked him whether we didn't want to continue looking at the option of a partial grant, because even though the Energy Bill did look good, well, at that point it was clear that it was going to be passed and signed into law, the Energy Bill was not going to change the three criteria of the Clean Air Act, the three legal criteria that we had to evaluate. Therefore, certainly the best legal option was to grant or partially grant the waiver.

However, the Administrator made clear that he had made up his mind, and we went to work drafting a letter to Governor Schwarzenegger. That letter was in the works over the course of Monday and Tuesday, the 17th and 18th. President Bush signed into law the Energy Independence and Security Act of 2007 on the morning of December 19th. It was made known to us by I think at least two separate news organizations, that they had information that the Administrator was planning on denying the waiver and that they were going to run a story the next morning.

So the decision was made to release the letter to the Governor, announcing the denial of the California waiver, at least a day or two earlier than we had anticipated. The plan, frankly, was to release that letter either later in that week, so as to not, to not be in the same at least day news cycle of the President's signing of the Energy Bill. But given the information that the news organizations had, the decision was made to release that finding, I am

sorry, to release the letter to the Governor late in the day Wednesday December 19th.

Senator WHITEHOUSE. Going backward, there was the release on December 19th, the Administrator told you what his decision was on December 17th. When had, if you recall the date, when had you notified or when had the Department or Environmental Protection Agency notified the White House of its recommendation to grant a partial waiver? Do you remember what date that was?

Mr. BURNETT. I believe that we continued throughout the early December to explain the case for a partial grant. I believe that it was early December when the Administrator made his plan known. Of course, that plan ultimately was not followed.

Senator WHITEHOUSE. And in between that, the White House response came back that the President desired there to be the single standard?

Mr. BURNETT. Yes.

Senator WHITEHOUSE. OK. Dr. Trenberth, I am a little bit at a disadvantage, because both you and Dr. Spencer are scientists and I am not. But I noticed you reacting from time to time to Dr. Spencer's testimony. I was wondering if there was anything that you would care to say regarding his testimony that would help a non-scientist understand or assess it properly and give it its appropriate context in the global warming/climate change discussion.

Dr. TRENBERTH. Thank you for the opportunity to respond.

First, the IPCC has extensively studied natural variability, and tried to assess what the natural variability would be without any what we call external influences on the climate. So that includes the sun and things like volcanoes, which are natural sources of variations. And we do that through paleoclimate and we do that through models. And in fact, it is an important part of the validation of climate models that they should be able to replicate the record in the past and the natural variability in the past.

The second point I would make is that natural variability also has a cause. It may be the redistribution of heat within the ocean, but it is not magic, it doesn't come out of nowhere. We have the ability nowadays to track that. For instance, we can track what is happening on the sun, and we know that the sun is not responsible for the changes that have occurred. We also know that it is not clouds.

Einstein said that we should make things as simple as possible, but not simpler. I think Roy's model is in the latter category. His simple model is simply fatally flawed, in my view. There are two figures in his written testimony, Figure 3A and 3B, and just very briefly, the radiation that is contrived there is about a factor of ten too large, the ocean mix layer that he uses is about a factor of ten too large. And he starts the model off with an artificial starting point.

So unlike the IPCC models that have been scrutinized by hundreds of scientists and many papers have been written about them, analyzing them and diagnosing what they are doing, Roy's model has no standing whatsoever. So I don't think I would go along with the statements that he has made.

At the same time, clouds are an issue. We need to do clouds better. But my group has also been intensively studying the so-called

sensitivity of the climate system, which is how much the climate system would change in response to a doubling of carbon dioxide. We use the annual cycle. And what we find is that the climate models that are somewhat more sensitive are the ones that replicate the changes from summer to winter better than the other models. So we come to quite the other conclusion. That is work under development.

So I don't think you should accept Roy's written testimony as gospel at this point.

Senator WHITEHOUSE. Let me ask a final question, if I may, Madam Chair.

Senator BOXER. Please.

Senator WHITEHOUSE. Now I am really going to hazard myself by going into potentially scientific areas as again a non-scientist. But it strikes me that a lot of things in nature and in science can be described by the famous bell curve, and indeed, that scientific data, if you were to plot it on an x and y axis in which the one axis was the severity of the threat and the other axis was the numerosity or consensus of the opinion, you would end up plotting a curve in which some people at the one low end of the curve though that this was really, really dangerous, far more than perhaps the IPCC as a consensus judgment might admit. And there are other people at the other end of the bell curve saying that it is actually very low risk, but at both ends it is a relatively small number, and the consensus is sort of right down the middle of where the IPCC conclusions lie.

Do you believe that is, as far as you know, do you believe that is an accurate way to look at or try to understand the varying scientific opinion and its relative weight on this question?

Dr. TRENBERTH. Well, there are certainly some scientists who take much more extreme views than I do as to how seriously the planet is in peril. And there are some who are—and the IPCC includes scientists from all parts of the political spectrum, I might say—and it includes many skeptics who are involved in the IPCC process.

What I have found, though, and I have given about 40 public lectures over the last couple of years, in dealing with people, and some of these are very technical people, like 700 engineers, IEEE engineers, is that they really appreciate the information on which the IPCC is based. Once they become adequately informed, they become convinced indeed that there is a real problem here. It is the ones that in general are not well-informed about the basic information, and the complexity of the climate system doesn't make that an easy process, those are the ones who are more inclined to be skeptical.

Senator WHITEHOUSE. Here is my concern. It is sort of a political and practical concern, to a degree. I see this as being an environment in which we are hearing a great deal from people who are like the IPCC and like yourself, sort of right down the middle, right at the high point of the bell curve with respect to the concerns about the severity of what we have to look forward to from climate change.

Then we hear from people like Dr. Spencer, who have a different view, that it is going to be much more moderate and not going to

be really a problem and only 1 degree increase by 2100 and so forth. And in Washington, which is a city built around compromise, there may be a tendency to sort of hedge between those two views. I think that will build in a bias toward inaction that would be very dangerous if we didn't reflect that for every Dr. Spencer, there is somebody on the other side of the bell curve whose views are far more profoundly concerned about the threat of climate change than those of the IPCC and those of yourself.

Again, I am asking for your comment. Is that a fair way to look at the lay of the land on this?

Dr. TRENBERTH. In that regard, the IPCC is a very open process. Anyone can be involved. It is the consensus view as to what is happening. There are a few people, and Roy is among them, who dissent from that view. But as Senator Klobuchar was saying, there are a lot of facts and hard evidence and good information that can be brought to bear on this problem. When you do that, some of the things that Roy has been saying can be simply disproved.

Senator WHITEHOUSE. My time has more than expired. I am very, very grateful to the Chair for her patience and courtesy. I yield.

Senator Boxer.

[presiding]. It is so important. I hope, Senator, if you could possibly stay, because I think we need to talk after this is over.

When I left, Mr. Burnett, I said that I was going to ask you, and I want to say this, I want to sort of tell a story. If there is anything in that story that I am saying wrong, I want you to correct me, please. And this is the story.

The story is that under the Clean Air Act, and it is in this book, under a section called Waiver, it says "The Administrator shall, after notice and opportunity, waive application of this section to any State which has adopted standards for the control of emissions from new motor vehicles or new motor vehicle engines," and it goes on and on, that if those standards are at least as protective of the public health, and there are only two reasons given, essentially, for denying such a waiver. The first is the determination of the State is arbitrary and capricious, and the second, B, is, I guess there is three. Such State does not need such State standard to meet compelling and extraordinary conditions, or such State standards and accompanying enforcement procedures are not consistent with Section 7521 of this title.

So this is the Clean Air Act. And here is my story. California and about 19 other States evidenced interest in going along with this, asked for such a waiver, because they are concerned about global warming, because they want to get started doing more than the Federal Government, just get going to cut down on global warming emissions. And that after many meetings, Mr. Burnett, and make sure that I am right when I say this, many meetings of the scientists at the EPA, of the people like yourself, and even meetings, as I understand it, with others, Cabinet people and others, and correct me if I am wrong on that, EPA decided that it would make sense to grant a partial waiver to the State and the partial has to do with the number of years, as I understand it, that it would be in effect. So far, is that a correct recitation?

Mr. BURNETT. I want to be careful about—

Senator BOXER. Go ahead.

Mr. BURNETT [continuing].—the word decided. Because it is my understanding under the law that ultimately the Administrator doesn't make a decision until he puts pen to paper. But it is true that we had a plan, and the Administrator had a plan to grant—

Senator BOXER. Well, let me put it this way. The EPA decided to recommend to the Administration a partial waiver. Is that a better way to say it? They decided to recommend this partial waiver?

Mr. BURNETT. The Administrator had a plan to partially grant the waiver, provided that the Clean Air Act was not enacted by Congress.

Senator BOXER. He planned to do it, and he was just going to let the Administration know about it, is that correct?

Mr. BURNETT. Yes, he—

Senator BOXER. About his decision? Or his plan?

Mr. BURNETT. Yes, that is right. He—

Senator BOXER. So I won't use the word decision. This is why I am trying to tell the story in exactly the right way. He had a plan to sign a partial waiver. And he went over to the White House to inform them of this decision, of this plan, of this plan, that you were intimately involved in getting him prepared for this meeting, and he went over there and this is what I am trying to get now.

When he came back, he let people like yourself know, I assume there were others, that the President, the President wanted a single standard for, is it for fuel economy or for controlling greenhouse gas emissions from cars? How would I say it best?

Mr. BURNETT. The President had a policy preference for a single standard for automobiles.

Senator BOXER. OK, a single standard. And so my question to you is, is it your understanding that the President understood this law? Did he make reference to it? Did he say, despite the law or anything like that, despite the law or notwithstanding the law?

Mr. BURNETT. I cannot personally speak about conversations at that level.

Senator BOXER. OK.

Mr. BURNETT. What I do know is that I was involved as part of the process, explaining to a number of officials at the White House the three criteria under the Clean Air Act.

Senator BOXER. Right, that I read. So to the best of your understanding, Mr. Johnson understood clearly the Clean Air Act, when he went over to the White House?

Mr. BURNETT. This issue is one of the most important issues that was facing EPA. It received very high level attention, many meetings with the Administrator and many meetings with senior officials at the White House, yes. Everyone—

Senator BOXER. OK, let me put it this way. Is there any information that you have when Mr. Johnson reported back to you about the President didn't want to follow this plan, was there any doubt in your mind that the President didn't understand the law? I mean, just forget conversations. Was it pretty clear that the President and his folks had understood what the law required and they chose the single standard?

Mr. BURNETT. We did our best to ensure that all policy officials involved in this decision were apprised and informed of the law and

EPA's assessment that all three criteria were, that the, clearly, the most supportable case under the law is that all three criteria had been met.

Senator BOXER. OK. So to finish my story, this issue had gotten a tremendous amount, had generated a tremendous amount of interest. It was certainly very important in this Committee, we were talking about it a lot with Mr. Johnson. And that if I were to say to my constituents that the professionals in the EPA and even Mr. Johnson himself had a plan to grant a partial waiver, they presented that plan and despite what the law requires, the President chose to ignore that plan and said he didn't want to grant the waiver. Is that a layman's way of putting it?

Mr. BURNETT. Again, I want to be very careful about the words that I use.

Senator BOXER. Well, these are my words, not yours. These are my words. If I were to say to my constituents, from what I have gathered, very clearly, because I don't have the documents I want. That is another problem. We can't get the documents we want on this. We have asked for e-mails, we have asked for—so you are the only thing we have standing up for what happened.

So let me say again, if I were to say to my constituents that Mr. Johnson and his key team and the professionals at EPA felt California had made their case and furthermore, if there was a lawsuit, the probability was that they would prevail, and yet and still, knowing all this, and despite the fact that there is a Clean Air Act which lays out the case, the President chose not to grant the waiver? That is my words. If I were saying that to my constituents, how would you correct me?

Mr. BURNETT. The policy preference of the President led to the denial of California's waiver request, because granting the waiver or a partial grant of the waiver would have led to two standards, not one, as the President desired.

Senator BOXER. Right. And isn't it true that in the Clean Air Act, it is very clear that there have been 50 waivers granted already. California has never been denied, the other States have never been denied. This wasn't anything new. This was the first outright denial, is that correct?

Mr. BURNETT. That is correct. It is the most clear reading of the law that California should have and should still receive its waiver request, despite the policy preferences of the President.

Senator BOXER. OK. I want to submit to the record, and I think Senator Whitehouse would be very interested in this, first of all, the opinion of the Court which clearly says, the fact that DOT, that is the Department of Transportation's mandate to promote energy efficiency by setting mileage standards may overlap with EPA's Environmental responsibilities, in no way licenses EPA to shirk its duty to protect the public health and welfare.

I am not asking Mr. Burnett or anybody else anything. I am saying here, as a United States Senator who is sworn to uphold the laws, I just want to say to my colleague, the Supreme Court said, no matter what standard is set by DOT, EPA must not shirk its responsibilities to the public health and welfare. Despite this, and despite everything that the good professionals and scientists have done, this President, I believe, made a decision that flies in the face

of the Supreme Court case. So I believe it is clearly unlawful. Clearly unlawful. And I think the importance of having Mr. Burnett here is to get the behind the scenes before this bad decision was made by this President, this what I call unlawful decision was made by this President. That is my opinion, that he was strongly advised not to do it.

And the reason I am so grateful to you, Mr. Burnett, is I can't tell you how hard it has been for us to connect the dots. We gathered certain things happened, because we got Mr. Johnson's calendar, and we saw the day he went over to the White House. We tried to piece it together, it looked to us like the EPA had told him to go forward, we had some information on that, but it wasn't complete. You are helping us connect the dots. I know it is very difficult for you. And I know you are cautious in every word you say and you should be and you have been. And the record will certainly show that.

What you have helped us to do is to fill out the picture. I just have—

Mr. BURNETT. Madam Chair.

Senator BOXER. Yes.

Mr. BURNETT. If I may, I have left the agency in early June, and plan on continuing to work on the same issues. I think that there is a profound challenge for the next Administration in two regards that flow from decisions this Administration has made. First, I think it is clear that either the courts or the next Administration will grant California the waiver. However, this temporary denial of the waiver creates complications, both for California, the other States that have chosen to follow California's lead, and ironically for the very industry that is directly affected, the automobile industry. Because the denial will eliminate the phase-in period of the program and overall, will make a program harder to meet, not easier to meet. So it is really a disservice not only to the environment but actually to the industry.

And the challenge will be for the next Administration to try to sort out how to deal with the ramifications of the denial and move forward with a grant in a way that works as best as possible for all parties involved.

The other challenge, of course, is a response to the Supreme Court. This Administration has simply decided to delay that response. But it is going to be a complicated, difficult task to use the Clean Air Act. But that is what the law requires. And it is my personal judgment that we are best served starting now to begin developing a path forward so that we can best use the Clean Air Act and avoid the parade of horrors that other people have suggested will come from the Clean Air Act. Responsible use of the law can be done to channel regulation in a way to avoid that scenario.

Senator BOXER. Well, thank you so much for getting us back to why we are here. We want to be able to move forward. And as we all know, every day we waste is a day that we can't make up for, because that carbon stays out there. So let me just, since you brought up the endangerment finding, essentially, I want to close on this and then read a statement. I will ask you a question, then I will turn to—we have time—turn to Senator Whitehouse.

Now, one of the things, as you know, everybody, we are going to have a meeting here on Thursday where we are attempting to get the e-mail that contained the endangerment finding, and you were involved in preparing that e-mail, is that correct?

Mr. BURNETT. Yes, that is correct, I was involved both in preparing the endangerment finding itself and I was the individual who sent the e-mail for formal OMB review.

Senator BOXER. Right. It is my understanding that if that e-mail had been opened by the Office of Management and Budget over there at the White House, it would have triggered an obligation to reveal its contents to the public. Is that your understanding?

Mr. BURNETT. It is my understanding under the Clean Air Act, I believe it is Section 307(d) and the Executive Order 12866, which was a President Clinton Executive Order, but has been reaffirmed by this President, that there are public transparency provisions that require drafts of regulations submitted for review to OMB to be made public, so that the public can understand any differences between the draft submitted for review and the final regulation released.

It is my understanding that by submitting this finding for formal review that would have triggered the public transparency provisions of both the law and the Executive Order, and that the e-mail and the contents of the e-mail, the finding of public endangerment, would be made public upon the Administrator's signature of a document for the Federal Register notice.

Senator BOXER. Well, me speaking here, the fact is, all along we have seen a pattern and a practice of this Administration to cover up any finding that deals with the impacts of unchecked global warming on our people. We saw it with the CDC testimony and I wanted to thank you for letting the public know about that. You were asked personally to redact that CDC testimony, you said, in the press you wouldn't do it. And it wound up that it was done—where was it done, in the OMB? We are not exactly sure who redacted it. Do you know who redacted those six pages of Dr. Gerberding's testimony?

Mr. BURNETT. I do not. I can only speak for my actions.

Senator BOXER. It was not the EPA. So what happened, and that is the one where Dana Perrino said it was, what was his name? Dr. Marburger, and Dr. Marburger said he didn't do it. So it is just like, did the butler do it? We don't know.

But the bottom line is—yes, in the parlor with the candlestick—what we need is a candle to light to put a little light on the subject. We can't find out this information. So your e-mail that you sent was never opened, this is me speaking, I believe in part to keep what you found from the public. I know you have said you don't have a copy of it. So Thursday, we are going to meet here and we are going to try and subpoena that endangerment finding, that document.

Now, we need two of our Republican friends to show up, and we need four, we need eight Senators, but only two Republicans? Oh, eight Senators and two Republicans, eight Democratic Senators and two Republican Senators need to show up. Then I guess we need a majority of those present and voting to subpoena this document. This isn't easy, and I have avoided this, because I know on

the House side it is a little easier for the majority. But they can't get the document. The only thing they were allowed to do, as I understand it, is read it, not take any notes. One person. And I am not going there. Nobody made me queen of this Committee. If we can't get this for everybody to see, that is not an offer I take. It has to be made public. This is about public endangerment.

So I am going to call on Senator Whitehouse to ask a couple more questions, then I have a closing statement. And I so appreciate your all being here.

Senator, please go ahead.

Senator WHITEHOUSE. Just one very quick question. Mr. Burnett, do the procedures of the Clean Air Act relative to granting or denial of waivers anywhere provide for a policy preference of the President to enter into that process?

Mr. BURNETT. First, I should say, be clear, I am not a lawyer.

Senator WHITEHOUSE. It is OK, I am not a scientist, and I have been messing around with that.

Mr. BURNETT. I think that your question does involve at least a matter of administrative law. It is—

Senator WHITEHOUSE. Let me ask it to you in a non-legal way. Let me ask it to you just in a factual way, then. In the course of preparing Administrator Johnson for this, in the course of preparing the decision that was made to recommend that a partial waiver be granted, do you recall any discussion about how the process required at some point evaluation of a Presidential preference, or, sorry, a policy preference of the President?

Mr. BURNETT. I will simply observe that in the final decision document, I don't believe that there is any reference to a policy preference as a legal justification for the decision made.

Senator WHITEHOUSE. Fair enough. I appreciate it.

Senator BOXER. OK. The information we have obtained through the investigation in this Committee raises serious questions regarding the account of events provided to this Committee, including statements by Administrator Johnson. This Committee will pursue this matter further with all the resources at its disposal. Along with Senator Whitehouse, who has taken the lead on this, I will participate in a full Committee hearing in the Judiciary Committee convened by Chairman Leahy on the extraordinary use of privilege and obstruction of oversight in the Congress on global warming issues.

This Thursday, we will convene, as I said, a business meeting to consider a subpoena for the endangerment finding Mr. Burnett spoke of today. The White House has not agreed to provide this critical EPA document, clearly subjected to oversight of this Committee. Our Committee rules do require that we have Republican participation in the meeting, and we are so hopeful that they will be here. Because it isn't a question of how we view global warming, it is a question of information, frankly, that has been developed by professionals at the EPA. We are paying the salaries of those people, the taxpayers are. The people have a right to see what good, caring people like Mr. Burnett have put on paper, have put in an e-mail to lay out a strategy as to first of all, are we endangered? They said yes. How? They explain it. And very important, I note to Mr. Burnett and others, who serve so courageously over at EPA,

and Mr. Burnett had to take his stand by leaving, but there are many others there, they want us to do something.

And in this document, we will learn what we can do under the Clean Air Act. And as Mr. Burnett said, you can use it responsibly, you could use it in not such a responsible way. I am very anxious to see that document. I need to see the document to do my job. My colleagues need to see the document to do their job.

So all I want to say to all of you here today who came to testify, that we really so appreciate your valuable time. We are going to get to the truth. The most important thing is, when we get to the truth, truth is power. And we are going to start acting in a responsible way to address a critical issue that is coming at us very hard and very fast. If we owe nothing else to our kids and grandkids, it is to take action. And you are going to help us do that.

So I thank you very much. We stand adjourned.

[Whereupon, at 12:28 p.m., the committee was adjourned.]

STATEMENT OF HON. JAMES M. INHOFE, U.S. SENATOR
FROM THE STATE OF OKLAHOMA

Madame Chairman, I am very disappointed to see that this Committee is once again beginning its deliberations on global warming in the wrong manner. Rather than focusing on substantive issues that would be helpful to the debate on global warming legislation, this Committee is choosing to engage in more political theater with a predetermined outcome. The rushed process and the complete lack of understanding of the policy implications of the Lieberman Warner doomed it from the start. Opposition to the bill was not limited to Republicans, as nearly 30 percent of Senate Democrats refused to support the bill.

If this Committee were serious in undertaking efforts to draft global warming policy rather than score political points, it should be focusing its efforts in a much more methodical and deliberative manner that acknowledges the complexity of the issues surrounding any mandatory emission reduction policy. Regardless of my own position on this topic, the Committee should be exploring issues to help build a record on how to draft a cap and trade system, the level of technology currently available to achieve reductions, how to allocate credits, how to design an auction system, how to create a domestic offset program, what the international impacts will be on trade and particularly exports, how to effectively contain costs through a transparent mechanism, and the list could go on.

Instead we are here to politicize the internal deliberative process of the Administration under the guise of an update on the science of global warming hearing. While I welcome the opportunity to discuss the latest science on global warming, doing it in this heavily political setting with a predetermined outcome focused on internal deliberations of the Executive is not the right venue for such discussion. It is my view that regardless of Administration, the President acting through the entire executive branch is fully entitled to express his policy judgments to the EPA Administrator, and to expect his subordinate to carry out the judgment of what the law requires and permits. It can be argued that the "unitary Executive concept" promotes more effective rulemaking by bringing a broader perspective to bear on important regulatory decisions. It also enhances democratic accountability for regulatory decisionmaking by pinning responsibility on the President to answer to the public for the regulatory actions taken by his Administration. Therefore, I consider this debate over censorship within the Administration to be a non issue. All administrations edit testimony and all documents go through interagency review before any final agency action. I cannot support any investigations that could have a chilling effect within the deliberative process of the Administration, and cause future career and political employees from refraining from an open and honest dialog.

Regarding the real subject of the hearing, it is no secret what my views on the science of man-made global warming are. I welcome Dr. Roy Spencer, who will be updating the Committee on his recent theoretical and observational evidence that climate sensitivity has been overestimated, as well as giving his perspective on White House involvement in the reporting of agency employee's work.

I am also happy to report that there are several updates that are worth noting for purposes of the record for this hearing. Numerous peer-reviewed studies, analyses and prominent scientists continue to speak out to refute many conclusions of

the IPCC. I have documented in the past how the consensus on the “science is settled” debate has been challenged, and in many cases, completely refuted, from the hockey stick, to the Stern Review, to the IPCC backtracking on conclusive physical links between global warming and observed hurricane frequency and intensity.

Just this past week, a major new study was published in the peer-reviewed journal *Climate Dynamics* that finds worldwide land warming has occurred largely in response to oceans, and not carbon dioxide. There have also been recent challenges by Russian scientists to the very idea that carbon dioxide is driving Earth’s temperature and a report from India challenging the so-called “consensus.” The Physics and Society Forum, a unit within the American Physical Society, published a new paper refuting the IPCC conclusions where the editor conceded there is a ‘considerable presence’ of global warming skeptics within the scientific community.

More and more prominent scientists continue to speak out and dissent from man made global warming. In June, the Nobel Prize Winner for Physics, Ivar Giaever, declared himself a “skeptic” and said “global warming has become a new religion.” Atmospheric Scientist Dr. Joanna Simpson, the first woman in the world to receive a PhD in meteorology also dissented in 2008. “As a scientist I remain skeptical” of climate fears, Dr. Simpson said in February of this year. In June, a top U.N. IPCC Japanese Scientist, Dr. Kiminori Itoh, turned on the IPCC and called man-made global warming fears the “worst scientific scandal in the history.” In addition, more evidence of challenges to global warming occurred when two top hurricane scientists announced they were reconsidering their views on global warming and hurricanes.

As the normal scientific process continues to evolve and models continue to improve, there have many more instances documented that are positive developments, which should be embraced, rather than ridiculed or immediately attacked by the media or policymakers. It is my hope that as more and more of these researchers speak out, scientific objectivity and integrity can be restored to the field of global warming research.

