

**A TIME FOR CHANGE:
IMPROVING THE FEDERAL CLIMATE CHANGE
RESEARCH AND INFORMATION PROGRAM**

HEARING

BEFORE THE

**COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE**

ONE HUNDRED TENTH CONGRESS

FIRST SESSION

NOVEMBER 14, 2007

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SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED TENTH CONGRESS

FIRST SESSION

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**A TIME FOR CHANGE:
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WEDNESDAY, NOVEMBER 14, 2007

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Committee met, pursuant to notice, at 10:08 a.m. in room SR-253, Russell Senate Office Building, Hon. John F. Kerry, presiding.

**OPENING STATEMENT OF HON. JOHN F. KERRY,
U.S. SENATOR FROM MASSACHUSETTS**

Senator KERRY. Good morning. This hearing of the Commerce Committee will be in order. Thank you for being here today to update us on a critical topic, which is the status of our Federal Government's Climate Science and Assessment Program.

This is an issue which has, for some period of time, been pretty high on the Committee's list of priorities. This is the 6th hearing of the Commerce Committee, this session, that touches on aspects of the Climate Change Research Program. And we've been discussing this program now for the last 7 years.

In preparation for this hearing, I looked back at the opening statements that I'd made from similar hearings in 2001 and 2002, and frankly, I was dismayed to see that the same concerns that Senator McCain and I raised, remain all too relevant today.

A number of events this year have highlighted ongoing weaknesses in the Federal Government's Climate Research Program. First of all, GAO released a report that Senator McCain and I requested, addressing the serious impacts of climate change on our Federal land and water resources. That report found that the Federal Government is not providing resource managers with the information that they need to address the impacts of climate change, and as everybody knows, adaptation and mitigation are two of the most critical response factors that have been singled out by the international community in order to deal with this, and will be the subject of the negotiations over the next 2 years for the follow-on to the Kyoto Treaty.

So, it would be helpful, obviously, if the United States were dealing with that more effectively.

Second, the National Academy of Sciences released a report highlighting major gaps in the Federal Climate Research Program, no-

tably with regard to impacts of climate change and the communication of those impacts.

Third, a Federal District Court in California found the Administration violated the requirements of the Global Change Research Act of 1990, by failing to produce a national assessment as required by the Act.

Now, I'm going to focus on some of these questions, issues, during the Q&A, but let me briefly emphasize the importance of the national assessment.

The 1990 Global Change Research Act requires that any Administration produce an assessment report no less frequently than every 4 years. The last report was issued by President Clinton in the year 2000. Seven years later, the Bush Administration has not produced a new report. GAO has criticized the alternative strategy that's been put forward of producing 21 separate reports, which incidentally, only 4 of which, of the 21, have been completed, to date.

The GAO has suggested that's insufficient for meeting the needs of Congress, and other policymakers.

Now, I'd like to understand something that the Administration has not yet answered adequately, which is why they refuse to produce these reports, and provide information to the American people. I hope the Administration will follow the court order, and issue a comprehensive assessment report by May of 2008, and I look forward to discussing that, also, today.

I might just remind everybody that these reports are required by law, they are the law of the land, and it's important to have them met, because that is the intent of Congress, and it is not our desire to have a vast array of watered-down reports from various departments in ways that would not contemplate it.

In light of these developments, in addition to the latest IPCC report, Senator Snowe and I recently introduced a bill that would address many of the weaknesses of the current climate change research and assessment program, and we're confident that this legislation, the Global Change Research Improvement Act of 2007, will prepare the Federal Government to address the risks and the impacts that are associated with climate change and provide city managers, resource managers and citizens with the information they need to try to deal with this in their communities. I thank Senator Snowe for her ongoing leadership and involvement in this issue.

In all of these discussions, it's important to keep in mind, that the policy needs to be driven by the best possible science, that's what we've always sought to do here in this Committee. When Senator McCain was Chairman, he held hearings looking at and examining the state of our science. It's been a bipartisan effort.

The bill that we've introduced, we hope will ensure that the Federal Government provides us with the information that we need in order to make good policy.

I want to thank Dr. Marburger for joining us today, everybody knows he's the Science Adviser to the President, Director of the Office of Science and Technology Policy, accompanied by Dr. Jack Kaye, Director of Research Division of the Office of Earth Science.

And let me just turn quickly to my colleagues for opening statements they may have.

Senator Boxer?
Senator Lautenberg?

**STATEMENT OF HON. FRANK LAUTENBERG,
U.S. SENATOR FROM NEW JERSEY**

Senator LAUTENBERG. Thanks very much, Mr. Chairman.

We've got to face it, global warming for most of us, is one of the most important issues facing this country, this Congress and our world. Most Americans are convinced about it, but not all. And it's distressing.

Science tells us that the man-made emissions of greenhouse gases threatens our environment and our health. And that's why, frankly, I'm perplexed that the Bush Administration continues to ignore, censor, and suppress science. And, obviously, they show by their inaction that they're not convinced that this is a serious matter.

One year ago, 13 of my Senate colleagues, including Senators Kerry and Boxer, on this Committee, and others, joined with me to ask the Inspector General of NOAA and NASA, to investigate interference by political appointees about scientific research on the dangers of global warming. We are waiting for their reports. And meanwhile, as we wait, the problem grows worse.

Meanwhile, the Administration's censorship and outright denial of these risks has continued. In May of this year, the NASA Administrator, Michael Griffin said, and I quote him here, "I'm not sure that it's fair to say that global warming is a problem we must wrestle with." How about that?

Now, just 3 weeks ago, the White House deleted 6 pages of CDC officials' Senate testimony on the health effects of global warming. And what's worse, Mr. Chairman, it seems that when the Administration is not censoring or suppressing the information, it is simply ignoring the issue entirely.

A national climate assessment from the Bush Administration on the effects of climate change, as the Chairman noted, was due to Congress, 3 years ago. We still haven't seen it, and there's apparently no plan to produce it. The scientific research is critical to our country, to my State of New Jersey where climate change will cause more air pollution, sea level rise, ocean acidification.

And that's why I'm working with my Senate colleagues to fight global warming, I think it's a terrible threat. And I look at it—and this isn't something that's so far off that those who are here now—like my grandchildren and other people's grandchildren—won't be affected by our neglect or our choice to go slow on this.

Just last week, we had the Lieberman-Warner bill that, we negotiated together and we made significant changes, and that bill passed out of Environment and Public Works Subcommittee, and I'm pleased to be here with our, the Chairman of the Environment Committee, Senator Boxer. We're all eager to get things moving, here, and we're beginning to do it in the Environment Committee, and happy to see it taking place here.

I also have legislation before this Committee, along with Senator Cantwell, to expand and coordinate the government's research on ocean acidification, a danger caused by greenhouse gases. As ocean acidification intensifies, the fish and coral reefs that we depend on

for food, tourism and other economic benefits are going to suffer substantially.

Left unchecked, this threat could affect hundreds of millions of people worldwide who rely on our oceans. Every day that we fail to fight global warming, is another day that our planet gets sicker, and every time science is suppressed, it gives people reason not to act.

So, we've got to let science chart our course as we fight global warming, and we must act now. Doing nothing is not the legacy any of us would want to leave behind.

And Mr. Chairman, I thank you.

Senator KERRY. Thank you, Senator Lautenberg.
Senator Boxer?

**STATEMENT OF HON. BARBARA BOXER,
U.S. SENATOR FROM CALIFORNIA**

Senator BOXER. Mr. Chairman, thank you so much. I just want to take a moment to just thank you personally for your leadership on this issue of global warming. You've been there for a very long time. You've been to every single international conference, trying to reassure the world that, "Yes, America is going to be a partner." Unfortunately, we've lost valuable time—terribly valuable time—these last, I guess it's 7 years, it feels like forever.

And, your leadership on this issue extends to working with me and so many others, to help us move a good bill forward, and you've played a pivotal role.

I mean, I just wanted to say, I say it privately to you, but I want to say it publicly to you. And the fact that we have so much overlap on our Committees, this Committee has a very important jurisdiction, the Energy Committee, the Environment Committee—I'm proud that three of my Members of my Committee, three of us are here, because it just shows that we want to work together—we're not in a little bubble over there. We can't do it without everyone's help. This is a big deal. And there are forces out there that are trying to shut us down.

Now, the reason I took time to come here today, first to thank you, second, to raise an issue that is of great concern to me, and will take me 3 minutes to talk to you about it, and to colleagues. And my colleagues on the Committee know about this issue.

We invited Dr. Julie Gerberding, the Director for the Centers for Disease Control, to come forward and talk to us about the potential problems that the world will face and the country will face—public health problems—if we don't get our arms around this. Because, we all know the problems with rising temperatures, and what does that mean for our rivers, streams and lakes and the amoebas and the bacteria that live there? What does it mean when sea levels rise? What does this all mean?

She produced testimony, and when I read it, Mr. Chairman, and members, I thought, "It's a little disjointed," frankly. I mean, it didn't really comport with what I had talked with her about before.

And I said something to her, I said, "Gee, your testimony is a little disjointed." She didn't say anything.

Well, later, because a whistle-blower came out and told the truth, we found out that, in fact, her testimony was decimated, pages and

pages of it redacted. And, when I saw that Dr. Marburger was here, I wanted to come, because my understanding is he was involved in some of those edits.

When Dana Perino was asked about it, the press person for the White House, she said, "Well the reason it was redacted is, some of the things that she said were in conflict with the IPCC," totally baloney. And I want to take the last 2 minutes to show you a chart here, well, show all of them.

She said, "As I understand it, the draft did not comport with what the science was in the IPCC report, and so it was reviewed, and scientists took a look at it."

OK, let's go to the next.

Now, we went back and we got some of the deleted text—and I don't have time, I don't want to take your time to go through it—

Senator KERRY. No, it's very important.

Senator BOXER. But, there's absolutely—here's the deleted text that, "In the U.S. climate change is likely to have a significant impact on health through links with the following outcomes: Direct effects of heat, health effects related to extreme weather, air pollution, allergic diseases, water and food-borne infectious diseases, vector-borne and zoonotic diseases, food and water scarcity, mental health problems, long-term impacts of chronic diseases and other health effects," this was deleted by the so-called scientists over there. At the Bush Administration.

And here, we put the IPCC report, and without reading it, you can see it matches, it's a match. Dr. Gerberding is brilliant. Dr. Gerberding is not going to say things that aren't true.

Luckily we had a whistle-blower over there, maybe they're the ones who are laughing, I don't know, but thank the Lord, there are people inside there that told us the truth.

Now, last point, Mr. Chairman, if I can engage you in this, this would be a big day for me. We wrote to the President, we said, "Outrageous. Send us the documents. We got a whistle-blower to do this, send us all of the document." Guess what? We haven't gotten any documents. Guess what? We got a letter from Fred Fielding, the White House Counsel, "executive privilege." Executive privilege? About public health? The taxpayers are paying your salaries, they're paying our salaries, don't you think they have a right to know what the top doc of the country thinks?

So, I came here today, I have to say, with a motive to engage you more on this effort, because this is a lonely fight, when they write "executive privilege," the door slams. And maybe through this Committee, because my other Committee is so crazed with everything we're doing, we could work on this to get these documents and I would urge you to join with me, and I will wait for questioning of Dr. Marburger for the rest.

[The prepared statement of Senator Boxer follows:]

PREPARED STATEMENT OF HON. BARBARA BOXER, U.S. SENATOR FROM CALIFORNIA

Mr. Chairman, thank you for holding this hearing.

Global warming is the greatest environmental challenge of our generation. We must have a comprehensive and robust science program to assess this threat.

The Environment and Public Works committee recently held a hearing examining the human health impacts of global warming in which Dr. Julie Gerberding, the Director of the Center for Disease Control and Prevention or CDC testified.

Dr. Gerberding prepared testimony, but when the testimony was reviewed by the Bush Administration it was heavily edited and essentially cut in half. I understand that John Marburger, science advisor to the President, was involved in this editing.

I find this heavy editing appalling. I would like to read from a letter I sent to President Bush on October 24, concerning this censorship:

U.S. Senate,
Committee on Environment and Public Works,
Washington, DC.

October 24, 2007

The President,
The White House,
Washington, DC.

Dear Mr. President:

Yesterday, at a hearing before the Senate Committee on Environment and Public Works, Dr. Julie Gerberding, the Director of the Centers for Disease Control and Prevention (CDC), delivered testimony on the public health implications of global warming. I have learned that the Director's written statement was heavily edited during a review process coordinated by the Office of Management and Budget (OMB) in the Executive Office of the President. Among the changes made in the written testimony were the removal of several pages of detailed information summarizing scientific studies and reports on the public health impacts of global warming.

The public has a right to all of the facts about global warming and the threat it poses to their families and communities. I am deeply concerned that important scientific and health information was removed from the CDC Director's testimony at the last minute. I write to ask you to ensure that the public receives a full accounting of what occurred during that review process, and who was involved.

Please provide to my office, no later than Monday, October 29, 2007, a copy of all drafts of the CDC Director's testimony sent to the Office of Management and Budget or other offices within the Executive Office of the President or other agencies. Please also provide any records reflecting comments on the draft testimony of any of those entities or officials within or affiliated with the Executive Office of the President or any of the White House Offices (including the Office of the Vice President), or of any other agency, and the names and titles of the persons involved in the review.

If your staff has any questions, please contact Bettina Poirier, Staff Director for the Committee at 202-224-8832.

Sincerely,

BARBARA BOXER,
Chairman

The White House responded to my request with a letter on October 30, that I will read from now:

The White House,
Washington.

October 30, 2007

Hon. Barbara Boxer,
U.S. Senate,
Washington, DC.

Dear Senator Boxer:

Thank you for your letter to the President dated October 24, 2007, which has been referred to me for a response. Your letter seeks information in the possession of the White House relating to testimony provided by Dr. Julie Gerberding, the Director of the Centers for Disease Control and Prevention, to the Senate Committee on the Environment and Public Works.

A member of my staff spoke with your Staff Director, Bettina Poirier, on Friday, October 26, 2007, and informed her that we have begun the process of identifying and locating materials that may be responsive to your request. We expect to have a timetable for assembling these materials in the next several days. We will contact your office as soon as we have solidified dates for our internal processes.

I note that the request by its very nature seeks communications involving pre-decisional deliberative materials relating to an inter-agency review process. However, until the requested materials are gathered, it will not be possible to say with particularity which responsive materials may fall into this category. Nevertheless, it is clear that the request implicates core Executive Branch interests and raises separation of powers concerns as well. For that reason, we anticipate that once re-

sponsive documents are gathered, it will be necessary to discuss with representatives of your committee the basis for any decision to withhold documents and, if appropriate, the possibility of reaching an accommodation that balances Executive Branch prerogatives with the committee's legitimate oversight needs.

We refer you to the Office of the Vice President in regard to the letter's request for vice Presidential records.

We look forward to working with the Committee to achieve a resolution respectful of the needs of both the Executive and legislative branches. Please telephone me or Emmet Flood in my office if you have any questions concerning the foregoing.

Sincerely,

FRED F. FIELDING,
Counsel to the President

It has been several weeks and the dates for response have come and gone. I have seen no documents from them.

I find this to be outrageous. The American people have a right to a full accounting: how did our leading public health official with a responsibility to brief a Senate Committee have many pages of critical information blacked out by the White House?

Dana Perino, the White House Press Secretary, said in a press conference that "the draft information did not comport with what—the science that was in the IPCC report."

The White House
Office of the Press Secretary
Internal Transcript

October 24, 2007

Press Gaggle
By Dana Perino
James S. Brady Briefing Room
9:08 A.M. EDT

Ms. PERINO: OK, I'm going to go ahead and start. The President had his normal briefings at 8 a.m. We moved up this gaggle because the President, at 9:30 a.m., is going to participate in a video teleconference with administration officials who are in California monitoring the wildfires, and he will get an update. He got one last night by phone, and this will be 12 hours later to find out what's going on.

Ms. PERINO: We'll check into it. John, you had something on climate.

Question. Yes. I just wanted to ask about this AP article that says that Dr. Judy Gerberding's testimony—

Ms. PERINO: Gerberding.

Question. What is it?

Ms. PERINO: OK, since you're going to have to pronounce it so much.

Question. Thank you. (Laughter.) Can you pronounce again then so that I can hear?

Ms. PERINO: Sorry to be condescending. I'm taking my cue from Wendell. (Laughter.) Gerberding.

Question. Thank you.

Question. Do you want to start this battle? (Laughter.)

Ms. PERINO: You start it every day, I've just started to fight back.

Question. OK, all right.

Question. OK, whatever her name is—the AP story quotes an unnamed CDC official saying that her testimony was heavily edited by the White House, taking out references to specific diseases in this climate change report to Congress. And the suggestion seems to be that it was politically unpalatable in its original form. Can you just tell what happened?

Ms. PERINO: I checked into this a little bit. Look, it's not unusual. All testimony goes through interagency review here through the OMB process. A number of the agencies had some concerns with the draft and I know that our scientists at the Office of Science and Technology Policy looked at the draft and wanted to make sure that it was taking advantage of the science that had been provided in the International Panel on Climate Change—that was the IPCC report that came out last spring that we largely funded and that we embraced in its conclusions. It is also the one that Nobel Peace Prize winner Al Gore—one of the reasons he is sharing the Nobel Peace Prize is because the IPCC work.

And she herself said in the testimony that there are links to public health and climate change. And her spokesperson said that she was able to provide the Congress with everything that she wanted to say. And I think that the other thing to

keep in mind is that it was only less than a month ago that the President brought 15 of the major economies of the world together to try to work on the problem of global warming together because he recognized that without the participation of those major economies, like China and India, that had been left out of the process beforehand, that we wouldn't get anywhere without it. So I'll refer you to CDC for anything additional about what they wanted to say.

Question. Well, wait a minute. Come on, if you say that she provided the Congress with everything that she would have wanted to say, it seems that it was—it seems evident then that you didn't want it said in public.

Ms. PERINO: No, if I—

Question. You just said she provided the Congress with the material—

Ms. PERINO: She testified yesterday. Her spokesperson said that she was able to say everything that she wanted to say. Look, when there—testimony that comes over that is drafted goes through the interagency review process. It was not watered-down in terms of its science. It wasn't watered-down in terms of the concerns that climate change raises for public health. And her spokesperson said that, as well. So I'm not going to say that—we're not going to stop doing interagency review because there's—

Question. Of course not, but how did it go from eight pages to four, or whatever it was? It was cut down by about half.

Ms. PERINO: Look, what I do know is that the Office of Science and Technology Policy, those scientists over there, led by Dr. Jack Marburger, are the ones who have been encouraging us to do even more on climate change.

They are—they have been robust in pushing for additional resources in order to get more science. They encouraged us to participate in the IPCC process, which we did; we accepted those findings that climate change is real and it is, in large part, caused by humans, and that we have to do something about it. There are—

Question. No argument. But why shouldn't—

Ms. PERINO: What is the argument?

Question. Why shouldn't we think that there was something excised from that testimony that you did not want her to say?

Ms. PERINO: Because of what she said and what her spokesperson said and what I'm telling you here.

Question. Dana, you said—sorry, your mention of the IPCC—is what was taken out after this interagency review—

Ms. PERINO: No, no, no, they wanted to make sure that the science that was provided in the IPCC report and—

Question. Right, you're saying that what came out was not consistent with—

Ms. PERINO: I don't know. As I understand it, the draft information did not comport with what—the science that was in the IPCC report—that was the International Panel on Climate Change. And so it was reviewed, and the scientists took a look at it.

END 9:29 A.M. EDT

*South America

We were able to obtain one prior version of Dr. Gerberding's testimony to see some of what was deleted. The science that was removed is actually very similar to what the IPCC has told us.

The pattern of censorship by this White House on crucial information on global warming is unconscionable. There is no excuse.

We need an open and honest scientific process to ensure we know all we can possibly know about our climate, so that we can avert the worst impacts of global warming. I look forward to addressing questions to Dr. Marburger today.

Deleted Text from CDC Testimony on Global Warming and Public Health Compared With Relevant Findings of Nobel Prize Winning Scientific Body on Global Warming's Impacts

Deleted Text	IPCC Report Statements
<p><i>“Climate Change is Public Health Concern</i> In the United States, climate change is likely to have a significant impact on health, through links with the following outcomes:</p> <ul style="list-style-type: none"> • Direct effects of heat, • Health effects related to extreme weather events, • Air pollution-related health effects, • Allergic diseases, • Water- and food-borne infectious diseases, • Vector-borne and zoonotic diseases, • Food and water scarcity, at least for some populations, • Mental health problems, and • Long-term impacts of chronic diseases and other health effects” 	<p><i>“Emerging evidence of climate change effects on human health shows that climate change has:</i></p> <ul style="list-style-type: none"> • [A]ltered the distribution of some infectious disease vectors . . . ; • [A]ltered the seasonal distribution of some allergenic pollen . . . ; • [I]ncreased heatwave-related deaths . . . <p><i>Projected trends in climate-change-related exposures of importance to human health will:</i></p> <ul style="list-style-type: none"> • [I]ncrease malnutrition and consequent disorders, including those relating to child growth and development . . . ; • [I]ncrease the number of people suffering from death, disease, and injury from heatwaves, foods, storms, fires and droughts . . . ; • [C]ontinue to change the range of some infectious disease vectors . . . • [I]ncrease the burden of diarrhoeal diseases . . . ; • [I]ncrease cardio-respiratory morbidity and mortality associated with ground-level ozone. . . .”¹ <p><i>“Several studies have confirmed and quantified the effects of high temperatures on common forms of food poisoning, such as salmonellosis. . . .”²</i></p> <p><i>“There is increasing evidence of the importance of mental disorders as an impact of disasters Prolonged impairment resulting from common mental disorders (anxiety and depression) may be considerable.”³</i></p> <p><i>“Water-borne diseases will rise with increases in extreme rainfall In regions suffering from droughts, a greater incidence of diarrhoeal and other water-related diseases will mirror the deterioration in water quality”⁴</i></p>
<p><i>“Heat Stress and Direct Thermal Injury</i> The United States is expected to see an increase in the severity, duration, and frequency of extreme heat waves. This, coupled with an aging population, increases the likelihood of higher mortality as the elderly are more vulnerable to dying from exposure from excessive heat.”</p>	<p><i>“Severe heatwaves will intensify in magnitude and duration over the portions of the U.S. . . . where they already occur”⁵</i></p> <p><i>“Local factors, such as the proportion of elderly people, are important in determining the underlying temperature-mortality relationship in a population”⁶</i></p>
<p><i>“Extreme Weather Events</i> Climate Change is anticipated to alter the frequency, timing, intensity, and duration of extreme weather events, such as hurricanes and floods”</p>	<p><i>“[C]onfidence has increased that some weather events and extremes will become more frequent, more widespread and/or more intense during the 21st century; and more is known about potential effects of such changes.”⁷</i></p>

Deleted Text from CDC Testimony on Global Warming and Public Health Compared With Relevant Findings of Nobel Prize Winning Scientific Body on Global Warming's Impacts—Continued

Deleted Text	IPCC Report Statements
<p><i>“Air Pollution-Related Health Effects</i> Climate change can affect air quality by modifying local weather patterns and pollutant concentrations, affecting natural sources of air pollution, and promoting the formation of secondary pollutants. Of particular concern is the impact of increased temperature and UV radiation on ozone formation. Some studies have shown that higher surface temperatures, especially in urban areas, encourage the formation of ground-level ozone. As a primary ingredient of smog, ground-level ozone is a public health concern. Ozone can irritate the respiratory system, reduce lung function, aggravate asthma, and inflame and damage cells that line the lungs. In addition, it may cause permanent lung damage and aggravate chronic lung diseases.”</p>	<p>“Surface ozone concentrations may increase with a warmer climate. Ozone damages lung tissue, causing particular problems for people with asthma and other lung diseases. Even modest exposure to ozone may encourage the development of asthma in children . . . For the 2050s, daily average ozone levels are projected to increase by 3.7 ppb across the eastern U.S. . . . with the cities most polluted today experiencing the greatest increase in ozone pollution . . . One-hour maximum ozone follows a similar pattern, with the number of summer days exceeding the 8-hour regulatory U.S. standard projected to increase by 68 percent.”⁸</p>
<p><i>“Allergic Disease</i> Studies have shown that some plants, such as ragweed and poison ivy, grow faster and produce more allergens under conditions of high carbon dioxide and warm weather. As a result, allergic diseases and symptoms could worsen with climate change.”</p>	<p>“Pollen, another air contaminant, is likely to increase with elevated temperature and atmospheric CO₂ concentrations. A doubling of the atmospheric CO₂ concentration stimulated ragweed-pollen production by over 50 percent . . .”⁹</p>
<p><i>“Water- and Food-borne Infectious Diseases</i> Altered weather patterns resulting from climate change are likely to affect the distribution and incidence of food- and water-borne diseases. Changes in precipitation, temperature, humidity, and water salinity have been shown to affect the quality of water used for drinking, recreation, and commercial use. For example, outbreaks of <i>Vibrio</i> bacteria infections following the consumption of seafood and shellfish have been associated with increases in temperatures. Heavy rainfall has also been implicated as a contributing factor in the overloading and contamination of drinking water treatment systems, leading to illness from organisms such as <i>Cryptosporidium</i> and <i>Giardia</i>. Storm water runoff from heavy precipitation events can also increase fecal bacterial counts in coastal waters as well as nutrient load, which, coupled with increased sea-surface temperature, can lead to increases in the frequency and range of harmful algal blooms (red tides) and potent marine biotoxins such as ciguatera fish poisoning.”</p>	<p>“Water-borne disease and degraded water quality are very likely to increase with more heavy precipitation. . . .”¹⁰ “Several studies have confirmed and quantified the effects of high temperatures on common forms of food poisoning, such as salmonellosis . . . In temperate countries, warmer weather and milder winters are likely to increase the abundance of flies and other pest species during the summer months, with the pests appearing earlier in spring . . . Warmer seas may thus contribute to increased cases of human shellfish and reef fish poisoning (ciguatera) and poleward expansions of these disease distributions . . . Overall, climate change is projected to increase the number of people at risk of hunger.”¹¹ “Extreme rainfall and runoff events may increase the total microbial load in watercourses and drinking-water reservoirs . . . , although the linkage to cases of human disease is less certain . . . A study in the USA found an association between extreme rainfall events and monthly reports of outbreaks of water-borne disease . . .”¹²</p>

Deleted Text from CDC Testimony on Global Warming and Public Health Compared With Relevant Findings of Nobel Prize Winning Scientific Body on Global Warming's Impacts—Continued

Deleted Text	IPCC Report Statements
<p><i>“Vector-borne and Zoonotic Diseases</i> Vector-borne and zoonotic diseases, such as plague, Lyme disease, West Nile virus, malaria, hantavirus pulmonary syndrome, and dengue fever have been shown to have a distinct seasonal pattern, suggesting that they are weather sensitive. Climate change-driven ecological changes, such as variations in rainfall and temperature, could significantly alter the range, seasonality, and human incidence of many zoonotic and vector-borne diseases. More study is required to fully understand all the implications of ecological variables necessary to predict climate change effects on vector-borne and zoonotic diseases. Moderating factors such as housing quality, land-use patterns, and vector control programs make it unlikely that these climate changes will have a major impact on tropical diseases such as malaria and dengue fever spreading into the United States. However, climate change could aid in the establishment of exotic vector-borne diseases imported into the United States.”</p>	<p>“Climate change is likely to increase risk and geographic spread of vector-borne infectious diseases, including Lyme disease and West Nile virus.”¹³</p> <p>“Many zoonotic diseases are sensitive to climate fluctuations . . . The strain of West Nile virus (WNV) that emerged for the first time in North America during the record hot July 1999 requires warmer temperatures than other strains. The greatest WNV transmissions during the epidemic summers of 2002 to 2004 in the U.S. were linked to above-average temperatures . . . A 1993 hantavirus outbreak related indirectly to heavy rainfall led to a significant reduction in tourist visits to the American Southwest . . .”¹⁴</p> <p>“Recent investigations of plague foci in North America and Asia with respect to the relationships between climatic variables, human disease cases . . . have suggested that temporal variations in plague risk can be estimated by monitoring key climatic variables.</p> <p>There is good evidence that diseases transmitted by rodents sometimes increase during heavy rainfall and flooding because of altered patterns of human-pathogen-rodent contact . . . Cases of hantavirus pulmonary syndrome (HPS) were first reported in Central America (Panama) in 2000, and a suggested cause was the increase in peri-domestic rodents following increased rainfall and flooding in surrounding areas . . ., although this requires further investigation. The distribution and emergence of other infectious diseases have been affected by weather and climate variability.”¹⁵</p>
<p><i>“Food Scarcity</i> Climate change is predicted to alter agricultural production, both directly and indirectly. This may lead to scarcity of some foods, increase food prices, and threaten access to food for Americans who experience food insecurity.”</p>	<p>“Both acute and chronic nutritional problems are associated with climate variability and change. The effects of drought on health include deaths, malnutrition (undernutrition, protein-energy malnutrition and/or micronutrient deficiencies), infectious diseases and respiratory diseases . . .”¹⁶</p> <p>“North American agriculture has been exposed to many severe weather events during the past decade. More variable weather, coupled with out-migration from rural areas and economic stresses, has increased the vulnerability of the agricultural sector overall, raising concerns about its future capacity to cope with a more variable climate . . . North American agriculture is, however, dynamic. Adaptation to multiple stresses and opportunities, including changes in markets and weather, is a normal process for the sector.”¹⁷</p>

Deleted Text from CDC Testimony on Global Warming and Public Health Compared With Relevant Findings of Nobel Prize Winning Scientific Body on Global Warming's Impacts—Continued

Deleted Text	IPCC Report Statements
	<p>“Vulnerability of North American agriculture to climatic change is multi-dimensional and is determined by interactions among pre-existing conditions, indirect stresses stemming from climate change (e.g., changes in pest competition, water availability), and the sector's capacity to cope with multiple, interacting factors, including economic competition from other regions as well as advances in crop cultivars and farm management . . . Water access is the major factor limiting agriculture in south-east Arizona, but farmers in the region perceive that technologies and adaptations such as crop insurance have recently decreased vulnerability . . . Areas with marginal financial and resource endowments (e.g., the U.S. northern plains) are especially vulnerable to climate change . . .”¹⁸</p>
<p><i>Climate Change Vulnerability</i> The effects of climate change will likely vary regionally and by population. The northern latitudes of the United States are expected to experience the largest increases in average temperatures.</p>	<p>“The United States (U.S.) and Canada will experience climate changes through direct effects of local changes (e.g., temperature, precipitation and extreme weather events), as well as through indirect effects, transmitted among regions by interconnected economies and migrations of humans and other species. Variations in wealth and geography, however, lead to an uneven distribution of likely impacts, vulnerabilities and capacities to adapt.”¹⁹</p> <p>“Late in the century, projected annual warming is likely to be 2 to 3 °C across the western, southern, and eastern continental edges, but more than 5 °C at high latitudes. The projected warming is greatest in winter at high latitudes and greatest in the summer in the southwest U.S. Warm extremes across North America are projected to become both more frequent and longer.”²⁰</p>

¹ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 8, Human Health, 393 (2007).

² Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 8, Human Health, 400 (2007).

³ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 8, Human Health, 399 (2007).

⁴ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 3, Freshwater resources and their management, 189 (2007).

⁵ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapter 14, North America, 632 (2007).

⁶ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapter 8, Human Health, 398 (2007).

⁷ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Summary for Policymakers, 17(2007).

⁸ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 14, North America, 632 (2007).

⁹ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 14, North America, 632 (2007).

¹⁰ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 14, North America, 619 (2007).

¹¹ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 8, Human Health, 400, 414 (2007).

¹² Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 8, Human Health, 401 (2007).

¹³ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 14, North America, 619 (2007).

¹⁴ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 14, North America, 625 (2007).

¹⁵ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 8, Human Health, 404 (2007).

¹⁶ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 8, Human Health, 399 (2007).

¹⁷ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 14, North America, 624 (2007).

¹⁸ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 14, North America, 631 (2007).

¹⁹ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 14, North America, 619 (2007).

²⁰ Intergovernmental Panel on Climate Change, *Climate Change 2007, Fourth Assessment Report*, Working Group II, Chapt. 14, North America, 627 (2007).

Senator KERRY. Well, Senator Boxer, let me just say, first of all, I am ready, willing and anxious to engage with you on this. And I'm shocked, I mean, I'm really stunned—I guess I'm not surprised, but I'm shocked. I'm not surprised, because it's not the first time that we have had reports that have been redacted, where basic scientific fact is being eliminated from reports by this Administration.

You know, Dr. Marburger, I don't know when you came to this job, I don't recall, we'll get into all of that. But you have a lifetime reputation at stake here, you and everybody in here. You're scientists. A man of reputation. And I would think, at some point, some people in this Administration would either start resigning, or standing up and talking out publicly about this, because it's a disgrace. Just an utter disgrace. Science is being rendered completely irrelevant to the politics, and it's unacceptable to the American people.

You know, this Administration's record on this is going to be recorded in infamy—infamy. The degree to which they have avoided the reality of what's happening in other countries—Presidents, Prime Ministers, Foreign Ministers, Economic Ministers, Trade Ministers—all of them have invested their countries' efforts to respond to this, but not the United States of America.

And it's embarrassing, let alone tragic when we look at the potential implications for our children and our grandchildren and what we leave behind us.

You know, you can go up to Wyoming and Montana right now, and you can see tens of thousands of acres of forests that are being destroyed by pine needle, bark—bark insects, that used to die, but don't now, because it isn't as cold. You could listen to Lisa Murkowski yesterday, in another Committee that we had, talking about what's happening to the permafrost in Alaska, they're moving a village at a cost of \$140 million, that's \$140 million for one village, mitigation, against what's happening to climate change.

And the IPCC report says that some 46 million people are going to be effected, just by the level of sea level rise today, without taking into account the hundred billion metric tons that is melting in the Greenland ice sheet which was stable in 1990 and is no longer stable.

I'm not going to go on and on about it, but I'll tell you, it's just shocking to me as a United States Senator and as a citizen of America, which prides itself on the truth and on the free exchange of ideas and truth that we have so much lying and deception and avoidance going on in this country, it's just shocking.

And I cannot emphasize enough, how it will be recorded in infamy, and I will make every effort to get this Committee to challenge the Administration on this question of executive privilege with respect to this, we need to know why and how and who is

doing this. And we're going to try to find out. And I thank you, Senator Boxer, for bringing that up today.

Senator Nelson?

**OPENING STATEMENT OF HON. BILL NELSON,
U.S. SENATOR FROM FLORIDA**

Senator NELSON. Mr. Chairman, I am looking forward to traveling with you and Senator Boxer to the global gathering on global warming in Bali, Indonesia.

I think that the reason I bring this up, Dr. Marburger, is that—as was explained to us in an extensive hearing yesterday that this global climate change gathering in Indonesia, is not about the substance of the issue, it's about the process by which we should start to address the substance. And what is important, is that the United States be well-represented as being very much a part of wanting internationally, to solve this problem.

The story was told yesterday that basically, the Senate was not consulted as it should have been in the 1990s, well, that's not going to be a problem with having the Senate consulted this time, because we're going to be in it with all four feet.

But the—an expression from the Administration, even though there will be a change of Administrations in little over a year—the expression of the Administration at this point, about the concern of global warming, and the need, not only for other countries to do something about it—but for our country to take the lead, is going to be very important.

Now, I say this to you, Mr. Marburger—you've got a lot on your plate, and you have certainly had your own personal challenges, recently. And it is good to see you looking so well, and I'm very hopeful for you and in this Administration, there's only a little over a year left for you to put your stamp of approval, your stamp of influence on this process.

There's another one that, of course, as we get into this subject, that I would like you to be concerned about, and that is the measuring of the changes in our climate, as a result of our assets overhead. Because we're ending up not having the right satellites up there to measure all of the delicate changes in the environment that we need.

As a matter of fact, the National Research Council of the National Academy of Sciences, has cited concerns with the demanifesting of the climate sensors from NASA and NOAA satellites. We chaired a hearing, that's in my Subcommittee of the full Committee, in a hearing in July of this year, we had NASA and NOAA here, and I asked that by the end of this year, 2007, to see their plans for replacing the sensors NPOESS that never did pan out, in implementing what they call the Decadal Study of the missions.

I followed that up from that hearing on July 11 of this year, with letters to Dr. Griffin, and to Admiral Lautenbacher, and I have not received a reply.

Now, that just simply shouldn't be. Here, you want us to help you all, which is our appropriate duty, since we authorize and appropriate, that we have the proper assets up in space so that we can measure the changes on this delicate planet, in order to be able

to make more informed decisions. And, I'd like you to go in and rattle their cages at NASA and NOAA.

What they did, unfortunately—you want the bottom line on what goofed up? NASA, who knows how to build and design, build and operate satellites, they put it over to NOAA, that doesn't know anything about it, and they ended up designing this satellite that was all things to all people, and then, of course, the technology didn't work, and the budget just went through roof, so we are where we are.

In July I asked, "What are we going to do about it?" I haven't heard anything. So, I wish you would get, since you are in a strengthened condition, looking very good, I want you to get out your cane and go bang their cage, and get an answer.

Thank you, Mr. Chairman.

Senator KERRY. Thank you very much, Senator Nelson.
Senator Klobuchar?

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

Senator KLOBUCHAR. Thank you, Chairman Kerry.

And thank you, Chairman Boxer, Chairman of the Environment Committee for the work that you've done in bringing people together on this issue.

I want to introduce our Speaker of the House from Minnesota, Margaret Kelliher, who is out here, and I think she would probably be very surprised to look at this hearing room and see that there is only one side of the aisle represented at a hearing on climate change. Because in Minnesota, we have approached this on a bipartisan basis, passing one of the most aggressive renewable electricity standards in the country, 25 percent by 2025, 30 percent for Excel Energy, with their agreement. And we've done it on a bipartisan basis with a Republican Governor, and we've gotten it done.

And that's what I find so incredibly depressing about this issue, is the intransigency of this Administration, in terms of really moving on this issue. We view it in our State, again, as a bipartisan issue.

And I think part of that is that in our State, first of all, it is the people in our State who have started to see what's happening with climate change—kids with penguin buttons, ski resort owners have seen a 30 percent reduction in profits because of the lack of snow, hunters in Hibbing, Minnesota, who see the changes to their wetlands, people who ice fish who are taking months to put their fish houses out, because they've seen the changes in the climate.

And I can tell you that we are a State that believes in science. We brought the world the Post-It Note, and the pacemaker, and we believe in science. And to us, this means that you put the scientific information out there, Dr. Marburger.

And I wanted to, as a Member of the Environment Committee, echo what Chairman Boxer has said, that I was just incredibly surprised, that in this time, when we're trying to work on a bipartisan basis with Senator Warner, and Senator Lieberman, to make some progress in climate change, that this testimony of the head of the Centers for Disease Control was edited, was censored, as Chairman Boxer said, that was a bunch of baloney—which I like because it

sounded like something we'd say in Minnesota—and I, you know, I just want to use one example of what I've found so distressing about this.

And that is that, in this original testimony—and you can see the pages that were deleted—it, while the fires were raging in California, a portion of the testimony that was deleted said, quote, this was from Dr. Gerberding, deleted testimony, “The West Coast of the United States is expected to experience significant strains on water supplies, as regional precipitation declines, and mountain snow packs are depleted. Forest fires are expected to increase in frequency, severity, distribution and duration.”

So, while the world was transfixed on the raging wildfires in California, the Administration deleted this portion of the testimony.

And then as the Chairman explained, the reason given was that it wasn't consistent with what the IPCC said in their reports.

Well, the fourth assessment of the IPCC report said, “Warm spells and heat waves will very likely increase the danger of wild-fire.” And we will get into this more. But, I just think that was a bogus answer for why this part of the testimony was deleted. We need the science out there, we need this information, and I think the Senate needs to act now on climate change, I don't think we can wait until after the Presidential election, I think we need to move now, and I think we need to move in a bipartisan basis, with the Administration at our side.

Thank you.

Senator KERRY. Thank you very much, I appreciate it, Senator Klobuchar.

Thank you all for being here. I hadn't noted, but it is sort of interesting that there's a vacuum over here. I hope it's not going to persist throughout this process.

Senator Cantwell originally intended to be here, but she had a last-minute scheduling conflict, so her opening statement will be placed in the Record in full.

[The prepared statement of Senator Cantwell follows:]

PREPARED STATEMENT OF HON. MARIA CANTWELL, U.S. SENATOR FROM WASHINGTON

Mr. Chairman, thank you for holding this incredibly important hearing.

I would like to take a moment to commend Senator Kerry for his leadership on this issue, and the ongoing efforts by him and many of my colleagues to develop legislative solutions to meet the enormous challenges global warming poses our Nation and our planet.

I am proud that Washington state is taking the lead on the issue of global climate change. While my state's contribution to global warming is relatively small—because we are fortunate enough to derive about 70 percent of our electricity from inexpensive, emissions free hydropower—global warming threatens to seriously impact our economy.

Ironically, one of the primary impacts of global warming on the Pacific Northwest will be to change our rainfall patterns in a way that reduces the amount of water available for hydropower production.

And these changes will not only harm electricity generation, they will also impact billions of dollars of economic infrastructure associated with irrigation systems, municipal water supplies, even ski resorts that depend on our historic snowfall patterns.

Faced with these possibilities, we must ask several simple questions:

- What are we doing to prepare for these changes?

- How are predicted sea level rises being incorporated into shoreline restoration projects, siting of public infrastructure, or disaster response plans, among many other examples?
- What tools do we need to give Federal, state, and local decisionmakers to take climate change into account on long-term, multi billion dollar decisions?

Unfortunately, the answers to these questions do not come easily.

As we discovered when I held a hearing on ocean acidification as chair of the Oceans, Atmosphere, Fisheries and Coast Guard subcommittee last May, our government is ill-equipped to plan for the consequences of global climate change. We simply lack the tools to develop the strategies we need to adapt.

In August, the Government Accountability Office found that the Federal Government is not providing Federal agencies with the proper tools or policy mandates to take climate change impacts into account in carrying out their responsibilities to manage public resources.

In September, the National Academy of Sciences concluded there is a tremendous need to improve the delivery of climate change information to Federal, regional, and local levels so they can take climate change impacts into account in planning and managing resources.

The reality is that even if we were somehow able to stop using fossil fuels today, a certain degree of warming and ocean acidification will still occur over the next two or three decades.

While my top priority is to move our Nation to a clean energy system, we must face the fact that global warming is happening already, and it is only going to get worse.

That's why I am pleased today to be introducing the Climate Change Adaptation Act—a bill to ensure that our government plans for the changes that global warming will inevitably bring. This bill will require the President to develop a national strategy for addressing the impacts that climate change will have on our natural resources. It will also specifically require NOAA to conduct vulnerability assessments on the impacts of climate change on coastal and ocean resources, and to prepare adaptation plans for those resources.

Planning for the future isn't just common sense—it's responsible government.

This bill is complementary to several bills under consideration by the Commerce Committee, including the Kerry-Snowe Global Change Research Improvement Act. That bill contains many provisions I believe are vitally important—including language I authored with Senator Collins on the need for a program to study the threat of abrupt climate change. I'm also proud to work with Senator Lautenberg on legislation combating ocean acidification.

I look forward to working with my colleagues to move all these critical bills out of the Committee and through the Senate in the coming weeks.

Thank you.

Senator KERRY. Dr. Marburger, you see the stage is set. We certainly look forward to your testimony, we do appreciate your being here, and we look forward to hearing from you. We're interested not in having a battle, but in really trying to get beyond what seems to be just kind of a reluctance to embrace fact. And maybe you can help shed some light on all of this.

You know, right here in this room, Senator Gore and I and a few others, held the very first hearings on climate change 20 years ago. And Jim Hansen and others were giving the early warnings of all of this. That was in 1987.

Five years later, Senator Gore, Senator Wirth, Senator Lautenberg—who was here earlier—myself, Senator Chaffee, Senator Larry Pressler, a few others, we all went down to Rio, to the Earth Summit. Where President George Herbert Walker Bush, and his Chief of Staff, John Sununu, and Bill Riley and others joined in signing on to the voluntary framework.

Over the 20 years since then, we've had an enormous development of science. And what's shocking to me, and others, is as we've sort of, I mean, you know, we try to keep up on this, we read a lot, meet with a lot of people, stay up on the science, and met fre-

quently with John Holdren at Harvard, with Bob Correll, others, you know these folks—their warnings are just growing in intensity.

The science is coming back at a greater rate with their models being shattered, not to the contrary, but being shattered by the increasing evidence and increasing rate above and beyond what they had predicted earlier. And yet, still, we don't see the response from the Administration.

And then we see things like Senator Boxer just described a few minutes ago. It really is disturbing.

The most recent scientific reports talk about the oceans, having reached the saturation point, in terms of CO₂ sink. I, as Chairman of the Oceans Subcommittee, sat here 10 years ago and listened to scientists predict—they couldn't tell us when it happens, they didn't know what the saturation point was, but they knew that that possibility existed. Now, we see it happening in places. Not to mention the importance of deforestation, of tropical forests, particularly—you can run down a long list, and it's all science.

So, help us understand where we're going on this, and what we can anticipate, and we look forward to your testimony. Pull the mic down near you and close to you, that would be terrific.

STATEMENT OF JOHN H. MARBURGER III, PH.D., SCIENCE ADVISER TO THE PRESIDENT AND DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, ACCOMPANIED BY JACK A. KAYE, PH.D., DIRECTOR, RESEARCH DIVISION, NASA OFFICE OF EARTH SCIENCE

Dr. MARBURGER. Thank you, Mr. Chairman. I am pleased to be here this morning, and I want to acknowledge that climate change is occurring, it's a very serious issue, there's no question that we're producing more CO₂ than we should be for the future health of this planet, and something must be done about it.

I want to be clear that there is widespread agreement on this. This Administration agrees with the statements of the status of science that are embedded in the IPCC reports that were released, and before I begin with my prepared testimony, I would like to say that these IPCC reports—which are the gold standard for science and the summary of the status of scientific knowledge about climate change—have been very substantially supported by U.S.-funded research. Far from being behind or second following the pack, as it were, in climate science, this country—during this Administration as well as in previous Administrations—has led the world in funding climate science, and U.S. scientists have contributed very substantially to the conclusions that many people are citing here and in Europe. We should be proud of our leadership in climate science, not ashamed of it.

So, Mr. Chairman, the testimony that I had prepared, addresses rather bureaucratic issues associated with the structure of the Climate Science Program in the U.S., its history, some of its current characteristics, and some ideas about what it takes to make a strong science program.

I'm going to have a brief oral statement about those, and address other questions that you may have regarding climate science and issues that other speakers this morning have addressed.

Senator KERRY. We appreciate that, we'll put your full statement in the Record, as if read.

Dr. MARBURGER. Thank you very much.

My written statement has three parts, a history of the Global Change Research Program that was created in 1990, by the Global Change Research Act, a description of the current structure of the climate change science, climate change technology programs that were established by this Administration in 2002, and a list of seven characteristics essential for the successful management of an inter-agency Federal science program, basically my ideas and observations about this.

I listed 8 accomplishments of the original 1990 Act in my testimony, but noted some weaknesses that became apparent during the first decade of its operation. Some of those weaknesses were pointed out in a 2001 report of the National Academies of Sciences, and it was in that year, 2001, that President Bush decided to introduce a management structure that would establish a clear line of accountability for the climate change science, and climate change technology programs.

Rather than have the lines of responsibility end at an inter-agency group with relatively weak authority, he stipulated that officers of his cabinet should bear responsibility for these functions. And that is the underlying rationale for adding the new groups to the existing Global Change Research Program structure, and requiring the Secretary of Commerce and the Secretary of Energy to head the programs. The Secretaries serve as the top management of the programs in alternate years.

As I explained in my written testimony, the Climate Change Science Program was developed to balance the near-term focus of the President's Climate Change Research Initiative with the breadth and long-term objectives of the U.S. Global Change Research Program, pursuing accelerated development of answers to the scientific aspects of key climate policy issues, while continuing to seek advances in the knowledge of the physical, biological and chemical processes that influence the Earth's system.

Finally, as to what it takes to make a successful interagency science program, let me briefly state that the statute that establishes the program should not be overly prescriptive. The program's structure should engage line management, the budget structure must acknowledge the realities of Federal budgeting, which involves a number of different Senate and House committees. That the frequency and level of reports must not impede the management of the science, that communication of results is important, that explicit arrangements should be made for stakeholder input and that an interagency coordination office is a best practice.

I also mention the importance of strong leadership in science and management. The full testimony has details on these things. I think it's probably more productive for us this morning for me to respond to your questions.

Dr. Kaye is here with me as an expert, he does not have a prepared testimony, but—I am not a climate scientist myself, although I am a physicist and understand a good bit of it, Dr. Kaye has been actively involved in the scientific support to the IPCC process, and I'm going to rely on him for any technical questions you may have.

Thank you.

[The prepared statement of Dr. Marburger follows:]

PREPARED STATEMENT OF HON. JOHN H. MARBURGER III, PH.D., SCIENCE ADVISOR
TO THE PRESIDENT AND DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY

Chairman Inouye, Vice Chairman Stevens and Members of the Committee, I appreciate the opportunity to appear before you today at this hearing on climate change. My remarks will focus on how climate change science has been conducted in the Federal Government in the past, and on drawing lessons from our experiences that might inform future coordination and management of the Federal climate science enterprise.

Summary of USGCRA

The U.S. Global Change Research Act of 1990 (USGCRA) was not the first legislation to deal with climate change science, but it was a landmark piece of legislation that established, for the first time, a structured Federal process for addressing the scientific questions associated with global change in an organized way across agencies.

The USGCRA did not focus only on climate change. Although it included climate change and variability as one of the agents of global change, it also expressed concerns about a growing human population and the effects of industrial and agricultural practices on Earth habitat, including the effects of chlorofluorocarbon emissions on the ozone layer. Only later did the Federal agencies focus settle on climate change. All these issues of global change, however, overlap to some extent with climate change—not so much with the physical mechanisms of the climate as with the impacts of a changing climate on human, plant, and animal populations.

USGCRA accomplished several important things. First, it created the U.S. Global Change Research Program (USGCRP or Program), the first interagency program aimed at climate change and other global change processes and agents. At that time, several Federal agencies had begun to investigate global change processes, and the enactment of the USGCRA brought those research efforts together.

Second, USGCRA established a governance structure for the interagency Program. It created a committee under the Federal Coordinating Council on Science, Engineering, and Technology (which has since evolved into the National Science and Technology Council (NSTC)) and specified that it would be populated by high-ranking officials from a minimum of fourteen Departments, agencies, and White House Offices. Under this structure, the Director of the Office of Science and Technology Policy (OSTP), as Director of NSTC, provided oversight for the interagency process.

Third, USGCRA required that the Program develop a plan. It specifically required that the plan define roles and responsibilities, identify key research activities, and foster domestic and international partnerships. A set of specific research elements was also included.

Fourth, USGCRA recognized the value of external guidance, provided for broad public participation in the development of the Plan, and required periodic review of the Plan by the National Research Council.

Fifth, the legislation called for budget coordination among the Program participants. Budget coordination among agencies can be a tricky process, but the USGCRA called for guidance to be issued by the interagency Committee to the participating agencies. It also required each agency to identify its global change research activities and to report those elements to the Committee and as part of its budget request. In turn, the President was instructed to provide the Committee with an opportunity to review and comment on the budget requests of the participating agencies.

Sixth, the USGCRA required two periodic reports: a scientific assessment of global change and an additional report.

Seventh, the law recognizes the value of communicating the results of research investigations and calls for the establishment of a global change research information office.

Eighth, the USGCRA highlighted the importance of U.S. participation in international cooperative efforts to advance research and to work with international partners in mitigating and adapting to the effects of global change.

How well did this structure and management approach work? During the nineties, the U.S. supported long-term studies, research into basic climate change processes, the development of models, and cooperative international field campaigns and assessments. But it was not until 2000, 10 years after the USGCRA was passed, that

a National Assessment was published. Further, all the prescribed statutory elements of the scientific assessment provision were not completed until July 2003.

During that time, however, U.S. scientists played a central role in the investigation of many critical climate change processes, and U.S. scientists from Federal agencies and from numerous research institutions supported by Federal funds produced a significant portion of the scientific work underlying the Intergovernmental Panel on Climate Change (IPCC) assessment reports, as well as other international scientific efforts.

Summary of the President's Plan

In a report commissioned by the current Administration, *Climate Change Science: An Analysis of Some Key Questions*, the National Research Council reviewed and evaluated the climate change assessment produced by the Intergovernmental Panel on Climate Change (IPCC, 2001) and made a number of recommendations about climate change research needs. In response to that report and a growing concern about climate change, the President launched the Climate Change Research Program, and to accelerate progress in resolving uncertainties about the global climate system that had been identified by policymakers or described in the National Research Council report.

At that time, it also became clear that energy consumption and energy technologies would play central roles in understanding and forecasting climate change and mitigating emissions of greenhouse gases. As a result, the Climate Change Technology Program (CCTP) was created to pursue the research and development of technologies to complement the science research efforts. The Program subsequently was authorized in the Energy Policy Act of 2005.

In order to improve the research support for decisionmaking and to increase accountability, the Administration developed a new management structure for these research programs. The President announced this change on February 14, 2002, when he established a new high-level structure for coordinating Federal climate change science and technology development.

At the highest level, the new structure acknowledges the responsibility of the White House policy offices to examine high level climate science and technology policy and make recommendations to the President.

To establish clear line authority for execution of the program, the President designated the Secretaries of Commerce and Energy to assume responsibility for integrating and managing the program offices. A Committee on Climate Change Science and Technology Integration was established to oversee the Federal climate change science and technology programs. The Committee consists of the Secretaries and Administrators of Departments and Agencies that have substantial research activities in climate change science or technology and is co-chaired by the Secretaries of Commerce and Energy. The Executive Director of the Committee is the Director of the OSTP. The Committee, in coordination with the Office of Management and Budget (OMB), provides recommendations concerning climate science and technology to the President and may, if needed, recommend the movement of funding and programs across agency boundaries.

In addition to the Cabinet-level Committee, an interagency working group was established at the Deputy Secretary or Undersecretary level to ensure implementation of priority research activities within the Departments. The Interagency Working Group on Climate Change Science and Technology reports to the Committee on Climate Change Science and Technology Integration and meets regularly to address pressing issues within the Climate Change Science Program and the Climate Change Technology Program. The Chair and Vice Chair rotate annually between the Department of Energy and the Department of Commerce. The Executive Secretary of the Working Group is the OSTP Associate Director for Science. The Working Group reviews all programs that contribute to climate change science and technology and makes recommendations to the Committee about funding and program allocations in order to implement a climate change science and technology program that will contribute to the enhanced understanding needed to better support policy development.

The Climate Change Science Program (CCSP) was developed to balance the near-term (2- to 4-year) focus of the Climate Change Research Initiative with the breadth of the USGCRP, pursuing accelerated development of answers to the scientific aspects of key climate policy issues while continuing to seek advances in the knowledge of the physical, biological and chemical processes that influence the Earth system. CCSP has joint membership with the NSTC's Subcommittee on Global Change Research (SGCR), the interagency body that coordinates the USGCRP under the NSTC Committee on Environment and Natural Resources. CCSP includes representatives from all agencies that have mission activities and/or funding in climate

science research. The CCSP is responsible for defining integrated program goals and priorities and for reviewing all programs that contribute to climate change science. Participating agencies are responsible for ensuring their plans and programs implement the goals, priorities, and plans defined by the CCSP in the course of fulfilling their respective agency missions. For this reason, participating agencies' personnel play an active role in the formulation of CCSP strategy.

The CCTP provides for the coordination and development, across all Federal research and development (R&D) agencies, of a comprehensive, multi-year, integrated climate change technology R&D program for the United States. An interagency working group carries out much of the technical coordination. The CCTP Office provides technical and staff support, and performs certain integrative, analytical, modeling, communication, and administrative functions. As with the CCSP, participating CCTP agencies are responsible for ensuring their plans and programs implement the goals, priorities, and plans defined by the CCTP in the course of fulfilling their respective agency missions, and here too participating agencies' personnel play an active role in the formulation of CCTP strategy.

Within this management structure the Director of OSTP serves as Executive Director of the Cabinet-level Committee, the OSTP Associate Director for Science serves as Executive Secretary of the Deputy-level Interagency Working Group, and an OSTP representative serves on the CCSP Principals' Group. OSTP maintains an oversight role in the current management structure of CCSP and CCTP, but the day-to-day management is the responsibility of the Directors of CCSP and CCTP. While this committee structure appears to be complex, there is considerable overlap among the membership of each component, and frequent communication among OSTP, the Council on Environment Quality and relevant Department and Agency officials.

Optimizing Structure and Management for Climate Change Science Research

Based on an examination of the interagency coordination process that drove the U.S. Global Change Research Program, and comparing it with the activities and management of the shorter-term CCSP, I consider the following characteristics to be essential for successful management of an interagency Federal science program.

First, the statute that prescribes the research program should not be overly prescriptive. Today, the 2007 program is diligently working to produce assessments on topics that were prescribed in 1990. Fortunately, the program is also working to produce results on other important climate change topics that were not envisioned in 1990—such as the likelihood of abrupt climate change and understanding the mechanism of melting in ice sheets. An appropriate reauthorization, therefore, should not attempt to direct the research program's specifics for years to come, but rather provide flexibility for the program managers to determine the topics to be addressed through their interaction with the National Research Council and other stakeholders.

Second, the program must have a governance and management structure in which the scientists, the agency managers, and the program coordinators for whom they work. Strong interagency coordination is essential, but scientists work for funding institutions and will respond to direction from line management. Having line managers involved in the management of the interagency process at several levels is a strength of the CCSP model.

Third, it is a reality that central budgeting for an interagency effort like CCSP or CCTP is incompatible with the Federal budget structures and processes. Each agency must submit its own budget for its work. Centralizing funding of interagency efforts is not a desirable goal.

Fourth, reports and other products must be useful and the number and timing of products must be reasonable. A scientist who produces several synthesis products in addition to his or her primary scientific publications will lose valuable research time to the effort. Demands for assessment products must include careful budgeting for the human and financial resources necessary to produce those secondary or tertiary publications.

Fifth, communication of research results and assessment products is necessary and very valuable. Development of decision support tools requires specialists in that field. Communications professionals that are capable of translating highly technical research results into publications for decisionmakers are essential.

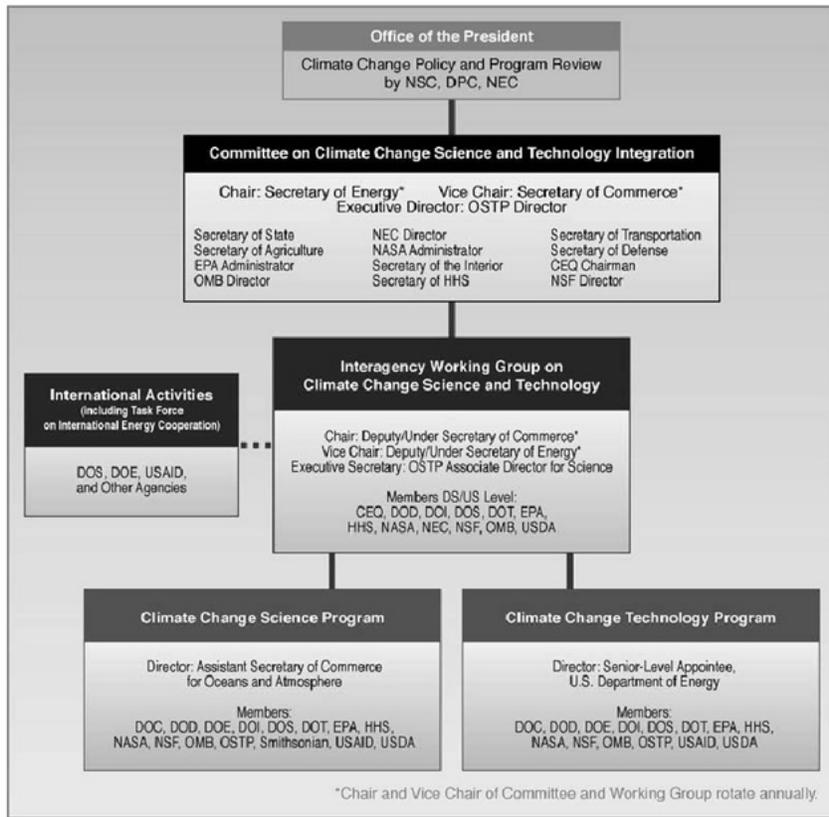
Sixth, a well-run program coordination office has great value in the implementation of an interagency program. The establishment of a coordination office should be part of any interagency program.

Seventh, input from stakeholders during the planning process is an essential ingredient of successful programs. The current interaction with the National Research

Council is vital to program strength and credibility, and the current role of the states and Governors is particularly important. The increasing emphasis on regional and local impacts of climate change will require the advice and cooperation of state and local governments. An advisory panel for the climate change research program would be entirely appropriate.

One intangible factor—strong leadership in science and management—has an enormous impact on the success of an interagency effort. Leadership is required at every level of the program—in the central coordinating office and in each of the participating agencies and groups of research scientists. The interdisciplinary nature of climate science and technology and the very high degree of interest in climate issues among a wide diversity of stakeholders renders the leadership function an extremely challenging one in this case. We have been fortunate to have talented individuals willing to devote themselves to the success of this important Federal program, and I wish to take this opportunity to express my gratitude to them on behalf of the Administration.

Thank you for the opportunity to speak with you today. I am prepared to answer any questions you have.



Senator KERRY. We appreciate it. Thank you very much.

Senator Stevens, did you have any opening statement you wanted to make?

**STATEMENT OF HON. TED STEVENS,
U.S. SENATOR FROM ALASKA**

Senator STEVENS. Well, I would like my statement to be printed in full in the Record.

I would like to indicate, though, climate change research has been an emphasis we have been pursuing for quite some time. When I was Chairman of Appropriations, I saw to it that we appropriated nearly, or since that time, nearly \$37 billion in climate change research. As a matter of fact, we currently spend more on research on the climate than any nation in the world.

I think this is a very important hearing, and I look forward to the statements. I would appreciate it if you would put my statement in full in the Record.

[The prepared statement of Senator Stevens follows:]

PREPARED STATEMENT OF HON. TED STEVENS, U.S. SENATOR FROM ALASKA

The United States is the world leader in climate change research. We currently spend more on research than any other nation in the world. Since 2001 Congress has appropriated nearly \$37 billion for climate change research, technology and incentive programs. In fact much of this funding was appropriated during my term as Chairman of the Appropriations Committee.

A robust research program is essential because any decision about the mitigation and prevention of climate change must be based on sound science.

In Alaska we have already begun to see the effects of climate change. This is especially true along our Arctic coast where communities are literally falling into the sea due to erosion. It is vital that we have the tools to allow these communities to adapt.

There is consensus that manmade carbon emissions have an impact on climate change. This, along with the need to achieve energy independence, is why I support raising the corporate average fuel economy standard. However, there is no agreement on how much of an influence these emissions carry. Sound science will help to resolve this question and avoid making policy decisions that can be unnecessary and over burdensome.

I look forward to hearing from our witnesses on how we can improve our understanding of climate change.

Senator KERRY. Absolutely, your full statement will be placed in the Record. And I did acknowledge in my opening statement, Senator Stevens, the degree to which the Committee has followed that and we've been trying to do it. I think the questions here are regarding the structure and format, and also the follow-through, because we haven't received the reports that we've asked for regarding it.

But, let me begin by asking, your opening statement, Dr. Marburger, is an important one. You say that it's happening, it's happening rapidly, it's a serious issue, we need to respond to it, et cetera.

We have United States Senators who don't believe what you just said. Who fight that. Have you ever reached out and come up here to brief some of those known resisters to this process?

Dr. MARBURGER. Yes, I have spoken with some of those who are skeptical about climate change, and gone over some details.

One of those things that I do when I talk with people who resist the notion of climate change, is encourage them to take a visit to the Koshland Museum, which is operated by the, under the auspices of the National Academy of Sciences over here on, I think it's 6th and E Streets, NW, it's a nice little science museum, and it has an exhibit on global change and climate change, in particular, which pretty well spells out findings of the National Academics, as expressed in its reports, and gives visual instruction in the impacts and the causes of climate change, and I would recommend that to anyone who's interested in learning more about it.

Senator KERRY. Have you suggested that to some of those that you've talked with?

Dr. MARBURGER. I have, indeed.

Senator KERRY. Has the Administration, in your judgment, engaged in a proactive, urgent process of trying to create a consensus with respect to what science tells us we must now begin to do, *i.e.*, reduce those carbon dioxide emissions, perhaps begin moving in alternative directions with respect to fuels and so forth.

Dr. MARBURGER. I think it's somewhat subjective to judge the effectiveness of these statements, but I always point to a speech that President Bush made, in the summer of 2001, when he acknowledged the existence of climate change, and the importance of taking action to reduce greenhouse gas emissions.

Since then, this Administration has worked very hard to support technologies that do, in fact, reduce or eliminate greenhouse gas emissions, but are related, as well, to energy independence. And while the emphasis has been, in public statements, about energy independence, there is a very strong overlap between the technology that's required for energy independence, and the technology that's required to address the serious problem of excessive greenhouse gas emissions.

Senator KERRY. We're obviously aware, I mean, we've seen a few of the tidbits that have been thrown, frankly, to certain sectors of the energy economy. I mean, these energy bills we've passed to date, for instance, 2 years ago we passed an energy bill—we in the Senate had a 65 percent concentration of the funding on alternatives and renewables, and about a 30 percent, 30, 40 whatever it was, remainder on fossil fuels.

In the conference Committee, that was rewritten and changed, and the Administration supported it, and they, in fact, came back with about a 65 percent fossil fuel, and 30 percent to the alternative renewable. So, you're going to have a very hard time persuading—at least this Member of the Committee—that the Administration has been a leader with respect to moving in that direction. Have they thrown some bones out there? Sure.

But let me, perhaps, phrase the question this way—you're the Chief Science Advisor to the President of the United States, who is the leader of the free world, and one of the most, we're the largest emitter of emissions in the world, and we're the biggest and strongest economy, for a little while longer.

My question to you is, what urgency do you tell the President? I mean, how urgent do you believe it is that we put in place some kind of mandatory movement, in order to meet what the science is telling us we must meet?

Dr. MARBURGER. Sir, that's a somewhat, that's a multiple question, and the issue of exactly how you go about changing the behavior of a large fraction of the human population of the world is one that's very difficult—

Senator KERRY. Well, just answer the first part of the question, how urgent do you believe the science is telling us it is? It's a simple question.

Dr. MARBURGER. I believe the science is telling us that it's important to begin to address the emission of greenhouse gases—

Senator KERRY. Is it urgent?

Dr. MARBURGER. We need to do it as soon as we can.

Senator KERRY. Does that mean it's urgent? I mean you're a science advisor, I hear you resisting the word urgent.

Dr. MARBURGER. There is—yes, absolutely, there is a sense of urgency here—

Senator KERRY. Sense of urgency? Or in your judgment, is it really urgent?

Dr. MARBURGER. In my judgment, it's important to begin to reduce our greenhouse gas emissions as soon as possible.

Senator KERRY. So, the top science advisor to the President is resisting using the word urgent.

Dr. MARBURGER. Yes, I am resisting the use of the word urgent, I think that the—

Senator KERRY. Frankly, I think you ought to resign. I really do. Can you tell me why it isn't urgent when you have the science that we've heard? When Jim—do you disagree with Jim Hansen that there's a 10-year window to get this right? You disagree with that?

Dr. MARBURGER. I am conflicted on this issue, because I know that it's going to be very, very difficult to reduce the greenhouse gas emissions as rapidly as is desirable. There is—it is very important for us to begin, it is very important for us to take the problem seriously—

Senator KERRY. Then you don't agree with the IPCC report? I basically hear you disagreeing with it. Because the IPCC report and the consensus of scientists is that you have to hold our greenhouse gas emissions to a level of about 450—it was 550, but now they say 450—parts per million. Now, we're at 370 today, 370, 380. We've gone up 100 in the course of the industrial revolution. China's coming online with hundreds of coal-fired powered, pulverized coal plants, India is doing the same, we're going to do the same—at the rate we're going, we're looking at 600 to 900 parts per million, which every scientist I've listened to tells me is catastrophic, beyond the tipping point of global climate change. Do you accept that?

Dr. MARBURGER. Yes, I accept those high numbers.

Senator KERRY. Then how can it not be urgent to move?

Dr. MARBURGER. What is urgent is to begin to reduce the greenhouse gas emissions, there's no question about that. That we must begin, this Administration has begun, by calling together the leaders of countries that are responsible for the greatest fraction of the emissions—

Senator KERRY. But they're not in favor of mandatory reductions.

Dr. MARBURGER.—and beginning to develop plans in each of those countries that are consistent with the particular circumstances of those countries. I don't—

Senator KERRY. Let me just interrupt you—do you believe that we can meet the goals we need to meet on a voluntary basis, Doctor?

Dr. MARBURGER. I believe that meeting the goals will require a mixture of policy and technology alternatives.

Senator KERRY. That's not what I asked you.

Dr. MARBURGER. And they would—

Senator KERRY. I asked you, do you believe we can do it without mandatory requirements?

Dr. MARBURGER. Belief is not a word that I tend to use for these issues.

Senator KERRY. Do you have confidence that as a policy we can achieve our goals without their being mandatory?

Dr. MARBURGER. It is possible that we could achieve the goals without mandatory.

Senator KERRY. And you have confidence that that is doable?

Dr. MARBURGER. I don't have confidence that it's doable.

Senator KERRY. Senator Stevens?

Senator STEVENS. I regret you asked someone to resign just because they disagree with you.

Senator KERRY. That's not why I asked him to resign.

Senator STEVENS. I certainly disagree with you, and I am not going to resign. What do you think of the International Arctic Research Institute that we have at the University of Fairbanks?

Dr. MARBURGER. Well, I think these institutes are an important part of the science that's done to keep us informed about the progress of global change.

Senator STEVENS. Do you have a climatologist on your staff?

Dr. MARBURGER. I do.

Senator STEVENS. Who is it?

Dr. MARBURGER. His name is Phil DeColla, and he is a scientist who is temporarily on loan to us from NASA.

Senator STEVENS. I find it interesting—

Dr. MARBURGER. I might add that he reports in his NASA capacity to Dr. Kaye, here, on my left.

Senator STEVENS. I will save some questions for Dr. Kaye.

I find it interesting that we listen to so many people who claim to have knowledge, yet the climatologists that have been studying this matter for 40 years at our University, and that's an international organization, sponsored by Japan, Canada, the United States, and sometimes other countries, have given us a definite impression what we are seeing is a continuum that is the ending of the warming, coming out of the "little Ice Age." Have you seen their presentations?

Dr. MARBURGER. Yes, I have, Senator.

Senator STEVENS. Have they influenced you at all, in terms of your work?

Dr. MARBURGER. Well, there's no question that there are natural—that is to say, nonanthropogenic, or non-human—causes for climate change, but there is a strong consensus that recent warming of the climate, which is observable, does have human origins, and—

Senator STEVENS. It all has human origins?

Dr. MARBURGER. Not all, but—

Senator STEVENS. I am told that one-fifth of the change in the last 100 years is a result of human intervention. Do you disagree with that?

Dr. MARBURGER. I'm not sure of that number.

Dr. KAYE, do you know?

Dr. KAYE. I'm not familiar with any one number, I know that we have to look at a wide range of parameters when you're trying to assign to what extent something's anthropogenic, or to some extent it's natural. You really have to look at a suite of things and try to—

that's how you get a fingerprint for what's human-induced, and what would be natural.

Senator STEVENS. We will ask questions later. I don't think there is a human contribution to the current problem of the increased warming. It is added to the ongoing warming trend that has been going on for well over 900 years. We are at the end of that trend, in terms of the climatologists I have visited with. If they are right, if we overreact now, and set arbitrary goals, we are liable to do more harm than good.

I look forward to the hearing.

Thank you very much, Mr. Chairman.

Senator KERRY. Thank you.

Senator, the reason I made the comment about resigning, I didn't call on him, I said I think he should, because I think the President of the United States ought to be getting what represents the scientific consensus and fact that is being put forward in the IPCC and elsewhere. And if the President is not getting that sense of urgency and fact, then I don't think the President is getting the best advice, that's my feeling.

Second, with respect—well, I'll come back to that afterwards. Let me turn to Senator Boxer.

Senator BOXER. Thank you, Senator.

You know, I think the statement from the Senator from Alaska is very close to what Senator Inhofe says every time we have a meeting. And I was pleased, Dr. Marburger, with your unequivocal statement that you do believe the IPCC is correct.

We better get off the dime here. There are always people that say, "HIV didn't cause AIDS, and Dr. Jonas Salk was wrong when he said there could be a vaccine," there are people who still say, "Smoking doesn't cause cancer." You know what? It's dangerous to follow that kind of lead. And Dr. Marburger, I'm very pleased with your unequivocal statement, and the fact that you did say there's—you didn't say there's—you didn't say it's urgent, you said there are—what was your comment? You used the word urgency.

Dr. MARBURGER. There's an urgency, I believe there's an urgency to begin to solve this problem, we must get started.

Senator BOXER. OK. There's an urgency to begin to solve this problem. I think Senator Stevens ought to hear that. The top science adviser, Senator Stevens says, there's an urgency—I'll wait, it's OK—the top science adviser—I thought girls gossiped.

Senator STEVENS. You do not stop when I am talking.

[Laughter.]

Senator BOXER. I always stop, I always listen to you.

[Laughter.]

Senator BOXER. Well, Senator—

Senator KERRY. All right, all right everybody, let's keep going forward here.

Senator BOXER. Senator Stevens, my entire talk so far which has been 60 seconds, has been aimed at what you said, I listen to everything you say.

Senator KERRY. Senator Boxer, I want you to know I was bringing him along, I was bringing him over to our side.

[Laughter.]

Senator BOXER. I know, I know, I know.

[Laughter.]

Senator BOXER. Well, you have better luck than I've had.

Now, here's the point. You had the President's top science advisor, George Bush's top science advisor, although he may not have used all of the words that I think he should, and I agree with Senator Kerry on that—saying that there is an urgency to start to reduce these carbon emissions. So, you can talk to scientists who are off in the corner, who are—maybe there's 5 percent of the scientists in the world that believe that—I'd rather go with 95 percent of the scientists.

Because if you look at the history of our nation, we listen to science. We don't go with the people who said, "The world is flat, the world is flat," there's still people who say the world is flat. But, here's why—because what's at stake here, is the whole future of the planet. And Dr. Marburger, I think you understand it, and that's why I'm going to segue way to my issue that I opened up with.

I know it's very unpleasant for you. But since you were blamed for the redacting, and I'll show you the *Washington Post* story, they show—one, two, three, four, five pages—five and a half pages redacted, Dana Perino blamed it on you. Did you redact those pages?

Dr. MARBURGER. Well, I'm not sure Dana Perino blamed it on me—

Senator BOXER. Well, I'll read you what she said—

Dr. MARBURGER.—but I—

Senator BOXER.—but go ahead.

Dr. MARBURGER. But my office participated in a process that is run by the Office of Management and Budget that reviews all testimony provided by senior Administration officials. And because there was a sharp media reaction to this incident that you described in your statement, Senator Boxer, I issued a statement of my own—

Senator BOXER. I read that, yes.

Dr. MARBURGER.—following this—

Senator BOXER. I read that.

Dr. MARBURGER.—that explained our role in the process. We were one of a number of commenters on the testimony, and we did recommend changes in the draft testimony that we saw. We did not recommend dropping, you know, wiping out 8 pages of it, but I gave examples in my statement, and in fact, I would like to submit my statement for the record for this hearing, if Chairman Kerry—

Senator BOXER. Chairman Kerry, is that OK, if we include that in the Record? OK.

[The information previously referred to follows:]

STATEMENT FROM DR. JOHN MARBURGER, DIRECTOR,
OFFICE OF SCIENCE AND TECHNOLOGY POLICY

October 26, 2007

"I am taking the unusual step of commenting on OSTP's participation in the review of testimony given by another Executive branch agency in order to respond to reports and press statements that have alleged or insinuated that OSTP acted inappropriately.

OSTP was asked to review draft CDC testimony as part of a standard interagency review process. The OSTP climate science experts who reviewed the draft testimony thought it was focused on the appropriate connections between climate change and impacts on human health, which is one of many topics in the recent Intergovern-

mental Panel on Climate Change's (IPCC's) Working Group II (WGII) report. However, they also found that there was an overall lack of precision in aspects of the draft testimony describing important details regarding the level of certainty for specific findings, the spatial scale for which certain impacts have been assessed, and the specific nature of some climate change impacts on human health. The draft testimony did not contain reference to any sources, either to the IPCC Fourth Assessment or more recent work completed and published after the deadline for inclusion in the IPCC. This led to OSTP comments asking the authors to either make more precise reference to IPCC conclusions, or cite the new work that supports a different conclusion.

OSTP regards the science that is reflected in the IPCC's Fourth Assessment—which was not cited or referenced in the draft testimony—as an accepted and important source of credible scientific information on the current state of climate change science. The comments of the OSTP reviewers were grounded in their in-depth understanding of the IPCC report.

The OSTP comments did not seek to redact sections of the report, but instead made a number of substantive and constructive comments and suggestions to ensure the testimony accurately represented the state of climate science and asked a number of questions intended to solicit clarity in the statements being made. My office takes our role in evaluating the scientific accuracy of Administration documents very seriously, and the comments of the OSTP reviewers in this instance were made based on their scientific knowledge of climate change science and upheld the high standards for scientific accuracy that I expect from my staff.

Several commentators have suggested that the draft testimony mapped faithfully to the IPCC's report. Those commentators have missed or ignored several nuanced but important differences between the IPCC report's findings and the draft testimony.”

Below are several examples:

1. Scalability of Impacts. The draft testimony begins by stating that “In the United States, climate change is likely to have a significant impact on health, through links with the following outcomes,” and then lists nine main areas of climate change impacts on health. The IPCC is not an assessment of impacts in the United States. Chapter 8 of the IPCC WGII report addresses human health impacts globally, and Chapter 14 of that same report focuses on impacts within North America—a large and diverse continent. While some studies have focused on U.S.-based impacts, it is imprecise to simply apply global or continental-scale impacts to the U.S. without a basis in more geographically-centered studies.

2. Extreme Weather Events. The draft testimony says “Climate change is anticipated to alter the frequency, timing, intensity, and duration of extreme weather events, such as hurricanes and floods.” The IPCC reports do not provide a basis for a link between hurricane *frequency* and climate change. Most of the text in the recent IPCC reports focuses on the link between hurricane *intensity* and climate change—an issue about which there is considerable debate within the scientific community. The testimony appeared to have modified a more general reference in the WGII report that “. . . some weather events and extremes will become more frequent, more widespread and/or more intense during the 21st century . . .”—a reference that may be accurately applied to certain weather events, but not, based on current science, to hurricanes.

3. Food Scarcity. The draft testimony says “Climate change is predicted to alter agricultural production, both directly and indirectly. This may lead to scarcity of some foods, increase food prices, and threaten access to food for Americans who experience food insecurity.” These statements do not reflect the full and complex consideration of agricultural impacts in the IPCC working group reports, and appear to be an ill-supported application of a potential global condition to the United States. In fact, the IPCC WGII report, in the chapter on North America says “Research since the [last IPCC report] supports the conclusion that moderate climate change will likely increase yields on North American rain fed agriculture . . . Most studies project likely climate-related yield increases of 5–20 percent over the first decades of the century . . . Major challenges are projected for crops that are near the warm end of their suitable range or depend on highly utilized water resources.”

4. Mental health problems. The testimony says “Some Americans may suffer anxiety, depression, and similar symptoms in anticipating climate change and/or in coping with its effects.” The IPCC report focuses on mental health issues in the context of post-disaster effects, not in *anticipating* them, as the testimony suggests.

Dr. MARBURGER. So——

Senator BOXER. Well, I read that, and I read very carefully what you wrote—those were small edits. And I read those.

Dr. MARBURGER. Right.

Senator BOXER. And that could have been changed with one word. I used to be an editor at a small paper and I know how to edit, all you had to do is change one or two words in those four areas, and that would have been fine. Someone redacted six pages, was it six pages?

Here we go, one, two, three, four, five, six and a half, right? Six and a half pages.

Now, when Perino was asked about it, she said, “I know our scientists at the Office of Science and Technology Policy looked at the draft, and wanted to make sure it was taking advantage of the science.” And that was all she said, she didn’t say anybody else looked at it—who else looked at it? Do you know?

Dr. MARBURGER. As I explained in my statement, there is a process of reviewing all testimony by senior Administration officials that’s run by the Office of Management and Budget——

Senator BOXER. OK.

Dr. MARBURGER.—they gather——

Senator BOXER.—well I just want you to know, they’re blaming you for it. And I will put in the Record, without objection, if I might, Mr. Chairman, Dana Perino’s statement. First she blamed you, then they came back again at her, and she said, “Well, look, I do know is the Office of Science and Technology Policy those scientists over there, led by Dr. Jack Marburger, are the ones who have been encouraging us to do climate change and they’re the ones who said these were wrong.” So, in your name, they’ve redacted this testimony.

Further, Fred Fielding—is that Fielding?—said that he will not turn over this material because of Executive Privilege.

So, I want to ask you something. You’re the top scientist. Do you think that the American people have a right to know what you think on global warming?

Dr. MARBURGER. Oh, of course, I do. Yes.

Senator BOXER. Do you think they have a right to know what the top doc, Dr. Gerberding, thinks about global warming?

Dr. MARBURGER. Yes, indeed.

Senator BOXER. Do you agree that the taxpayers pay the salary of not only us, but you and her, right?

Dr. MARBURGER. Certainly.

Senator BOXER. OK. Well, could you take this back to this Administration? Because I find it vile that they would not allow Dr. Gerberding’s testimony to be seen by the taxpayers of this country. You’ve got people like Senator Stevens, and Senator Inhofe saying that human beings really—in their opinion, after talking to their scientists—they don’t really believe humankind is the major cause of this.

Senator STEVENS. That is not true.

Senator BOXER. Well, I’ll reiterate what you said, you said it was 5 percent of the cause.

You just said it.

Senator STEVENS. No, I said it was one-fifth.

Senator BOXER. One-fifth of the cause. So, four-fifths of the cause have to do with other things. That is directly contrary to what the scientists are telling us at the IPCC who said, "Most of the observed increase in global average temperatures during the mid-20th Century is very likely due to the observed increase in greenhouse gas concentrations," and they go through it and they say, "Human influences now extend," et cetera, et cetera.

So, here's the point, Dr.—Dr. Stevens—

[Laughter.]

Senator BOXER. Senator Stevens has the absolute right to his opinion. His state is the one most at risk, by the way. Most at risk.

Senator STEVENS. From methane, not from CO₂.

Senator BOXER. Greenhouse gas emissions include methane.

Senator KERRY. In fairness, Senator Boxer, let me just say, Senator Stevens and I—and I've talked about this also in the past—there is an enormous amount—methane is released now in Siberia and Alaska, and elsewhere, and it's been released for a long period of time. Methane is 20 to 30 times more powerful than CO₂.

Senator BOXER. Right.

Senator KERRY. And there are pockets of methane that have been frozen for some 200,000 years, that now because the permafrost is melting, are also suddenly being exposed. So, we need to talk about methane capture and the natural capture, as well as the CO₂ component. And, the Senator is correct, that in his state there is a significant methane issue.

Senator KLOBUCHAR. But the permafrost is melting because of the climate change.

Senator BOXER. If I might take back—

Senator KERRY. Right, I understand—

Senator STEVENS. Not totally because of methane. It is a process of time.

Senator BOXER. Go ahead. I don't want to get in the way of this, this is great.

Let me just say this point. Our bill deals with greenhouse gas emissions, we all know it's not just carbon, OK? We understand that. The fact of the matter is, Senator Stevens has his scientific theories on it, after speaking with scientists, I have my own speaking with scientists, the taxpayers deserve to hear what you think, they deserve today, to hear what you said. That we need to start to act, there's a sense of urgency in the need to act.

And the thing in closing I would say is, you're getting blamed for this redacting, whether you like it or not. Somebody's hanging you out there to dry, and you ought to find out who it is, do you know who it is? Who redacted those pages, sir?

Dr. MARBURGER. No, I—

Senator BOXER. OK.

Dr. MARBURGER. They were sent back by OMB.

Senator BOXER. Well, I hope you get your—

Senator KERRY. By OMB?

Dr. MARBURGER. The process of reviewing testimony is run by the Office of Management and Budget.

Senator KERRY. Right.

Dr. MARBURGER. And they gather together comments from all of the offices and then send them back.

Senator KERRY. It's usually OMB that we hear does most of the deleting, I think, because they just see dollars.

Senator BOXER. Well, I would just say this—if I were you, and I were sitting over there, just knowing me, and somebody was hanging me out to dry, I wouldn't take it in as sweet as—you're a sweet person. I would not be sweet. I would demand to know who was ruining my reputation, I would demand to know who is responsible.

And I would say to this President—who I think doesn't know about these things, I can't imagine he does—that his lawyer is hiding information from the people. It's an absolute outrage. You didn't redact it. Somebody else redacted it, for political purposes. It is a scandal.

And it lets people sit around here and say, "Oh, there's no problem, there's no science, there's no this, there's no that." Yes, there is.

So, sir, I just hope you will come away from this with hope, not fear, and I sensed in your answer to Senator Kerry, you said, "I'm conflicted because it's difficult for us to make these changes." You are right. But that is not your job. Your job is the pure science. Our job is to make the political, you know, decisions. It's my job to fight with Senator Stevens, and say, "I hope you will come on the Snowe-Kerry bill, or the Kerry-Snowe bill or the Lieberman-Warner bill," and try to convince him to do it, he has his right never to do it. But that's our job. Your job is to give us the science.

So, I hope, as a result today, when you go home tonight and talk with your family, you'll realize that you're in a pivotal position here, as the top scientist to this President and I hope you'll get the courage to do what is right.

Thank you very much.

Senator KERRY. Thank you very much, Senator Boxer, I appreciate it.

Senator Klobuchar, and then Senator Snowe, Senator Thune, Senator Vitter.

Senator THUNE. Mr. Chairman, I am going to go. I have a statement to submit.

Senator KLOBUCHAR. It's fine with me if he goes.

**STATEMENT FROM HON. JOHN THUNE,
U.S. SENATOR FROM SOUTH DAKOTA**

Senator THUNE. No, I know, it is all right, go ahead. I am just saying I would like to submit a statement for the Record.

Senator KERRY. Absolutely. Your full statement will be put in the Record, and we appreciate it.

Senator THUNE. Thank you, Mr. Chairman.

Senator KERRY. Thank you.

[The prepared statement of Senator Thune follows:]

PREPARED STATEMENT OF HON. JOHN THUNE, U.S. SENATOR FROM SOUTH DAKOTA

Mr. Chairman: I want to thank the Chairman for holding today's hearing on an important topic: research on Global Climate Change and the impact it may have on our environment.

With regard to climate change research, it is critical that policymakers at all levels of government have clear, concise, and reliable data on global climate change.

Objective, science-based research is needed to understand the magnitude and cause and effect of climate change. And I appreciate today's witnesses for joining us today on this topic.

However, regardless of your beliefs of the causes and impacts of global climate change or on the objectivity of climate change research, it is clear that Congress should continue to make clean renewable energy the cornerstone of our national energy policy.

My state of South Dakota is rich in renewable energy potential, and is a fine example of how clean renewable energy can benefit the entire nation.

By the end of 2008, South Dakota will be producing over 1 billion gallons of ethanol each year.

According to Argonne National Laboratory, ethanol consumption could result in a significant reduction in greenhouse gas emissions.

In a recent study, Argonne National Laboratory measured the life-cycle greenhouse gas emissions for corn-based E85, which is a mix of 85 percent ethanol and 15 percent regular gasoline. Argonne concluded that corn-based E85 results in a 20 percent reduction in greenhouse gas emissions relative to regular gasoline.

If the renewable fuel is cellulosic ethanol, Argonne National Laboratory predicts that greenhouse gas emissions are reduced by 67 percent to 89 percent.

Additionally, our electrical power sector can contribute to a reduction of greenhouse gas emissions. Over 50 percent of our electricity is generated by coal-fired power plants.

Last week, the Commerce Committee held an informative hearing on the potential of clean coal technologies. Capturing and sequestering carbon from traditional power sources can greatly reduce greenhouse gas emissions.

These traditional sources of energy can be supplemented with clean renewable sources of energy such as wind and geothermal energy. Wind energy in particular is growing part of our Nation's energy portfolio. Additionally, it is one of the few energy sources we have at our disposal that is truly carbon neutral.

Again, Mr. Chairman I thank you for today's hearing and I look forward to working with members of this committee as we look for ways to improve upon climate change research and promote clean renewable sources of energy.

Senator KLOBUCHAR. Thank you, Chairman Kerry. And I'd like to also note, I'd said earlier that I think this should be bipartisan solutions to this issue, like we've done in our state, where we have a Republican Governor, Democratic legislature working together with one of the most aggressive renewable electricity standards in the country.

I'm happy to see my colleagues here, Senator Snowe and I have worked together on the carbon registry, which is a piece of the climate change bill that is going through the Environment Committee.

And I would also like to note that I have heard Senator Stevens talk about the change to the permafrost, and make some statements about how he sees the climate change issue evolving, and I think there has been some movement on this from our colleagues, and I really appreciate that, and I think it's the only way we're going to go through this. But, again, I don't think we're going to get there unless the Administration has a sense of urgency about what's happening.

And I wanted to, first of all, Dr. Marburger, and I appreciate your statement that climate change exists. But, in your official statement you released, in response to our Committee's inquiry and to the editing of Dr. Gerberding's testimony, you stated, "The IPCC is not an assessment of impacts in the United States." Do you really believe that the IPCC's findings are not applicable to the United States?

Dr. MARBURGER. No that's not quite correct, but the IPCC report tends to describe impacts around the world. There is a section in the IPCC report that addresses phenomena in North America. But

one of the problems that we had with the testimony as we saw it, was that it tended to accept the impacts that could happen anywhere in the world, as signaling what would happen in the U.S.

Senator KLOBUCHAR. But you don't believe that this would happen in the United States, what could happen in the rest of the world?

Dr. MARBURGER. Some—there are important variations in impacts in different parts of the world. And in the U.S., for example, some of impacts will be significantly modified, compared with sub-Saharan Africa, for example, or the Polar Regions, or—so there are different impacts in different places. This is one of the areas that I expect will receive priority for climate change science research in the future—

Senator KLOBUCHAR. You know, I know firsthand, as we see rises in sea level, we see decreases in Lake Superior, where I live, because the—and the barge industry is very concerned about this, because the ice is evaporating, and they can't get their barges in and we see the effect on the economy—I know that there are differences for different regions in different parts of the world. But, what I'm getting at, is their findings must be applicable to the United States when they say that there could be an increase in fires, there could be an increase in more severe hurricanes, or storms and flooding—is that not applicable to the United States?

Dr. MARBURGER. Of course, but case-by-case. For example, the impact on agriculture will be very different in the U.S. than in other parts of the world, where conditions are different.

So, you know—

Senator KERRY. But it will have an impact.

Dr. MARBURGER. It certainly will have an impact. Absolutely.

Senator KERRY. That's all the IPCC report says.

Dr. MARBURGER. Well, no, the IPCC report is specific—when it comes to health impacts it does make a difference what, exactly, you're talking about. And impacts on agriculture, for example, could be expected to have major impacts on health of people, people who may already be at risk for, undernourished.

So, I think it's important to make those distinctions, and those are the kinds of distinctions that we recommended should be made in the testimony. Not deleting multiple pages, but to be precise.

Senator KLOBUCHAR. So, you disagree with the deleting of multiple pages in the testimony.

Dr. MARBURGER. I think it was not necessary to delete the multiple pages in the testimony. It would have been much better, simply to make the corrections that were proposed, and have it go forward. Obviously, no one likes to see this kind of reaction, and accusations of censorship and so forth, it's—

Senator KLOBUCHAR. Now, in your official statement, you mentioned that you, "Asked the authors to either make more precise reference to the IPCC conclusions, or cite to new work." How many times have you testified before Congress, Dr. Marburger?

Dr. MARBURGER. I can't remember.

Senator KLOBUCHAR. Well, do you cite sources in all of your testimony?

Dr. MARBURGER. In my written testimony I try to do that.

Senator KLOBUCHAR. But, are there citations in your testimony today?

Dr. MARBURGER. In my testimony today, no.

Senator KLOBUCHAR. All right, and that wasn't censored. Because it was one of the reasons that was given for why this testimony was deleted.

In the original testimony of Dr. Gerberding, it included this statement, "The United States is expected to see an increase in the severity, duration, and frequency of extreme heat waves. This, coupled with an aging population, increases the likelihood of higher mortality, as the elderly are more vulnerable to dying from exposure to excessive heat."

You and—well, the Administration claims—that Dr. Gerberding's testimony was edited because it, "Missed or ignored several important differences between the IPCC report." Now, the IPCC report says, "Severe heat waves will intensify in magnitude and duration over the portions of the U.S. where they already occur," and "Local factors, such as the proportion of elderly people, are important in determining the underlying temperature-mortality relationship in a population."

So, what is the Administration's response for why they edited that section? What is the rationale?

Dr. MARBURGER. I'm not prepared today to give you the detailed rationale for each of the recommendations that we made, but I would respond to that for the record. I was not the one that made those recommendations, but I believe that they are justified, and I will be glad to respond to that question for the record.

[The information previously referred to follows:]

Regarding the section in the draft CDC testimony on "Heat Stress and Direct Thermal Injury," OSTP raised two concerns regarding statements that described links between projected increases in temperature and health impacts within the United States. OSTP's climate experts found that the health impacts of climate change discussed in that section were largely congruent with the science described in the recent IPCC report, and we did not suggest any specific changes, deletions, or addition of text. However, OSTP's two concerns were motivated by the fact that our reviewers found inconsistencies between important scientific details in the draft testimony and those of the relevant IPCC conclusions.

One OSTP comment concerned the assessment of the likelihood of a future increase in the frequency of hot days, hot nights, and heat waves. The OSTP expert who reviewed the testimony pointed out that the IPCC assigned an even stronger likelihood to that projection than stated in the CDC testimony. The other issue raised by the OSTP reviewer dealt with the spatial scales of the specific impacts described in the testimony, which were inconsistent in their details (see below) with the science cited in the IPCC report. However, recognizing that there could be recently published results that were not included in the IPCC report because of IPCC-imposed deadlines for inclusion, OSTP simply asked for clarification regarding the source of the statements in the testimony.

Regarding the specific concern of the OSTP reviewer mentioned above, the draft CDC testimony on heat waves refers to projections for both "the United States" and for "Midwestern and Northeastern cities." Chapter 8 of the IPCC Working Group II report addresses human health impacts globally, and Chapter 14 of that same report focuses on impacts within North America—a large and diverse continent. It is imprecise to simply apply the global- or continental-scale impacts described in the IPCC report to the U.S. without a basis in more geographically-centered studies. It is equally problematic to take very geographically narrow studies (the IPCC report cites specific studies focused on Chicago, as well as four cities in California) and extrapolate the results to larger areas, without a scientific basis for the extrapolation. Thus OSTP's question suggested either a more careful representation of the IPCC assessment's conclusions be made, or that CDC identify more recently published research as the basis for the different conclusions.

The differences between the CDC testimony and the conclusions of the IPCC report—such as the one I have addressed above regarding heatwaves—may be subtle, but they are extremely important. The OSTP experts who reviewed the draft testimony appropriately called attention to these types of subtle, but scientifically important, differences in their comments on the draft CDC testimony.

Senator KLOBUCHAR. And then also, I'd cited earlier in my opening statement the similarity between the testimony of Dr. Gerberding about wildfires, and the IPCC report. And no one said wildfires are caused by climate change, they said the increases of severity of them, because of the drought conditions. And if you could explain what the differences were with that, and why that was deleted, I would appreciate that, as well.

Thank you.

[The information previously referred to follows:]

OSTP had no comments, questions, or edits to the section of the draft CDC testimony related to wildfires.

Senator KERRY. Thank you very much, Senator Klobuchar. Senator Snowe?

**STATEMENT OF HON. OLYMPIA J. SNOWE,
U.S. SENATOR FROM MAINE**

Senator SNOWE. Thank you, Mr. Chairman, and thank you for your leadership on this most critical issue. I am very pleased to join you in introducing legislation to reform the Climate Science Research Program, to update it. Revamping it is absolutely vital, and certainly in our national security interest, without a doubt.

Policymakers and local decisionmakers at all levels of government have to make decisions that are predicated on sound scientific information. We have to have a better understanding of the environmental information and evidence on which to base our policies and our decisions, and also to act in a timely fashion.

I think you can sense, Dr. Marburger and Dr. Kaye, there is a great deal of frustration. I share that frustration with my colleagues on the Committee, because frankly, the Administration has not lived up to its commitment within the strategic plan of the Climate Science Research Program.

Based on the National Academy of Sciences, when you hear what the Chairman had to say with respect to the fact the program has not produced but three of the 21 reports. We have seen declining budgets, declining personnel, at a time in which we are facing this global challenge to which the United States clearly plays an integral role. Good science is absolutely vital, and imperative.

What I would like to ask you Dr. Marburger, at a time in which we are seeing more than 67 bills introduced in the Congress, so all the more reason to have this strong science in which to make our decisions. Your agency, for which you're responsible, has not produced but 3 of the 21 reports that you are responsible for.

Can you tell this Committee as to why only 3 of the 21 planned reports to address various components and aspects of climate change have not been forthcoming?

Dr. MARBURGER. I don't know, in detail, why it has taken so long to produce these reports. I'm very disappointed that they have not been produced on schedule. I take very seriously the finding of a

Federal court in California that this is not appropriate, and I'm taking steps in my office to make sure that the timetable that was specified by the Court is adhered to, and that these reports will come out on time.

Senator SNOWE. When could we expect them? What kind of time-frame are we talking about?

Dr. MARBURGER. The deadline established by the Court which is also, by the way, the deadline that was set by the climate change science program itself, which is, it's not my program, although I accept some responsibility for it on behalf of the Administration, that deadline was in May of 2008, I believe, when all the reports were supposed to be done. There are other deadlines, a schedule, that was in the court decision that I don't recall at the present time. But the idea is to have everything done, including a new plan by May 2008.

Senator SNOWE. You can understand the depth of our concern, frustrations, and skepticism about the intent of the Administration with respect to this issue. Where it seems in concentrating on the uncertainties of whether or not climate change is a problem, human-induced or otherwise, rather than concentrating on solutions to this national and global problem.

The United States has an enormous responsibility. It is certainly in our national security interests. It is our Federal obligation, not only to provide a national policy, but also to assist local decision-makers, at the local and State level. To be able to anticipate, to adapt, to predict future environmental events. It is a matter of life and death.

I believe the Administration is in a time warp on this issue. The world has moved ahead, and we have stood still. That is why it is so important, not only to update this program, but obviously, we need the support of the Administration in the meantime. I do not believe the Administration has lived up to the strategic plan of this program. Do you believe it has?

Dr. MARBURGER. The reports are certainly delinquent, and it's very disappointing that they haven't appeared. I think this is a problem that needs to be addressed.

Senator SNOWE. In addition to that, the National Academy of Science panel, and I know others have mentioned it, as well, has indicated the number of environmental satellites are anticipated to be reduced from 120 to 80 by 2010. I would like to have you address that, as well, Dr. Kaye. That is a critical issue. We are providing more in the NASA budget. At the same time, we are seeing that we are cutting the environmental science and the satellites are so important to be able to understand what is going on here on earth.

Dr. MARBURGER. My office is equally concerned about the fate of the instruments, the sensor instruments that Senator Nelson also referred to in his opening remark, that had been scheduled to be flown on the NPOESS satellite. That program was, became—its budget grew beyond limits, statutory limits—it required it to undergo a review that led to the cancellation, or removal, or demanifestation, I think is the word, of important sensors from the NPOESS satellite.

My office, when we became aware that that might happen, immediately contacted NOAA and NASA and asked them to produce plans for filling that gap. And, that we could take to the President, if necessary, and seek support for through the budget process. We do have some plans from NASA, they should be shared with Congress at the appropriate time, and I hope that it will be possible for us to make up for the losses that were anticipated when the demanifestation occurred.

Senator SNOWE. What would be that timeframe?

Dr. MARBURGER. That time-frame would be within a matter of months, in connection with the President's budget request.

Senator SNOWE. Do you believe we should take any mandatory approach to a reduction in greenhouse gas emissions?

Dr. MARBURGER. I don't have an opinion on that. Let me tell you what I do think—

Senator SNOWE. From a scientific standpoint, knowing what you know today.

Dr. MARBURGER. You know, when you begin to talk mandatory, that's not scientific. I can't tell you what motivates people.

I do know that you have to give people a choice as to how they're going to improve their lives. We have countries like China and India that are developing very rapidly, that are insisting on access to the same kinds of advantages that we have. And I think when you talk mandatory under conditions like that, you're not going to get a very favorable reaction. It's necessary to design approaches for those countries that are appropriate, that they will be willing to live with. The problem is not only within the U.S., the problem is also with other countries that are developing very rapidly.

Within the U.S., I think it's absolutely essential to have technical alternatives to the way we produce and use energy today. So, in my view, the most important thing, is to develop technologies that are feasible, alternatives, to the greenhouse gas-producing way of life that we have. And this has been a priority with this Administration, there's been major investments in research in these areas, and I believe that that's important.

Now, no doubt, there will have to be policy actions taken, the sorts of actions that are currently being discussed in Congress, no doubt will have to be taken to provide the appropriate incentives to switch technologies. But, I don't—I am not advising on mandatory versus non-mandatory. That is a policy issue that's not in my purview.

Senator SNOWE. But don't you think the United States should be part of some agreement? I mean, beyond Kyoto, obviously. There are ways of structuring—

Dr. MARBURGER. Climate change—

Senator SNOWE.—international agreements—

Dr. MARBURGER. Climate change—

Senator SNOWE.—that addresses the concerns you have mentioned? I have attempted—I co-chair an international group we presented to the President that hopefully would have been on the G-8 agenda, at a time when Prime Minister Blair was the President of the G-8, to something beyond Kyoto. I understand, the United States was not a party to that agreement. What else could we do beyond that, rather than just allowing the problem to persist?

Dr. MARBURGER. I believe the actions that President Bush has taken to call together the governments of the countries that are major greenhouse gas emitters is a very good action, it's the sort of thing that has to be done, to bring these other countries into the fold, as it were, and have them to be eager participants in the problem of addressing greenhouse gas emissions. This is—I think—a very forward-looking program, and one that seems to have receptivity on the part of those countries that need to be involved.

There's no question that climate change is a global problem, and we must bring other countries along.

Senator SNOWE. The Montreal Protocol just celebrated its 20th anniversary, and they had different timing for underdeveloped, and developing, nations, in terms of the timelines for compliance. And that's been effective and successful. There are ways in which to address the issues the United States might be concerned about, but it is not an option just to ignore the problem, and allow it to remain unaddressed.

[The prepared statement of Senator Snowe follows:]

PREPARED STATEMENT OF OLYMPIA J. SNOWE, U.S. SENATOR FROM MAINE

Thank you. Mr. Chairman.

I am very pleased that you have called this full committee hearing today as the planet is facing a critical problem—that of global climate change—and this country is challenged with a critical question—is our Nation's current Federal climate research program meeting the needs of our researchers, of the end-users of its products, services and information, and most importantly to members of this committee, of those of us who are elected to make the most informed scientific decisions on U.S. climate policy?

I am pleased to have recently joined with Senator Kerry in introducing the Global Change Research Improvement Act of 2007, so I guess our answer to the above question would be *absolutely not*, as we seek to amend and strengthen the existing U.S. climate change research and assessment program that will ultimately benefit all of the citizens of our Nation. Our intent is to improve upon the basic research and products that the Federal Government develops on climate change and its inherent impacts. Our legislation would refocus the emphasis of the nations' climate change research program and fulfill the need for relevant information for states, and local and nongovernmental decision-makers.

In addition, the creation of a new National Climate Service within NOAA will provide climate change forecasting on a regular basis to end-users, and create a permanent information network so that decisionmakers in every city and town, county and state, and the Federal Government can make timely planning decisions to deal with impacts and develop adaptation methodologies.

Our bill also calls for an Abrupt Climate Change Research Program within NOAA—a program I have been strongly supporting for at least 5 years now—so that scientists can gather more knowledge about a change in the climate that occurs so rapidly or unexpectedly that human or natural systems have difficulty adapting to the change. My alma mater, the University of Maine at Orono, has a world renowned abrupt climate change research program under the direction of Dr. Paul Mayewski. He and his colleague Dr. George Denton have been major contributors to research on past climate shifts so that scientists can better predict future climate change.

The U.S. Global Change Research Program, the country's esteemed climate research and assessment program, was established in law by the Global Change Research Act of 1990, and I know that cosponsors of the 1990 Act, Senators Inouye, Stevens, Rockefeller, McCain, and Kerry should feel justifiably proud in creating the program that was signed into law by President George H. W. Bush. We now need to consider what has happened technologically since then, what was generally unheard of at that time. We now drive hybrid cars, we are tuned into iPods, we use hand held Blackberries for instant communication, we have much more advanced and high speed computers for modeling and, most importantly for our legislation, more comprehensive knowledge and understanding of climate change through 17 more years of peer-reviewed scientific research, monitoring, and assessments. Our

nation's climate change research program needs restructuring so that we can turn all of that knowledge into timely and useful information for decision-makers. This is exactly what our bill does.

We in Congress need a strong foundation of updated scientific information to make good climate policy; as of November 1, 67 climate change bills have been introduced in Congress. Yet, the National Academy of Sciences' September 13, 2007 assessment stated that the Climate Change Science Program has only completed and delivered 3 of its 21 planned reports on various aspects of climate science. The reason, past managers have commented is because the program is bureaucratically-driven. In fact, a Federal District Court found that the current Administration has failed to comply with the 1990 statute's mandate to provide regular assessments of the impacts of climate change on critical resources; no such assessment has been published since October 31, 2000.

The NAS panel pointed out that the CCSP's director does not have the power to direct or prioritize climate spending at the 13 different agencies involved. So he must watch helplessly as, for instance, the number of environmental satellites has been cut from 120 to 80 by 2010. As the NAS panel Chair states, "There is no national assessment of [climate change] impacts on agriculture, water and health." "And as of last year, there were 2 billion people living in urban areas. That's going to double 20 years from now, and how is that going to impact pollution and production of greenhouse gases?"

Our bill addresses these weaknesses and gaps, making important changes to strengthen the mandate to provide assessments, enabling the GCRP to perform critical climate observations and research on climate systems; improve our ability to predict climate impacts at national, regional and local levels; and, importantly, to communicate those impacts in a timely and useful fashion to state and local decision-makers, resource managers, and other stakeholders.

Thank you, Mr. Chairman. I look forward to the testimony of our panelists this morning.

Thank you, Mr. Chairman.

Senator KERRY. Thank you very much, Senator Snowe.

Senator Vitter?

**STATEMENT OF HON. DAVID VITTER,
U.S. SENATOR FROM LOUISIANA**

Senator VITTER. Thank you, Mr. Chairman.

Thank you, Doctor. First of all, I share everyone's frustration about the lateness of these climate assessments under the 1990 Act, but I did want to point out, do you know what the timing record of the previous Administration on that was?

Dr. MARBURGER. Yes, it did take 10 years after the Act to produce the first assessment.

Senator VITTER. Right. My notes say 10 years for the beginning assessment, an additional 3 years for the technical documents for a total of 13 years. I wanted to point that out, for the record.

Doctor, a lot of folks, including me, are very surprised when we look at the annual investment our government makes in climate science, and one of the reasons is, we do not see a lot of very concrete or tangible returns on that investment.

Besides our contributions to the IPCC, could you share some of the products of this very significant annual investment?

Dr. MARBURGER. Well, there are several important points to be made on this.

The first one is that, the measurements that we make of Earth parameters, rainfall and sea level, and temperatures, and so forth over time, are useful for a large number of things, of planning shorter-term weather prediction, for example, or cycles that are important for agricultural planning and land-use planning. So, many of these products that are important for climate science are also

important for other things, that fall within the missions, for example, of NOAA or the U.S. Geological Survey or NASA or the Department of Defense.

The United States is acknowledged to be the world's leader in climate science, and the physical properties of the earth and modeling, and particularly in the satellite measurements—the rest of the world depends on us, which is why we take so seriously the satellite program that Senator Snowe just mentioned.

So, our science, U.S. science informs—not only the IPCC process—but also the missions of all of the agencies in the United States that have responsibility for our land and sea activities.

Senator VITTER. I would just underscore the point in my opinion, I think both a substantive and a political problem with the program is a lack of things we can really get our arms around, in terms of more concrete results for this very substantial investment.

One possible reaction to that is taking steps to regionalize and interpret the information, to make it more useful or relevant for State and local planners. What steps could be taken in that regard?

Dr. MARBURGER. There's another activity that overlaps with the Climate Change Science Program, it's a system of earth observation, earth observation system that is a multi-agency program, just as the climate change program is. And that program attempts to address gaps in our current observing system, and produce products such as the ones you've just described that could be useful to other agencies and local planners, to address their land-planning needs, so—

Senator VITTER. In conjunction to that, could there be a useful role for NOAA's Regional Climate Centers?

Dr. MARBURGER. Absolutely, Climate Centers are an example of assets that should be coordinated and integrated into a system that can produce better planning documents.

Senator VITTER. To my knowledge, and correct me, I may be wrong, but to my knowledge, there is not much of a role right now for those NOAA Regional Centers, and I would suggest a way to make this research more relevant and useful, regionally.

In your testimony, you also cite the authority of the Integration Committee and OMB is to move science and technology monies among agencies. Either off the cuff, or maybe follow up in writing, it would be really useful for me to know how that authority has been used in the past, how many times, and to what effect?

Dr. MARBURGER. I'll say something briefly now, but I can follow up in the Record.

During the process of assembling the President's budget proposal to Congress each year, the Office of Management and Budget solicits input from the agencies and from the policy offices in the White House, and it's in connection with that process that the—any transfers for adjustments of the research programs related to climate change would take place.

Senator VITTER. It would be useful for me to know how that has specifically been used in the past—how often monies are moved around, and for what effect, in the last few years.

Finally, as Senator Snowe mentioned, there are an enormous number of climate change and energy-related bills floating around. One provision, included in the House-passed Energy bill, restruc-

tured the Climate Change Science Program. It is based off H.R. 906 that passed the House Science Committee.

Is this a proposal you would support? Do you have specific reaction of this proposal?

Dr. MARBURGER. There is—I believe there is an administrative statement of Administration’s policy on this bill, but I’ve just saw it this morning, and I’m not totally familiar with it, so I would defer to—I would rather respond to that for the record.

Senator VITTER. OK, thank you, Mr. Chairman.

Senator KERRY. Dr. Marburger, if I could just come back to a couple of things here.

At the beginning of the year, the National Academy of Science Decadal Study sounded grave concerns about the loss of climate sensors, we’ve discussed a couple of aspects of the satellite, but NOAA and NASA environmental satellites.

Subsequent to that, the Administration’s budget came out, it had significant reductions in the climate research budget. The GAO came out with its study in August, concluding that our federally managed resources are suffering from climate impacts, yet the Administration is providing no guidance for addressing such impact.

A Federal District Court, as we’ve discussed earlier, decided the Administration was violating the Global Climate Change Research Act, due to its failure to issue the national assessment. The NRC released a preliminary review of the CCSP that found many weaknesses in the program, notably its focus on climate change impacts. And through all of this, NOAA, the agency that chairs CCSP, has not appointed a climate scientist to fill the vacancy left by the departure of Jim Mahoney.

So, I mean, as we look at this mix of returns on this program, how do you counter the notion that this just ain’t working right? This is not what we put in place, and this is not the way it ought to be?

Dr. MARBURGER. I think it could work better, and——

Senator KERRY. Well, who’s responsible for that?

Dr. MARBURGER. The responsibility lies with us. I would have to say that this is an Administration responsibility, it is important for us to get it right, and we’re determined to do it.

Senator KERRY. What’s going to make it, sort of, get right, in a sense? I mean, first of all, you’ve got this issue of 21 reports versus one report. I mean, the Court ruled that we envisioned one report—we envisioned one report, we’ve now introduced legislation to make it clear we envisioned one report, and most people have determined that that’s the best way to help people be able to make decisions about this. Not to wade through 21 disparate reports, but to have a centralized reporting thing.

Notwithstanding that, the Administration has announced that it’s going to plan to do the 21 reports, that it comports with the law. So, it just don’t seem to be getting from here to there.

Dr. MARBURGER. Senator, the Court decision did acknowledge that the 21 reports could be appropriate, and insisted that they be submitted on time. The strategic plan that led to the creation of the 21 reports, or to the plan to create them was, in fact, vetted by the National Academies at that time when it was produced, and they commented favorably, as far as I can recall, on this proposal.

Now, it turns out that each one of these 20, more than 20 assessment reports has taken a lot longer than anyone expected to complete, and to clear through the agencies. It's a cumbersome process, and it really needs to be streamlined. So, our experience there has not been totally satisfactory and we're concerned about it.

Senator KERRY. Well, it's hard to understand, I mean, look, I'm not trying to, I mean, if you want to have 21 reports come in, and you pick and struggle through them, and sort of do an Administration document about them, that's one thing. But to sort of have 21 different reports is not a national—"a", the word "a"—a national assessment, is what Congress asked for. That's not a national assessment. That's 21 agencies giving us a report.

It seems to me that the GAO concurs completely, I mean, you sort of choose to ignore the GAO, and pick and select how you want to approach this. What's the virtue of the 21 reports and their disparate manner not being—and why would you not choose to give us a national assessment, as an Administration, speaking with one voice, in that assessment?

Dr. MARBURGER. Senator, I believe that it would be appropriate to have a single assessment report. But to do it right, that report would have to be very long, and include much of the material that would occur in the 21 assessment reports—

Senator KERRY. Well, that's why you get—put a report together.

Dr. MARBURGER. One of the reasons that the first report, one that was prepared during the Clinton Administration took so long is that there was so much in it. And each one of the different components of the whole climate change picture had to be addressed and studied and written up and included in the final document.

I believe that the management of the Climate Change Science Program at the time felt that it would be appropriate to focus—not agency by agency—but topic by topic on the key remaining areas of uncertainty that had been pointed out by the National Academies that needed to be addressed by the program, to focus on those, and really clean them up and provide the information that was needed to move ahead. And, I still think that's not a bad strategy, but it clearly—clearly doesn't satisfy the desire for Congress, and for the public to have a single document that summarizes these findings.

Senator KERRY. Well, are we going to get a single document by May 31, 2008? That's what the judge directed you to do, to produce a research plan by March 1, and a scientific assessment by May 31.

Dr. MARBURGER. We will obey the law.

Senator KERRY. And it doesn't say multiple scientific assessments, it says a scientific assessment.

Dr. MARBURGER. That—my understanding is that that will be produced by the program office.

Senator KERRY. Well, that's good news.

And, I might comment to Senator Vitter who's no longer here, I believe the Clinton Administration took too long to do it, no question about it, but the law was passed in 1990, under the other Bush Administration, and they didn't come in until 1993, so you, you know, you have what you have to get organized, and it was released in 2000, that's not 13 years.

Nevertheless, it was too long. We requested one every 4 years, and I think we have a right to expect it.

But, given that, why is the research budget being cut? Being, when the resource demands for climate science are increasing, and we have this issue of getting a report out every 4 years, and the struggle of it, et cetera, but that's to guide us, intelligently, not every 8 years, but every 4 years—we've seen the budget steadily decline from a high of nearly \$2 billion in 2004, to \$1.54 requested for 2008. So, when you factor in inflation, additional costs and everything else, that's just a big whack at a budget—while people have lauded here the notion we spend a lot, we do, it's not what we need to do. And this is a critical area.

NOAA's budget request for climate research is a \$23 million decrease from last year, and so forth. Why are we moving in the wrong direction?

Dr. MARBURGER. I can't give a single answer for why the sum of all of the climate science programs in different agencies is going, has gone down. I do believe that these budgets are subject to large fluctuations because of the satellite programs, which are quite expensive, as one goes down, and another one comes up, the construction costs and the launch costs and so forth tend to make the budget rather erratic.

But, as far as the details of this budget, which is not a single-agency budget, but rather a roll-up of expenditures in many different agencies, I can't give details at this point.

Senator KERRY. Well, I don't want to belabor it now, we have another panel and we're getting late as it is. A couple of other colleagues, I think may have a couple more follow up questions, so we need to do those and move on.

But, I think, Doctor, I mean, I don't envy your position at all. I've got to tell you. I'm sure that there's some frustration in you that you don't articulate, but there's got to be—it just seems like every time you turn around, Senator Snowe and I are Ranking and Chair of the Small Business Committee, and we keep hearing how we can't do this and can't do that, and doing more with less, and it's not more with less, it winds up, you know, this is just a very frustrating allocation of resources that we're seeing from department to department. And, you're put in the tough position of coming up here to defend it, without having made the decisions on those budgets, and I respect that.

But, it's pretty hard from this side of the table to keep listening to it in Committee after Committee after Committee.

Senator Boxer?

Senator BOXER. Thank you, Senator.

I just have some closing comments, I don't think I'll go too long. I never know, though, once I get started. But I'll try to keep them short.

I've been living and breathing this, as so many of us here on this panel have for so long, as you have, sir.

So, Doctor, you seem very strong in your certainty that global warming is real, and that you are very strong about agreeing with the scientists, the IPCC that say that human activity is responsible—not for 20 percent of it, but for most of it for the past 50 years, and I praise you for that. And I think that's news, I think

that's a good thing. That this President's top adviser agrees with us, Mr. Chairman, that we have this serious problem.

But, what I worry about is that you get weaker when it comes to action to combat global warming, and you seem to back away and pedal-back, and get very uncomfortable with it, and tell us that it's hard. We know it's hard.

Look, do you know how long it took for Senators Kerry and Snowe to put together their legislation, how long it took for Senator Jeffords—who we all miss so much—to put together the Jeffords-Boxer bill, and then Sanders took it, and for Jeff Bingaman, and I know that colleagues, it's hard, but frankly, we don't want you caught up in that. We want you concentrating on telling us the truth, and standing up for the truth.

And then you say, you go on in answer to Senator Snowe about China, "Oh, they need choices." Well, let me tell you something. Humankind doesn't have a choice but to deal with this, and China's coming to realize it, the worst thing we can do is nothing. Because then, that's what they'll do. So, since when do we sit around saying, "Oh, woe is me, China, India, China, India," since when do we wait for those countries to take the lead on environmental issues—it's never happened.

Now look at my state, Republican governor, Democratic legislature. It's hard work, but they have got it right. They have got the gold standard, they have done it right. And, look at California, for 30 years, under Republican governors, Democratic governors—we kept our energy consumption per capita, even. Imagine, we never increased it, while the Nation doubled. If the whole Nation had just done what our state did, and there were visionary leaders in the state, in terms of energy efficiency, a lot of the low-hanging fruit, we would save the equivalent of all of the oil we import from the Middle East every year. We would save the equivalent of energy of all of the oil we import from the Middle East every year, if we had just stayed steady on a per capita basis.

But we know this can be done. If we had stayed steady, and not increased our per capita use, we would save the equivalent of all of the oil we import from the Middle East every year.

Now, California is a place where we live well there. We have not had to walk around in sack cloth and ashes, we have beautiful homes, we have beautiful cars, everything's great. But we have kept this in our sights.

So, I think your tenant, your nervousness about the next step, I hope you get over that. Because I think when our kids and our grandkids and their kids look at us, you know what it's going to be, Mr. Chairman? You're a war hero, Senator Stevens—I will say, every generation has its challenges, this is ours. It's a little different than the other challenges, which were in many ways tougher. Because they involved young men and women putting their lives on the line—this is a little different than that, but we will save lives.

So, you are in the position, as are we, every one of us, and you, and the staff and the people in this room—to really do something about one of the greatest challenges.

Now, we can hide behind a minority of scientists who say, “Pull the covers over your head, you can’t do anything about it, it’s happening anyway,” or we can step up to the plate.

What I want to urge you to do is, don’t sit back and let Dana Perino hang this redacting thing on you, take her on. That’s an outrage. You didn’t redact those pages, I know you didn’t. But it is an outrage that the President’s legal counsel won’t let us see them.

The fact is, you should engage in this. I think you should.

The last point I’d make, you talked about the Administration’s calling the nations of the world together. Guess what, I wrote the letter and asked them to do it, on February 7, I said, “Call the nations of the world together, in the White House,” and they did it. That’s the great news. The bad news is the President said, there’s only two things off the table—cap-and-trade and mandatory cuts. That’s ridiculous.

I guess you’re a Republican, I don’t know. But the Republicans in my state, the big businesses, the Silicone Valley people are all telling us, business wants mandatory cuts, and they want a price on carbon. Because as we all know here who have worked on this, that’s the signal in a free market economy that we’re serious about these technologies.

So, I want, in closing, which is the word you’ve been waiting for, to say—you can lead. You’re in a position to lead on this, and if I say anything to you, it’s that I respect your knowledge and your wisdom, I agree with you on how you feel about this issue. But don’t be afraid, because when history is written the people who were afraid are just not going to be—they’re going to be part of the problem. I hope you’ll help us.

Thank you.

Senator KERRY. Anybody else? Senator Stevens?

Dr. Marburger, thank you very much. We appreciate it, and certainly want to follow up. I’m glad to hear you’re going to have those reports in, we look forward to seeing them, and if you can work with us on this issue the 21, et cetera, we’d love to work with you on it, see how we can do it.

Thank you.

Can we invite the second panel up, and we thank you very much for their patience.

We have Donald Boesch, Professor of Marine Science, University of Maryland; Braxton Davis, Chair of the Climate Change Working Group, Coastal States Organization; Peter Frumhoff, Director of Science and Policy, Chief Scientist, Climate Campaign, Union of Concerned Scientists; Lynne Carter, Adaptation Network; John Christy, Professor and Director of Earth Science Center; and Richard Moss, Vice President and Managing Director, Climate Change World Wildlife Federation.

We have a lot of very bright and capable people about to testify, and we look forward to your testimony. I would like to ask you to each do a 5-minute summary or so. Your full statements, as you all know, you’ve all done this before, will be placed in the record, as if read in full, and we look forward to hearing from you.

Dr. Boesch, do you want to begin?

**STATEMENT OF DONALD F. BOESCH, Ph.D., PROFESSOR AND
PRESIDENT, UNIVERSITY OF MARYLAND CENTER FOR
ENVIRONMENTAL SCIENCE**

Dr. BOESCH. Yes, Senator Kerry and Members of the Committee, I'm Donald Boesch, I'm President of the University of Maryland Center for Environmental Science. I'm pleased to appear before you today to address this, "Improving the Federal Climate Change Research and Information Program."

You asked that I address the Government Accountability report that you discussed earlier on Federal lands, also the National Academies assessments of this climate change science program, and my own experiences. I actually was a participant in the 2000 national assessment, chairing the coastal areas and marine resource sector group that prepared reports that led to that integrated assessment.

I'll summarize my main points, and refer to these experiences.

The first point I want to make is that the Global Change Research Program requires a significant increase in financial support, more effective budgetary and programmatic coordination and accountability among Federal agencies, and urgent action—I use that word "urgent," I'm afraid—attention to critical observations of system requirements—satellites, in particular, and more focus on providing information to users. Senator Vitter earlier talked about what we get from the investment, I think this will be a theme of the point I want to make, is that we need to think about serving the American people, by providing information, providing states information on which they need to manage—Federal resource managers are only one of those important constituencies.

The second point I want to make is that research on climate change and its intended impacts at regional and sub-regional scales in this country should be greatly expanded in order to provide information relevant for State and local managers and policymakers, and the general public.

The NRC, for example, found that discovery science and understanding of the global climate system, as Dr. Marburger pointed out, appropriately leads the world, we can be very proud of that.

However, progress in understanding and predicting climate change has improved more at global, continental and oceanic scales, then what we have here in our own nation, on regional and local scales where people actually live. And so, again, if we have this, we can provide information that people can understand—understand the consequences, and begin to act on how to deal with the effects.

Expanded regional-scale science will require integrated modeling, appropriately scaled observations, scenarios of climate change and impacts, partnerships among the Federal Government and states and universities which have a lot of this local, regional knowledge and experience on the issues that which we're trying to manage, are the most effective means to accomplish this. If we had that, we wouldn't have to debate about whether the quotations from the IPCC were relevant to the United States, we'd have some very specific information to help us in this—help us understand the consequences to our own country.

The third point is that more informative and effective products and services should be provided to decisionmakers to inform policies and actions for mitigation and adaptation of risks and opportunities.

This need is discussed, of course, with Federal lands, Federal resources by the GAO. I am currently involved with the Maryland Commission for, on climate change that Governor O'Malley, our Governor, has established, and we're desperately in need of climate predictions, evaluations of the consequences to our citizens so that they, our Governor, and members of the General Assembly can make well-based decisions, regarding our commitment to reductions that we would need to make in our state, as well as adapting to the consequences—inevitable consequences—of climate change, even regardless of what we do to mitigate the results.

From a regional perspective, we had a hearing 2 months ago, Senator Boxer had, on the Chesapeake Bay, on climate change, and we're trying to, you know, spend an enormous effort restoring the Bay, now we're finding ourselves addressing a moving target because of the climate change is already changing the Bay, as we manage forward.

This is just an example of the kind of information that we need going forward.

The fourth point I want to make is that regular, fully informed, fully integrated assessments of the consequences of climate change and variability should be conducted on regional scales, as was discussed, a single national assessment on national scales, but also, importantly on regional scales.

The 2000 national assessment did include regional impacts assessments that involved local stakeholders, and importantly, there are a number of regions of the country that are actually undertaking this, and doing this. We have much more experience, much more powerful tools than we had in 2000 for integrated assessments, and I'll point to the recent reports of the non-governmental Northeast climate impacts assessment, led by my fellow panelist, Dr. Frumhoff here, as an excellent model of the scientifically sound, approachable, useful, regional integrated assessments that I think are needed.

I should also point out that we talked—you had a discussion about the timing, the time it takes to these impacts, these assessments. They are very challenging, complicated activities. But it's noticeable that the IPCC has been able to complete its reports on a timelier basis than the Climate Change Science Program in this country, even though they were dealing with global collaboration, very large numbers of volunteer scientists, peer-review, extensive negotiation and the like.

And the last point I want to make is to support your efforts, Senator Kerry and Senator Snowe, on the Global Change Research Improvement Act, which addresses my four points fairly directly and establishes a National Climate Service that would bring focus, financial and material and intellectual resources to bear on this issue of unparalleled national and global significance.

Thank you.

[The prepared statement of Dr. Boesch follows:]

PREPARED STATEMENT OF DONALD F. BOESCH, PH.D., PROFESSOR AND PRESIDENT,
UNIVERSITY OF MARYLAND CENTER FOR ENVIRONMENTAL SCIENCE

Chairman Inouye and Members of the Committee, I am Donald F. Boesch and am pleased to appear before you today to address improving the Federal climate change research and information program.

By way of background, I am a marine environmental scientist who has conducted research along our Atlantic and Gulf coasts and in Australia and the East China Sea. Although not a climate scientist, I have been engaged in several assessments of the environmental consequences of climate change. Notably, I served as co-chair of the Coastal Areas and Marine Resources Sector Team for the U.S. National Assessment of Climate Variability and Change¹ and I participated in workshops and consultations that contributed to the Government Accountability Office's (GAO) report on addressing the effects of climate change on Federal land and water resources. As a member of the Ocean Studies Board of the National Research Council, I am engaged in various evaluations of the consequences of climate change for oceans and coastal zones and, currently, I am serving as chair of the Scientific and Technical Working Group of the Maryland Commission on Climate Change that is responsible for preparing a Comprehensive Climate Change Impact Assessment for Maryland. From these multiple perspectives, I offer the following observations on improving the Federal climate change research and information program.

Integrated Assessment of Climate Change Effects

The National Assessment of the Potential Impacts of Climate Change in which I participated was conducted pursuant to the requirements of the Global Change Research Act of 1990 and produced Overview and Foundation reports² published in 2000 and 2001, respectively. In addition to these integrated assessments of diverse consequences over the entire nation, the National Assessment produced separate in-depth reports for five sectors (agriculture, water, health, forests and coastal areas and marine resources) and nine regions of the Nation. The process that produced these reports involved hundreds of scientists and stakeholders inside and outside of the Federal Government, was unwieldy at times, and was definitely under-resourced. However, it focused on developing an *integrated* assessment, not of the state of science, but of what could be reasonably concluded about the potential consequences of climate change on the United States from available knowledge and understanding.

It is distressing to me as a *pro bono* contributor to see how the 2000 National Assessment, an "inconvenient assessment" as it has been called,³ has been suppressed and marginalized when it should have been built and improved upon. As the Committee is aware, a Federal District Court recently issued a finding that the Administration has failed to produce another National Assessment as called for by the statute. Rather, the Climate Change Science Program has undertaken to produce 21 Synthesis and Assessment Products (SAPs), the majority of which are oriented to knowledge related to the past and present climate, quantification of forces bringing about changes, and reducing uncertainty in projections of how climate may change. Seven of the SAPs address the sensitivity and adaptability of ecosystems and human systems to climate change and three explore the uses of evolving knowledge to manage risks and opportunities. Although, as originally scheduled, the synthesis and assessment process was to have been completed by now, presently only three of the 21 SAPs are fully completed.⁴ Of the 10 SAPs that address sensitivity, adaptability and managing risks and opportunities five have progressed to the point of public review drafts.

Significantly, there does not appear to be a strategy of producing integrated assessments, either across systems (natural, managed or human) or within regions. Yet such integrated, regional assessments are critical to communicating to citizens and decisionmakers at the state and local levels the impacts of climate change where they live and over timeframes they can understand, and what they will be required to do to deal with those impacts. As an excellent example of such an inte-

¹Boesch, D.F., J.C. Field, and D. Scavia. 2000. *The Potential Consequences of Climate Variability and Change on Coastal Areas and Marine Resources*. NOAA Coastal Ocean Program Decision Analysis Series Number #21, National Oceanic and Atmospheric Administration, Silver Spring, MD.

²National Assessment Synthesis Team. 2000. *Climate Change Impacts on the United States The Potential Consequences of Climate Variability and Change*. <http://www.usgcrp.gov/usgcrp/nacc/default.htm>.

³Mooney, C. 2007. An inconvenient assessment. *Bulletin of the Atomic Scientists* 63(6):40-47.

⁴Status of Synthesis and Assessment Products as of November 12, 2007, as indicated at <http://www.climate-science.gov/Library/sap/sap-summary.php>.

grated regional assessment I point to the recent reports of the Northeast Climate Impacts Assessment (NECIA),⁵ a nongovernmental collaboration between the Union of Concerned Scientists and a team of independent scientific experts, chaired by Dr. Peter Frumhoff. The NECIA developed and effectively communicated an assessment of climate change and associated impacts on key climate-sensitive sectors in the northeastern United States in a way that provides thought leaders, policymakers, and the public a basis for informed choices about climate change mitigation and adaptation.

The process of developing the CCSP's 21 separate SAPs is much more formally structured than that of the 2000 National Assessment. While peer review, including the National Academies, and the opportunity for public comment are laudable, it seems that this elaborate design has slowed down the process. Colleagues within my Center who have contributed to the SAPs have found the process constraining and inefficient. It is notable that the Intergovernmental Panel on Climate Change has been able to complete its reports on a timelier basis, even though that involved global collaboration, a much larger number of volunteer scientists, peer review, and extensive negotiation. And, the IPCC delved deeper into adaptation and vulnerability (Working Group 2) than the CCSP and addressed mitigation, a topic not covered by the CCSP.

Federal Lands and Water Resources

In response to a request by Senators Kerry and McCain, the GAO released its report⁶ in August 2007. It found that Federal land and water resources are vulnerable to a wide range of effects from climate change and some of these climate-related effects have already been observed. In spite of the observed and projected impacts of climate change on land and water resources, undertaking activities that address the effects of climate change is not currently a priority within resource management agencies and is not specifically addressed in planning agencies. Furthermore, resource managers have limited guidance from their agencies about whether or how to address climate change in management activities and planning efforts. Moreover, these managers do not have sufficient site-specific information to plan for and manage the effects of climate changes on Federal resources that they oversee.

My own impression and that of some of my scientific colleagues who participated in GAO-convened workshops was that the resource managers with whom we interacted had serious concerns about their ability to meet their responsibilities in a world where climate is obviously already changing and were frustrated by the lack of substantive support from their headquarters. The GAO report underscores the deficiency in the CCSP synthesis and assessment approach, because such site or even region-specific information is not forthcoming in the SAPs, which also stop short of offering specific guidance or even general direction for managing resources through anticipated climate changes.

NRC's Preliminary Assessment of Climate Change Science Program

The National Research Council (NRC) of the National Academies is assisting the CCSP in evaluating progress toward its program goals and in a report released in September presented a preliminary assessment of progress.⁷ The NRC is also providing detailed reviews of some of the SAPs. Six main findings were presented in this preliminary assessment as indicated in the following box. The NRC found that discovery science and understanding of the science of the global climate system are proceeding well, keeping the United States appropriately at the forefront of this fast moving field. However, future progress is threatened as many existing and planned observing systems have been canceled, delayed, or degraded.

⁵Northeast Climate Impacts Assessment. 2006. *Climate Change in the U.S. Northeast*. Union of Concerned Scientists, Cambridge, MA. <http://www.northeastclimateimpacts.org/> Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. 2007. *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*. Union of Concerned Scientists, Cambridge, MA. <http://www.northeastclimateimpacts.org/>

⁶Government Accountability Office. 2007. *Climate Change: Agencies Should Develop Guidance for Addressing the Effects on Federal Land and Water Resources*. GAO-07-863. GAO, Washington, D.C.

⁷National Research Council. 2007. *Evaluating Progress of the U.S. Climate Change Science Program: Methods and Preliminary Results*. National Academies Press, Washington, D.C.

National Research Council's Preliminary Assessment of Progress in the Climate Change Science Program	
1.	The separation of leadership and budget authority presents a serious obstacle to progress in the CCSP.
2.	Discovery science and understanding of the climate system are proceeding well, but use of that knowledge to support decisionmaking and to manage risks and opportunities of climate change is proceeding slowly.
3.	Progress in understanding and predicting climate change has improved more at global, continental, and ocean basin scales than at regional and local scales.
4.	Our understanding of the impact of climate change on human well-being and vulnerabilities is much less developed than our understanding of the natural climate system.
5.	Science quality observation systems have fueled advances in climate science and applications, but many existing and planned observations have been canceled, delayed, or degraded, which threatens future progress.
6.	Progress in communicating CCSP results and engaging stakeholders is inadequate.

If these observing systems are not maintained and upgraded, not only will the U.S. lose its position as a world leader in climate science, but information critical to responding to climate change at regional and local scales will be lacking as climate change impacts worsen. Another recent NRC study⁸ documented a reduction in the purchasing power of NASA's Earth Science Program, which constitutes half or more of the total budget of the Global Change Research Program (GCRP), by about 30 percent over the past 7 years and prioritized the national imperatives that should be addressed. The GCRP budget is now about \$1.7 billion, down from \$2 billion in 1992. When inflation is taken into account, U.S. investments in science to address what is arguably the grand challenge of our time, have actually declined some 42 percent over the past 15 years!

In contrast to progress on understanding the global climate system, the NRC report concluded that progress in understanding and predicting climate change and attendant impacts at regional and local scales has lagged, thus limiting the information most relevant for state and local resource managers and policymakers, as well as for the general public. Improving this understanding would require expanded and improved integrated modeling, regional-scale observations, and the development of scenarios of climate change and impacts, in addition to socio-economic evaluations, in order to achieve improvements in adaptation responses.

Consistent with my earlier remarks on integrated assessment and with the GAO findings, the NRC found that progress in synthesizing research results or supporting decisionmaking and risk management and in communicating CCSP results and engaging stakeholders has been inadequate. While there have been some successes interacting with scientists, Federal agencies and water resource managers, "efforts to identify and engage in a two-way dialogue with state and local officials, nongovernmental organizations, and the climate change technology community have been limited and ad hoc." Consequently, the program is not gaining the input required and missing opportunities to inform decisionmakers.

State Needs as Exemplified by Maryland

In the absence of Federal policy for mitigation of and adaptation to climate change many states are charting their own course, most famously California, but also my own state of Maryland. More than 24 states have either adopted or are in the process of developing goals to reduce greenhouse gas emissions. Governor Martin O'Malley established the Maryland Commission on Climate Change⁹ in April and charged it with developing a Plan of Action to address the drivers and causes of climate change, to prepare for its likely consequences and impacts to Maryland, and to establish firm benchmarks and timetables for implementing the Plan of Action. Due to be completed in April 2008, the Plan of Action will include a comprehensive climate change impact assessment, a comprehensive greenhouse gas and carbon footprint reduction strategy, and a comprehensive strategy for reducing Maryland's climate change vulnerability. Because our state has extensive low-lying lands and wetlands on the Eastern Shore and around the Chesapeake Bay, particular empha-

⁸National Research Council. 2007. *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*. National Academies Press, Washington, D.C.

⁹Information on the Maryland Commission on Climate Change is available at <http://www.mdclimatechange.us/>

sis is being given to assessing and reducing vulnerability to sea-level rise and coastal storms.

I lead the working group responsible for the climate change impact assessment, which must be based on reliable and current scientific information in order to inform the Governor, the General Assembly, and the citizens of Maryland about the likely consequences of climate change on our environments, natural resources and people. As was done in the Northeastern Climate Impacts Assessment, we are conducting this assessment based on both business-as-usual and mitigated emission scenarios. This will allow our decision-makers and citizens to understand the consequences of climate change that would be experienced regardless of what actions are taken to control greenhouse gas concentrations in the atmosphere and the potential benefits of global action to stabilize those concentrations. Our assessment is a very challenging one because regional scale climate projections are not readily available and the relationship of climate to ecosystem processes and societal requirements are not always clear. We would be a ready user for information of this sort if it was provided by the CCSP.

The complexity of the understanding of the effects of global warming that is required is exemplified by the nearby Chesapeake Bay, the topic of a recent hearing by the Senate Committee on the Environment and Public Works at which I was a witness.¹⁰ In response to a follow-up question from Senator Cardin, I offered the following list of key questions that should guide a science program for Chesapeake Bay climate change. These questions could be addressed through a regional center representing a Federal-State-university partnership, much like the Climate Impacts Group,¹¹ based at the University of Washington, which engages in climate science in the public interest, working to understand the consequences of climate variability and climate change for the Pacific Northwest. The Climate Impacts Group is one of six Regional Integrated Sciences and Assessments (RISA) programs, which support research that addresses complex climate sensitive issues of concern to decision-makers and policy planners at a regional level. The RISA programs receive some of their funding from NOAA's Climate Program Office and involve university scientists and information users at regional, state and local levels. RISA is a useful model to consider for expanding regional climate change research and assessment to meet the deficiencies in CCSP identified by the NRC.

Key Questions for Understanding Climate Change Impacts on the Chesapeake Bay	
1.	How will likely changes in precipitation and evapotranspiration interact with projected land use changes to affect the flow of fresh water, nutrients and sediments into the Chesapeake estuary?
2.	How will likely sea-level rise and the resulting deepening of the Bay affect circulation, the distribution of salinity, groundwater intrusion, stratification, hypoxia, and sedimentation?
3.	How will tidal wetlands and shorelines respond to likely acceleration in sea-level rise and what are the most effective measures that can be taken to avoid or minimize negative impacts to natural environments and human infrastructure?
4.	How will likely increases in temperature and its seasonal timing affect ecologically and economically organisms, potential invasive species and key biogeochemical processes in the Bay?
5.	To what degree will increased CO ₂ concentrations in the atmosphere result in acidification of Bay waters and what will be the ecological consequences of such changes?

Global Change Research Improvement Act

Senators Kerry and Snowe have introduced S. 2307, the Global Change Research Improvement Act of 2007, which in my opinion, addresses many of the shortcomings of the Climate Change Science Program identified by the NRC. If these needs were filled this would go a long way to providing pertinent information for Federal resource managers, regional and state decision-makers such as those in Maryland and the Chesapeake Bay region, and informing citizens about the risks and opportunities presented by climate change.

¹⁰D.F. Boesch testimony at hearing of U.S. Senate Committee on the Environment and Public Works on "An Examination of the Impacts of Global Warming on the Chesapeake Bay," September 26, 2007 http://epw.senate.gov/public/index.cfm?FuseAction=Hearings.Testimony&Hearing_ID=23a539ea-802a-23ad-45fd-606dcd273a3a&Witness_ID=72fbc039-bd13-439e-9348-9951f808a982.

¹¹Climate Impacts Group at the University of Washington; <http://cse.washington.edu/cig>.

In particular, S. 2307 makes it clear and explicit that the purpose of the Global Change Research Program (GCRP) encompasses not only observation and research, but also assessment and outreach to better understand, assess, predict, mitigate and adapt to the effects of global change. It requires Strategic and Implementation Plans that provide information relevant and readily usable by local, state, and Federal decisionmakers and includes research and assessments to identify and describe regional consequences. The bill elevates the responsibility and accountability for the GCRP, including budgeting of investments across agencies and authorizes research grants to universities and other nongovernmental organizations. It explicitly requires “a single, integrated, comprehensive assessment” not less frequently than every 4 years, which given the urgency and magnitude of the decisions and actions that lie ahead seems most appropriate. The bill provides specific authorization for studies of the status of ice sheet melt and movement and hurricane frequency and intensity, both topics of great significance and uncertainty.

To ensure its overall effectiveness in integrated assessment activities, further reorganization of the GCRP would be useful. In particular, greater budgetary control of assessment activities under the central office rather than in the individual participating agencies would increase the likelihood that the assessment agenda can progress as intended. Also, a regional component of GCRP structure would improve stakeholder input and enhance communication with users of assessment information. The latter could take advantage of an expansion of NOAA’s RISA network or similar Federal-state-university partnerships.

S. 2307 also authorizes a National Climate Service within the National Oceanic and Atmospheric Administration to include a national center and a network of regional and local facilities. While there are already programs and assets that address climate science and applications within NOAA, I support the creation of the NCS to bring focus and additional financial, material and intellectual resources to this area of unparalleled national and global significance. As the bill indicates there is an urgent need to improve observations and “integrated modeling, assessment and predictive capabilities needed to document and predict climate changes and impacts and to guide national, regional, and local planning and decisionmaking.” For the NCS to achieve these objectives it will be necessary to reallocate and closely integrate and coordinate activities within the other NOAA line offices (NWS, NOS, OAR, NMFS, NESDIS) and with key programs in other agencies (NASA, NSF, EPA, DOI, USDA and others). In addition, it will be important that the contract and grant authority is used to develop effective partnerships with universities, states and other entities to implement effectively regional applications in the context of the environmental and social challenges that are being and will be addressed.

Summary

Based on the findings of the GAO and NRC reports and my own experiences with the 2000 National Assessment and Maryland Commission on Climate Change I offer the following summary suggestions for improving the Federal climate change research and information program:

1. The Global Change Research Program requires significantly increased financial support, more effective budgetary and programmatic coordination and accountability among Federal agencies, urgent attention to critical observations system requirements, and more focus on providing information to users.
2. Research on climate change and its attendant impacts at regional and sub-regional scales should be greatly expanded in order to provide information relevant for state and local managers and policymakers and the general public. This requires integrated modeling, regional-scale observations, and scenarios of climate change and impacts. Partnerships among the Federal Government, states and universities are the most effective means to accomplish this.
3. More informative and effective products and services should be provided to decisionmakers to inform policies and actions for mitigation and adaptation to the risks and opportunities.
4. Regular, fully integrated assessments of the consequences of climate change and variability should be conducted at national and regional scales. This is especially important now as our society struggles to become better aware of the likely consequences of climate change as it makes critical decisions during what increasingly appears to be a narrow response window for mitigation options.
5. The Global Change Research Improvement Act (S. 2307) addresses the above four requirements and establishes a National Climate Service that would bring focus and financial, material and intellectual resources to bear on this issue of unparalleled national and global significance.

Senator KERRY. Thank you very much, Doctor, I appreciate it.
Dr. Davis?

STATEMENT OF BRAXTON C. DAVIS, PH.D., CHAIR, CLIMATE CHANGE COMMITTEE, COASTAL STATES ORGANIZATION AND DIRECTOR, SCIENCE AND POLICY DIVISION, OFFICE OF OCEAN AND COASTAL RESOURCE MANAGEMENT, SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROLCHAIR, CLIMATE CHANGE WORKING GROUP, COASTAL STATES ORGANIZATION

Dr. DAVIS. Mr. Chairman, Members of the Committee, I appreciate the opportunity to offer testimony on the importance of climate change research to State and local resource managers. I serve as Director of the Science and Policy Division of South Carolina's, Coastal Zone Management Program, and over the past year, I've served as the Chair of the Climate Change Committee for the Coastal States Organization here in Washington.

Since 1970, CSO has represented the interests of the Governor's from the coastal states, commonwealths and territories on Federal, legislative, administrative and policy issues.

Your continuing support of climate change research and monitoring activities through the Global Change Research Act is of critical and growing importance to coastal States and communities. My testimony will focus primarily on the issues surrounding the impacts of climate change in the coastal zone. According to the IPCC, the impacts of climate change are projected to be most significant in the coastal areas in the United States, where communities and natural resource-based economies are especially vulnerable to accelerated sea level rise, shoreline erosion, increased storm frequency or intensity, and salt water intrusion into coastal rivers and aquifers, among other impacts.

So there are three primary points that I'd like to make today. First, there's a need to focus research on the local scale effects of climate change. Our general understanding of the impacts of climate change continues to improve through research supported under the Global Change Research Program, however, this research must be useful at scales appropriate for action by state and local resource managers.

Each city and town needs to understand the potential impacts of climate change, the associated risks, and the costs and benefits of various management options, and the cost—the potential cost—of inaction.

To support the needs of state and local decisionmakers, the Coastal States Organization recently identified priority information and research needs to address future impacts of climate change in the coastal zone, and those included the systematic collection of high-resolution, coastal elevation data, improved models of shoreline change under varying sea level rise projections, and a better understanding of the related socio-economic and environmental vulnerabilities, among other needs. I've included more specific information on those needs in my written testimony.

I'd like to emphasize that all of this information must be tailored to the specific environmental and socio-economic settings of individual communities. Federally-conducted or supported research ex-

aming climate change impacts at the local scale should be carried out in close cooperation with State and local partners to ensure that their information needs are met, that local conditions and data are appropriately considered, and to avoid duplication of efforts.

Second, there's an immediate need for adaptation planning and implementation activities. While ongoing Federal research is critical for future decisionmaking, State and local governments have immediate responsibilities for managing many of the resources likely to be impacted by climate change. State and local communities need to act now, and cannot wait for perfect information.

Many of the projected impacts will require adaptation solutions that cross Federal, state and local programs and jurisdictions. Because a wide variety of Federal activities influence coastal developments and responses to climate change, there's a need for a clear Federal strategy for intergovernmental coordination on coastal adaptation. The strategy should define the roles of the various Federal programs and the specific mechanisms by which those programs will coordinate with state and local partners.

We need a true partnership between Federal, state and local governments, if we're to successfully plan and implement sound adaptation strategies.

And third, we'd urge Congress to address the needs that I've discussed through existing mechanisms for interagency cooperation and information exchange. Several programs exist where partnerships between Federal, state and local governments are already in place.

For example, the Coastal Zone Management Act should be recognized by Congress and the Administration as one of the primary statutes that can foster adaptation to climate change at the state and local levels.

State coastal programs are interested in amending the CZMA to strengthen their climate change authorities and to support states and territories in developing specific coastal climate change strategies.

So, in closing, state and local resource managers are striving to leverage existing funds, programs and research to address projected climate change impacts, but have considerable and ongoing responsibilities beyond the issues that I've described. Through close collaboration with State and local partners, the science and technical support provided by the Global Change Research Program will inform critical decisions at the local level, in light of the uncertainty and considerable risks associated with climate change. If we conduct all of this research, but fail to get it into the hands of the decisionmakers at the appropriate scales, then we may become very knowledgeable, but ill-prepared to meet the challenges facing us in the coming decades.

Thank you again for the opportunity to help inform the Committee on the importance of climate change research to State and local resource managers.

And I'd be happy to answer any questions you may have.
[The prepared statement of Dr. Davis follows:]

PREPARED STATEMENT OF DR. BRAXTON C. DAVIS, CHAIR, CLIMATE CHANGE COMMITTEE, COASTAL STATES ORGANIZATION AND DIRECTOR, SCIENCE AND POLICY DIVISION, OFFICE OF OCEAN AND COASTAL RESOURCE MANAGEMENT, SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

Mr. Chairman and Members of the Committee: I appreciate the opportunity to offer testimony on the importance of climate change research to state and local resource managers. I serve as Director of the Science and Policy Division of South Carolina's Coastal Zone Management Program. Over the past year, I have also served as chair of a Climate Change committee for the Coastal States Organization (CSO). Since 1970, CSO has represented the interests of the Governors from the thirty-five coastal states, commonwealths and territories on Federal legislative, administrative, and policy issues relating to sound coastal, Great Lakes, and ocean management.

Your continuing support of climate change research and monitoring activities through the Global Change Research Act is of critical and growing importance to coastal states and communities. My testimony will primarily focus on issues related to the impacts of climate change in the coastal zone. According to the Intergovernmental Panel on Climate Change (IPCC), socioeconomic and environmental impacts of climate change are projected to be most significant in coastal areas of the United States. The U.S. population is concentrated in coastal areas, where communities and natural resource-based economies are especially vulnerable to accelerated sea level rise and lake level changes, shoreline erosion, increased storm frequency or intensity, changes in rainfall, and related flooding. Other impacts may include changes in chemical (ocean acidification) and physical characteristics of marine systems, saltwater intrusion into groundwater aquifers and coastal rivers, increased harmful algal blooms, spread of invasive species, habitat loss (wetlands and coral reefs), species migrations, and changes in population dynamics among marine and coastal species. These impacts will vary regionally, but scientists contend that many are likely to be experienced in the coming decades—even if greenhouse gas emissions are reduced significantly.

Focus on Local-Scale Effects of Climate Change

Our general understanding of climate change and related impacts continues to improve through research supported under the U.S. Global Change Research Program (US GCRP). However, this research must be useful at scales appropriate for actions by state and local planners and decision-makers. In many cases, regional information will be inadequate for individual communities. Each city and town needs to understand the potential impacts of climate change, the associated risks, and the costs and benefits of various management options, as well as the potential costs of inaction. To support the needs of local decision-makers, the Coastal States Organization identified priority information and research needs to address future impacts of climate change in the coastal zone. We ask for Federal support of state and local-level research and planning efforts in the following areas:

Coastal Topography and Bathymetry Data

High-resolution coastal elevation data are essential for states to begin assessing the lands and resources most vulnerable to accelerated sea level rise. Today, coastal topography is often limited to coarse 10–20 foot contour intervals, and therefore does not have sufficient detail for impact studies, modeling, or policy and regulatory use. Improved nearshore bathymetry data are also needed to improve our understanding of shoreline changes, since shoreline positions do not accurately convey changes to sand volumes and the steepness of shoreline slopes. In some cases, these data are available for beachfront areas, but do not capture the full extent of estuarine or “sheltered” coastlines. In other cases, funding to support high-resolution coastal mapping has recently been obtained from the Federal Emergency Management Agency (FEMA), U.S. Army Corps of Engineers (USACE), National Oceanic and Atmospheric Administration (NOAA), or through state and local interagency partnerships. However, there is a strong need for more predictable and consistent availability of high-resolution coastal topography and bathymetry data through systematic mapping of all coastal areas of the United States.

Improved Models of Shoreline Changes under Varying Sea Level Rise Scenarios

Where high-resolution coastal elevation data are available, state and local studies are beginning to use basic inundation models to consider the potential impacts of accelerated sea level rise. These models can identify the lands most vulnerable to sea level rise, and similar maps have been produced by Federal agencies on a regional (multi-state) scale, including the Environmental Protection Agency (EPA) and the U.S. Geological Survey (USGS). However, sea level rise, erosion, circulation pat-

terns, wave climates, sediment budgets, and other shoreline features are inter-related. Coastal states and communities will need more detailed and complex models that incorporate local changes in coastal geomorphology, hydrological conditions, and human alterations and responses (seawalls, sand replenishment, etc.) in order to more adequately assess social, environmental, and economic vulnerabilities. Coastal states and communities would benefit from the development of uniform methods for modeling local-scale shoreline changes associated with varying sea level rise projections.

Impacts of Accelerated Sea Level Rise on Social and Economic Resources

Building on improved models of sea level rise at the local-scale, Federal support is needed in assessing related social and economic vulnerabilities. Insufficient attention has been given to this important area of research. To make fully informed decisions, states and local communities need to be able to determine risks and the costs associated with mitigating those risks. The potential for significant losses of economic and cultural resources, such as public infrastructure (wastewater treatment systems, roads, ports, public facilities, river flood protection levees and bridge clearances for shipping interests), historic and cultural sites, shoreline property values, and coastal tourism activities, among other losses, are difficult to quantify, but need to be anticipated and planned for in light of sea level rise projections. Federal programs should seek to provide best practices, case studies, trainings/workshops, and accessible, intuitive software tools to support community-level and statewide vulnerability assessments and planning activities.

Impacts of Accelerated Sea Level Rise on Coastal Habitats

Several coastal states have begun focusing on the impacts of accelerated sea level rise on coastal wetlands, as well as potential conservation, mitigation, and restoration strategies. However, further research is needed to better understand natural erosion and deposition cycles in tidal marshes, and to improve our ability to predict the effects of accelerated rates of sea level rise. Natural sediment sources, the movement of sediment within the system, and the locations and rates of sediment deposition need to be quantified for discreet shoreline reaches in order for predictive capabilities to be developed. Similarly, beaches respond to the background sea level rise rate through the accumulation of sand on the berm and dune from wave and wind forces. The ability of sand supplies in coastal systems to keep pace with an accelerated rate of sea level rise is not well understood. There continues to be a need for improved models that predict the migration and/or vertical accretion of coastal wetlands and beaches in response to accelerated sea level rise, information on the costs of response options, and the consequences of taking no action. There is also a need for research on the anticipated role of sea level rise in beach nourishment frequency and volumetric requirements; as well as the potential use of artificial sediment supplies to “nourish” coastal wetlands.

Other habitats at risk include submerged aquatic vegetation, coral reefs, oyster reefs, and fringing maritime forests. Thermal and chemical changes in coastal waters may affect marine species survival and distributions. Further research is needed to understand the potential for latitudinal habitat changes as northern climates begin to resemble today’s southern climates.

Research Concerning Other Climate Change Impacts

As I mentioned earlier, coastal zones are subject to a wide variety of climate change impacts beyond the threat of sea level rise—many of which are not well understood. Coastal states need further information, research, and guidance on issues like invasive species introductions, ocean acidification, ecosystem migration, freshwater resources, and improved storm surge models. We anticipate that coastal and ocean observing systems within the U.S. Integrated Ocean Observing System (IOOS) will generate useful information products related to real-time and projected climate, storm surge, and physical, chemical, and biological changes in ocean and coastal systems. Guidance is also needed for modeling local-scale effects of storm events coupled with rainfall, river flooding, and sea level rise projections.

I would like to emphasize that all of this information must either be tailored to individual community needs or easily transferable. No single model can fit all of the diverse local environmental and socioeconomic settings around the country.

Avoid Duplication of Efforts

Some coastal states have already begun to support local-scale research on the potential effects of accelerated sea level rise on communities and resources, including models and maps of shoreline changes, community vulnerability analyses and socioeconomic studies; and projected environmental changes. A common concern of state coastal managers is that their research efforts and those conducted by the Federal

Government be well coordinated and not duplicative. Federally-conducted or supported research examining climate change impacts at the local scale should be carried out in close cooperation with state and local governments to ensure that their information needs are met, and that local conditions and data are appropriately considered. Input from state and local managers should be sought in the earliest planning phases.

While the U.S. GCRP provides important synthesis products related to climate change, state and local agencies would benefit from a "clearinghouse" mechanism for Federal, state, and local programs, research activities, and other information related to climate change in their region. It would also be helpful if the GCRP could spur improved collaboration between Federal agencies. State and local officials need to be aware of research that the USACE, FEMA, USGS, EPA, NOAA, National Science Foundation, and others are conducting (or have conducted) in their state or region, and of management activities and lessons learned by neighboring states and communities. There is also a need for up-to-date sea level rise and climate projections and information at the regional level, including documented coastal and ocean changes that have occurred or are occurring due to climate change. Beyond a single inventory of existing research programs and activities, states are interested in establishing sustained mechanisms for regional collaboration on climate change issues because states in the same region will likely face similar potential impacts and policy considerations.

Need for Adaptation Planning and Implementation

While ongoing Federal research activities will prove critical in future decision-making, state and local governments have immediate responsibilities for managing many of the resources and communities that are likely to be impacted by climate change. Preparing for and coping with these impacts has been termed "adaptation" by the research and management community. Many of the projected impacts will require adaptation solutions that cross Federal, state, regional, and local agencies, programs, policies, and jurisdictions. For example, new policies are being developed to address sea level rise scenarios in the siting of public infrastructure, wetland conservation and restoration projects, and increased shoreline building setbacks and elevations. States and local communities need to act now, and cannot wait for perfect information.

Because a wide variety of Federal agencies and programs influence coastal developments, alterations, and responses to coastal hazards, there is a need for a clear Federal strategy for intergovernmental coordination on coastal adaptation to climate change. The strategy should clearly define the roles of the various Federal agencies, and the specific mechanisms by which Federal programs will coordinate with state partners on adaptation planning and implementation. Again, because the impacts of climate change will vary regionally, and because regional coastal/ocean partnerships are already in development around the nation, an opportunity exists to establish a regional framework for Federal-state coordination on climate change adaptation activities.

Existing Mechanisms

We urge Congress to take advantage of existing programs and mechanisms to disseminate climate change research and information in support of state and local resource management. Many programs exist where partnerships between Federal, state and local governments are already in place. For example, the Federal Coastal Zone Management Act (CZMA) should be recognized by Congress and the Administration as one of the primary statutes that can foster adaptation to climate change at the state and local levels. State coastal programs often directly manage shoreline development, and work closely with local governments on land use planning, habitat acquisition, and a variety of other activities. States coastal programs also play a key role in coordinating Federal, state and local agencies, and have the authority to review and condition Federal permits in the coastal zone. As state and local governments consider future climate change policies and strategies, coastal zone management programs will play an important role in identifying local-scale impacts, vulnerabilities, and opportunities for adaptation; and in fostering interagency collaboration on climate change issues.

State coastal programs are interested in amending the CZMA to strengthen their climate change authorities and to allow states and territories to develop specific coastal climate change plans or strategies. States also support increased funding for climate change activities and support legislation that would encourage NOAA and other agencies to assist the states via technical assistance, mapping, modeling, data, and forecasting products, and intergovernmental coordination. Federal activities re-

lated to coastal adaptation should be coordinated closely with states by involving coastal zone management programs early in the planning process.

Conclusion

State and local resource managers are striving to leverage existing funds, programs, and research to address projected climate change impacts, but have considerable and ongoing responsibilities beyond those described here. Therefore, Federal agencies and programs should be encouraged to engage state and local officials early in planning and research efforts related to climate change. Through close collaboration with state and local partners, the science and technical support provided by the U.S. Global Change Research Program will inform critical decisions at the local level in light of the uncertainty and considerable risks associated with climate change. If we collect all of this research and data but fail to get it into the hands of the decision-makers at the appropriate scale, then we may become very knowledgeable but ill-prepared to meet the challenges facing us in the coming decades.

Thank you again for the opportunity to help inform the Committee on the importance of climate change research to state and local resource managers. I would be happy to respond to any questions that you may have.

Senator KERRY. Thank you, Dr. Davis, for that informative summary, we appreciate it.

Dr. Frumhoff?

STATEMENT OF PETER C. FRUMHOFF, Ph.D., DIRECTOR OF SCIENCE AND POLICY, AND CHIEF SCIENTIST, CLIMATE CAMPAIGN, UNION OF CONCERNED SCIENTISTS

Dr. FRUMHOFF. Thank you, Mr. Chairman, Members of the Committee for the opportunity to speak with you today.

I'm Peter Frumhoff, I'm the Director of Science and Policy of the Union of Concerned Scientists, I'm an ecologist and global change scientist, and a lead author of the current assessment report of the IPCC.

Over the past decade, I've also guided a series of scientific collaborations, both to assess and to communicate to policymakers and the public, the projected impacts of climate change on several regions of the United States, including California, the Great Lakes region, and most recently, the Northeast.

I'm here today to provide UCS's very strong support for the Global Change Research Improvement Act. We believe that the Federal Government has an essential leadership role to play in ensuring that the public and policymakers in our country have the best available science to inform sound decisions about both mitigating and adapting to global climate change. Let me make several specific points.

As you know, the climate change poses substantial risks to our nation, the IPCC report, other studies, make clear, for example, that our coastlines are highly vulnerable to sea level rise, to projected increases in the frequency and intensity of extreme summer heat that threatens public health in our cities. We know the declining winter snow pack is already reducing scarce water resources in the Intermountain West.

Managing these risks effectively requires that we have information for decisionmakers at all scales, the best available information on the impacts of climate change on those sectors for public health, the coastal resources, to agriculture that are sensitive to climate change.

The scientific capacity to assess climate change impacts at a regional scale has considerably improved since the U.S. national as-

assessment was released in 2001. The science exists today to provide decisionmakers with high-quality information on climate change risks and vulnerabilities. Information that needs to be framed in terms of where the uncertainties are, what our levels of confidences are, but we have that information today, which we're not producing in most parts of this country.

We need to make these assessments regularly updated to capture improvements in our understanding over time, and to respond to evolving information needs of decisionmakers.

Third, there is an enormous gap between the need and demand for this sort of information, and the information that's currently being provided by the Climate Change Science Program. With climate change, the conditions we face in the decades ahead will be very different from those we face today, yet since the publication of the U.S. national assessment, the Federal Government has not been systematically providing accessible, updated information on projected change, on risks and vulnerabilities.

The UCS-led regional impacts assessments, I noted earlier, have been designed to help fill this gap. This past July, for example, we released the Northeast Climate Impacts Assessment, a 3-year collaboration between our organization and more than 50 independent scientists and economists.

Our report details, for example, that sea level rise is projected to increase coastal flooding in the cities of Boston, Massachusetts, Atlantic City, New Jersey and others. For each of those two cities, the current 100-year coastal flood is conservatively—conservatively—projected to occur every 3 to 4 years by mid-century.

The information we're producing is not sitting on the shelf. We're engaged in the outreach and dissemination of the sort that we hope the National Climate Service will do effectively, we're speaking with Governor Corzine's staff, for example, in New Jersey, who've asked us to work with them, to incorporate the finding of this assessment into a variety of climate initiatives in that State. We're working with policymakers in New York. On Monday, I'm briefing Mayor Menino in Boston with his top officials, to help them understand how the impacts of climate change affect that city, and how they can best adapt to the changes that are likely to come.

We've done similar work in California that I had the privilege of reporting here to this Committee in September of 2004.

Senators I'm proud of the work that we've done. Every month we receive requests for similar information in regions of the United States where no recent integrated climate impact assessment has been done.

But we're not positioned to provide such information at a scale commensurate with the need. This is the responsibility of the Federal Government.

Finally, I want to highlight that it's critical to ensure that the assessments meet the highest standards of scientific integrity, and that the process is not subject to political interference.

We appreciate, for example, that the White House Office of Science and Technology Policy has an important role to play in interagency coordination on scientific and technology matters. However, we remain concerned that the proposed establishment of the integrated program office within OSTP may subject the assessment

process to undue political interference. To address this concern, we request that the Committee consider further strengthening the bill, to ensure that both the climate assessment and outreach activities carried out under it are subject to a transparent public review by a credible independent body charged with recommending any necessary corrective action.

I look forward to working with the Committee and my colleagues in the scientific community to assist in the transition to a new era of accurate, readily accessible policy-relevant information on climate change risks, adaptation strategies and mitigation options for the United States.

I thank you for your time.

[The prepared statement of Dr. Frumhoff follows:]

PREPARED STATEMENT OF PETER C. FRUMHOFF, PH.D., DIRECTOR OF SCIENCE AND POLICY AND CHIEF SCIENTIST, CLIMATE CAMPAIGN, UNION OF CONCERNED SCIENTISTS

Mr. Chairman and distinguished Members of the Committee, thank you for this opportunity to speak with you today on improving the Federal climate change research program and the communication of climate information to decisionmakers.

I am Peter Frumhoff, Director of Science and Policy and Chief Scientist of the Climate Campaign at the Union of Concerned Scientists (UCS). I am an ecologist and global change scientist, and a lead author of the current assessment report of the Intergovernmental Panel on Climate Change (IPCC). Over the past decade, I have also guided a series of scientific collaborations to assess and communicate to policymakers and the public the projected impacts of climate change on several regions of the United States, including California,¹ the Great Lakes region² and, most recently, across the Northeast states.³

I am here today to provide UCS's support for the Global Change Research Improvement Act of 2007 (GCRIA). We believe that Federal Government has an essential leadership role to play in ensuring that the public and policymakers in the United States have the best available science upon which to inform and motivate sound decisions about mitigating and adapting to global climate change.

We strongly support the bill's intent to serve all the regions of the country, and to provide information on climate change vulnerabilities and impacts across sectors and under a range of plausible scenarios of further climate change. We appreciate the explicit intent to couple high-quality policy-relevant climate assessments with ongoing outreach to public and private sector decision-makers and ensure that findings can inform and strengthen their capacity to adapt—to manage those impacts which are now unavoidable. We also appreciate that the work carried out under this bill will provide much needed information on those most severe impacts and costs of adaptation that can still be avoided through timely, effective actions to reduce further emissions.

I wish to make several specific points:

1. *Climate change poses substantial risks to the United States.* Research summarized by the IPCC,⁴ UCS-led regional impacts assessments, and other recent studies

¹Hayhoe, K., D. Cayan, C.B. Field, P.C. Frumhoff, E.P. Maurerf, N.L. Miller, S.C. Moser, S.H. Schneider, K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L. S. Kalkstein, J. Lenihan, C.K. Lunch, R.P. Neilson, S.C. Sheridan, and J.H. Verville (2004). Emissions pathways, climate change, and impacts on California, The Proceedings of the National Academy of Sciences 101: 12422–12427.

²Kling, G.W., K. Hayhoe, L.B. Johnson, J.J. Magnuson, S. Polasky, S.K. Robinson, B.J. Shuter, M.M. Wander, D.J. Wuebbles, D.R. Zak, R.L. Lindroth, S.C. Moser, and M.L. Wilson. (2003). *Confronting Climate Change in the Great Lakes Region: Impacts on our Communities and Ecosystems*. Union of Concerned Scientists, Cambridge, MA., and Ecological Society of America, Washington, D.C.

³Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. (2007). *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists.

⁴Field, C.B., L.D. Mortsch, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: *North America. ClimateChange 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental*

makes clear, for example, that our coastlines are highly vulnerable to sea-level rise, that projected increases in the frequency and intensity of extreme summer heat threatens the public health in many U.S. cities, and declining winter snowpack is reducing already scarce water resources in the intermountain west.

Managing these risks effectively requires that decision-makers across the Nation at all scales—from local to national—and across all climate sensitive sectors—from public health to coastal resources to agriculture—have access to the best available information upon which to make informed choices about both adaptation and mitigation.

Due to inertia in the Earth's climate, we are poised to experience substantial global warming over the next several decades—to these changes we must adapt. But the further extent and severity of climate change impacts by mid-century and beyond depends upon the choices that the U.S. and other nations make today about our emissions of heat-trapping gases.

2. *The scientific capacity to assess climate change impacts at a regional scale has considerably improved since the U.S. National Assessment⁵ was published in 2001.* Continued dedicated efforts to improve that capacity are essential, but the science exists today to provide decision-makers with high-quality information on climate change risks and vulnerabilities. Assessments must be produced at regular multi-year intervals, both to capture improvements over time and to respond to evolving information needs of decision-makers.

3. *There is an enormous gap between the need and demand for policy-relevant climate change information and the information provided by the current U.S. Climate Change Science Program.*

With climate change, the conditions we face in the decades ahead will be very different from those we face today. Yet, since the publication of the U.S. National Assessment in 2001, the Federal Government has not been systematically providing accessible, updated information on climate change risks and impacts across climate-sensitive sectors and regions of the United States.

The UCS-led regional impacts assessments I noted above have been designed to help fill this gap. In every region in which we have worked, the public and policy-maker demand for high quality information on impacts and response options is enormous.

In July 2007, for example, we released the Northeast Climate Impacts Assessment (NECIA), a three-year collaboration between UCS and more than 50 independent scientists and economists. Our report details, for example, that sea-level rise is projected to dramatically increase coastal flooding in the cities of Boston, MA and Atlantic City, NJ—for each, the current 100 year coastal flood is conservatively projected to occur every 3–4 years by mid-century.

We have distributed thousands of copies of the report and held briefings for municipal leaders, business leaders, senior officials of state agencies, and several Governors and Members of Congress from across the Northeast. New Jersey Governor John Corzine's staff has cited the NECIA as extremely valuable to their work and has asked UCS to work with them to incorporate NECIA findings into a variety of climate initiatives under way in the state. New York State's new climate office has asked for several different NECIA briefings to delve more deeply into the climate implications for their relevant state agencies and to support climate initiatives under consideration by the Spitzer Administration. New York City's Office of Long-Term Planning and Sustainability is convening a citywide agency task force to prepare for the climate impacts that are no longer avoidable and has asked NECIA experts for assistance in developing the action plan. In New Hampshire, the New Hampshire Department of Environmental Services placed strong emphasis on the NECIA findings in the rationale for the draft legislation that would implement the Regional Greenhouse Gas Initiative in that state.

Three years ago, in September 2004, I had the privilege of appearing before this Committee to share with you the findings of a major new study on the projected impacts of climate change on California, published in the *Proceedings of the National Academy of Sciences*.⁶ Joining me that day for the presentation was one of

Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617–652.

⁵National Assessment Synthesis Team (2001). *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*, Report for the U.S. Global Change Research Program, Cambridge University Press, Cambridge UK, 620 pp.

⁶Hayhoe, K., D. Cayan, C.B. Field, P.C. Frumhoff, E.P. Maurerf, N.L. Miller, S.C. Moser, S.H. Schneider, K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L. S. Kalkstein, J. Lenihan, C.K. Lunch, R.P. Neilson, S.C. Sheridan, and J.H. Verville (2004). Emissions path-

my co-authors, Dr Daniel R. Cayan, Director of the Climate Research Division at the Scripps Institute of Oceanography, University of California, San Diego. I am very pleased to tell you that we have learned from senior policymakers in California that our report has been an enormously important resource to the state as it develops aggressive plans to reduce emissions and to cope with the substantial impacts of climate change (including steep declines in the Sierra snowpack that provides water to millions across the state) that are now unavoidable.

I am also sorry to tell you that Dr. Cayan lost his home in the recent Southern California wildfires. Let me be clear: There is no evidence that climate change had a significant role in these recent fires. But the research of Dr. Cayan and his colleagues indicates that global warming may be increasing the risk and severity of high elevation forest wildfires across much of the western United States. Such research is at its early stages. The GCRIA should help ensure that citizens and decision-makers across the west have access to state-of-the-art research on such risks and vulnerabilities—research that is designed to help communities, resource managers, and policymakers constrain and manage the impacts on property, air quality and natural ecosystems.

Senators, I am proud of the work that we have done. Every month, I receive requests for similar information in regions of the U.S. where no recent integrated climate impacts assessments have been done. But the Union of Concerned Scientists should not be in the business of providing the Nation with robust, accessible, policy-relevant information on climate change impacts. We are simply not positioned to provide such information at a scale commensurate with the need. This is the responsibility of the Federal Government.

4. *It is critical to ensure that the assessment products be produced in accordance with highest standards of scientific integrity and the assessment process is not subject to political interference.* Toward that end, UCS strongly endorse the GCRIA's provisions to protect the integrity of the scientific research and the unfettered dissemination of research results by participating scientists.

We appreciate that the White House Office of Science and Technology Policy (OSTP) has an important role to play in interagency coordination on scientific and technology matters. However, we remain concerned that the proposed establishment of the Integrated Program Office within (OSTP) may subject the assessment process to undue political interference. To address this concern, we request that the Committee consider further strengthening the bill to ensure that both the climate assessment and outreach activities carried out under the GCRIA be subject to transparent public review by a credible, independent body that is charged with recommending any necessary corrective action. For example, the President could appoint an independent, bipartisan commission that includes stakeholders, scientists, and social scientists to provide ongoing oversight and review of the program. The commission could issue a public report to the President and Congress at regular intervals (*e.g.*, every 3 years) with the requirement that a timely response to recommendations be provided (*e.g.*, within 6 months of report production).

Finally, I wish to thank Senators Kerry and Snowe for their recognition that Congress needs more expert advice to address the broad range of critical science and technology policy issues facing our Nation. UCS looks forward to working with Congress to further assess and refine this proposal for a National Science and Technology Assessment Service and ensure that it receives the needed resources to fulfill this crucial mission.

I look forward to working with the Committee and my colleagues in the scientific community to assist in the transition to a new era of accurate, readily accessible, and policy-relevant information on climate change risks, adaptation strategies, and mitigation options for the United States. I thank you for your time.

Senator KERRY. Thank you very much, Dr. Frumhoff.
Dr. Carter?

**STATEMENT OF LYNNE M. CARTER, Ph.D., CO-DIRECTOR,
ADAPTATION NETWORK**

Dr. CARTER. Mr. Chairman, Senator Kerry, and distinguished members of the Committee, thank you for your invitation to testify. I'm Lynne Carter, and I'm here to strongly support the Global

Change Research Improvement Act of 2007, and I will center my remarks where you requested, where I believe the present-day Climate Change Science Program could see improvement, in both research focus and communication of results. And I especially support a regional perspective that you have outlined in the bill and that my other panelists have also mentioned.

My perspective as the Co-Director of the non-profit Adaptation Network, and the former liaison to the regions for the first U.S. national assessment, is that regions and local areas are where the impacts of climate changes are felt most, and where adaptations will be required.

Therefore, I strongly support improvements where regional and locally relevant research is undertaken, and the scale of the research closely matches the scale of the issue for the region; where the region and locally relevant information—not just data—is generated and distributed; where regionally relevant assistance is provided to help regional and local decisionmakers make use of the information in appropriate ways, including identifying and assessing adaptation options; and, where a formal mechanism is established to provide for regular dialogue between regional and local decisionmakers, and Federal research planners to identify regional and locally relevant research needs.

To have a more effective communication plan for research findings to be useful to regional and local decisionmakers would require a synthesis of information from many sources and across many sectors, delivery of information at the appropriate scales, a delivery mechanism for useful and usable information, and the climate information must be within the public domain. Available to all who need it, and not just those who have a great deal of expertise or are able to afford it. This could be an important equity issue.

In all of these facets of a communication effort could be included in a program such as a cooperative extension service for climate.

The basis for my support for a regional approach stems from the fact that the regional mosaic in this country is rich and distinct. Working with the 20 regions as the regional liaison for the first U.S. national assessment, it became increasingly clear to me that there were some issues where many regions had similar concerns. Also, there were some issues that were completely regionally unique, and only one issue that every region had in common. That one common issue was water.

But, however, while water may be a common concern to all regions of the nation, each region still has particular regional water issues, and will need to consider appropriate adaptation options.

In some of the examples I'm going to describe come from the U.S. national assessment.

The Midwest region's water issues related to likely reductions in lake and river levels, as were mentioned previously by one of their Senators testifying meant describing, and the resulting impacts from those reduced water levels to water supply, water quality, water-based transportation, hydropower generation, recreation, and major changes in freshwater ecosystems.

Western regional water issues revolved around changes in the water resources, and that included both concerns about possibilities

around too much water—flooding—and too little from such as early spring runoff resulting in summer droughts.

Alaska water issues included concerns around thawing permafrost and melting sea ice, and the resulting impacts of increased erosion, land slides and sinking, as well as impacts of larger storm surges on coastal villages and marine ecosystems.

Island water issues included impacts on freshwater resources through sea level rise and salt water intrusion, along with possible droughts and floods and the resulting impacts on tourism and agriculture, fish processing, urban and municipal users and natural ecosystems.

So averages in broad-brush results as currently being produced do not adequately reflect the rich mosaic of regions and localities in this country. Nor do they reflect the variety of perspectives or information needs, even on what seems like the same issue, water.

In terms of useful communication of research results, I'd like to focus on just one example, to show how important it is to have the scale of the climate issue needing to be addressed, match the scale of the climate information available to address the issue, and the data are taken from the New England regional assessment.

The New England region included all of the six New England States and upstate New York. The annual precipitation in the region had increased, on average, nearly 4 percent between 1895 and 1999, when those data were collected. If we were to tell any planner in that region to be ready to accommodate an increase of precipitation of 4 percent in their planning efforts, all of their plans would have been wrong, because the scale of the information that we gave them did not match the scale of the region that they were planning for.

If you drill down into those data, even just to the State average levels, you'll find that a planner in Massachusetts would have been subject to more likely a positive, an increase of 30 percent in precipitation over that timeframe, and someone from Maine would have been subjected to a minus 12 percent of precipitation over that same timeframe.

So, recognizing that all future projections have a level of uncertainty in them, efforts to provide the decisionmaker with more appropriately scaled regional climate change information, information that is as close as possible to their planning areas, should be an integral part of any Federal Climate Change Research Program. Accomplishing this would not only enable the decisionmaker to be more effective in planning and adapting to climate change, but it would also improve the effectiveness of this important Federal research program.

Thank you for this opportunity to testify, and I'd be glad to answer any questions.

[The prepared statement of Dr. Carter follows:]

PREPARED STATEMENT OF LYNNE M. CARTER, PH.D., CO-DIRECTOR,
ADAPTATION NETWORK

Mr. Chairman (Senator Kerry) and distinguished members of the Committee, thank you for your invitation to testify. I am here to strongly support the Global Change Research Improvement Act of 2007 and will center my remarks on where I believe the present day Climate Change Science Program could see improvement in both research focus and communication of results.

My perspective as the former liaison to the regions for the first U.S. National Assessment and the co-Director of the Adaptation Network on improvements to the Federal climate change research program, is that regions and local areas are where the impacts of climate changes are felt most and where adaptations will be required. Therefore, I am highlighting four areas of improvement to the Federal climate change research program: (1) regional and locally relevant research needs to be undertaken, and the scale of the research must match the scale of the issue for the region; (2) regional and locally relevant information (not just data) needs to be generated and distributed; (3) regionally relevant assistance must be available to help regional and local decisionmakers make use of the information in appropriate ways including identifying and assessing adaptation options; and (4) a formal mechanism must be established to provide for regular dialogue between regional and local decisionmakers and Federal research planners to identify regional and locally relevant research needs.

To have a more effective communication plan for research findings to be useful to regional and local decisionmakers would require: a synthesis of information from many sources; delivery of information at appropriate scales for decisionmaking; a delivery mechanism for useful and useable information; and the climate information must be within the public domain, available to all who need it and not just those who have a great deal of expertise or are able to afford it—this could be an important equity issue. All of these facets of a communication effort could be included in a program such as a cooperative extension service for climate.

The basis for my proposed regional approach to improve the Federal climate change research program stems from the fact that the regional mosaic in this country is rich and distinct. Working with the 20 regions as the regional liaison for the first U.S. National Assessment, it became increasingly clear to me, that there were some issues where many regions had similar concerns. Also, there were some issues that were completely regionally unique, and only one issue that all regions had in common. That one common issue was water (fresh or salt). However, while water may be a common concern to all regions of the nation, each region still has particular regional water issues and will need to consider appropriate adaptation options. Examples (examples taken from the *U.S. National Assessment of the Potential Consequences of Climate Variability and Change*) of the range of issues around the theme of water follow:

- The Midwest region's water issues related to likely reductions in lake and river levels and the resulting impacts to water supply, water quality, water-based transportation, hydropower generation, recreation, and major changes in freshwater ecosystems.
- Western regional water issues revolved around changes in water resources and that included both concerns about possibilities around too much water (flooding) and too little from such as early spring run-off resulting in summer droughts.
- Alaska water issues included concerns around thawing permafrost and melting sea ice and the resulting impacts of increased erosion, landslides, and sinking as well as impacts of larger storm surges on coastal villages and marine ecosystems.
- Island water issues included impacts on freshwater resources through sea level rise and salt-water intrusion, along with possible droughts and floods and the resulting impacts on tourism, agriculture, fish processing, urban/municipal users, and natural ecosystems.

So averages and broad-brush results as currently being produced do not adequately reflect the rich mosaic of regions and localities in this country, nor do they reflect the variety of perspectives or information needs even on what seems like the same issue.

In terms of useful communication of research results, I would like to focus on an example to show how important it is to have the scale of the climate issue needing to be addressed match the scale of the climate information available to address that issue. The data are taken from the NE Regional Assessment and the example is mine.

The NE region included all of the six NE states and upstate New York. The annual precipitation in the region has increased on average nearly 4 percent between 1895 and 1999. If we were to tell any planner in the region to be ready to accommodate an increase in precipitation of about 4 percent in their planning efforts, all of their plans would be incorrect, because the scale of the information that we gave them did not match the scale of the region that they were planning for. If you drill into those data even just to the state average level you will find that a planner in Massachusetts would really have been subject to an increase of probably closer to

+ 30 percent and one in Maine would have been subject to a decrease of more like -12 percent over that same time period. Recognizing that all future projections have a level of uncertainty in them, efforts to provide the decisionmaker with more appropriately scaled regional climate change information—information that is as close as possible to their planning areas—should be an integral part of any Federal climate change research program. Accomplishing this would not only enable the decisionmaker to be more effective in planning and adapting to climate change, but it would also improve the effectiveness of this important Federal research program.

Thank you again for this opportunity to testify. I would be glad to answer any questions Members of the Committee may have.

Senator STEVENS. Well, thank you very much.

Our next witness is Dr. John Christy, Professor and Director of Earth Science System Center at National Space and Science Technology Center at the University of Alabama.

Dr. Christy?

STATEMENT OF JOHN R. CHRISTY, Ph.D., PROFESSOR AND DIRECTOR, EARTH SYSTEM SCIENCE CENTER, NATIONAL SPACE SCIENCE AND TECHNOLOGY CENTER, UNIVERSITY OF ALABAMA IN HUNTSVILLE

Dr. CHRISTY. Senator Stevens, and Committee Members, I'm Director of the Earth Systems Science Center at the University of Alabama in Huntsville, and Alabama State Climatologist, where I work on economic development.

Thank you for allowing me to share a few comments on climate change. First, any science program on climate must be built on the foundation of continuous and accurate data. In other words, we must know what the climate is doing before we can understand why it does what it does.

For example, we know through continuous and accurate satellite observations since 1979 that this year the area of Arctic sea ice retreated to a record minimum, and curiously, that the area of Antarctic sea ice expanded to a record maximum.

But why these disparate results? Blaming increasing greenhouse gases is too quick and easy an answer, in my view.

In another example, I was co-author on a publication by my UA Huntsville colleague, Dr. Roy Spencer, in which he used some terrific satellite data, to discover that the greenhouse effect of clouds evidently naturally mitigates warming rather than reinforcing it. This has powerful implications because it means the climate might react differently to increasing greenhouse gases than current theory predicts.

Climate observations from space are indispensable for our climate program, and their continuations is mandatory so that we may know what the climate is doing, and why. I support the recommendations of the National Research Council Decadal Survey which insists that we add sensors in spacecrafts soon, to keep current measurements from disappearing. What we miss now, will be missed forever.

The topic of human-caused climate change is a media darling these days. As a result, many proposals to "do" something are offered, but are based on the projection of climate models. The utility of models as predictive tools is highly questionable, in my view. When the national assessment chose two of the best models to describe the coming climate for the Southeastern U.S., one projected

a jungle-like environment, the other a semi-arid savannah, and none—not one—of the many models we examined reproduced the actual climate of the last century, in which we experienced declining temperatures, and increasing rainfall in the Southeast.

Climate models will not provide reliable projections of regional climate, yet that's the climate in which we actually live, work, and grow our food. Further, the relatively tiny impacts on global emissions of these proposals are so small, relative to the large variations of local climate, that there will not be a confident, predictable outcome of legislation nor means to detect its efficacy.

Though regional predictions and models vary widely, their least problematic projection may be the global average surface temperature. The model calculations indicate that the global average temperature is quite stubborn. For example, 1,000 new nuclear power plants operating by 2020, replacing about 10 percent of the CO₂ emissions would have a tiny impact of about fifteen-hundredths of a degree by 2100.

In addition to continuous and accurate observations, I believe something else is needed. The climate model industry should be subject to a red team approach. Since the output of these models is being used to drive billion dollar strategies to inhibit emissions, and whose cost can have tremendous negative consequences for our economic health and welfare, they should be evaluated in the most hard-nosed program possible. Such an inexpensive program would provide policymakers with an independent point of view about the level of confidence that may be ascribed to the models.

Whatever trajectory the climate takes, we will, of course, adapt. As State Climatologist, I'm heavily involved in defining and assessing climate-related impacts to our State's economy. Parts of my State are coping with the lowest rainfall in 100 years. Sketchy records show a similar drought back in 1839 and 1840.

When Alabama was also dry in 1988, I penned my General Rule of Climate—if it happened before, it will happen again, and probably worse. And the point here is that by carefully examining what we know has happened in our past, add insurance, we will know how to reduce the negative consequences of events certain to occur in the future.

In the case of our present drought, our farmers suffered severe losses, but Senator Sessions has included in the Farm bill, a provision to offer farmers help to build environmentally sustainable impoundments to store our abundant winter water for use in the summer, and thereby alleviate the terrible consequences. This is a perfect example where climate observations serve as a foundation to tell us when important variations occur, and what we can do to adapt.

Finally, there is no guarantee that energy policies intended to deal with climate change will have the desired effect, or any effect. Making energy more expensive will, however, hurt my State. I'm optimistic, though, that the natural course of innovation, spurred by government investment and research, will lead to energy sources that deal with the significant issues of energy security, balance of trade, economic stability, as well as emissions reductions, while achieving the emphatically desirable goal of keeping energy affordable.

Thank you.
 [The prepared statement of Dr. Christy follows:]

PREPARED STATEMENT OF JOHN R. CHRISTY, PROFESSOR OF ATMOSPHERIC SCIENCE,
 AND DIRECTOR OF THE EARTH SYSTEM SCIENCE CENTER, UNIVERSITY OF ALABAMA
 IN HUNTSVILLE, AND ALABAMA'S STATE CLIMATOLOGIST

Summary

The foundation of a climate science program must be a commitment to continuous and accurate observations. We must know WHAT the climate is doing before we can understand WHY it does what it does. However, we now face the loss of satellite and other observations critical to understanding the climate. The NRC Decadal Survey goals for satellite systems should be pursued vigorously as well as support for other systems.

The climate science program now has a large climate-modeling component. However, based on limited studies, too much confidence in my view is placed in model projections. These projections cannot reliably predict the climate on regional scales where we live and grow our food. The potential of billion-dollar economic impacts of proposals designed to mitigate "global warming" are based on these models and some common misunderstandings. Thus it is imperative that a "Red Team" approach be taken with climate model evaluation. Such teams, independent from those with vested interests in the modeling industry, would evaluate models with a hard-nosed methodology to inform policymakers about model confidence from a different and scientifically defensible point of view.

The human race will adapt to whatever trajectory the climate system selects. Having a firm understanding of past variability allows society to adapt more intelligently to variations almost certain to occur in the future. Such is a benefit of a robust observing system. In 1988 I penned a General Rule of Climate, "If it happened before, it will happen again, and probably worse." The point is that if we prepare for what has already been observed (*e.g.*, hurricanes, droughts, floods, heat waves, blizzards) and then some, we will be much better prepared for whatever the climate does.

There is no guarantee that energy policies intended to deal with climate change will have the desired effect, either in sign or magnitude. However, policies which address the reduction of emissions as well as other important issues, one being the emphatically desirable goal of affordable energy, are worth pursuing.

Making energy more expensive by direct taxes or cap-and-trade schemes (around which business may cleverly skirt) is troublesome. First, these are regressive taxes since the poor disproportionately spend more on energy. Second, as a manufacturer, who employs hundreds in my state, told me last week, "If my energy costs go up according to these proposals, I'm closing down and moving offshore." Irony and tragedy are here. The irony is that higher energy costs will lead to an increase in greenhouse emissions as offshore plants have less stringent rules. The tragedy is that this will lead to further economic suffering in a part of my state where no more suffering is needed.

Observations are Foundational

A climate science program must be built on a foundation of continuous and accurate observations. In other words, it is prerequisite that we know WHAT the climate system is doing before we can understand WHY it does what it does. We know, for example, because of continuous and accurate satellite monitoring since 1979, that in 2007 the Arctic sea ice area retreated to a record minimum, and curiously, that the Antarctic sea ice area expanded to a record maximum. Even as I write this, the global sea ice extent is only about 4 percent lower than the long-term average: <http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/global.daily.ice.area.withtrend.jpg>.

But why these disparate results between north and south? Blaming increasing greenhouse gases is too quick and easy an answer in my view.

While "global warming" due to extra greenhouse gases seems to be consistent with Arctic melting it is at odds with Antarctic sea ice expansion. A more reasonable explanation for at least part of the Arctic ice reduction is offered by a NASA team (Nghiem, *et al.*, 2007) suggesting that an anomalous circulation pattern of the atmosphere over the Arctic in 2007 pushed a large part of the sea ice to lower latitudes where it melted. Higher polar temperatures, near those of the late 1930s, likely also had a role as did the thinner ice. However, more research, and more observations are necessary to understand why such events occur. The complexity of this climate system can not be overstated.

In another example, I was a co-author on a publication led by my UAHuntsville colleague Dr. Roy Spencer in which he used some terrific satellite data to discover that the greenhouse effect of clouds evidently behaves in a way that naturally mitigates warming rather than reinforcing it. We found that as the tropical atmosphere warms through heating related to rainfall, that the types of clouds that trap heat in the atmosphere shrink in coverage, allowing more heat to escape to space and cooling to ensue. This is an apparently strong negative feedback in the climate and has powerful implications because it indicates the climate might react differently to increasing greenhouse gases than current theory predicts.

Climate observations from space are indispensable for a climate program and their continuation is mandatory so that we may know WHAT the climate is doing and thus WHY. I support the recommendations of the National Research Council Decadal Survey report which insists that we add sensors and spacecraft soon to keep current measurements from disappearing. What we miss now, will be missed forever.

Ground-based observations are also critical. With the support of Congressman Cramer and Senator Shelby, Alabama has a nearly completed statewide system of the highest quality, federally-owned and operated climate stations. This type of system is needed world-wide where poor and lost measurements prevent us from having a full picture of what the climate is now doing. This is especially important because of new research in the factors that influence the historical record of surface temperatures.

Mounting observational evidence and theoretical studies are shedding light on the utility of the heretofore iconic representation of the Earth's climate change over the past 150 years—the global average surface temperature. This metric has been promoted as the key proxy to represent the impact of enhanced greenhouse gases. However, I and others have published articles which suggest that this mean surface temperature quantity is a poor metric for this task. The basic problem is that the mean surface temperature is the average of the nighttime low and the daytime high. The inclusion of the nighttime low, our research suggests, is where the problem lies.

Many studies have shown that the nighttime low has warmed more rapidly than the daytime high in most regions. The cause of this nighttime warming however is more consistent with the effects of human development of the surface and consequent influence on the near surface air (*e.g.*, urbanization, farming, aerosol pollution) rather than greenhouse warming. The reasoning is as follows.

The nighttime temperature over land occurs generally in a shallow, cold “boundary layer”, disconnected from the deep and warmer atmosphere aloft. As it so happens, the deep atmosphere does not experience large temperature changes from day to night, yet the deep atmosphere is where the impacts of greenhouse gases are thought to be most pronounced over time. The nighttime boundary layer forms in a delicate balance of physical processes (radiation, heat and moisture fluxes, turbulence, etc.) that can be disrupted by minor changes in the surface characteristics such as urbanization, farming or radiative forcing such as from clouds, aerosols or greenhouse gases (Pielke Sr. *et al.*, 2007, Christy *et al.*, 2006, Walters *et al.*, 2007).

If the formation of the boundary layer is disrupted, the warmer air from above is mixed downward at night, leading to an appearance over time of an increasing temperature trend. However, this trend is not due to a warmer deep atmosphere, but to a mixing of that already-warmer air down to the surface more often than before. Global climate models, due to their coarse resolution, do not in general capture these nighttime boundary layer processes (Walters *et al.*, 2007). Thus, while surface temperatures may show warming, these studies suggest it is not due to a global accumulation of heat (as depicted in climate models) but only to a very local redistribution of heat near the surface.

The basic point here is that it appears that a significant portion of the rising surface temperatures over land, as depicted in the mean surface temperature—most of which is due to nighttime increases—are not related to enhanced greenhouse gases but to development of the surface around locations where thermometers reside. This is another example of the type of research that requires further analysis with more detailed observations and theory, and which has the potential to alter views of the causes of some of the temperature changes now assumed to be linked to greenhouse gas increases.

Thus, from satellites above to the deepest ocean measurements and all parts in between, observations of the Earth System must have priority as the foundation of any climate science program.

Climate Model Issues

The topic of human-caused climate change is ubiquitous in the media today. As a result, people are often made to be frightened about the future and their anxiety

leads to many state and Federal proposals to “do something” about climate change. It is essential to point out that these scenarios are based on the projections of climate models and are often announced from media personalities whose goals are viewer ratings. However, the utility of climate models as predictive tools is highly questionable in my view. The current climate science program has a large climate modeling component, but how effective is it?

When the National Assessment chose two of the best models to describe the coming climate for the Southeastern U.S., one projected a jungle-like environment, the other a semi-arid savannah. And, none—not one—of the many models we examined were able to reproduce the actual climate of the last century in which we experienced declining temperatures and increasing rainfall in the Southeast.

Climate models will not provide reliable projections of regional climate—yet that’s the scale of climate where we actually live, work and grow our food. Further, the relatively tiny impacts on global emissions of these proposals are so small relative to the large variations of local climate, that there will not be a confident, predictable outcome of legislation, nor a means to confidently detect its efficacy. No one can say for a specific region whether a policy option would increase or decrease rainfall, or whether there was even any impact at all. The climate cannot be predictably-managed.

Though regional predictions of models vary widely, the least problematic projection of models may be a single number, the global average surface temperature (problems with which were addressed earlier). Model calculations indicate that global average temperature is quite stubborn. For example, 1000 new nuclear power plants operating by 2020 would have a tiny impact of about 0.15 °C by 2100 according to the best estimate of the IPCC AR4 using the “Business and Usual” emission scenario named A1B. This is roughly equivalent to halving the U.S. carbon dioxide emissions. Thus, even on the global average scale (which has little to do with local climate variations) one must be quite circumspect as to what is possible even with dramatic changes in energy infrastructure.

Red Team Evaluations of Climate Projections

Dr. Roger Pielke, Jr. observed in commenting on Roe and Barker (2007), who themselves discussed the intrinsic uncertainties of climate modeling, “. . . the uncomfortable reality—for climate modelers—[is] that finite research dollars invested in ever more sophisticated climate models offer very little marginal benefit to decisionmakers.” (*New Scientist*, 25 Oct 2007) Where could resources be invested with regard to climate model understanding if further investment in the activity itself will likely lead to little further knowledge?

In addition to continuous and accurate observations, I believe there is gap in the model evaluation program and thus this represents a productive area of research. The climate model industry should be subject to a “Red Team” analysis in which the teams take a critical look at model efficacy. If the simulations of these models are being used to drive billion dollar strategies to inhibit emissions and whose costs can have tremendous negative consequences for our economic health and welfare, they should be evaluated by the most hard-nosed program possible. Such an inexpensive program would provide policymakers with an independent point of view about the level of confidence that may be ascribed to models. This is the way science works and thus such a Red Team program would be scientifically defensible. Additionally, this evaluation would very likely lead to improvements in model formulations. If the modeling industry objects to this approach, one should ask why.

Adaptation Will Occur

Whatever trajectory the climate takes, we will of course adapt. As State Climatologist, I’m heavily involved in defining and assessing climate-related impacts to our state and the resulting viability of our economy. Parts of my state are coping with the lowest rainfall in 100 years. Sketchy records show a similar drought back in 1839–40. In general terms, changes in water supply are more important than changes in temperature, so dealing with rainfall variations is crucial for any society.

When Alabama was also dry in 1988 I pinned my General Rule of Climate: “If it happened before, it will happen again and probably worse.” The point here is that by carefully examining what we know has happened in our past, add a little insurance, we will know how to reduce the negative consequences of events certain to occur in the future.

In the case of our present drought, our farmers suffered severe losses, but Senator Sessions has included in the Farm Bill a provision to offer farmers Federal help in building environmentally sustainable impoundments to store our abundant winter water for use in the summer and thereby alleviate the terrible consequences. This

is a perfect example of how climate observations serve as a foundation to inform us of the important variations that occur and what we can do to adapt.

The situation is more precarious in the West where the current 6-year drought pales in comparison to droughts of the past which lasted 50 years.

Make no mistake, the concentrations of some atmospheric greenhouse gases, especially carbon dioxide, are increasing. These added gases will affect the radiation budget of the atmosphere in a way that allows the earth's atmosphere and ocean to retain more heat energy. Increasing carbon dioxide, which is the basic building block of life, has other effects too, such as the invigoration of the biosphere which is manifested among other things in increased food production. But, as noted above, determining the climate impact of the total amount of the extra energy retained in the climate system due to additional greenhouse gases involves no simple or fully-understood calculation.

Energy Policy

In closing, I want to draw attention to my Op-Ed contribution to *The Wall Street Journal* (attached) which suggests that various social and environmental policy options vying for our limited resources should be understood and prioritized for effectiveness. Regarding energy policy, it is simply a fundamental fact that energy has brought uncountable benefits to human life. Thus, the demand for energy will grow given (a) the deep human desire for its benefits and (b) the enormous pent-up demand for these benefits in the developing world.

In my view, government's role is to support, as it currently does, the discovery of new sources of energy which address simultaneously several economic and geopolitical issues (*e.g.*, energy security, balance of trade, economic resilience, air pollution (CO₂ is not a pollutant)) besides the marginal and uncertain consequences of a desire to "do something" about climate change.

Making energy more expensive, whether by direct taxes (most effective in reducing energy use) or cap-and-trade schemes (around which business may cleverly skirt) is troublesome in my view. First, these represent regressive taxes as the poorest in our Nation proportionally spend more on energy than the rest of us. And second, as a manufacturer, who employs hundreds in an economically-challenged part of my state, told me last week, "If my energy costs go up according to these proposals, I'm closing down and moving offshore." There is irony and tragedy in this path. The irony is that artificial increases in energy costs here will likely lead to an increase in greenhouse gas emissions because: (a) offshore plants have less stringent requirements all around and (b) the product we need will then require transportation (and even more emissions). The tragedy is that this will lead to further economic suffering in a part of my state where no more is needed.

Please note, there is no guarantee at all that specific energy policies designed to deal with climate change will actually have the intended effect either in magnitude or sign. Will they produce more or less rain? . . . no one knows. However, energy policies which address other important issues mentioned above and which include the emphatically desirable goal of affordable energy, and also reduce emissions, are worth pursuing.

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MY NOBEL MOMENT

By John R. Christy

I've had a lot of fun recently with my tiny (and unofficial) slice of the 2007 Nobel Peace Prize awarded to the Intergovernmental Panel on Climate Change (IPCC). But, though I was one of thousands of IPCC participants, I don't think I will add "0.0001 Nobel Laureate" to my resume.

The other half of the prize was awarded to former Vice President Al Gore, whose carbon footprint would stomp my neighborhood flat. But that's another story.

Both halves of the award honor promoting the message that Earth's temperature is rising due to human-based emissions of greenhouse gases. The Nobel committee praises Mr. Gore and the IPCC for alerting us to a potential catastrophe and for spurring us to a carbonless economy.

I'm sure the majority (but not all) of my IPCC colleagues cringe when I say this, but I see neither the developing catastrophe nor the smoking gun proving that human activity is to blame for most of the warming we see. Rather, I see a reliance on climate models (useful but never "proof") and the coincidence that changes in carbon dioxide and global temperatures have loose similarity over time.

There are some of us who remain so humbled by the task of measuring and understanding the extraordinarily complex climate system that we are skeptical of our ability to know what it is doing and why. As we build climate data sets from scratch and look into the guts of the climate system, however, we don't find the alarmist theory matching observations. (The National Oceanic and Atmospheric Administration satellite data we analyze at the University of Alabama in Huntsville does show modest warming—around 2.5 degrees Fahrenheit per century, if current warming trends of 0.25 degrees per decade continue.)

It is my turn to cringe when I hear overstated-confidence from those who describe the projected evolution of global weather patterns over the next 100 years, especially when I consider how difficult it is to accurately predict the system's behavior over the next 5 days.

Mother Nature simply operates at a level of complexity that is, at this point, beyond the mastery of mere mortals (such as scientists) and the tools available to us. As my high-school physics teacher admonished us in those we-shall-conquer-the-world-with-a-slide-rule days, "Begin all of your scientific pronouncements with 'At our present level of ignorance, we think we know . . .'"

I haven't seen that type of humility lately. Rather I see jump-to-conclusions advocates and, unfortunately, some scientists who see in every weather anomaly the specter of a global-warming apocalypse. Explaining each successive phenomenon as a result of human action gives them comfort and an easy answer.

Others of us scratch our heads and try to understand the real causes behind what we see. We discount the possibility that everything is caused by human actions, because everything we've seen the climate do has happened before. Sea levels rise and fall continually. The Arctic ice cap has shrunk before. One millennium there are hippos swimming in the Thames, and a geological blink later there is an ice bridge linking Asia and North America.

One of the challenges in studying global climate is keeping a global perspective, especially when much of the research focuses on data gathered from spots around the globe. Often, observations from one region get more attention than equally valid data from another.

The recent CNN report "Planet in Peril," for instance, spent considerable time discussing shrinking Arctic sea ice cover. CNN did not note that winter sea ice around Antarctica last month set a record maximum (yes, maximum) for coverage since aerial measurements started.

Then, there is the challenge of translating global trends to local climate. For instance, hasn't global warming led to the five-year drought and fires in the U.S. Southwest?

Not necessarily.

There has been a drought, but it would be a stretch to link this drought to carbon dioxide. If you look at the 1,000-year climate record for the western U.S. you will see not five-year but 50-year-long droughts. The 12th and 13th centuries were particularly dry. The inconvenient truth is that the last century has been fairly benign in the American West. A return to the region's long-term "normal" climate would present huge challenges for urban planners.

Without a doubt, atmospheric carbon dioxide is increasing due primarily to carbon-based energy production (with its undisputed benefits to humanity) and many people ardently believe we must "do something" about its alleged consequence, glob-

al warming. This might seem like a legitimate concern given the potential disasters that are announced almost daily, so I've looked at a couple of ways in which humans might reduce CO₂ emissions and their impact on temperatures.

California and some Northeastern states have decided to force their residents to buy cars that average 43 miles-per-gallon within the next decade. Even if you applied this law to the entire world, the net effect would reduce projected warming by about 0.05 degrees Fahrenheit by 2100, an amount so minuscule as to be undetectable. Global temperatures vary more than that from day to day.

Suppose you were very serious about making a dent in carbon emissions and could replace about 10 percent of the world's energy sources with non-CO₂-emitting nuclear power by 2020—roughly equivalent to halving U.S. emissions. Based on IPCC-like projections, the required 1,000 new nuclear power plants would slow the warming by about 0.2 degrees Fahrenheit per century. It's a dent.

But what is the economic and human price, and what is it worth given the scientific uncertainty?

My experience as a missionary teacher in Africa opened my eyes to this simple fact: Without access to energy, life is brutal and short. The uncertain impacts of global warming far in the future must be weighed against disasters at our doorsteps today. Bjorn Lomborg's Copenhagen Consensus 2004, a cost-benefit analysis of health issues by leading economists (including three Nobelists), calculated that spending on health issues such as micronutrients for children, HIV/AIDS and water purification has benefits 50 to 200 times those of attempting to marginally limit "global warming."

Given the scientific uncertainty and our relative impotence regarding climate change, the moral imperative here seems clear to me.

Senator KERRY. Thank you. Dr. Moss?

**STATEMENT OF RICHARD MOSS, PH.D., VICE PRESIDENT AND
MANAGING DIRECTOR, CLIMATE CHANGE WORLD WILDLIFE
FUND**

Dr. MOSS. Thank you, Mr. Chairman. I'm Richard Moss, and I currently serve as Vice President and Managing Director of Climate Change for the World Wildlife Federation. From May 2000 to February of 2006, a period spanning both the Clinton and Bush Administrations, I served as Director of the Office of the U.S. Global Change Program, and its successor, the U.S. Climate Change Science Program. Since 1993, I've also served in a number of capacities with the intergovernmental panel on climate change.

At the outset, I want to thank you, Senator Kerry and Senator Snowe for your leadership in improving our scientific understanding of climate change, and particularly applaud your leadership in introducing the Global Change Research Improvement Act of 2007. I think the Act is a tremendous step forward in revitalizing our Nation's global change research capacity.

I'd like to offer my comments on the Act, drawing on my experience in both Administrations, serving as the Director of the Coordinating Office.

The bill, I think, is extremely important in that it adopts a comprehensive approach for providing integrated information that's going to be needed to cope with future changing climate conditions. I think it's wise that the bill incorporates a climate and global change signs, a climate service, technology assessment and the development of measuring and monitoring technologies and standards. I think all of these components are going to be essential if we are to identify the highest priority threats and opportunities, and provide information for implementation of adaptation and mitigation options. So, I think this comprehensive approach is extremely important.

I also think it's extremely important to pay more attention to the needs of decisionmakers and to improve approaches for interacting with stakeholders. I think in this sense, it is extremely important that you've include the climate service, information on climate that is provided through such a service, can improve decisions so long as it's accompanied by information about associated uncertainty and technical guidelines for the proper uses and limits of the information. I think it's key to realize that no one should use any single model, but what you want to do is use a range of models that span uncertainty, and I do disagree, I think that models can be extremely important in guiding future decisionmaking.

I would recommend to strengthen the provisions about interactions with users that one might consider creation of a council of users from lake, state, local, regional and Federal levels to actually provide input on research needs, and to create opportunities for improving interactions between users and researchers.

On the structure of the program that you've outlined, I think it's very wise to continue the distributed, multi-agency program. I think this is the best option, and it does draw on the strengths of the existing agencies.

I also think it's extremely important that the bill formalizes the existing informal program office, and that that will also help to improve program management, and budgetary coordination. But I think we heard this morning in the colloquy with Dr. Marburger, two central tensions that exist.

I think on the one hand, there were concerns about the performance of the program that stem from decentralization. You have these different agencies, they each respond to their own stakeholders and their own process, it's sometimes difficult to get them all on the same page, moving to do something like produce a national assessment.

On the other hand, once you centralize, you have a potential for political influences coming into the reporting of the science, and I think we also heard that in a tremendous number of comments, concerns about redacting of science in the Administration and so forth. I think that the program structure that's created needs to try to deal with those central tensions.

I'm not yet convinced that the legislation putting the Program Office in the Office of Science and Technology Policy will, in fact, solve that problem. I think it might be interesting to look at some other ideas, including the possibility of something like an independent Commission, which could be non-partisan or bipartisan, long-term membership that, in fact, might provide a better guarantee about some of this concern about political influence over the reporting of the findings.

It might also be a good idea to actually request something like the National Academy of Public Administration to work with the National Research Council in developing some detailed recommendations on that.

Two other very quick points, I think that an important gap not filled by the bill is to provide dedicated funding for the assessment process, including for the researchers at universities, think tanks and laboratories, who actually give of their time, in many cases, as

volunteers now to do this work. I think there might be some dedicated funding to help provide them support necessary to do it.

And finally, I think that the amendments to the Act should also be looking at communications and public education, and insisting there actually be an explicit strategy prepared. We, right now, in the old legislation have something called the Global Change Research Information Office, which has been extremely useful, but I would recommend actually looking to beef that up, it's extremely important to carry the information out to the public.

So, in conclusion, I'd just like to thank you again for the opportunity to testify, and for your leadership in putting this great bill together.

Thank you.

[The prepared statement of Dr. Moss follows:]

PREPARED STATEMENT OF RICHARD H. MOSS, PH.D., VICE PRESIDENT AND MANAGING DIRECTOR, CLIMATE CHANGE, WORLD WILDLIFE FUND

Chairman Inouye, Ranking Member Stevens, and Members of the Committee, and in particular Senator Snowe: thank you for your invitation to address the Committee today on the important topic of "A Time for Change: Improved Federal Climate Research and Information Program."

I am Richard H. Moss, and I currently serve as Vice President and Managing Director, Climate Change, for the World Wildlife Fund. From May 2000 to February 2006 (a period spanning both the Clinton and Bush Administrations) I served as the Director of the Office of the U.S. Global Change Research Program (GCRP) and, as it was subsequently renamed, the U.S. Climate Change Science Program (CCSP). The USGCRP/CCSP involves 13 Federal agencies conducting and overseeing Earth system observations, scientific research, computer simulations, and evaluation of possible adaptation and mitigation actions to address climate change. Since 1993, I have served in a number of capacities with the Intergovernmental Panel on Climate Change (IPCC), including Director of the Technical Support Unit of the Working Group on Impacts, Adaptation, Vulnerability and Mitigation (from 1993-1998), the coordinating lead author (with Dr. Stephen Schneider of Stanford University) of the first IPCC guidance document on characterizing and communicating uncertainty, and as lead author or editor of a number of IPCC reports related to impacts, adaptation, and mitigation. I currently chair several IPCC task groups related to the preparation and use of scenarios and other climate information.

WWF is the largest private conservation organization working internationally to protect the world's wildlife, rich biological diversity and the ecosystems upon which they depend. We currently sponsor conservation programs in more than 100 countries, thanks to the support of 1.2 million members in the United States and more than 5 million members worldwide. We seek to address the threat of climate change through our work in field programs that stretch from the Arctic to Antarctica; our work with corporations seeking to transform their business practices; our work with communities throughout the world attempting to maintain their livelihoods; and our work with governments in the U.S. and abroad in shaping policies for reducing greenhouse gas emissions and strengthening resilience and adaptive frameworks.

At the outset, I want to thank Senators Kerry and Snowe for their longstanding leadership on addressing the need to improve our scientific understanding of climate change, which is so critical in shaping the policy decisions with which Congress is now grappling. In particular, I applaud their leadership for introducing S. 2307, the Global Change Research Improvement Act of 2007. This bill tackles the important issues of amending the Global Change Research Act, establishing a national climate service, and establishing initiatives to address technology-related aspects of climate change.

My testimony today provides my views about the current state of the Climate Change Science Program, its milestones, and how the program needs to be improved and amended in light of current knowledge and events. My testimony also offers my thoughts specifically on S. 2307 in terms of addressing those needs, along with some recommendations for further improving S. 2307. My comments are drawn from the specific perspective of my experience as Director of the Office of the GCRP and CCSP under two Administrations, as well as my experiences with the IPCC, particularly related to characterization and communication of scientific uncertainty.

I. Background

I.1. *The Global Change Research Act of 1990 is in need of significant updating.* Our understanding of climate science has progressed significantly since 1990. The IPCC has concluded that there is better than a 9 in 10 probability that these changes are the result of human activities. Research to project future changes in climate and their potential implications is also advancing. Perhaps more importantly, our view of how to conduct problem-oriented research on global change has also evolved toward a model in which researchers and users of research information interact more closely in defining research questions and applying the results. This approach is essential for more rapidly incorporating knowledge into decisionmaking. Finally, our understanding of how to effectively run an interagency science program like the GCRP has improved, given our experiences with the program over the past 17 years. Our different understanding of what constitutes effective research and specific lessons about how to manage the program provide a basis for changes that must be incorporated into the amended Global Change Research Act.

I.2. *A multi-agency approach to research is still appropriate.* The multi-agency organization of the GCRP makes sense because essential capacities for research are widely distributed across a number of government agencies. Each agency has different specialized capabilities, networks and relationships with the external research community that enable it to conduct focused research and activities at greater depth than would be the case in a single program attempting to cover all facets of global change. Moreover, it would be counterproductive to attempt to consolidate these different capabilities in one specialized climate research agency. We would lose a great deal of time that we don't have to waste.

I.3. *The single most important management challenge for the future is balancing the need for greater central political authority to achieve programmatic and budgetary integration with the need to ensure the actual and perceived independence of the program's research and assessment reports from political influence.* While a distributed program taps the strengths and research capacity of powerful Federal agencies, it makes it more difficult to integrate program plans and budgets. Each agency responds to the requirements of its own mission and stakeholders, and makes program and budget decisions through different processes, and according to somewhat different schedules. Thus it is essential to provide for effective administrative and budgetary authority to ensure that agencies coordinate their plans and work to eliminate gaps and overlaps in program. Sufficient central authority is also required for implementation of program-wide activities that require coordination, such as a national assessment. While it would initially appear that a logical place to centralize this authority is within the Executive Office of the President (EOP), specifically the Office of Science and Technology Policy (OSTP) and the Office of Management and Budget (OMB), giving an increased role to the EOP also opens the door to political influence in the reporting of research results. The failure to disseminate the findings of the U.S. National Assessment of the Consequences of Climate Variability and Change is a prime example of this sort of political influence on the work of the GCRP agencies. This central tension between the need for centralized authority and freedom from political influence must be better managed if the GCRP is to succeed in its mission.

I.4. *A comprehensive approach for providing integrated information on energy use/emissions, climate system response, impacts, adaptation, and assessment of mitigation potential is required to cope with changing future conditions.* Climate change and measures to respond to it will touch many aspects of the environment, society, and the economy. The decisions we make in the coming decades will determine the extent of future climate change and the degree to which we successfully adapt. A comprehensive national global change research enterprise that provides for climate and global change science, a climate service, technology assessment, and development of measurement and monitoring technologies and standards is needed to identify the highest priority threats and opportunities, to deliver useful information in a timely fashion, to compare the relative strengths and weaknesses of different response options, and to provide vital information for implementation of responses. WWF looks forward to working with Congress to further refine this comprehensive approach to ensure that it is capable of informing tradeoffs and realizing synergies between adaptation and mitigation options.

I.5. *It is vital to pay more attention to the needs of decisionmakers and to improve approaches for interacting with stakeholders.* There is increased public concern about the consequences of climate change and thus a significant demand for data, information, models, and tools to help decisionmakers and resource managers cope with the increased risks. The CCSP's Synthesis and Assessment Products (SAPs) were intended to meet a particular set of information needs identified by Bush Administration decisionmakers, and they will constitute a valuable resource when com-

pleted. They were never, however, intended to constitute a “national assessment” of consequences of climate change for the United States. Technical planning for the next such assessment should be undertaken by the program as soon as possible. The CCSP strategic plan calls for development and use of research-based tools to support “adaptive management.” In developing these resources, GCRP agencies have built, to some extent, on the legacy of the previous national assessment. NOAA’s Regional Integrated Sciences and Assessment (RISA) Program is an excellent example of a program that has successfully integrated sustained interaction with stakeholders into a research framework. Ensuring that stakeholders have continued access to research teams has led to improved communication of scientific results and improved sensitivity of research agendas to the evolving needs of decisionmakers attempting to incorporate climate change into management and planning. But there is an unprecedented opportunity to build on the GCRP’s past accomplishments and to significantly improve and increase the Federal research effort to provide “decision support” to resource managers and other stakeholders around the country.

1.6. *There must be balance between the need for increased attention to the information demands of the public and decisionmakers, and the need to allow researchers to define a research agenda that addresses what they believe to be the most important scientific uncertainties.* While a consensus about human-caused climate change has emerged, investigator-driven research is required to make progress on many issues, including abrupt climate change, extreme events and climate change, regional manifestations of climate variability and change, and climate-carbon-cycle interactions, to name a few key areas.

1.7 *The GCRP must adequately support needed observations, climate research, and resources for decisionmaking.* No amount of good management can compensate for inadequate resources. While the Bush Administration should be given credit for maintaining resource levels during its first term, even in the wake of increased security spending following the 9/11 attacks, recent budgets have fallen short, especially in light of the increased demands on the program to accelerate research, complete the SAPs, and provide additional decision support products. Additional funding must be provided so that the preparation and provision of needed science is not jeopardized.

II. Analysis and Recommendations

II.1. *S. 2307 is a tremendous step forward in revitalizing our Nation’s global change research capacity.* I commend Senators Kerry and Snowe for their leadership. During my testimony I point to what I consider the strengths of the bill, as well as to opportunities where it can be further strengthened. I am an extremely enthusiastic about the legislation, and my suggestions for improvement in no way indicate a lack of support. With that in mind, here are my recommendations.

II.2. *The establishment in Section 102 of Title I of the Committee on Global Change Research provides a good foundation for the program.* The proposed structure of a senior-level interagency committee with representatives of sufficient authority to allocate budgetary resources to meet program needs is appropriate. However, a stronger mechanism for budgetary coordination and integration needs to be identified.

II.3. *S. 2307 helpfully formalizes the existing informal program office to help manage the program and achieve budgetary coordination.* The program office should be staffed by individuals with expertise in the key research areas being addressed by the program and should be tasked with leading interagency coordination to prepare a draft strategic plan, annual program plans, reports, and budgets. It should report to the senior interagency committee responsible for overall decisionmaking. It is important to consider whether placing the program office within the Office of Science and Technology Policy of the White House is the best option. While this may give the office greater authority to manage and coordinate the program across the agencies, it increases opportunities for political influence and thus potentially reduces the perceived credibility of research reports and assessments produced by the program.

II.4. *Beyond this, further clarification is required regarding the structure of the program and its top-level management to ensure that the tension between needed programmatic authority and scientific integrity is well managed.* Because of the need for unbiased, credible research information, it is essential to carefully consider what management structure will most effectively create needed central authority while also protecting actual and perceived political independence of the program. The legislation should call for a study of options for organizing government-sponsored research in a multi-agency setting that creates adequate authority for program and budget integration but that also ensures scientific integrity. Such a study could examine the potential role of OMB, OSTP, the proper location of the integrated pro-

gram office, and the establishment of incentives that reward interagency cooperation, among other issues. The National Academy of Public Administration and an appropriate panel of the National Research Council could be called upon to collaborate on such a study. A public review period would be essential and would provide researchers and other stakeholders with an opportunity for input. Ideally, the panel should report its findings 6–9 months after enactment of the legislation. Assuming the legislation passes this year, the panel’s report and public review comments will then be available for the use of transition teams and ultimately by the next Administration.

II. 5. *The legislation should propose creation of a high-level, independent, non-partisan oversight mechanism.* Section 113 of Title 1 (“Scientific Communications”), which calls for agencies to adopt policies that ensure scientific independence of their investigators, will not be sufficient to guard against political influence in program-wide activities and products such as a national assessment. The National Academy of Sciences (NAS) has successfully provided guidance to the GCRP/CCSP, reviewed specific reports, and commented on the quality of research plans and products developed by the program. It has not been asked, nor is it particularly well placed, to serve as a “watchdog” of the independence of the program from political influence. Financial support for the NRC’s activities should be provided outside of direct grants from USGCRP agencies to minimize perceived or actual exertion of influence over NAS reviews. One possible model for the Committee to consider is that of the independent commission. The rationale for establishing independent commissions includes the assumptions that: (1) long-term appointment of commissioners would promote stability and develop expertise, (2) independent status would insulate them from undue economic and political pressures, and (3) commissioners with different political persuasions and interests would provide diverse viewpoints. WWF would be eager to work with the Committee members and staff to help develop an appropriate structure.

II.6. *Given the need of decisionmakers for information, especially in light of continuing and in some cases irreducible uncertainties, it is appropriate for S. 2307 to launch a national climate service.* The proposal for a national climate service recognizes the importance of climate variability and change for public safety, the environment, natural resources, human health, and even national security. Information on the state of the climate through such a service can improve decisions so long as it is accompanied by information about associated uncertainties and technical guidelines for the proper uses and limits of the information. The approach will bring needed focus among disparate programs and seems workable provided that the research program and climate service mandate a close link between the climate service and the GCRP. Research must inform the activities of the climate service, and user-driven questions and information needs should be used to stimulate scientific exploration and discovery. The relationship between the activities of the climate service and decision-support programs within the GCRP (such as the national assessment and development of tools for adaptive management) will need to be clarified.

II.7. *S. 2307 effectively balances the tension between the needs of the public and decisionmakers for research information and the opportunities for scientific discovery afforded by a research agenda defined by the science community.* Section 108 of Title I establishes a provision for supplemental research grants to priority areas not being adequately addressed by the participating Federal agencies. This is an excellent addition to the program that can be further strengthened by specifying that disbursement of these funds should be determined by an interagency committee of senior science program managers, with review by the senior interagency committee, and with administration of the funds by one of the participating Federal Agencies. This is similar to an approach to funding employed in the National Oceanographic Partnership Program. Paragraph 3A and B of Section 108 call for administering these funds through the Science and Technology Policy Institute. According to the Institute’s website, <http://www.ida.org/stpi/index.html>, the Institute is part of the Institute for Defense Analyses, which has no obvious expertise or experience in global change, and thus may not be the most appropriate choice.

III. Additional Recommendations

III.1. *The timing of the preparation of the strategic plan for the Global Change Research Program and the “plan of action” for the National Climate Service should be revised.* Title I, Section 105 of S2307 amends Section 104 of the 1990 Act to require a Strategic Plan for the 10 year period beginning in 2008 and requires that the plan be submitted within 1 year of passage of the act. However, it does not make sense to have the program develop a plan under this Administration but deliver that plan to the following one. This should be changed so that the Strategic Plan covers the

10 year period beginning in 2011 and that the plan be submitted to Congress no later than 1 January 2010. This would give the incoming administration input to the plan. The current research plan, while in need of updating, can continue to provide effective guidance in research program development. The “plan of action for the National Climate Service” (p. 29 of the bill) should be on a similar schedule. Instead of developing a new strategic plan at this time, the CCSP should concentrate on completing the existing SAPs and initiating technical planning for scenarios and other elements for the next national assessment.

III.2. *S. 2307 should mandate further improvements in the reporting of uncertainty of products of the research program and climate service.* A key requirement of all activities supported under S. 2307 should be a commitment to characterize and communicate uncertainty so that decisionmakers understand the level of confidence and explanations for why a particular piece is uncertain. Improving communication about uncertainty and its implications for decisionmaking will require close interaction between producers and users of the information developed. While the Climate Change Science Program has endeavored to improve its approach to uncertainty, further attention is required (see SAP 5.2, “Best practice approaches for characterizing, communicating, and incorporating scientific uncertainty in decisionmaking,” <http://www.climate-science.gov/Library/sap/sap5-2/default.php>).

III.3. *A “User Council” should be created to provide input on research needs and to create opportunities for improving interactions between researchers and users.* A “user council” or similar body should be created and empowered to provide input on directions as well as to provide funding for user-oriented programs and products. The Council needs to involve users at the local, state, and regional levels, drawing on representatives from the private sector, non-governmental organizations, and government entities. Mission-oriented Federal agencies (e.g., USDA, DOI, etc.) should also participate in the user council. In general, the program should improve the delineation of roles between agencies that are predominantly research oriented (e.g., NSF, NASA, DOE, parts of NOAA) and those that are mission oriented and thus key user stakeholders.

III.4 *An important gap not filled by S. 2307 is to provide funding for researchers at universities, think tanks, and laboratories to participate in future assessments and decision support activities.* In the past, many scientists and other experts have volunteered their time for these assessments. But as the need for both international and national decision support increases, failure to provide such dedicated assessment resources will have a negative impact on the quality of research and decision support. There is only so much assessment researchers can be expected to do in their free time. Providing assessment funding will enable researchers to engage graduate students and additional technical experts under their supervision. This could also contribute to training the next generation of researchers who are able to participate in decision support activities.

III.5. *The existing Act should be amended to explicitly call for development and funding for an overall communications and public education strategy for the program.* Without an explicit mandate for such activities, it is almost impossible to obtain approval for communications and education activities in the President’s budget. And without support for communications and education activities, the efficiency of transmitting climate change information to potential users throughout the Nation will be seriously diminished. Section 204 of the 1990 established the Global Change Research Information Office. This bill should seek to strengthen this function through a review of communication needs and provision of mandated funding.

III.6. *Abrupt climate change should be considered within the Global Change Research Program, not in a separate program under NOAA.* Section 501 of Title V calls for establishment of a research program on abrupt climate change with the Office of Oceanic and Atmospheric Research of NOAA. This research is closely related to other research topics in the broad area of climate variability and change and should be integrated into the overall global change research effort.

IV. Conclusion

In conclusion, Mr. Chairman and Members of the Committee, I would like to again thank you for the opportunity to testify before you today on this important issue, and to commend you on your leadership in introducing and entertaining views on S. 2307. WWF stands ready to work with you and your staff on advancing this essential legislation in the coming weeks and months, and working with you on the vital efforts needed to address climate change in the years ahead.

Senator KERRY. Well, we appreciate all of you testifying, and you’ve had some important contributions to this question of science,

of the assessments and coming from different places, which is important in that regard.

Just a few questions then I want to turn to my colleagues, and then maybe I'll ask a few more at the back end.

But, do all of you support the notion that we ought to be able to get this report done, and we ought to be aiming to get a national assessment done within a 4-year period. Is there something, I mean, wrong in that? There's sort of been these assertions, "Well, it's long, it's big, it's complicated," you mentioned at the opening, I think, Dr. Boesch, that the IPCC does this and, you know, it's big global effort, et cetera. So, I just want to have everybody on record—should this be done in 4 years, and can it be done in 4 years? It's important to have it in every 4 years, yes or no?

Doctor?

Dr. BOESCH. Yes, yes, Senator, given the speed at which we're developing knowledge, and we're seeing consequences already, that's a required time stamp.

Senator KERRY. Dr. Davis?

Dr. DAVIS. I believe so, yes sir. I think that's an important time period to keep.

Senator KERRY. Dr. Carter?

Dr. CARTER. Yes, I think it's critically important, for lots of reasons.

Senator KERRY. And doable.

Dr. CARTER. It's doable, yes. It's work, but it's doable.

Senator KERRY. Dr. Christy?

Dr. CHRISTY. Well, science just doesn't quite work like that. I was on the Climate Change Science Program the first panel, and I would say there's quite a bit of stuff in there that's already out of date, because of that. So, in that sense, you would want to have almost a webpage update, because science changes so fast like this. Kind of official updates—

Senator KERRY. In other words, 4 years is not unreasonable, and we ought to be staying at that rate or faster?

Dr. CHRISTY. It moves fast.

Senator KERRY. Dr. Moss?

Dr. MOSS. I believe science evolves very quickly, and what we're getting here is a 4-year snapshot to apply that new information to new concerns and questions as they come up. So, yes.

Senator KERRY. Let me start with you and go back the other way on this issue of the budget. Is the budget adequate, and if not, by what degree do you believe—what would be adequate in your judgment as to what we ought to be doing as an increase in the science effort nationally?

Dr. MOSS. It's all, all kind of back-of-the-envelope calculations, but I think to include all of the provisions that you've included in the draft legislation, I think you'd need at least a doubling.

Senator KERRY. Dr. Christy?

Dr. CHRISTY. I'm not familiar with the bill, but I do agree with what Richard said about, those of us who are working stiffs who participate in the program, and have no funding, or a way to cover our time—I like that part of it.

Senator KERRY. Dr. Carter?

Dr. CARTER. I really can't speak to the budget, Senator.

Dr. FRUMHOFF. I think it's critical that the budget both support the research and the dissemination and outreach and engagement of stakeholders. I can't speak to whether it's sufficient, as it's currently written, but the budget implications for outreach are not insignificant, and should be given significant attention.

Dr. DAVIS. I'd be happy to go back to the Coastal States and get some comments on the budget, in terms of the priorities we've recently identified.

Senator KERRY. That would be helpful. I think, we would appreciate that input from the States.

[The information previously referred to follows:]

RESPONSE FROM DR. BRAXTON C. DAVIS

We appreciate the opportunity to offer testimony on the importance of climate change research to state and local resource managers, and strongly support the climate change research and monitoring activities through the Global Change Research Act. During the hearing, Senator Kerry asked each panelist if the overall budget authorized in the bill was "adequate, and if not, by what degree do you believe—what would be adequate in your judgment as to what we ought to be doing as an increase in the science effort nationally?"

Based on continued discussions of the bill with state-level resource managers and delegates to the Coastal States Organization, we would like to re-emphasize the importance of research concerning the unique and significant impacts of climate change in coastal areas of the United States, where communities and natural resource-based economies are especially vulnerable to accelerated sea level rise and lake level changes, shoreline erosion, increased storm frequency or intensity, changes in rainfall, and related flooding. Other impacts may include changes in chemical and physical characteristics of marine systems, saltwater intrusion into groundwater aquifers and coastal rivers, increased harmful algal blooms, spread of invasive species, habitat loss (wetlands and coral reefs), species migrations, and changes in population dynamics among marine and coastal species.

State and local managers have *immediate* research and information needs in order to respond to these threats through adaptation planning and implementation. However, research conducted at the Federal level often cannot be applied at the scale of state and local decisionmaking and planning. To meet these state and local needs, we respectfully ask that S. 2307 incorporate two key elements in relation to the general budget:

1. Federal research grants authorized under the bill should include a requirement for engaging state and local resource managers in the planning phases of proposed research, through project completion, to ensure that the findings are relevant at the appropriate spatial scales for decisionmaking and planning, and take advantage of (and avoid duplication of) state and local research and data collection efforts already underway.
2. Under the newly authorized NOAA National Climate Service, we request an authorization for research grants to states, territories, and commonwealths in the amount of \$10,000,000 each year to support *partnership proposals* from NOAA-supported state coastal programs (Coastal Zone Management programs, Sea Grants, and National Estuarine Research Reserves), in coordination with Federal agencies involved in climate change research under the GCRP, to carry out state and local-scale research and data collection efforts in the following areas:
 - a. data collection and research related to sea level rise (or lake level changes) and related inundation, erosion, flooding, and storm impacts;
 - b. habitat loss, including effects on tidal wetlands;
 - c. invasive species introductions, species and ecosystem migration;
 - d. saltwater intrusion and changes in estuarine conditions; and
 - e. other coast-specific climate change impacts.

Thank you again for the opportunity to help inform the Committee on the importance of climate change research to state and local resource managers.

Dr. BOESCH. Given the requirements to deal with the deficiencies that we're looking at in terms of the observing systems, the satellites, in particular, given the need to bolster the regional scale research and assessments, I would think that Dr. Moss's experience with the evolution of the program, I would trust his judgment, and that should be, sort of, a goal that we're headed toward, very quickly.

Senator KERRY. Well, let me just say to all of you that from my perspective, and I think Senator Stevens, and I know Senator Snowe would share this—I think, in fact, I'm confident Senator Stevens would—I mean, the decisions we've been trying to make about fisheries over the last 25 years have been lacking in science. And, if you look at all of these other decisions we're trying to make, it's critical to have as much of, and the best science possible to determine cause and effect, connect the dots, and have the best picture possible.

And, we're so far—just stunningly far from doing that. I mean, in terms of lakes, rivers, streams, monitoring, regular monitoring, knowing, tracking, it's shocking to me, frankly, how blind we are flying with respect to some of this. So, I think it's one of the most critical areas of our research augmentation we ought to be doing, and ought to be more urgent. Senator Stevens?

I'm going to come back afterwards.

Senator STEVENS. I do appreciate all of your testimony.

As I mentioned at the beginning, we are spending more, or have spent more than any nation on earth. If we are to increase the budget, what do you want to cut out? We are spending that money already, it has not gotten you the answers. Do you want more money? I say to you, no one else in the world is spending the kind of money we are spending now. What portion of the science base we are supporting now would you not support in order to go into this?

Senator KERRY. Well, why don't you describe what you need to do, why you need more money, what's the money going to do?

Senator STEVENS. Yes.

Dr. MOSS. Well, I think it's already been pointed out that there are serious gaps and problems in observing systems, I think those are going to be expensive to fix, but they have to be fixed, because as Dr. Christy pointed out, once we lose the continuous record, that's gone forever. We may be able to come back with a new satellite or something, but it's not going to be that continuous record, which from a climate perspective is extremely important.

Senator STEVENS. I agree, absolutely, with what Dr. Christy said. I also agree we need something like a red team, we need someone to assess what is going on now, that is not giving us the information we need. Why should we continue to spend money on that, and then add what you want now, to the budget that is already greater than any nation on earth?

Dr. MOSS. I would respectfully disagree that the program is not giving us information we need now, I think it is giving us a lot of information. I think if you look, for example, at climate modeling, there are certainly still deficiencies, but we've made tremendous progress, and I credit the Bush Administration for a lot of that, because when they came into office in 2001, there were still problems

with the modeling system, and they've devoted the resources to help fix that. So, I think there are improvements underway.

I think it's, we've also heard from the National Academy of Sciences that there is a need to improve the regional research, and the kinds of work that's done to help bring the implications of climate change to people who are living in the regions, and trying to live and work there, and make decisions.

Senator STEVENS. I agree with your assessment about trying to assist to correct the models we have had in the past, but I go back further than that. It was 30 years ago we started the International Arctic Research Commission. We have had people out getting, collecting data every year for 40 years. They have come to some conclusions, and they have published those conclusions. They are internationally-known climatologists from 3 different countries and our scientific community completely ignores them.

I do not understand why. I do not understand why the scientific community in this country has ignored the advice of the climatologists who have dedicated their lives, and a lot of Federal money, a lot of Japanese money, and a lot of Canadian money to their studies.

As Dr. Christy points out, yes, there is a lot less ice up our way right now, but there is a tremendous increase in ice in Antarctica. No one, at all, has addressed that, in all of the things I have heard from our scientific community.

I know it is going to cause problems for us in the future if that ice does not come back. The prediction of the climatologists is, it will come back. There are other reasons for the ice disappearing right now, particularly the oscillations of the Pacific and the Atlantic, and the warm water that was dumped into the Arctic Ocean for 5 years in a row.

Under those circumstances, every one of you has said give us more money. I was Chairman of the Committee that gave you more money, for 8 years. Now, the answer is, just give us more money, for more science. I have really got to tell you, I think the scientific community has to tell us, what have we been doing now that is wrong, and stop doing it, and find out what we should do right and assist in using the money we have available to pursue that new course?

Dr. MOSS. Well, again, I would just have to disagree, I don't think we've been wasting money at all, I think we've made tremendous progress, and I think you yourself, among others, have pointed out how complex the climate system is. There are different scales of natural variability that are underway, we've identified a number of these oscillations, El Niño, a Pacific decadal oscillation, a North Atlantic oscillation that operates on even longer time scales, perhaps as yet others, undiscovered, these are all important.

We also see the fact that humans are really intervening very sharply in the climate system, that's going to have an effect on these natural cycles, these things occur in different periods, in different phases, we don't always know how they add up. So, you have to look at this from a long-term perspective. We can't solve this problem in 8 years.

Furthermore, I think it also points to the importance of these periodic assessment reports, including the one that we have not yet

started, under this Administration to look at the consequences of climate change, because as Dr. Christy and all of us will point out—science moves quickly, you have to look at what’s available in 2004, and 2008, and 2012—there will be better information each one of those years, that information needs to be assessed and then applied to decisionmaking.

Senator STEVENS. Along with these, I have to tell you, we had a typhoon off of Rangle Island, which is the tip of Russia, across the Bering Straits from us. The ravages of that typhoon hit at least 19 villages along our coast, and put 9 into direct danger, right now, they are still in danger.

We have, so far, received a total of \$10 million to help those people out there, and in each instance, there had to be an environmental impact statement made before they did anything to help those villages.

When Katrina came along, I helped get Katrina about \$140 billion. There were no environmental impact statements required. The area that has suffered the worst, I think, in the world, has been Alaska Arctic from this global warming. Yet, we want more study of what might happen in the future, and right now, we cannot deal with the present. Because we are not doing anything to help them.

I am going up again to hold meetings next Monday on the erosion problems that occurred 3 and 4 years ago. Now, I think we ought to find out a little bit better about why the amount of money we have put up in the past has not given us the information we need right now to predict the future.

Thank you very much, Mr. Chairman.

Senator KERRY. Thank you, Senator Stevens.

One thing I might just comment, Senator Stevens, and I think you’re aware of this, that a lot of the science starts down a certain road and people lay out certain projects and certain, you know, protocols, pedagogies for the approach to something, but then the budgets get cut. And the fact is, we’ve gone down—

Senator STEVENS. Eight years we’ve increased it, and they are operating on levels of—

Senator KERRY. Yes, but the overall climate budget, the overall climate budget in 2004, fiscal year, was \$2 billion.

Senator STEVENS. That is up from about \$200 million under President Clinton.

Senator KERRY. It’s gone down now.

Senator STEVENS. President Clinton had about \$200 million.

Senator KERRY. I’m not getting into where we were with President Clinton—

Senator STEVENS. I raised it up there to about \$200 million.

Senator KERRY. My argument is not relative to where we were with President Clinton, it’s relative to where we have been ourselves, and where we ought to be today.

Senator STEVENS. The money is there to do what they want to do, if it had been used right.

Senator KERRY. Well, I can’t—I know that across the board, the reductions are having an impact, and we’re losing satellites, and losing measurements. But we can take that up at another time.

Senator Snowe?

Senator SNOWE. Thank you, Mr. Chairman.

I want to thank all of you for your outstanding testimony.

Dr. Moss, you made a number of recommendations, and I appreciate that, to our legislation. One of which was to strengthen scientific integrity, because there is a tension that exists between the programmatic authority and scientific research and those engaged in it, as we have seen in the past.

What would you recommend? One of the ideas you suggested is examining the potential role of various agencies, such as the Office of Science and Technology which is where we place this program, or OMB. Could you elaborate on your thoughts on that?

Senator KERRY. And before you do, if I could just comment, because I have to, I unfortunately have to be somewhere in a moment. Senator Snowe can close this out.

I just wanted to thank you, personally, all of you for coming. We'll leave the record open for 2 weeks, in case colleagues have questions and we want to submit further questions in writing.

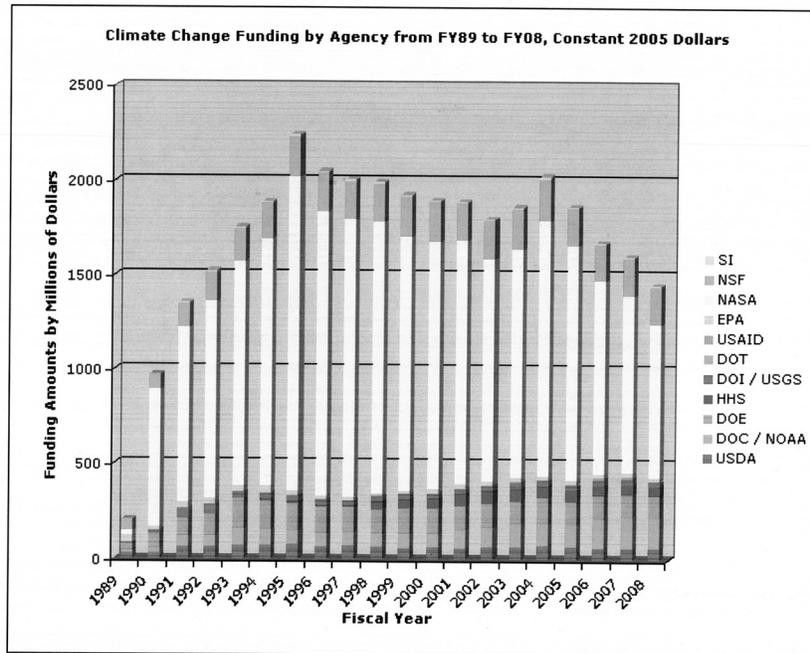
Senator Snowe, thank you.

Senator SNOWE. Thank you.

Dr. MOSS. Thank you, I'd also just like to suggest that there's a budget chart which could be read into the record from the U.S. Global Change Research Program, and Climate Change Science Program Office that actually describes the decline in funding since 2004, basically, going down from about a high of \$2 billion at that point, now to just about \$1.5 billion. So, I think that does substantiate that there's not been a kind of steady increase in the funding, and that's probably an important thing to put into the record.

[The information previously referred to follows:]

Budget of the U.S. Climate Change Science Program/Global Change Research Program Fiscal Years 1989–2008, by agency, Constant 2005 Dollars



USDA: U.S. Department of Agriculture. *DOC/NOAA*: Department of Commerce/National Oceanic and Atmospheric Administration. *DOE*: Department of Energy. *DOT*: Department of Transportation. *USAID*: U.S. Agency for International Development. *EPA*: Environmental Protection Agency. *HHS*: Department of Health and Human Services. *DOI/USGS*: Department of Interior/U.S. Geological Survey. *NASA*: National Aeronautics and Space Administration. *NSF*: National Science Foundation. *SI*: Smithsonian Institution.

Dr. MOSS. My thoughts, Senator Snowe, on the organization of the program is that right now, the Program Office—while not formalized the way you suggest, and I think that is an important change—does report basically in through the Office of Science and Technology Policy and the Office of Management and Budget, and we can still see the continuing concerns, both about program performance, and about the independence of the science that's done.

So, I think—my own thought was that we might ask something like the National Academy of Public Administration to work with the National Research Council to examine a variety of models that are out there, including the possibility of an independent Commission, which would clearly take out of this operation of the program, the potential for political influence, or at least would establish some kind of a watchdog function to make sure that it doesn't happen.

Because, I think it really hurts the science, each time one of these things gets out. Even though it's—you know, the testimony we just heard about being redacted—unfortunately what it does is it, it calls into the question in the minds of the public anything that the science program then produces. “Ah ha, is that something

else that's been messed with and changed as a result of political influence?"

So, it seems to me, if we're making such an investment in this area we really owe it to the taxpayers to try to protect it, and ensure that what the science says, in fact, is what comes out.

Senator SNOWE. It is an interesting suggestion, one we will certainly talk to Chairman Kerry about. It is certainly well-worth pursuing.

Anybody else here care to comment on that? Agree, disagree? You all agree?

Dr. FRUMHOFF. Senator Snowe, I strongly agree that we need to look hard at appropriate mechanisms to ensure the integrity of the science as effectively represented through this work, and I'm not sure the bill quite gets us there yet.

Senator SNOWE. OK. That is something we really should look at in that respect, before we pass this legislation.

You also mentioned the creation, I think others suggested, as well, of a high-level, independent, non-partisan oversight mechanism. How would you expect that to work?

Dr. MOSS. Well, again, I'm not an expert on the idea of these Commissions, but it would be something where you would have longer membership, perhaps, equally appointed by both parties, in some way, that would ensure that there is a review function, and that there was an escape mechanism, really, or a safety valve, if you will, for scientists and reports to be vetted, make sure that there's a public review process and that the comments are taken care of, that there isn't this kind of, sort of black box editing at the last stage, which has really been a problem.

Senator SNOWE. Yes, Dr. Frumhoff?

Dr. FRUMHOFF. Senator, I might add, I think it's important to think through, what are the elements of the program the Commission might provide oversight on. One certainly is the quality of the science, and the effectiveness of the communication of that science.

Another—given the goals of the National Climate Service, as designed in this bill to engage with local stakeholders, provide this information in a way that is directly useful to decisionmakers at multiple levels.

If the Commission—as one option—includes such stakeholders, representatives, in its body in addition to scientists, it could also, I think, appropriately review whether that information is being constructed in a way that's useful, and whether the information is actually being helpful to choices about adaptation, and mitigation. That is, is the overall intent of the bill to provide information that decisionmakers can actually, then, work with and adapt to change coastal planning or responses to extreme heat or other kinds of choices that we face in a changing climate, how well is that information being incorporated in other opportunities for improvement?

And so, I think that element of the process could also be subject to a kind of oversight.

Senator SNOWE. Yes, Dr. Boesch?

Dr. BOESCH. Let me add to that, you know, right now I think we've been concerned about views about whether climate change, human-induced climate change is real or not, and the debate that way. I think as the scientific consensus has grown, and the public

understanding and consensus has grown, in the future, I think these—the independence of the oversight is not going to be so much about whether climate change is happening or real, but about the various alternatives we have to deal with it, and the battle of interests among the economic interests in dealing with those alternatives.

So, in either case, even if we resolve the grand debate about human-induced climate change, we're still going to have some very contentious issues to deal with, as we both determine, as we look at our mitigation options, as well as the appropriate adaptation strategies.

So, in the future, I think regardless, we need some sort of independence in the process, some oversight.

Senator SNOWE. No, that is very helpful.

Dr. Boesch, you talked about how states are going their own way, and that is true. Demonstrating the leadership, and really grappling with these challenges, because I see it daily, and they pursue effective leadership.

Do you think our bill strikes the right balance in this regard in certainly assisting the states and local governments, and making the decisions and providing them with the important research and scientific information upon which to base these decisions and strategies, or mitigating future impact?

Dr. BOESCH. I would certainly like to look at it more carefully, but it certainly has—articulates that goal. Maybe we could offer some suggestions about how to put some practical implementation—

Senator SNOWE. Right.

Dr. BOESCH.—elements in it that would make it that much more effective.

But I can't emphasize more, and I just made a very brief point, I think my other, my colleagues here raised this as well. If you have a—if you view a climate service, for example, that's going to be the Federal entity that's going to do everything in all of these regions, it's going to fail, because there's so much knowledge, there's much responsibility within the regions, it has to be a partnership that engages the states, engages the other local governments, engages the universities, the experts there, in a way that can bring this new need and expansion of climate information and projections, to some practical use and purpose.

Senator SNOWE. It cannot be from the top-down, you're right. We're going to have to do something to spur the involvement at the local level, and regional level, as well. Absolutely, because of the knowledge that has been amassed.

Dr. Carter, you referred to balancing, creating a scale between acknowledging there are certain regional problems, and balancing the research to address the regionalism. Do you think we strike the right balance, or do we need to do more in that regard? Some regions may have one problem, others have another, so you have to adapt accordingly.

Dr. CARTER. That's right. And some of the research, then, would be applicable everywhere, but I think as I mentioned in here, there were really regional and locally specific factors that need to be

taken into account. And, I can't agree more with Don and the others, with Dr. Boesch and the others, we need a formal mechanisms.

What happened with the U.S. National Assessment was, we have people involved all around the country. But then once the assessment was finished, they were finished. And what was—we had mobilized people in, all over, and we had people working on the issue and thinking about the issue and how do we connect, and who else around this area has this knowledge, and you know, who should we be talking to and, you know, those kinds of things, and we've lost all of that.

So, we need to really think about, how do we create a formal mechanism that doesn't go away, but that can be, you know, can stay longer than any Administration, or than any, you know, particular focus, but to keep people engaged, that's really crucial, I think.

Senator SNOWE. That is a very critical point, to provide the continuity.

Dr. CARTER. Absolutely.

Senator SNOWE. We'll examine our bill from that standpoint.

Dr. CARTER. And when people participate, they really feel much more ownership in what's going on.

Senator SNOWE. Absolutely.

Dr. CARTER. They're much more willing to implement what they have talked about, and what they have had input into and think about ways in which they can help the situation, much more than if it just is handed to them from someone else, it didn't—it doesn't work very well.

I mean, I joked about the fact that there were 20 regions, and even working with just the directors was kind of like herding cats, because everyone had their own issue, but they all had a focus. That was to make it work. And that's, you know, that changes things.

Senator SNOWE. Absolutely. Actually, the local, state, and regions have developed the laboratories and they become a real source of information, rather than having it come from the top down.

Dr. CARTER. Well, they know what they need to know.

Senator SNOWE. Absolutely, that is what I'm saying, they are living it.

Dr. CARTER. They're living it every day. And we actually found that changed the research, some of the regions, once the stakeholders got involved. They actually changed the focus of the research, because they knew what really was happening in that area.

Senator SNOWE. We have to bring everybody to the table and keep them there, on an ongoing basis there.

Dr. CARTER. Keep them there, that's right.

Senator SNOWE. Yes.

Dr. Boesch, did you have any more?

Dr. BOESCH. Yes, I have one point that's sort of a take-off on that, but it goes back to a point—I'm sorry Senator Stevens isn't here to discuss or to bring this point to his attention, Dr. Christy mentioned, for example, in the 2000 U.S. National Assessment, that for Alabama there were two models that we use—one predicted a jungle and the other, a savannah. So, you know, how do we trust the models?

Well, the real embarrassment, actually, of the National Assessment in 2000 is that both of those models were from other countries. One was from Canada and one was from the United Kingdom, and part of the delay in completion of the National Assessment was the anxiety that we didn't have ready a national, U.S.-based modeling capacity of that generation of models, to do the assessment.

Now, things have changed dramatically in this regard, we have now scores of models, actually, internationally, the IPCC has looked at, you know, scores of these things, and the Northeast Climate Impacts Assessment looked at multiple models in which they judge their performance over the past. You know, and pursuant to Senator Stevens concern about, "Well, there's this change that's going on, and our impact didn't make much effect of it," these models were—the performance of these models was judged on their ability to predict, and going backward, the 20th century observations, in the Northeast, in this case.

So, we now have the capacity of looking at using these models to actually judge their performance on regional scales. There's more work to be done in downscaling the models, to give you more regional texture, but we have much more capacity to do this than we did in the year 2000, for sure. And it's because of the investments in the climate science program.

Senator SNOWE. That is right.

Yes, Dr. Carter?

Dr. CARTER. Yes, there's one other point about that, and that is local and regional decisionmakers know—they make long-term plans, and they know that anything in the future is uncertain.

But, if we can give them—even with the models—some range of uncertainty that's most likely, it really is helpful to people. They, you know, we never would recommend, "Take this model, and on this day it's going to be this temperature in this place," that's not it. It's helping people to understand uncertainty and educate people on how to use this information and to look to the future with this range of information, it's kind of like planning for your retirement. You know, you kind of have some ideas of what it's going to be like, but if this parameter changes, well then that's going to be different. People can understand that, we just have to, you know, give it to them in a way that's useful.

Senator SNOWE. That is very helpful, and it does illustrate the point about how critical the funding is. I mean, to suggest we did not even have a model, in 2000. To think how far we have come.

And even since the original program was established back in 1990, 17 years later, it really is hard to conceive, of all of the technological advancements that have occurred during that period of time, and that is why this program obviously needs to be seriously updated, in all respects, to tailor it to the moment, and to the future. The unpredictability and the uncertainty of the future, knowing all of this change.

Dr. Moss, you mentioned the abrupt climate change program, and we have it in our legislation within NOAA, and you think it should stay within the Climate Change Science Program?

Dr. MOSS. I just feel that it's important to keep these issues addressed in an integrated way, and there will always be new ones

that come up, we can't keep spawning yet another new research program. I think the abrupt climate change issue should be highlighted, as something for which there's a real interest and need for extra support.

I think ocean acidification which came up in Senator Nelson's comment, I think is also going to be extremely, and again, I think should be an integrated part of the overall global change program.

Senator SNOWE. I just do not want it to get lost in the process. I am a big advocate of abrupt climate change program and research. I really think it is critical. Given the fact it really is hard to anticipate and predict when it happens.

In any event, we will look at that and examine your recommendation in that regard.

Dr. MOSS. But, I agree completely about the importance of the issue—

Senator SNOWE. OK.

Dr. MOSS.—I think you're exactly—

Senator SNOWE. You do not think it will get lost by keeping it in that program?

Dr. MOSS. Well, I think that there are ways of making sure that it doesn't.

Senator SNOWE. OK.

Dr. MOSS. But still, you wouldn't want to necessarily have a separate function for governing that program, because there's so much of what you would need to do to study abrupt climate change, that you need to study other components of climate change, that you wouldn't—it would be inefficient, in a way, to separate them out, and probably scientifically detrimental.

Senator SNOWE. Dr. Davis, one last question here on coastal zone management, because I was previously Chair of the Subcommittee that oversaw coastal zone management, and you made some recommendations in this regard for adaptation strategies, what would you recommend that we consider?

Dr. DAVIS. Well, currently the Coastal Zone Management Act does authorize the coastal states that are participating to develop plans to respond to sea level rise and related impacts. But we would look for a voluntary partnership, to expand the authorities for climate change adaptation plans for the coastal zone, under coastal programs. Potentially through a new section, but that's something that CSO would like to work with you on, in the future.

Senator SNOWE. Oh, to create a separate section?

Dr. DAVIS. Potentially.

Senator SNOWE. OK.

Dr. DAVIS. But certainly, a lot of us are at the beginning phases of this, and we would like to develop in partnership with our local communities adaptation plans specific to coastal impacts.

Senator SNOWE. OK, we will follow up with you on that question, because it is important. Hopefully, we can get this reauthorized, it has been some time, and a long-standing struggle, not unique to this institution, on this and every other issue.

In any event, hopefully we can do that. Is it also an important suggestion and I'd like to follow up with you on that as well.

I thank all of you. I think it has been very useful and helpful and informative. I am going to really explore some of these issues

you have raised today with respect to our legislation, because it is essential to get it done. This is going to help to expedite the process, we hope, and not get bogged down anywhere along the way.

I thank all of you, for your very critical testimony and for your leadership in this global challenge that we face, thank you.

Dr. DAVIS. Thank you, Senator.

Senator SNOWE. This hearing is adjourned.

[Whereupon, at 12:58 p.m., the hearing was adjourned.]

A P P E N D I X

Summary for Policymakers

A REPORT OF WORKING GROUP I OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

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Introduction

The Working Group I contribution to the IPCC Fourth Assessment Report describes progress in understanding of the human and natural drivers of climate change,¹ observed climate change, climate processes and attribution, and estimates of projected future climate change. It builds upon past IPCC assessments and incorporates new findings from the past 6 years of research. Scientific progress since the Third Assessment Report (TAR) is based upon large amounts of new and more comprehensive data, more sophisticated analyses of data, improvements in understanding of processes and their simulation in models and more extensive exploration of uncertainty ranges.

The basis for substantive paragraphs in this Summary for Policymakers can be found in the chapter sections specified in curly brackets.

Human and Natural Drivers of Climate Change

Changes in the atmospheric abundance of greenhouse gases and aerosols, in solar radiation and in land surface properties alter the energy balance of the climate system. These changes are expressed in terms of radiative forcing,² which is used to compare how a range of human and natural factors drive warming or cooling influences on global climate. Since the TAR, new observations and related modelling of greenhouse gases, solar activity, land surface properties and some aspects of aerosols have led to improvements in the quantitative estimates of radiative forcing.

Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1,750 and now far

¹ *Climate change* in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change, where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

² *Radiative forcing* is a measure of the influence that a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. Positive forcing tends to warm the surface while negative forcing tends to cool it. In this report, radiative forcing values are for 2005 relative to pre-industrial conditions defined at 1,750 and are expressed in watts per square metre (W m^{-2}). See Glossary and Section 2.2 for further details.

exceed pre-industrial values determined from ice cores spanning many thousands of years (see *Figure SPM.1*). The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture. (2.3, 6.4, 7.3)

**CHANGES IN GREENHOUSE GASES FROM ICE CORE
AND MODERN DATA**

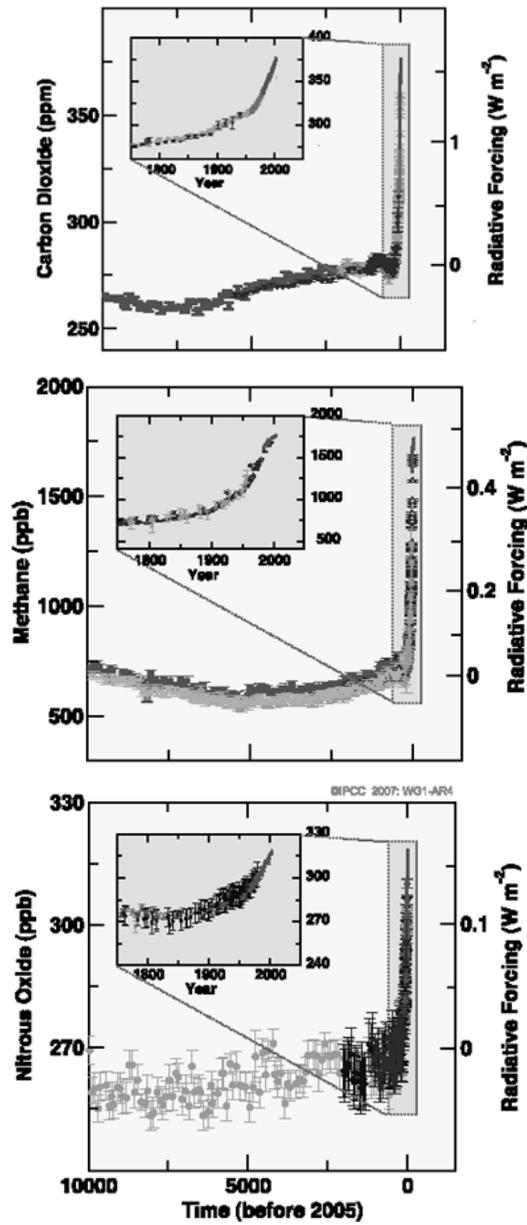


Figure SPM.1. Atmospheric concentrations of carbon dioxide, methane and nitrous oxide over the last 10,000 years (large panels) and since 1750 (inset panels). Measurements are shown from ice cores (symbols with different colours for different studies) and atmospheric samples (red lines). The corresponding radiative forcings are shown on the right hand axes of the large panels. (Figure 6.4)

- Carbon dioxide is the most important anthropogenic greenhouse gas (see Figure SPM.2). The global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 ppm to 379 ppm³ in 2005. The atmospheric concentration of carbon dioxide in 2005 exceeds by far the natural range over the last 650,000 years (180 to 300 ppm) as determined from ice cores. The annual carbon dioxide concentration growth rate was larger during the last 10 years (1995–2005 average: 1.9 ppm per year), than it has been since the beginning of continuous direct atmospheric measurements (1960–2005 average: 1.4 ppm per year) although there is year-to-year variability in growth rates. {2.3, 7.3}

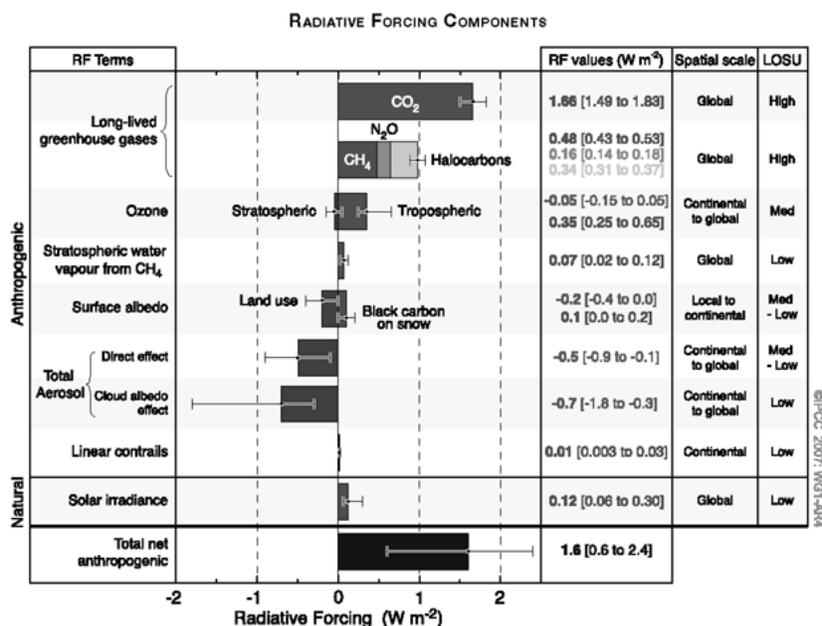


Figure SPM.2. Global average radiative forcing (RF) estimates and ranges in 2005 for anthropogenic carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). The net anthropogenic radiative forcing and its range are also shown. These require summing asymmetric uncertainty estimates from the component terms, and cannot be obtained by simple addition. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional natural forcing but are not included in this figure due to their episodic nature. The range for linear contrails does not include other possible effects of aviation on cloudiness. {2.9, Figure 2.20}

- The primary source of the increased atmospheric concentration of carbon dioxide since the pre-industrial period results from fossil fuel use, with land-use change providing another significant but smaller contribution. Annual fossil carbon dioxide emissions⁴ increased from an average of 6.4 [6.0 to 6.8]⁵ GtC (23.5

³ ppm (parts per million) or ppb (parts per billion, 1 billion = 1,000 million) is the ratio of the number of greenhouse gas molecules to the total number of molecules of dry air. For example, 300 ppm means 300 molecules of a greenhouse gas per million molecules of dry air.

⁴ Fossil carbon dioxide emissions include those from the production, distribution and consumption of fossil fuels and as a by-product from cement production. An emission of 1 GtC corresponds to 3.67 GtCO₂.

⁵ In general, uncertainty ranges for results given in this Summary for Policymakers are 90 percent uncertainty intervals unless stated otherwise, that is, there is an estimated 5 percent

Continued

[22.0 to 25.0] GtCO₂) per year in the 1990s to 7.2 [6.9 to 7.5] GtC (26.4 [25.3 to 27.5] GtCO₂) per year in 2000–2005 (2004 and 2005 data are interim estimates). Carbon dioxide emissions associated with land-use change are estimated to be 1.6 [0.5 to 2.7] GtC (5.9 [1.8 to 9.9] GtCO₂) per year over the 1990s, although these estimates have a large uncertainty. {7.3}

- The global atmospheric concentration of methane has increased from a pre-industrial value of about 715 ppb to 1,732 ppb in the early 1990s, and was 1,774 ppb in 2005. The atmospheric concentration of methane in 2005 exceeds by far the natural range of the last 650,000 years (320 to 790 ppb) as determined from ice cores. Growth rates have declined since the early 1990s, consistent with total emissions (sum of anthropogenic and natural sources) being nearly constant during this period. It is *very likely*⁶ that the observed increase in methane concentration is due to anthropogenic activities, predominantly agriculture and fossil fuel use, but relative contributions from different source types are not well determined. {2.3, 7.4}
- The global atmospheric nitrous oxide concentration increased from a pre-industrial value of about 270 ppb to 319 ppb in 2005. The growth rate has been approximately constant since 1980. More than a third of all nitrous oxide emissions are anthropogenic and are primarily due to agriculture. {2.3, 7.4}

The understanding of anthropogenic warming and cooling influences on climate has improved since the TAR, leading to *very high confidence*⁷ that the global average net effect of human activities since 1750 has been one of warming, with a radiative forcing of +1.6 [+0.6 to +2.4] W m⁻² (see *Figure SPM.2*). {2.3., 6.5, 2.9}

- The combined radiative forcing due to increases in carbon dioxide, methane, and nitrous oxide is +2.30 [+2.07 to +2.53] W m⁻², and its rate of increase during the industrial era is *very likely* to have been unprecedented in more than 10,000 years (see *Figures SPM.1 and SPM.2*). The carbon dioxide radiative forcing increased by 20 percent from 1995 to 2005, the largest change for any decade in at least the last 200 years. {2.3, 6.4}
- Anthropogenic contributions to aerosols (primarily sulphate, organic carbon, black carbon, nitrate and dust) together produce a cooling effect, with a total direct radiative forcing of -0.5 [-0.9 to -0.1] W m⁻² and an indirect cloud albedo forcing of -0.7 [-1.8 to -0.3] W m⁻². These forcings are now better understood than at the time of the TAR due to improved *in situ*, satellite and ground-based measurements and more comprehensive modelling, but remain the dominant uncertainty in radiative forcing. Aerosols also influence cloud lifetime and precipitation. {2.4, 2.9, 7.5}
- Significant anthropogenic contributions to radiative forcing come from several other sources. Tropospheric ozone changes due to emissions of ozone-forming chemicals (nitrogen oxides, carbon monoxide, and hydrocarbons) contribute +0.35 [+0.25 to +0.65] W m⁻². The direct radiative forcing due to changes in halocarbons⁸ is +0.34 [+0.31 to +0.37] W m⁻². Changes in surface albedo, due to land cover changes and deposition of black carbon aerosols on snow, exert respective forcings of -0.2 [-0.4 to 0.0] and +0.1 [0.0 to +0.2] W m⁻². Additional terms smaller than ±0.1 W m⁻² are shown in *Figure SPM.2*. {2.3, 2.5, 7.2}
- Changes in solar irradiance since 1750 are estimated to cause a radiative forcing of +0.12 [+0.06 to +0.30] W m⁻², which is less than half the estimate given in the TAR. {2.7}

likelihood that the value could be above the range given in square brackets and 5 percent likelihood that the value could be below that range. Best estimates are given where available. Assessed uncertainty intervals are not always symmetric about the corresponding best estimate. Note that a number of uncertainty ranges in the Working Group I TAR corresponded to 2 standard deviations (95 percent), often using expert judgment.

⁶In this Summary for Policymakers, the following terms have been used to indicate the assessed likelihood, using expert judgment, of an outcome or a result: *Virtually certain* > 99% probability of occurrence, *Extremely likely* > 95%, *Very likely* > 90%, *Likely* > 66%, *More likely than not* > 50%, *Unlikely* < 33%, *Very unlikely* < 10%, *Extremely unlikely* < 5% (see *Box TS.1* for more details).

⁷In this Summary for Policymakers the following levels of confidence have been used to express expert judgments on the correctness of the underlying science: *very high confidence* represents at least a 9 out of 10 chance of being correct; *high confidence* represents about an 8 out of 10 chance of being correct (see *Box TS.1*).

⁸Halocarbon radiative forcing has been recently assessed in detail in *IPCC's Special Report on Safeguarding the Ozone Layer and the Global Climate System* (2005).

Direct Observations of Recent Climate Change

Since the TAR, progress in understanding how climate is changing in space and in time has been gained through improvements and extensions of numerous datasets and data analyses, broader geographical coverage, better understanding of uncertainties, and a wider variety of measurements. Increasingly comprehensive observations are available for glaciers and snow cover since the 1960s, and for sea level and ice sheets since about the past decade. However, data coverage remains limited in some regions.

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 average sea level (see *Figure SPM.3*). {3.2, 4.2, 5.5}

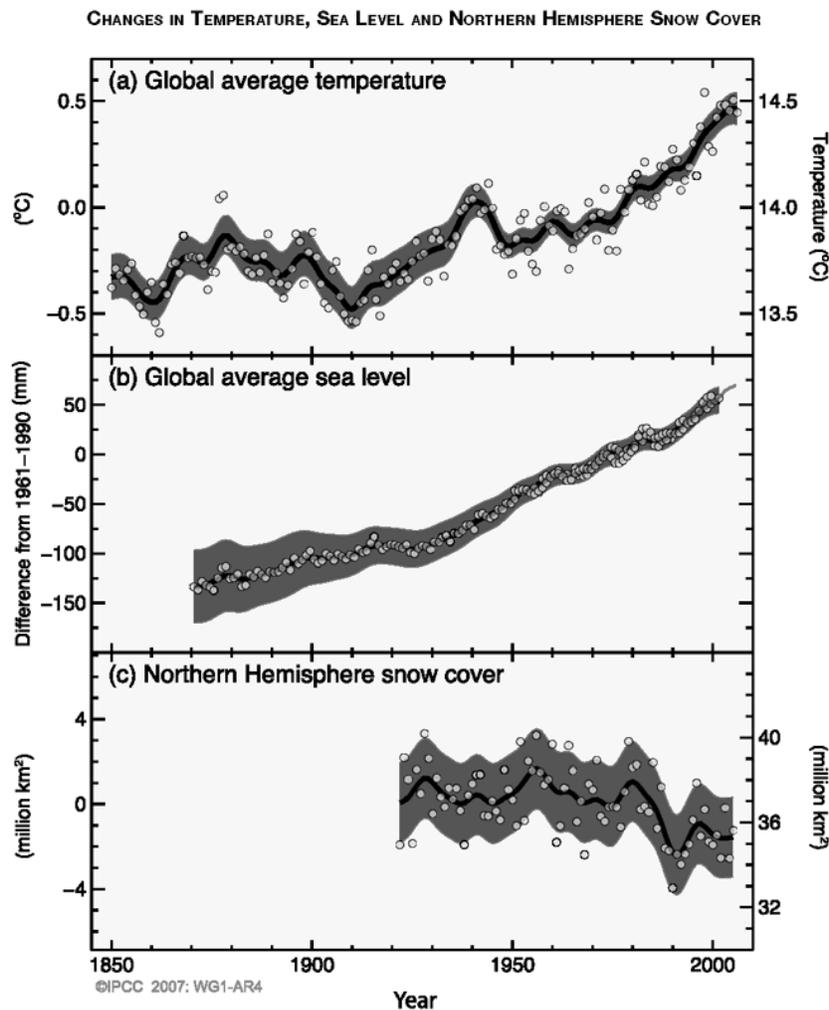


Figure SPM.3. Observed changes in (a) global average surface temperature, (b) global average sea level from tide gauge (blue) and satellite (red) data and (c) Northern Hemisphere snow cover for March–April. All changes are relative to corresponding averages for the period 1961–1990. Smoothed curves represent decadal average values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series (c). {FAQ 3.1, *Figure 1*, *Figure 4.2*, *Figure 5.13*}

- Eleven of the last twelve years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature⁹ (since 1850). The updated 100-year linear trend (1906 to 2005) of 0.74 °C [0.56 °C to 0.92 °C] is therefore larger than the corresponding trend for 1901 to 2000 given in the TAR of 0.6 °C [0.4 °C to 0.8 °C]. The linear warming trend over the last 50 years (0.13 °C [0.10 °C to 0.16 °C] per decade) is nearly twice that for the last 100 years. The total temperature increase from 1850–1899 to 2001–2005 is 0.76 °C [0.57 °C to 0.95 °C]. Urban heat island effects are real but local, and have a negligible influence (less than 0.006 °C per decade over land and zero over the oceans) on these values. {3.2}
- New analyses of balloon-borne and satellite measurements of lower- and mid-tropospheric temperature show warming rates that are similar to those of the surface temperature record and are consistent within their respective uncertainties, largely reconciling a discrepancy noted in the TAR. {3.2, 3.4}
- The average atmospheric water vapour content has increased since at least the 1980s over land and ocean as well as in the upper troposphere. The increase is broadly consistent with the extra water vapour that warmer air can hold. {3.4}
- Observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3,000 m and that the ocean has been absorbing more than 80 percent of the heat added to the climate system. Such warming causes seawater to expand, contributing to sea level rise (see *Table SPM.1*). {5.2, 5.5}
- Mountain glaciers and snow cover have declined on average in both hemispheres. Widespread decreases in glaciers and ice caps have contributed to sea level rise (ice caps do not include contributions from the Greenland and Antarctic Ice Sheets). (See *Table SPM.1*.) {4.6, 4.7, 4.8, 5.5}
- New data since the TAR now show that losses from the ice sheets of Greenland and Antarctica have *very likely* contributed to sea level rise over 1993 to 2003 (see *Table SPM.1*). Flow speed has increased for some Greenland and Antarctic outlet glaciers, which drain ice from the interior of the ice sheets. The corresponding increased ice sheet mass loss has often followed thinning, reduction or loss of ice shelves or loss of floating glacier tongues. Such dynamical ice loss is sufficient to explain most of the Antarctic net mass loss and approximately half of the Greenland net mass loss. The remainder of the ice loss from Greenland has occurred because losses due to melting have exceeded accumulation due to snowfall. {4.6, 4.8, 5.5}
- Global average sea level rose at an average rate of 1.8 [1.3 to 2.3] mm per year over 1961 to 2003. The rate was faster over 1993 to 2003: about 3.1 [2.4 to 3.8] mm per year. Whether the faster rate for 1993 to 2003 reflects decadal variability or an increase in the longer-term trend is unclear. There is *high confidence* that the rate of observed sea level rise increased from the 19th to the 20th century. The total 20th-century rise is estimated to be 0.17 [0.12 to 0.22] m. {5.5}
- For 1993 to 2003, the sum of the climate contributions is consistent within uncertainties with the total sea level rise that is directly observed (see *Table SPM.1*). These estimates are based on improved satellite and *in situ* data now available. For the period 1961 to 2003, the sum of climate contributions is estimated to be smaller than the observed sea level rise. The TAR reported a similar discrepancy for 1910 to 1990. {5.5}

At continental, regional and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in Arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones.¹⁰ {3.2, 3.3, 3.4, 3.5, 3.6, 5.2}

- Average Arctic temperatures increased at almost twice the global average rate in the past 100 years. Arctic temperatures have high decadal variability, and a warm period was also observed from 1925 to 1945. {3.2}
- Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7 [2.1 to 3.3] percent per decade, with larger decreases in summer of 7.4 [5.0 to 9.8] percent per decade. These values are consistent with those reported in the TAR. {4.4}

⁹The average of near-surface air temperature over land and sea surface temperature.

¹⁰Tropical cyclones include hurricanes and typhoons.

- Temperatures at the top of the permafrost layer have generally increased since the 1980s in the Arctic (by up to 3 °C). The maximum area covered by seasonally frozen ground has decreased by about 7 percent in the Northern Hemisphere since 1900, with a decrease in spring of up to 15 percent. {4.7}
- Long-term trends from 1900 to 2005 have been observed in precipitation amount over many large regions.¹¹ 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, and data are limited in some regions. Long-term trends have not been observed for the other large regions assessed.¹¹ {3.3, 3.9}
- Changes in precipitation and evaporation over the oceans are suggested by freshening of mid- and high-latitude waters together with increased salinity in low-latitude waters. {5.2}

Table SPM.1.—Observed Rate of Sea Level Rise and Estimated Contributions from Different Sources. {5.5, Table 5.3}

Source of Sea Level Rise	Rate of Sea Level Rise (mm per year)	
	1961–2003	1993–2003
Thermal expansion	0.42 ± 0.12	1.6 ± 0.5
Glaciers and ice caps	0.50 ± 0.18	0.77 ± 0.22
Greenland Ice Sheet	0.05 ± 0.12	0.21 ± 0.07
Antarctic Ice Sheet	0.14 ± 0.41	0.21 ± 0.35
Sum of individual climate contributions to sea level rise	1.1 ± 0.5	2.8 ± 0.7
Observed total sea level rise	1.8 ± 0.5 ^a	3.1 ± 0.7 ^a
Difference (Observed minus sum of estimated climate contributions)	0.7 ± 0.7	0.3 ± 1.0

Table note:

^aData prior to 1993 are from tide gauges and after 1993 are from satellite altimetry.

- Mid-latitude westerly winds have strengthened in both hemispheres since the 1960s. {3.5}
- More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics. Increased drying linked with higher temperatures and decreased precipitation has contributed to changes in drought. Changes in sea surface temperatures, wind patterns and decreased snowpack and snow cover have also been linked to droughts. {3.3}
- The frequency of heavy precipitation events has increased over most land areas, consistent with warming and observed increases of atmospheric water vapour. {3.8, 3.9}
- Widespread changes in extreme temperatures have been observed over the last 50 years. Cold days, cold nights and frost have become less frequent, while hot days, hot nights and heat waves have become more frequent (see *Table SPM.2*). {3.8}

Table SPM.2. Recent Trends, Assessment of Human Influence on the Trend and Projections for Extreme Weather Events for Which There Is an Observed Late-20th Century Trend. {Tables 3.7, 3.8, 9.4; Sections 3.8, 5.5, 9.7, 11.2–11.9}

Phenomenon ^a and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of a human contribution to observed trend ^b	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	<i>Very likely^c</i>	<i>Likely^d</i>	<i>Virtually certain^d</i>

¹¹The assessed regions are those considered in the regional projections chapter of the TAR and in Chapter 11 of this report.

Table SPM.2. Recent Trends, Assessment of Human Influence on the Trend and Projections for Extreme Weather Events for Which There Is an Observed Late-20th Century Trend. (Tables 3.7, 3.8, 9.4; Sections 3.8, 5.5, 9.7, 11.2–11.9)—Continued

Phenomenon ^a and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of a human contribution to observed trend ^b	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and more frequent hot days and nights over most land areas	<i>Very likely^c</i>	<i>Likely (nights)^d</i>	<i>Virtually certain^d</i>
Warm spells/heat waves. Frequency increases over most land areas	<i>Likely</i>	<i>More likely than not^f</i>	<i>Very likely</i>
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	<i>Likely</i>	<i>More likely than not^f</i>	<i>Very likely</i>
Area affected by droughts increases	<i>Likely in many</i>	regions since 1970s	<i>More likely than not Likely</i>
Intense tropical cyclone activity increases	<i>Likely in some regions since 1970</i>	<i>More likely than not^f</i>	<i>Likely</i>
Increased incidence of extreme high sea level (excludes tsunamis) ^g	<i>Likely</i>	<i>More likely than not^{f,h}</i>	<i>Likelyⁱ</i>

Table notes:

^a See Table 3.7 for further details regarding definitions.

^b See Table TS.4, Box TS.5 and Table 9.4.

^c Decreased frequency of cold days and nights (coldest 10 percent).

^d Warming of the most extreme days and nights each year.

^e Increased frequency of hot days and nights (hottest 10 percent).

^f Magnitude of anthropogenic contributions not assessed. Attribution for these phenomena based on expert judgment rather than formal attribution studies.

^g Extreme high sea level depends on average sea level and on regional weather systems. It is defined here as the highest 1 percent of hourly values of observed sea level at a station for a given reference period.

^h Changes in observed extreme high sea level closely follow the changes in average sea level. (5.5) It is *very likely* that anthropogenic activity contributed to a rise in average sea level. (9.5)

ⁱ In all scenarios, the projected global average sea level at 2100 is higher than in the reference period. (10.6) The effect of changes in regional weather systems on sea level extremes has not been assessed.

- There is observational evidence for an increase in intense tropical cyclone activity in the North Atlantic since about 1970, correlated with increases of tropical sea surface temperatures. There are also suggestions of increased intense tropical cyclone activity in some other regions where concerns over data quality are greater. Multi-decadal variability and the quality of the tropical cyclone records prior to routine satellite observations in about 1970 complicate the detection of long-term trends in tropical cyclone activity. There is no clear trend in the annual numbers of tropical cyclones. {3.8}

Some aspects of climate have not been observed to change. {3.2, 3.8, 4.4, 5.3}

- A decrease in diurnal temperature range (DTR) was reported in the TAR, but the data available then extended only from 1950 to 1993. Updated observations reveal that DTR has not changed from 1979 to 2004 as both day- and nighttime temperature have risen at about the same rate. The trends are highly variable from one region to another. {3.2}

- Antarctic sea ice extent continues to show interannual variability and localised changes but no statistically significant average trends, consistent with the lack of warming reflected in atmospheric temperatures averaged across the region. {3.2, 4.4}
- There is insufficient evidence to determine whether trends exist in the meridional overturning circulation (MOC) of the global ocean or in small-scale phenomena such as tornadoes, hail, lightning and dust-storms. {3.8, 5.3}

A Palaeoclimatic Perspective

Palaeoclimatic studies use changes in climatically sensitive indicators to infer past changes in global climate on time scales ranging from decades to millions of years. Such proxy data (e.g., tree ring width) may be influenced by both local temperature and other factors such as precipitation, and are often representative of particular seasons rather than full years. Studies since the TAR draw increased confidence from additional data showing coherent behaviour across multiple indicators in different parts of the world. However, uncertainties generally increase with time into the past due to increasingly limited spatial coverage.

Palaeoclimatic information supports the interpretation that the warmth of the last half century is unusual in at least the previous 1,300 years. The last time the polar regions were significantly warmer than present for an extended period (about 125,000 years ago), reductions in polar ice volume led to 4 to 6 m of sea level rise. {6.4, 6.6}

- Average Northern Hemisphere temperatures during the second half of the 20th century were *very likely* higher than during any other 50-year period in the last 500 years and *likely* the highest in at least the past 1,300 years. Some recent studies indicate greater variability in Northern Hemisphere temperatures than suggested in the TAR, particularly finding that cooler periods existed in the 12th to 14th, 17th and 19th centuries. Warmer periods prior to the 20th century are within the uncertainty range given in the TAR. {6.6}
- Global average sea level in the last interglacial period (about 125,000 years ago) was *likely* 4 to 6 m higher than during the 20th century, mainly due to the retreat of polar ice. Ice core data indicate that average polar temperatures at that time were 3 °C to 5 °C higher than present, because of differences in the Earth's orbit. The Greenland Ice Sheet and other arctic ice fields *likely* contributed no more than 4 m of the observed sea level rise. There may also have been a contribution from Antarctica. {6.4}

Understanding and Attributing Climate Change

This assessment considers longer and improved records, an expanded range of observations and improvements in the simulation of many aspects of climate and its variability based on studies since the TAR. It also considers the results of new attribution studies that have evaluated whether observed changes are quantitatively consistent with the expected response to external forcings and inconsistent with alternative physically plausible explanations.

Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.¹² This is an advance since the TAR's conclusion that "most of the observed warming over the last 50 years is *likely* to have been due to the increase in greenhouse gas concentrations". Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns (see *Figure SPM.4* and *Table SPM.2*). {9.4, 9.5}

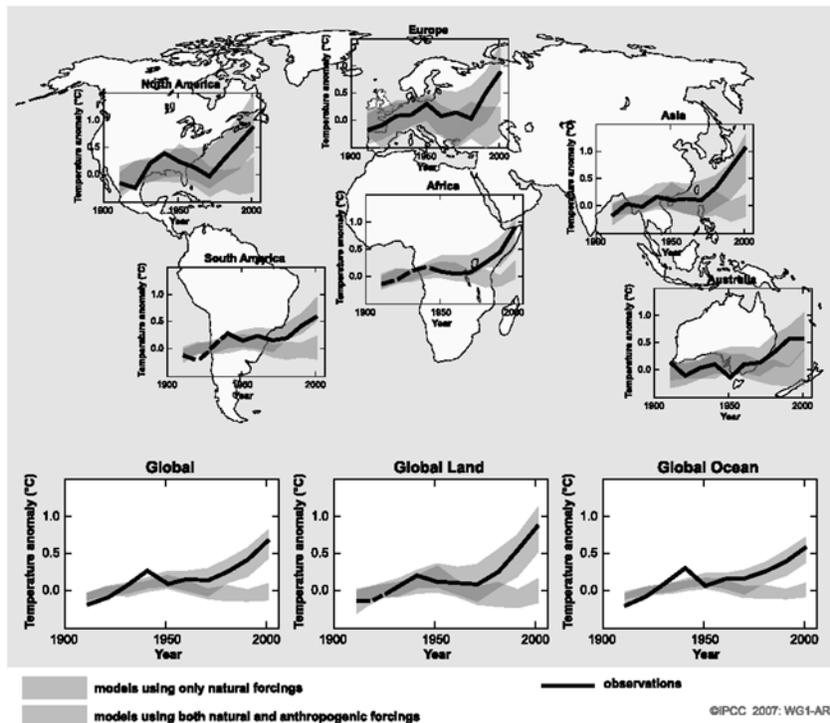
- It is *likely* that increases in greenhouse gas concentrations alone would have caused more warming than observed because volcanic and anthropogenic aerosols have offset some warming that would otherwise have taken place. {2.9, 7.5, 9.4}
- The observed widespread warming of the atmosphere and ocean, together with ice mass loss, support the conclusion that it is *extremely unlikely* that global climate change of the past 50 years can be explained without external forcing, and *very likely* that it is not due to known natural causes alone. {4.8, 5.2, 9.4, 9.5, 9.7}
- Warming of the climate system has been detected in changes of surface and atmospheric temperatures in the upper several hundred metres of the ocean, and in contributions to sea level rise. Attribution studies have established anthropo-

¹² Consideration of remaining uncertainty is based on current methodologies.

genic contributions to all of these changes. The observed pattern of tropospheric warming and stratospheric cooling is *very likely* due to the combined influences of greenhouse gas increases and stratospheric ozone depletion. {3.2, 3.4, 9.4, 9.5}

- It is *likely* that there has been significant anthropogenic warming over the past 50 years averaged over each continent except Antarctica (see *Figure SPM.4*). The observed patterns of warming, including greater warming over land than over the ocean, and their changes over time, are only simulated by models that include anthropogenic forcing. The ability of coupled climate models to simulate the observed temperature evolution on each of six continents provides stronger evidence of human influence on climate than was available in the TAR. {3.2, 9.4}
- Difficulties remain in reliably simulating and attributing observed temperature changes at smaller scales. On these scales, natural climate variability is relatively larger, making it harder to distinguish changes expected due to external forcings. Uncertainties in local forcings and feedbacks also make it difficult to estimate the contribution of greenhouse gas increases to observed small-scale temperature changes. {8.3, 9.4}
- Anthropogenic forcing is *likely* to have contributed to changes in wind patterns,¹³ affecting extra-tropical storm tracks and temperature patterns in both hemispheres. However, the observed changes in the Northern Hemisphere circulation are larger than simulated in response to 20th-century forcing change. {3.5, 3.6, 9.5, 10.3}
- Temperatures of the most extreme hot nights, cold nights and cold days are *likely* to have increased due to anthropogenic forcing. It is *more likely than not* that anthropogenic forcing has increased the risk of heat waves (see *Table SPM.2*). {9.4}

GLOBAL AND CONTINENTAL TEMPERATURE CHANGE



¹³In particular, the Southern and Northern Annular Modes and related changes in the North Atlantic Oscillation. {3.6, 9.5, Box TS.2}

Figure SPM.4. Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906 to 2005 (black line) plotted against the centre of the decade and relative to the corresponding average for 1901–1950. Lines are dashed where spatial coverage is less than 50 percent. Blue shaded bands show the 5–95 percent range for 19 simulations from five climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5–95 percent range for 58 simulations from 14 climate models using both natural and anthropogenic forcings. {FAQ 9.2, *Figure 1*}

Analysis of climate models together with constraints from observations enables an assessed *likely* range to be given for climate sensitivity for the first time and provides increased confidence in the understanding of the climate system response to radiative forcing. {6.6, 8.6, 9.6, Box 10.2}

- The equilibrium climate sensitivity is a measure of the climate system response to sustained radiative forcing. It is not a projection but is defined as the global average surface warming following a doubling of carbon dioxide concentrations. It is *likely* to be in the range 2 °C to 4.5 °C with a best estimate of about 3 °C, and is *very unlikely* to be less than 1.5 °C. Values substantially higher than 4.5 °C cannot be excluded, but agreement of models with observations is not as good for those values. Water vapour changes represent the largest feedback affecting climate sensitivity and are now better understood than in the TAR. Cloud feedbacks remain the largest source of uncertainty. {8.6, 9.6, Box 10.2}
- It is *very unlikely* that climate changes of at least the seven centuries prior to 1950 were due to variability generated within the climate system alone. A significant fraction of the reconstructed Northern Hemisphere inter-decadal temperature variability over those centuries is *very likely* attributable to volcanic eruptions and changes in solar irradiance, and it is *likely* that anthropogenic forcing contributed to the early 20th-century warming evident in these records. {2.7, 2.8, 6.6, 9.3}

Projections of Future Changes in Climate

A major advance of this assessment of climate change projections compared with the TAR is the large number of simulations available from a broader range of models. Taken together with additional information from observations, these provide a quantitative basis for estimating likelihoods for many aspects of future climate change. Model simulations cover a range of possible futures including idealised emission or concentration assumptions. These include SRES¹⁴ illustrative marker scenarios for the 2000 to 2100 period and model experiments with greenhouse gases and aerosol concentrations held constant after year 2000 or 2100.

For the next two decades, a warming of about 0.2 °C per decade is projected for a range of SRES emission scenarios. Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1 °C per decade would be expected. {10.3, 10.7}

- Since IPCC's first report in 1990, assessed projections have suggested global average temperature increases between about 0.15 °C and 0.3 °C per decade for 1990 to 2005. This can now be compared with observed values of about 0.2 °C per decade, strengthening confidence in near-term projections. {1.2, 3.2}
- Model experiments show that even if all radiative forcing agents were held constant at year 2000 levels, a further warming trend would occur in the next two decades at a rate of about 0.1 °C per decade, due mainly to the slow response of the oceans. About twice as much warming (0.2 °C per decade) would be expected if emissions are within the range of the SRES scenarios. Best-estimate projections from models indicate that decadal average warming over each inhabited continent by 2030 is insensitive to the choice among SRES scenarios and is *very likely* to be at least twice as large as the corresponding model-estimated natural variability during the 20th century. {9.4, 10.3, 10.5, 11.2–11.7, *Figure TS-29*}

Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the

¹⁴SRES refers to the *IPCC Special Report on Emission Scenarios* (2000). The SRES scenario families and illustrative cases, which did not include additional climate initiatives, are summarised in a box at the end of this Summary for Policymakers. Approximate carbon dioxide equivalent concentrations corresponding to the computed radiative forcing due to anthropogenic greenhouse gases and aerosols in 2100 (see p. 823 of the TAR) for the SRES B1, A1T, B2, A1B, A2 and A1FI illustrative marker scenarios are about 600, 700, 800, 850, 1,250 and 1,550 ppm respectively. Scenarios B1, A1B and A2 have been the focus of model intercomparison studies and many of those results are assessed in this report.

21st century that would *very likely* be larger than those observed during the 20th century. {10.3}

- Advances in climate change modelling now enable best estimates and *likely* assessed uncertainty ranges to be given for projected warming for different emission scenarios. Results for different emission scenarios are provided explicitly in this report to avoid loss of this policy-relevant information. Projected global average surface warmings for the end of the 21st century (2090–2099) relative to 1980–1999 are shown in *Table SPM.3*. These illustrate the differences between lower and higher SRES emission scenarios, and the projected warming uncertainty associated with these scenarios. {10.5}
- Best estimates and *likely* ranges for global average surface air warming for six SRES emissions marker scenarios are given in this assessment and are shown in *Table SPM.3*. For example, the best estimate for the low scenario (B1) is 1.8 °C (*likely* range is 1.1 °C to 2.9 °C), and the best estimate for the high scenario (A1FI) is 4.0 °C (*likely* range is 2.4 °C to 6.4 °C). Although these projections are broadly consistent with the span quoted in the TAR (1.4 °C to 5.8 °C), they are not directly comparable (see *Figure SPM.5*). The Fourth Assessment Report is more advanced as it provides best estimates and an assessed likelihood range for each of the marker scenarios. The new assessment of the *likely* ranges now relies on a larger number of climate models of increasing complexity and realism, as well as new information regarding the nature of feedbacks from the carbon cycle and constraints on climate response from observations. {10.5}
- Warming tends to reduce land and ocean uptake of atmospheric carbon dioxide, increasing the fraction of anthropogenic emissions that remains in the atmosphere. For the A2 scenario, for example, the climate-carbon cycle feedback increases the corresponding global average warming at 2,100 by more than 1 °C. Assessed upper ranges for temperature projections are larger than in the TAR (see *Table SPM.3*) mainly because the broader range of models now available suggests stronger climate-carbon cycle feedbacks. {7.3, 10.5}
- Model-based projections of global average sea level rise at the end of the 21st century (2090–2099) are shown in *Table SPM.3*. For each scenario, the midpoint of the range in *Table SPM.3* is within 10 percent of the TAR model average for 2090–2099. The ranges are narrower than in the TAR mainly because of improved information about some uncertainties in the projected contributions.¹⁵ {10.6}

Table SPM.3. Projected Global Average Surface Warming and Sea Level Rise at the End of the 21st Century. {10.5, 10.6, Table 10.7}

Case	Temperature Change (°C at 2090–2099 relative to 1980–1999) ^a		Sea Level Rise (m at 2090–2099 relative to 1980–1999)
	Best estimate	<i>Likely</i> range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations ^b	0.6	0.3–0.9	NA
B1 scenario	1.8	1.1–2.9	0.18–0.38
A1T scenario	2.4	1.4–3.8	0.20–0.45
B2 scenario	2.4	1.4–3.8	0.20–0.43
A1B scenario	2.8	1.7–4.4	0.21–0.48
A2 scenario	3.4	2.0–5.4	0.23–0.51
A1FI scenario	4.0	2.4–6.4	0.26–0.59

Table notes:

^aThese estimates are assessed from a hierarchy of models that encompass a simple climate model, several Earth System Models of Intermediate Complexity and a large number of Atmosphere-Ocean General Circulation Models (AOGCMs).

^bYear 2000 constant composition is derived from AOGCMs only.

¹⁵TAR projections were made for 2100, whereas projections in this report are for 2090–2099. The TAR would have had similar ranges to those in *Table SPM.3* if it had treated the uncertainties in the same way.

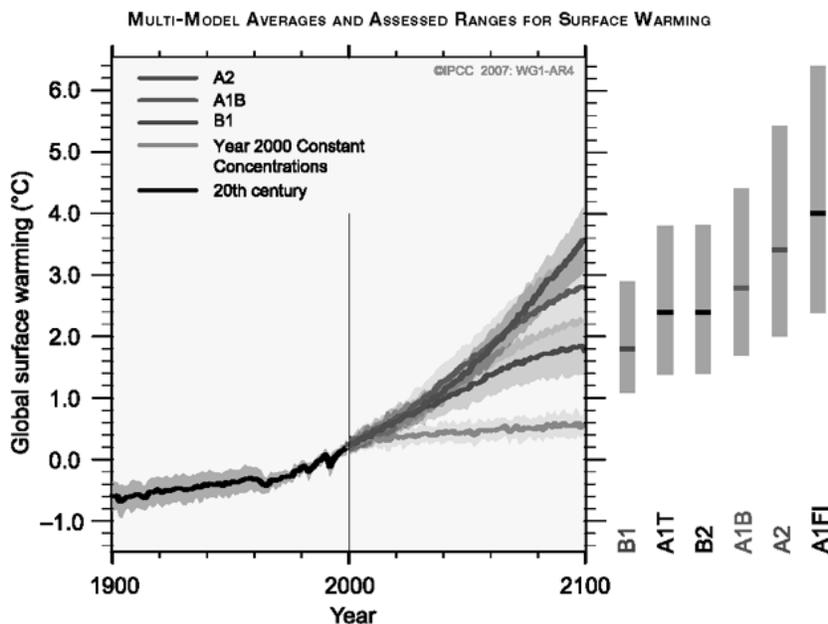


Figure SPM.5. Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. Shading denotes the ± 1 standard deviation range of individual model annual averages. The orange line is for the experiment where concentrations were held constant at year 2000 values. The grey bars at right indicate the best estimate (solid line within each bar) and the *likely* range assessed for the six SRES marker scenarios. The assessment of the best estimate and *likely* ranges in the grey bars includes the AOGCMs in the left part of the figure, as well as results from a hierarchy of independent models and observational constraints. (Figures 10.4 and 10.29)

- Models used to date do not include uncertainties in climate-carbon cycle feedback nor do they include the full effects of changes in ice sheet flow, because a basis in published literature is lacking. The projections include a contribution due to increased ice flow from Greenland and Antarctica at the rates observed for 1993 to 2003, but these flow rates could increase or decrease in the future. For example, if this contribution were to grow linearly with global average temperature change, the upper ranges of sea level rise for SRES scenarios shown in Table SPM.3 would increase by 0.1 to 0.2 m. Larger values cannot be excluded, but understanding of these effects is too limited to assess their likelihood or provide a best estimate or an upper bound for sea level rise. {10.6}
- Increasing atmospheric carbon dioxide concentrations lead to increasing acidification of the ocean. Projections based on SRES scenarios give reductions in average global surface ocean pH¹⁶ of between 0.14 and 0.35 units over the 21st century, adding to the present decrease of 0.1 units since pre-industrial times. {5.4, Box 7.3, 10.4}

There is now higher confidence in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation and some aspects of extremes and of ice. {8.2, 8.3, 8.4, 8.5, 9.4, 9.5, 10.3, 11.1}

- Projected warming in the 21st century shows scenario-independent geographical patterns similar to those observed over the past several decades. Warming is expected to be greatest over land and at most high northern latitudes, and least over the Southern Ocean and parts of the North Atlantic Ocean (see Figure SPM.6). {10.3}
- Snow cover is projected to contract. Widespread increases in thaw depth are projected over most permafrost regions. {10.3, 10.6}

¹⁶Decreases in pH correspond to increases in acidity of a solution. See Glossary for further details.

- Sea ice is projected to shrink in both the Arctic and Antarctic under all SRES scenarios. In some projections, Arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century. {10.3}
- It is very *likely* that hot extremes, heat waves and heavy precipitation events will continue to become more frequent. {10.3}
- Based on a range of models, it is *likely* that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures. There is less confidence in projections of a global decrease in numbers of tropical cyclones. The apparent increase in the proportion of very intense storms since 1970 in some regions is much larger than simulated by current models for that period. {9.5, 10.3, 3.8}

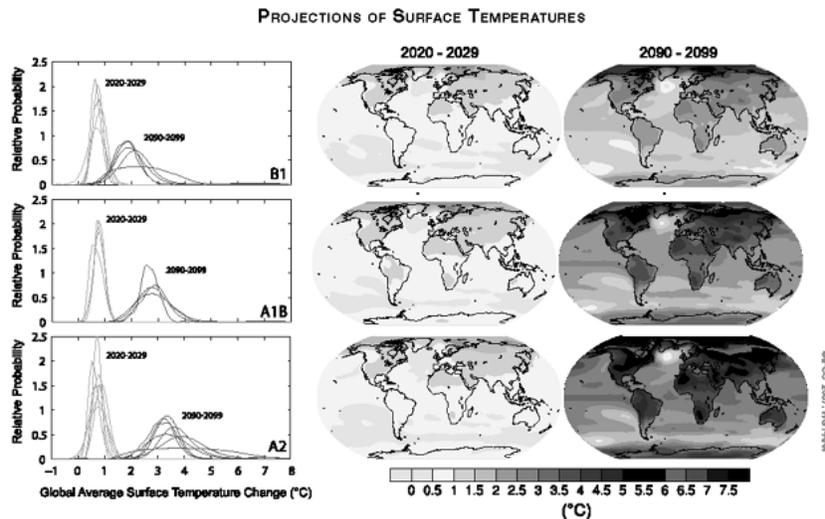


Figure SPM.6. Projected surface temperature changes for the early and late 21st century relative to the period 1980–1999. The central and right panels show the AOGCM multi-model average projections for the B1 (top), A1 B (middle) and A2 (bottom) SRES scenarios averaged over the decades 2020–2029 (centre) and 2090–2099 (right). The left panels show corresponding uncertainties as the relative probabilities of estimated global average warming from several different AOGCM and Earth System Model of Intermediate Complexity studies for the same periods. Some studies present results only for a subset of the SRES scenarios, or for various model versions. Therefore the difference in the number of curves shown in the left-hand panels is due only to differences in the availability of results. {Figures 10.8 and 10.28}

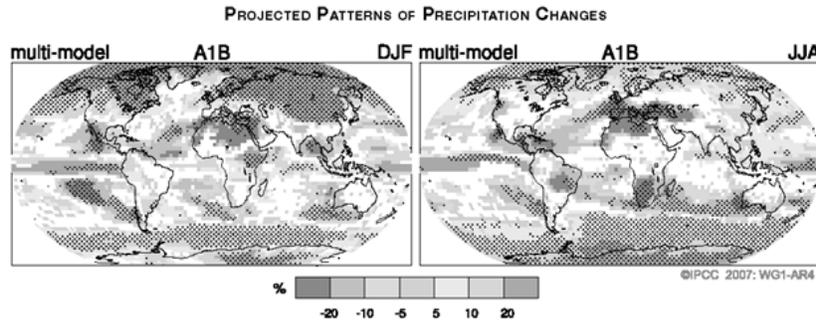


Figure SPM.7. Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66 percent of the models agree in the sign of the change and stippled areas are where more than 90 percent of the models agree in the sign of the change. {Figure 10.9}

- Extratropical storm tracks are projected to move poleward, with consequent changes in wind, precipitation and temperature patterns, continuing the broad pattern of observed trends over the last half-century. {3.6, 10.3}
- Since the TAR, there is an improving understanding of projected patterns of precipitation. Increases in the amount of precipitation are *very likely* in high latitudes, while decreases are *likely* in most subtropical land regions (by as much as about 20 percent in the A1B scenario in 2100, see *Figure SPM.7*), continuing observed patterns in recent trends. {3.3, 8.3, 9.5, 10.3, 11.2 to 11.9}
- Based on current model simulations, it is *very likely* that the meridional overturning circulation (MOC) of the Atlantic Ocean will slow down during the 21st century. The multi-model average reduction by 2,100 is 25 percent (range from zero to about 50 percent) for SRES emission scenario A1B. Temperatures in the Atlantic region are projected to increase despite such changes due to the much larger warming associated with projected increases in greenhouse gases. It is *very unlikely* that the MOC will undergo a large abrupt transition during the 21st century. Longer-term changes in the MOC cannot be assessed with confidence. {10.3, 10.7}

Anthropogenic warming and sea level rise would continue for centuries due to the time scales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilised. {10.4, 10.5, 10.7}

- Climate-carbon cycle coupling is expected to add carbon dioxide to the atmosphere as the climate system warms, but the magnitude of this feedback is uncertain. This increases the uncertainty in the trajectory of carbon dioxide emissions required to achieve a particular stabilisation level of atmospheric carbon dioxide concentration. Based on current understanding of climate-carbon cycle feedback, model studies suggest that to stabilise at 450 ppm carbon dioxide could require that cumulative emissions over the 21st century be reduced from an average of approximately 670 [630 to 710] GtC (2460 [2310 to 2600] GtCO₂) to approximately 490 [375 to 600] GtC (1800 [1370 to 2200] GtCO₂). Similarly, to stabilise at 1,000 ppm, this feedback could require that cumulative emissions be reduced from a model average of approximately 1415 [1340 to 1490] GtC (5190 [4910 to 5460] GtCO₂) to approximately 1100 [980 to 1250] GtC (4030 [3590 to 4580] GtCO₂). {7.3, 10.4}
- If radiative forcing were to be stabilised in 2100 at B1 or A1B levels¹⁴ a further increase in global average temperature of about 0.5 °C would still be expected, mostly by 2200. {10.7}
- If radiative forcing were to be stabilised in 2100 at A1B levels¹⁴, thermal expansion alone would lead to 0.3 to 0.8 m of sea level rise by 2300 (relative to 1980–1999). Thermal expansion would continue for many centuries, due to the time required to transport heat into the deep ocean. {10.7}
- Contraction of the Greenland Ice Sheet is projected to continue to contribute to sea level rise after 2100. Current models suggest that ice mass losses increase with temperature more rapidly than gains due to precipitation and that the surface mass balance becomes negative at a global average warming (relative to pre-industrial values) in excess of 1.9 °C to 4.6 °C. If a negative surface mass balance were sustained for millennia, that would lead to virtually complete elimination of the Greenland Ice Sheet and a resulting contribution to sea level rise of about 7 m. The corresponding future temperatures in Greenland are comparable to those inferred for the last interglacial period 125,000 years ago, when palaeoclimatic information suggests reductions of polar land ice extent and 4 to 6 m of sea level rise. {6.4, 10.7}
- Dynamical processes related to ice flow not included in current models but suggested by recent observations could increase the vulnerability of the ice sheets to warming, increasing future sea level rise. Understanding of these processes is limited and there is no consensus on their magnitude. {4.6, 10.7}
- Current global model studies project that the Antarctic Ice Sheet will remain too cold for widespread surface melting and is expected to gain in mass due to increased snowfall. However, net loss of ice mass could occur if dynamical ice discharge dominates the ice sheet mass balance. {10.7}
- Both past and future anthropogenic carbon dioxide emissions will continue to contribute to warming and sea level rise for more than a millennium, due to the time scales required for removal of this gas from the atmosphere. {7.3, 10.3}

THE EMISSION SCENARIOS OF THE IPCC SPECIAL REPORT ON EMISSION SCENARIOS (SRES)¹⁷

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil-intensive (A1FI), non-fossil energy sources (A1T) or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end-use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1-storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

An illustrative scenario was chosen for each of the six scenario groups A1B, A1FI, A1T, A2, B1 and B2. All should be considered equally sound.

The SRES scenarios do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.



¹⁷Emission scenarios are not assessed in this Working Group I Report of the IPCC. This box summarising the SRES scenarios is taken from the TAR and has been subject to prior line-by-line approval by the Panel.