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UPDATE ON THE LATEST GLOBAL WARMING SCIENCE

HEARING

BEFORE THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

FEBRUARY 25, 2009

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COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

ONE HUNDRED ELEVENTH CONGRESS
FIRST SESSION

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C O N T E N T S

UPDATE ON THE LATEST GLOBAL WARMING SCIENCE

WEDNESDAY, FEBRUARY 25, 2009

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

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

Present: Senators Boxer, Inhofe, Carper, Lautenberg, Cardin, Sanders, Klobuchar, Whitehouse, Udall, Merkley, Gillibrand, Barrasso, Specter, Bond.

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

Senator BOXER. The hearing will come to order.

Today we are going to have a very esteemed panel to discuss the latest global warming science. Senator Inhofe and I will have 6 minutes, not 5, for our opening statements, and then the rest of our colleague will have five. And then our friends on the panel, our distinguished panel, all of you will have seven minutes in which to present, and then we will have questions.

We are having this hearing because obviously we all feel we must be guided by the best available science as we address the challenge of global warming. This morning we will hear from several of the world's leading scientists about the latest global warming science.

In 2007, the Nobel prize-winning Intergovernmental Panel on Climate Change, the IPCC, painted a stark and sobering picture of the future that awaits us if we fail to act quickly to curb global warming pollution. The IPCC's projections for North American include an increase in the frequency and duration of heat waves and heat-related illness; an increase in water-borne disease from degraded water quality; more respiratory disease, including asthma and other lung diseases from increased ozone or smog concentrations, particularly dangerous to children and the elderly; more winter flooding, reduced summer flows and intensified water shortages in the West due to reduced snow pack; droughts and insect invasions that will kill crops and forests and will leave forests more susceptible to fire; intensified storms that will batter coastal communities and habitats, with the damage compounded by erosion.

Since 2007, new studies have confirmed the warnings sounded by the IPCC, and many of the latest findings suggest that the situation is more urgent than previously stated. Recent scientific reports

have found that greenhouse gas emissions are increasing faster than predicted, black carbon soot is trapping more of the sun's energy in the atmosphere than previously understood, sea levels may be rising faster than previous estimates predicted, the likelihood of destabilizing releases of carbon from melting permafrost is greater than once thought.

We are reminded of the mounting evidence of the threat posed by global warming in recent headlines. And I want to share some of these headlines with you. The Washington Post: Faster Climate Change Feared. The L.A. Times: West's Trees Dying Faster as Temperatures Rise. The Washington Post: Long Droughts, Rising Seas Predicted Despite Future CO_2 Curbs. And the San Jose Mercury News: Global Warming Danger Threat Increased.

The testimony we hear today will underscore the urgent need to respond to these findings with decisive action. I am so pleased to welcome our witnesses today. Dr. Pachauri is the Chairman of the U.N. Intergovernmental Panel on Climate Change. In 2008, Dr. Pachauri accepted the Nobel Prize on behalf of the panel's 2,000 participating scientists. And he has been, I say to my colleagues, so generous with his time. If any of you have questions for him, he is there for you.

We also have Dr. Christopher Field. He is with us from Stanford University. Dr. Field was the Co-Chair of Working Group II of the IPCC, which focused on the impacts of global warming. He is an expert on how global warming is already affecting North America, and the additional impacts that are likely to come with increased warming in the future.

I am also pleased that we have Dr. Howard Frumkin here today. Dr. Frumkin is Director of the National Center for Environmental Health at the CDC. The last time the CDC testified here on the public impacts of global warming, we discovered that the written testimony had been heavily redacted by the White House. I am looking forward to the opportunity for a full accounting of the dangers global warming poses to human health.

Dr. William Happer, a Professor of Physics at Princeton, is a witness for the minority today. And I also want to thank him so much for participating in this hearing.

In one of his first major statements after the election last November, President Obama said "Now is the time to confront this challenge once and for all. Delay is no longer an option. Denial is no longer an acceptable response. The stakes are too high, the consequences too serious." And in his speech last night, our President called on Congress to enact legislation that places a market-based cap on carbon pollution. And I believe we must and we will answer that call.

I am convinced that when we address the challenges of climate change, the steps we take will create jobs, will reinvigorate the economy and will make us more energy independent. The science makes it clear that we must not wait any longer to get started. And again, I want to say to the scientists here, thank you so very much. You are here with no political agenda, you are here to tell us the truth as you know it, as you see it. And that is what will guide us, the science will guide us. So thank you again very, very much.

And it is my pleasure to call upon our Ranking Member, Senator Inhofe.

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

Senator INHOFE. Thank you. Before my opening statement, let me just acknowledge, we have some very significant things in this Committee called Environment and Public Works that have nothing to do with the environment. But the public works, we have a Highway Bill coming up, a WRDA bill, Water Resources Development Act, which we want to get back on a 2-year cycle. And you are going to find that the Chairman and the Ranking Member will be inseparable in these issues. They will be working together, contrary to what you might see today.

[Laughter.]

Senator INHOFE. Now, thank you for holding the hearing today, Madam Chairman. As you know, no one likes to talk more about the global warming science than I do. However, with this being the first climate change hearing in the 111th Congress and in the midst of this deep financial crisis, the recession, I thought I would start by quoting Ronald Reagan: "There you go again." In these turbulent financial times, rather than opening with climate hearings that analyze issues that Americans are concerned about, such as how cap and trade policies, which were mentioned last night by the President, how they are going to affect the bottom line.

I don't need computer models to tell me that the people are hurting financially, that hundreds of thousands of Americans are losing their jobs every month, and I don't need a degree in science to tell me that the climate will continue to change and challenge us all. I see it every day. Rather as law makers, it is our duty here in this Committee to analyze the policy issues that affect all Americans, especially in the near term. And I am hopeful that this year we will schedule more hearings that address these types of issues.

Now before I comment on the science and welcome our distinguished witnesses, I thought I would try to put some of these economic issues in perspective with the science. I will use numbers that the Americans are unfortunately getting used to. By this chart up here, all the bailouts that we have been subjected to, one of the problems I have, we are thinking now in terms of billions and trillions, which used to be in millions. If you look at the auto bailout, housing bailout, mortgage bailout, and then of course the big bank bailout, $700 billion, the economic bailout that was just passed.

Now, when you compare that to the climate bailout, this is something you have to look at. And the figures we are using here are not my figures, these were the figures of the authors of the bill, the last climate bill that we had, which was the Warner-Lieberman bill.

Now, what they all have in common is that they represent previously unimaginable amounts of money that the Government is currently spending or eventually taxing to throw at our problems and try to boost our economy. In the cap and trade context, this comes in the form of taxes through passed on higher energy costs, in terms of effectiveness. We learned last week that at least with

the auto bailout, the initial offering didn't really work, because now both GM and Chrysler are coming back for more.

Now, where does this climate science come in? It comes in once again in terms of effectiveness, using our tax dollars wisely, assuming the IPCC's own targets for stabilization of CO_2 in the atmosphere at 450 parts per million, or even less realistic targets being argued by many.

Then the science dictates and the EPA confirms that the U.S. only cap and trade policy is not going to be effective. Now, if you just stop for a minute and just try logic, if this were back talking about the Kyoto thing, assuming all countries are going to do the same thing, there could be an argument that to say, even if you believe that anthropogenic gases, CO_2, in carbon, is causing global warming, then what good does it do for us unilaterally to try to do this as a Country? Because all that would happen is, and we have information from the National Association of Manufacturers and others that our manufacturing base would further erode and go to countries where there are no emission requirements. And I am talking about China and Mexico and some of these other countries.

So they may argue that on a new global international policy where the U.S. should lead in order to reach such pie in the sky reduction levels, however, these efforts should be contrasted with the reports from just last month from the Chinese government that show China is aiming to increase its co-production by about 30 percent in 2015. So they have no intention of dropping it down. We have many other quotes that there is not time to talk about here.

Now, regarding the science. I welcome all the witnesses here today including Dr. William Happer. I would say this, and I would have done the same, and tried to do the same thing when I was chairing this Committee, it is stacked three to one, so anyone who is evaluating, this is not representative of an even panel in terms of the positions. Dr. Happer is a professor at the Department of Physics at Princeton University and former Director of Energy Research in the Department of Energy from 1990 to 1993. He is a fellow of the American Physical Society, the American Association for the Advancement of Science, and the National Academy of Sciences. I welcome him and all the others.

As you know, I regularly serve as a disseminator of information on the latest science that is not being reported in the mainstream media. I have given 12 floor speeches on this document, if anyone wants to endure all 12 of them, you can get them on my site, Inhofe.senate.gov. And contrary to the media and the United Nations, what they have promoted, there is a growing body of scientific studies and scientists who are openly rebelling against these so-called consensus. Recently I released a new report on climate scientists, which documents many studies. The report included over 650 scientists who reject the assertions made by the United Nations. It features skeptical voices of over 650 prominent international scientists, including many, and it has been updated, I might add, there are now close to 800 on this list.

So I would note that with over 650 dissenting scientists or more than 12 times the number of U.N. scientists, that is 52, who authored the IPCC's 2007 summary for policymakers. And I would say that it is not really the report, it is the summary for policy-

makers that the media, all these guys at this table over here, are looking at. And that is not from scientists, that is from policymakers and for politicians.

Thank you, Madam Chairman.

[The prepared statement of Senator Inhofe follows:]

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

Thank you, Madam Chairman, for holding today's hearing. As you know, no one likes to talk more about climate science than I do. However with this being the first climate change hearing in the 111th Congress, and in the midst of a deep financial crisis and recession, I thought I'd start by quoting Ronald Reagan: "There you go again." In these turbulent financial times, rather than opening with climate hearings analyzing the issues that concern Americans, such as how cap-and-trade policies and taxes will affect our energy prices and our bottom line, we are here today to focus once again on speculative computer model predictions of 50 to100 years away of a looming climate catastrophe, and the public health and ecological chaos that will result from man's supposed effect on his climate by the continuing use of fossil fuels.

I don't need computer models to tell me that people are hurting financially, or that hundreds of thousands of Americans are losing their jobs every month, and I don't need a degree in science to tell me that the climate will continue to change and challenge us all. I see it every day. Rather, as lawmakers, it is our duty here in this Committee to analyze the policy issues that affect all Americans, especially in the near term, and I am hopeful that this year we will schedule more hearings that address these types of issues.

Now, before I comment on the science and welcome our distinguished witnesses, I thought I would try and put some of these economic issues in perspective with the science. I will use numbers that Americans are unfortunately getting used to seeing with all of the debate on bailouts. As you can see, this chart represents the costs of the various government bailouts within the last year (Auto Bailout $17 Billion, Housing Bailout $200B, Mortgage Bailout $275B, Bank Bailout, $700B, Economy Bailout $787B). The bottom number represents the amount of money the sponsors of the Lieberman-Warner bill said would be generated under their cap-and-trade bill, which is included in the billions, to keep the numbers in perspective.

What they all have in common is they represent previously unimaginable amounts of money that the government is currently spending or eventually taxing to throw at our problems to try to "boost" our economy. In the cap-and-trade context, this comes in the form of taxes through passed-on higher energy costs. In terms of effectiveness, we learned last week that at least with the auto bailout, the initial offering will be ineffective, with GM and Chrysler both asking for billions more and still leaving bankruptcy options open. Time will tell whether these other bailouts are also proven ineffective.

Now where does climate science come in? It comes in once again in terms of effectiveness, using our tax dollars wisely. Assuming the United Nations Intergovernmental Panel on Climate Change's (IPCC's) own targets for stabilization of CO_2 in the atmosphere at 450 ppm (parts per million), the EPA has confirmed that a U.S. only cap-and-trade carbon policy will be ineffective. These targets are simply not achievable with the approach to climate change that has been the focus of the policy debate for years.

Now my colleagues will argue that we must focus on a new global international policy the U.S. should lead in order to reach such pie-in-the-sky reduction levels. However, these efforts should be contrasted with last month's Chinese government reports that show China is aiming to increase its coal production by about 30 percent in 2015 to meet its energy needs. In addition, other developing countries state they will not agree to binding caps and that climate funding is an entitlement, not aid, to be paid for by who else but us? It is time for us to get realistic about these policies, and focus on what is achievable, both globally and domestically, to help bring down energy costs to consumers and make us more energy secure.

Now, regarding the science, I welcome all of our witnesses here today, including Dr. William Happer. Dr. Happer is a professor at the Department of Physics at Princeton University and former Director of Energy Research at the Department of Energy from 1990 to 1993. He is a fellow of the American Physical Society, the American Association for the Advancement of Science, and the National Academy of Sciences. I welcome his and all of the witnesses' testimony.

As you know, I regularly serve as a disseminator of information on the latest science that is not being reported in the mainstream media. I have given over 12 floor speeches documenting the politicization of the global warming science issue. My continuing fear is that objective, transparent, and verifiable science gets lost in the public dialog.

Contrary to what the media and the U.N. have promoted, there is a growing body of scientific studies and scientists who are openly rebelling against the so-called "consensus."

Recently, I released a new minority report on climate science which documents many of the studies. That report included over 650 scientists who have challenged man-made global warming claims made by the IPCC and former Vice President Al Gore.

It features the skeptical voices of over 650 prominent international scientists, including many current and former U.N. IPCC scientists. This updated report includes an additional 250 scientists and climate researchers since the initial release in December 2007. I would note the over 650 dissenting scientists are more than 12 times the number of U.N. scientists (52) who authored the IPCC 2007 Summary for Policymakers.

I would like to insert this report in the record and I look forward to referencing it in questions for the witnesses.

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

Senator BOXER. Thank you.

Senator, since I only took 5 minutes of my 6, I will answer something you said. The first briefing we held in this Committee was on January 7th, and it was called Investing in Green Technology as a Strategy for Economic Recovery. So I know you and I disagree on the point, but believe me, this Committee is geared toward green jobs. We, as a matter of fact, have a new subcommittee, that is going to be chaired by Bernie Sanders, and I appreciate your approving of this, that is going to be dealing with the creation of green jobs. Because we are going to focus not only on the public works side with jobs, jobs, jobs, but also on the Environment side.

And I also would point out on your chart that a cap and trade system isn't a bailout, it is revenues coming into the Government because we are going to have a private cap, we are going to have a system that sets a price on carbon and does it in the marketplace, just like the stock market. So it is going to be done out there.

So rather than a bailout, it is a bail-in. We are going to have help here, we are going to receive these large amounts of money from a cap and trade system, and I am very excited about that possibility.

Senator INHOFE. And I would concede to your first comments, but I would only say in terms of bailouts, this is the amount of money that people, not the people in this, well, including the people in this room, many of whom don't really care that much, but the people out in the real world who are going to have to pay for higher energy costs, they are going to have to pay for all this fun that we are having up here.

So I just think we owe it to them, and I applaud you for having this science hearing, and I think that we need to let them know that the science is not settled. And all these recent things that we were talking about have come up, many of whom were the IPCC individuals that actually started out with the United Nations on this thing, they have come over to the other side. And I named names when we had the hearing with Vice President Gore, and I notice he is a little bit concerned about the fact that people like Claude Allegre from France and people like Nir Shaviv from Israel and David Bellamy from the U.K., these are people who were on

the other side of this issue who are now over on the skeptic side, and they are all scientists.

Thank you, Madam Chair.

Senator BOXER. I allowed you to interrupt me, and now I will finish what I was going to say, which is that a lot of us believe that when we attack the problem of global warming, which we believe science tells us we must attack, and I would say probably more than 90 percent of the scientists, probably more than that, agree that we must, and agree on the science.

There are always outliers, that is fine, and they have their rights. But we think it will be a boon to our economy.

And the last thing I will say before I turn it over to Senator Lautenberg for his time, is that to say that the people in this room don't care about jobs, that is ludicrous. Eighty percent of the American people consider themselves environmentalists. That is, we have polled people, 80 percent. Of course they care about jobs. And to set the Environment against jobs is ludicrous, because when you look back in the history, since we started passing Clean Air, Safe Drinking Water and all that, many of which were started under Republican Presidents, jobs go along with it.

So I hope we don't say that people who care about the Environment don't care about jobs. We all work for a living.

Senator INHOFE. I don't think I said that, Madam Chair.

Senator BOXER. Well, you said people in this room don't care.

Senator INHOFE. I said that we have activists who are more concerned about causes than that.

Senator BOXER. Yes. You can see that this is a little bit of a touchy subject between us. But we love each other.

[Laughter.]

Senator BOXER. Senator Lautenberg.

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

Senator LAUTENBERG. Thank you, Madam Chairman, and thank you for calling these distinguished witnesses to this hearing.

I welcome our distinguished professor from Princeton, the State of New Jersey. We might even have a difference of view, but that doesn't mean that we are not proud of New Jersey and Princeton, and their long, distinguished academic record.

Madam Chairman, it kind of befuddles the mind a little bit when we review, have these traditional reviews of what was said and how dismissive views are about those who are in attendance here. It is hard to understand that, and I am sorry that our friend, Senator Inhofe, has left, because I don't want to disparage him when he is not here.

[Laughter.]

Senator LAUTENBERG. And Madam Chairman, thank you for having the hearing. In 2007, the Intergovernmental Panel on Climate Change said the world is warming and humans are responsible. This science is sound, their conclusions hard to ignore. The head of the IPCC, we are pleased to have Dr. Pachauri here. Welcome, all of you. And we look forward to your analysis, Dr. Pachauri, of the situation.

There are new reports that Antarctica is getting warmer. I had the opportunity to go there, go to the South Pole just a few years ago. And I was dismayed to see places that became kind of familiar to me in a very short period of time that had been standing there for thousands of years, and suddenly now the breakoffs are State-size and floating in the ocean as long as they last.

Members of this Committee were in Greenland. We went there, and I don't know what visual observations mean, but the fact of the matter is that the disappearance of ice was obvious. The ground that was left behind had turned black. And the rise in sea levels, in my view, cannot be further ignored. In fact, the amount of sea ice in the Arctic is nearly 40 percent below normal, according to a recent report.

A warming world means rising sea levels, and rising sea levels have global implications. Anyone with a coastline has to worry about that and plan for these changes. The EPA itself found States with coastlines such as our State, New Jersey, California and other States represented on this Committee will directly face these risks in coming years. With increased greenhouse gases and higher temperatures, we also risk more severe and unstable weather, less productive fisheries from an increasingly acidic ocean and extinction of entire species of animals.

And how about the degradation of health? What is the cost of that? Increases in respiratory diseases, those things, when we look at our chart, we see comparisons that are really irrelevant in terms of what we are talking about here. Because yes, we have to spend money on other things. We have to dig ourselves out of a deep economic hole. But we also have a responsibility to our families and succeeding generations to do something about this instead of scornfully reviewing what has taken place.

I don't know whether of you believe that one of the worst hoaxes, hoaxes, a joke perpetrated on the people of this Country is the discussion of the view of global warming. It is outrageous to be so casual about something and make comparisons that don't do our families any good. With increased gases and higher temperatures, we also risk, and we risk more severe unstable weather, less productive fisheries from an increasingly, as I said, I am repeating myself here, it gets me. All of us want to protect our planet and our way of life for our children and grandchildren and generations to follow. And every day we ignore the science and choose to do nothing, global warming gets worse and we need to make up for lost time.

Last year, scientists were talking about the need for America to reduce greenhouse emissions by 80 percent by 2050. Now, many scientists believe that we need to cut emissions by 90 percent. We need to be bold, and this Committee has to lead the way. And together, we will fight global warming and our dependence on foreign energy sources, improve our air quality, create millions of new high-paying jobs.

Madam Chairman, I look forward to working with you to craft a bill rooted in science to tackle the climate changes we face. Thank you very much.

Senator BOXER. Thank you so much, Senator Lautenberg.

Senator Bond.

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

Senator BOND. Thank you very much, Madam Chair, for hosting this hearing. I am concerned about the failure of climate modelers to predict accurately the global cooling we have seen the last 10 years. These models don't explain why we saw temperatures far warmer than today than 100 years ago, 1,000 years ago, when the Vikings were farming Greenland, and 2,000 years ago, when the Romans grew grapes in Britain. So there is much to be learned about the science of climate.

But I want to focus on economics and what the science says about the futility of proposed U.S. Government actions. The first chart is from the International Energy Agency in Paris. The left hand bar shows where carbon emissions are headed in 2030, business as usual. The red portion of the bar shows carbon emissions from developing countries in OECD, basically western countries, Japan and Australia. The blue portion of the bar is emissions from everyone else.

The green bar is where some want to be. That is worldwide carbon concentrations in the atmosphere of 450 parts per million is what some scientists tell us is needed to avoid serious climate harm from humans.

What this chart shows us is that if we cut 100 percent of the carbon emissions from the western developed world, tracked by the dashed red line, we would still not do enough to reach carbon concentrations some say are necessary. That means western developed countries could park every car, bus and truck, turn off almost every television, light, computer, air conditioner and many heaters, idle almost every factory and it still would not be enough. This is not a prediction, this is a scientific fact just by doing the math of carbon emissions and concentrations.

Now, the second chart, done with data from the U.S. Environmental Protection Agency, shows how science tells us that if the U.S. passes carbon legislation without developed countries like India and China taking similar actions, carbon levels will still rise dramatically. Near the red arrow pointing up, the thin red line is business as usual. The nearby line headed up is U.S. acting alone. Basically, no change.

The only way we halt the rapid rise in carbon concentrations is if the U.S. is joined by India and China cutting carbon emissions, the green arrow and dashed line. This is important, because our guests here from India and the United Nations have said developing countries like India will be exempted from any such restrictions in a new Kyoto Treaty. Our friends from China have made similar comments, when they will not accept carbon cut quotas from a new Kyoto Treaty.

For those who say we should be leaders and impose this pain on ourselves, what is the purpose of that, if science shows that countries needed to make a difference refuse to follow? We must then as why, during a worldwide economic crisis, should we take futile actions that science says will do nothing to solve the problem. Speaker Pelosi of the House has suggested that this will be a good way to raise governmental revenues.

OMB Director Peter Orszag said this week that the Obama budget is already counting on Government proceeds from a coming cap and auction bill. That says tax to me. That is not a market. Some have suggested this would be a climate bailout, like our previous bank and housing bailouts that have worked so successfully. With the Pelosi and Orszag comments, it seems clear that what they really want to bail out is the Federal Government with its runaway spending and the tremendous amounts of money that would be spent hiring people to do these things.

But how much is a hidden energy tax going to kill American jobs, burden U.S. families and devastate retirees, especially in coal-dependent regions? That is to be determined. I happen to live in one of those regions, and I am very much concerned that we would devastate the Midwest. Calling this proposed system of governmental costs on companies who provide jobs, who produce energy, support energy-related jobs, a "market-based solution," which clobbers people dependent on fossil fuels is a remarkable obfuscation. Let's call it what it is. It is going to be a huge unfair tax.

The science shows us that the United States acting while China and India refuse to act will be futile. I will certainly oppose raising energy costs on suffering families and workers during an economic crisis when the science says our actions will be futile. I hope my colleagues will, too.

And I thank you, Madam Chair, for giving me this opportunity.

[The prepared statement of Senator Bond follows:]

STATEMENT OF HON. CHRISTOPHER "KIT" BOND,
U.S. SENATOR FROM THE STATE OF MISSOURI

Thank you, Madam Chairman, for hosting this hearing on the current state of climate science. I am concerned by the failure of climate modelers to predict accurately the global cooling we have seen the last 10 years. These models also do not explain why we saw temperatures far warmer then today 1,000 years ago when the Vikings were farming Greenland and 2,000 years ago when the Romans grew grapes in Britain. So, I believe there is much to learn about the science of climate.

But today I want to focus on what science says about the futility of proposed government actions. This chart is from the International Energy Agency in Paris. The left hand bar shows where carbon emissions are headed in 2030 with business as usual. The red portion of the bar shows carbon emissions from developed countries in the Organization for Economic Cooperation and Development, basically western countries and Japan and Australia. The blue portion of the bar is emission from everyone else. The green bar is where some want to be—that is worldwide carbon concentrations in the atmosphere of 450 parts per million. This is what some scientists tell us is needed to avoid serious climate harm.

What this chart shows us is that if we cut 100 percent of the carbon emissions from the western, developed world, tracked by the dashed red line, we would still not do enough to reach carbon concentrations some say are necessary to avert dangerous climate change. That means western, developed countries could park every car, bus and truck, turn off almost every television, light, computer, air conditioner and many heaters, idle almost every factory, and it still would not be enough. That is not a prediction, that is a scientific fact just by doing the math of carbon emissions and concentrations.

This second chart, done with data from the U.S. Environmental Protection Agency, shows how science tells us that if the U.S. passes carbon legislation without developed countries like India and China taking similar actions, that carbon levels will still rise dramatically. Near the red arrow pointing up, the thin red line is business as usual. The nearby line headed up, is the U.S. acting alone—basically no change. The only way we halt the rapid rise of carbon concentrations is if the U.S. is joined by India and China cutting carbon emissions—the green arrow and dashed lines.

This is important because our guest here from India and the United Nations has said "developing countries [like India] will be exempted from any such restrictions"

in a new Kyoto treaty. Our friends from China have made similar comments that they will not accept carbon cut quotas from a new Kyoto treaty.

For those who say we should be leaders and impose this pain on ourselves, what is the purpose of that if science shows that countries needed to make a difference refuse to follow?

We must then ask why, during a worldwide economic crisis, should we take futile actions that science says will do nothing to solve the problem?

Speaker Pelosi of the House has suggested that this will be a good way to raise Federal Government revenues. OMB Director Orszag said this week that the Obama budget is already counting on Government proceeds from a coming cap and auction bill.

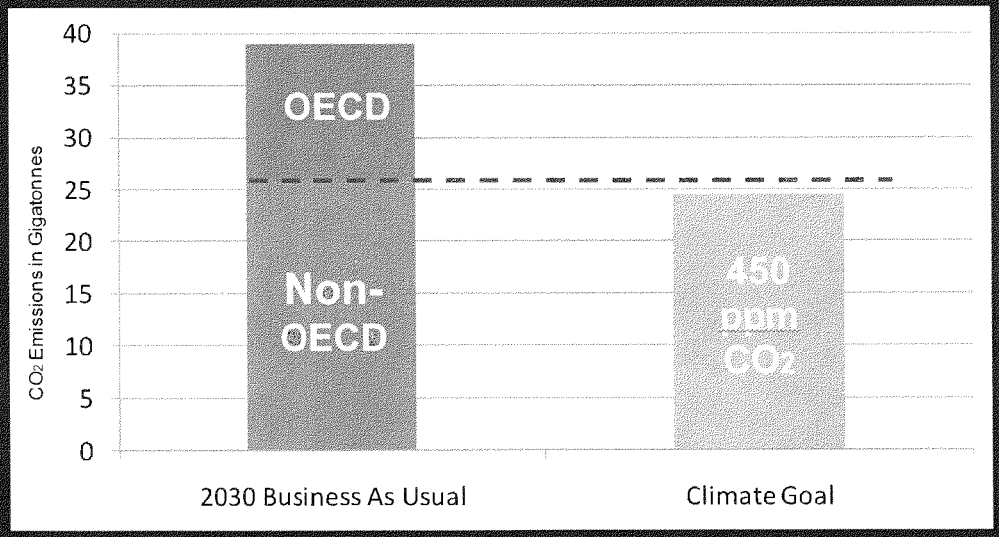
Some have suggested that this would be a climate bailout, like our previous bank and housing bailouts. With the Pelosi and Orszag comments, it seems clear that what they really want to bail out is the Federal Government and runaway spending.

The science shows us that the United States acting while China and India refuses to act will be futile. I certainly will oppose raising energy costs on suffering families and workers, especially during an economic crisis, when the science says our actions will be futile.

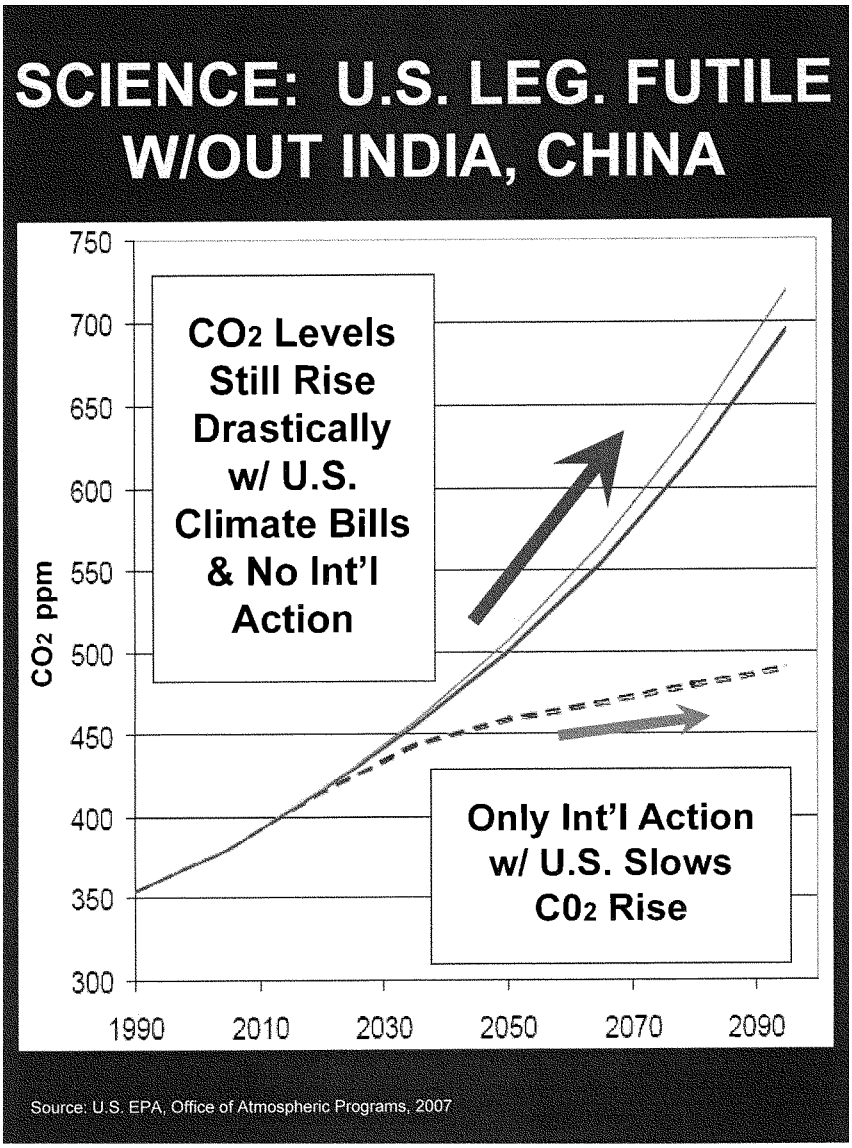
I hope my colleagues will, too. Thank you.

[The referenced material follows:]

SCIENCE: EVEN ZERO CO_2 FROM DEVELOPED NATIONS NOT ENOUGH



Source: International Energy Agency, 2008


SCIENCE: U.S. LEG. FUTILE W/OUT INDIA, CHINA
CO2 Levels Still Rise Drastically w/ U.S. Climate Bills & No Int'l Action
Only Int'l Action w/ U.S. Slows C02 Rise
CO2 ppm
750
700
650
600
550
500
450
400
350
300
1990
2010
2030
2050
2070
2090
Source: U.S. EPA, Office of Atmospheric Programs, 2007

Senator BOXER. Well, thank you, Senator Bond, for taking the opportunity to reiterate the message you have had for us for quite a while. I would say you do it very well.

But I would just point out that these countries that you point to, India and China, very key that they do attack this, they do like to come into our Country with their goods, and we do have leverage under the WTO. And I think that was part of our last approach. I am thankful to you for raising this issue because I think it has to be key to our next legislation as well.

And now it is my pleasure to call on Senator Klobuchar.

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

Senator KLOBUCHAR. Thank you very much, Chairman Boxer, and thank you again for making this such a prominent issue and having a review of the science, which I think we need to have.

I also, Senator Bond, live in a cold place, and I bet it is even colder than yours. But I will say that the citizens in my State, while we are concerned in these economic times to make sure that we come up with a solution to this that isn't going to bring them down, I think they see the possibility of opportunity here. Maybe it is because we have been a leader in renewable energy, that we are fourth in the Country with wind, that we have an aggressive renewable standard. But they see, I would say, the glass not just half empty, but half full, and see the possibilities.

We have always been in a leader in our State in science. We are the home of the Mayo Clinic, we have given the world everything from the pacemaker to the Post-It note, and we see this as our next opportunity. I am also a former prosecutor, so I believe in evidence. That is why I think it is important that we base our hearing today not just on everyone's rhetoric, but on the information that you are going to present us with.

Senator Lautenberg mentioned we had a trip to Greenland in 2007. And while I am no scientist, I was able to see first-hand from the people that live there what was going on. We learned that Greenlanders were planting potatoes in places that only a few years ago were covered year-round with ice. We learned that Greenland has lost a large portion of their ice sheet.

But what surprised me most was something I saw during the trip in the middle of the ice sheet. We landed on this island that was easily the size of a house, and our pilot explained to us that the island had only appeared in the last 5 years when the ice had melted. As one of the scientists who accompanied us on this trip explained to us, Greenland is really the canary in the coal mine when it comes to climate change.

As we all know, the Intergovernmental Panel on Climate Change concluded in November 2007 that global warming is happening, that most of the observed increase in temperature is very likely to due to greenhouse gases. The report predicted an increase in wildfires and public health problems, like heat stroke, asthma and even chronic disease. And what is particularly troubling is that actual warming trends are out-pacing the forecasts of the IPCC.

A story in last Sunday's Washington Post I thought was quite concerning. The article reported on the annual meeting in Chicago

of the American Association for the Advancement of Science. One of the scientists said, "We are basically looking now at a future climate that is beyond anything we have considered seriously in climate model simulations." I would like to hear about your thoughts on that.

He went on to note that greenhouse gases are being emitted at higher rates than previously anticipated and that this is causing an unexpectedly high release of carbon from the Arctic permafrost.

Madam Chairman, the oceans are warming, causing wind speeds to increase, which in turn makes the oceans more acidic. But as I have always said, to get the support for this across the Country, we have to talk about more than oceans. We have to talk about the fact that in the Great Lakes, Lake Superior, we have seen declining levels because of the ice melting sooner, which has affected our barge traffic. We have seen ice fish houses that can't get out until much later than they usually do, because the ice isn't freezing. We have seen an increase in storms and floods our State.

Glaciers around the world are melting. We saw this in Greenland, we are seeing it in the Himalayas. I thought it was interesting to learn about how the Chinese traditionally plant two crops a year. You think the huge country of China, and when the Himalayan glaciers disappear, where they get their water, the chances are that water levels on the main Chinese river that supply Chinese agriculture will also dry up.

But this is about the lakes in Minnesota. But it is also as far-reaching as agriculture in China. That is why this topic is so important. We need the best possible information about the science of climate change, so that we can anticipate what is coming. We need accurate information in order to draft this legislation, to make this legislation fair to the people of this Country, but to actually do something and get this done.

During his speech to the Country last night, President Obama talked about this issue and the challenge. He included a call to action, he included a call to action to this Congress to actually get cap and trade legislation passed. He sent a clear and powerful message to everyone in this Country and the rest of the world that addressing climate change is a priority.

I see this, unlike my colleague on the other side, from another M State in the Midwest, I see this as an opportunity. We have a scientific community that we are going to hear from today that is giving us sound information and we have a Congress that for the first time stands ready to turn that scientific information into action.

Thank you very much, Madam Chair, and thank you to our panelists.

Senator BOXER. Thank you, Senator Klobuchar.

Senator Specter.

OPENING STATEMENT OF HON. ARLEN SPECTER, U.S. SENATOR FROM THE STATE OF PENNSYLVANIA

Senator SPECTER. Thank you, Madam Chairwoman.

I am delighted to be a member of this very important Committee, Environment and Public Works. I had served on it many years ago, but other committee assignments precluded my being on it and

now I am glad to be here, especially because the global warming issue is going to be a central issue.

I thank you, Madam Chairwoman, for scheduling this hearing on the most up to date scientific evidence. Because that sets the stage for what we are going to do. I think the evolution of the views of President Bush on the threat of global warming are highly significant. For a considerable period of time, President Bush was a doubter. And in the later stages of his Administration, he came to agree that global warming was a critical issue.

There are still some who raise questions, and it is a legitimate inquiry. Some of the scientific evidence provides the underpinning for what we need to do.

Two years ago, Senator Bingaman and I introduced legislation on global warming and it differed from the parameters of the legislation introduced by Senator Warner and Senator Lieberman, which had more exacting standards. But the Warner-Lieberman standards could not be achieved within existing technology, at least that is what my studies showed. The contention was raised that if we had more exacting standards that technology would advance to meet them. Well, that is speculative. And my own view is that we ought to have very, very meaningful standards, but they ought to be within reach on existing technology. If our technology is improved at a later time, there will be ample opportunity to revise the standards, if we deem that necessary and attainable.

I think it is very important to structure legislation which can receive popular support, public support. My State, Pennsylvania, is a big coal-producing State, 30 billion tons of bituminous in western Pennsylvania and 7 billion tons of anthracite in northeastern Pennsylvania, very, very important for our economy. And while I applaud what we are doing with $80 billion in the stimulus package for energy that is renewable, wind power, solar power, hydropower, until we get there, we are dependent on, too much so, on OPEC oil. And with clean coal technology, we still have an opportunity to use these resources with due regard for the environment and environmental protection, which my record shows is a high point of consideration on my part.

The Bingaman-Specter bill has gotten significant support from not only the power companies, and many have joined in urging its adoption, but also from the United Mine Workers. Also a labor organization very concerned about jobs, obviously, which is what they should be. But acknowledging that significant steps have to be taken, so that when we take a look at the overall picture, I think we have to bear that in mind.

But this is a very important subject, highlighted again by the President last night. I look forward to working with you, Madam Chairwoman, and the others on this Committee to try to structure legislation which can be enacted this year. Thank you.

Senator BOXER. Senator, thank you very much. And thank you for the contribution you made to this debate, working with Senator Bingaman. It was very important, and it continues to be. Thank you.

Senator Merkley.

OPENING STATEMENT OF HON. JEFF MERKLEY, U.S. SENATOR FROM THE STATE OF OREGON

Senator MERKLEY. Thank you very much, Madam Chair, for bringing this panel of esteemed scientists together.

Every citizen in my State is certainly impacted by issues regarding climate change, from our farmers, for whom a small change in precipitation certainly can change a dry land wheat crop into a desert, to our folks in the timber industry who have concerns about insect infestations and forest fires, to our folks in our river economy and our coastal economy, dramatically affected by the temperature of the water, the water flows, the course of currents and so on and so forth.

So after a time period in which science has not always been at the center of the conversation, I am delighted that we are turning to you all for your best insights. Certainly one point I would love for you all to address if possible in your testimony is, if we do nothing as an international community, and I do take the point of Senator Bond that the international community needs to work together to tackle these issues, if we do nothing and the increase in carbon dioxide and methane gas continues apace over the next 50 years, what is your best estimate of how much the temperature of the planet will increase over a 50-year period, and what is the impact on ecosystems and human civilization?

I associate myself with other comments that have been made here, and look forward to your testimony.

Thank you very much, Madam Chair.

Senator BOXER. Thank you, Senator.

Senator Sanders.

OPENING STATEMENT OF HON. BERNARD SANDERS, U.S. SENATOR FROM THE STATE OF VERMONT

Senator SANDERS. Thank you, Madam Chair, and thank you for your leadership on this issue, not only of great significance to our Country, but the entire world. For many years now, at least for the last 8 years, the rest of this planet has been wondering what the United States of America is doing. I think at this particular moment in history, we are going to rise to the occasion.

As Senator Merkley just mentioned, I think one of the issues that we have to address is not just the cost of addressing the crisis of global warming, it is what is the cost, both monetarily, financially, as well as health-wise, of not addressing the issue. I think the evidence seems to suggest that if we do not act aggressively in cutting back on greenhouse gas emissions and reversing global warming, what we are going to look at are trillions of dollars of loss in the international economy over a period of years, we are going to look at a great amount of loss in terms of extreme weather conditions, flooding, of drought, of hunger, of political instability.

In fact, I think the CIA is now worried about mass migrations as people have to move around and are engaged in struggle for limited natural resources, for food. We are going to look at increased disease. What is the cost of all of that if we do not act?

Second of all, in terms of economics, Senator Boxer and I just came from a meeting earlier this morning talking to people from all over the Country who are seeing the potential for the creation

of millions, millions of good-paying jobs over the years as we move away from fossil fuels, as we address the economic crisis this Country faces from the importation of some $700 billion a year of foreign oil. Think of the jobs that we could create as we move to wind, as we move to solar, as we move to geothermal, as we move to biomass. Huge jobs creation in all of that area.

Clearly, I think as some of our friends on the other side have indicated, this is not just an American crisis, this is an international crisis. But we have no credibility with the rest of the world if we are not moving forward aggressively. And in fact, what we have just heard this morning, as you talk about China, China is moving forward aggressively in terms of energy efficiency, in terms of solar. Do you think they are dummies there? I don't think so. They know that their lakes and their rivers are heavily polluted. When I was in China, people were wearing these masks around their face because the air is so polluted. They are not dumb.

And if we can in fact take a leadership position once again in terms of sustainable energy, we can create significant numbers of jobs in this Country helping China, helping India with that technology. In fact, we should be a little bit embarrassed that some of the technologies that we created in this Country are now being aggressively used around the rest of the world, and we are importing products from them. This is the United States of America. We should be doing quite the opposite.

So Madam Chair, thank you, A, for recognizing the huge importance of this issue for people all over the planet, and second of all, for understanding what President Obama has made clear for many years now, that of course this is a crisis, but it is also an opportunity to make radical changes in energy in America and create millions of good-paying jobs.

Thank you, Madam Chair.

Senator BOXER. Thank you, Senator.

Senator Barrasso.

OPENING STATEMENT OF HON. JOHN BARRASSO, U.S. SENATOR FROM THE STATE OF WYOMING

Senator BARRASSO. Thank you very much, Madam Chairman. I welcome the panel.

It is fascinating, as we attempt to address this issue, that the Pew Research Center did a poll to show where different topics fit into the interest of the American people. And right now, at a ranking of 20 different items of importance to the American people, the issue of addressing climate change ranked 20th, dead last. The American public is dealing with the reality of an economic meltdown, that is a real and an immediate problem.

So with trillions of taxpayer dollars being directed to stimulate, "stimulate" the economy, each next step Congress takes to spend additional funds on anything is going to be watched closely by the American public. We have just passed numerous bailout bills. Senator Inhofe has gone through a chart of the different bailouts that we have been dealing with, passed numerous bailout bills over the last 6 months. Now, a new $787 billion economic bailout intended to create millions of jobs.

We heard in hearings last year that climate change legislation is needed to avert a 4 degree global temperature increase by the year 2050. This will occur only if India and China fall in line and take similar action. Well, China and India are emitting more carbon than the United States. It is essential that they participate in any international effort.

If these countries do enact strict and expensive regulations, we will then avert the 4 degree and instead incur only a 2 degree increase by the year 2050. And that only comes true if the science holds.

But science doesn't stop for policymakers. It continually adds to itself, building upon our knowledge base. That is why I am glad to see these experts here today. Because even now, as many scientists tell us that the earth is warming, the science changes as to the cause of warming. New reports, in a study that I have recently looked at, says that sulfur dioxide emissions from volcanic eruptions may be playing even a larger part in climate change than previously thought, maybe even more important than carbon dioxide. A recent study was released suggesting that analysis of leaves in peat and lake deposits, as opposed to examining the Arctic ice cores, may be a better measurement of the role carbon has played in our climate in the pre-industrial era.

Additional studies have been released suggesting the pace of warming has increased, dramatically increased. The Chairman of the Committee has shown headlines to that effect. I don't think we can ignore any of these studies. If we can't ignore these studies, then we must consider that a cap and trade bill heavily tilted toward capturing carbon at a cost of trillions to the economy could be an outdated solution to the problem.

We have to get this right. So I would say, let's get America's energy as clean as we can, as fast as we can, without raising energy prices on the people of America. That means increasing clean baseload 24 hour, 7 day a week power and making that available as soon as we can. That means clean coal technology, nuclear power, and natural gas.

Let's invest in the technology to retrofit existing power plants and yes, let's augment that with an intermittent renewable power supply. And we have plenty of available renewable power in Wyoming. All of these sources of energy are clean, low to zero carbon emitting and can be developed right here in America. But spending trillions of dollars, trillions of dollars, to address climate change through an untested cap and trade approach, an expensive proposal, is an unnecessarily risky approach. To me, it is a trillion dollar climate bailout. I would say, let's adopt a climate change policy that makes America's energy clean, affordable and domestic.

Thank you very much, Madam Chair.

Senator BOXER. Thanks, Senator.

I just wanted to point out, we have had a cap and trade system to fight acid rain. It has been tested and it has worked.

And I want to point out that we are going to hear from Senators Cardin, Crapo if he is back, and Whitehouse. But at that point, we are going to close off the opening statements and hear from our panel.

Senator Cardin.

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

Senator CARDIN. Thank you, Madam Chair. And let me thank you for this hearing. It is not the first that we have, and I am sure it is not going to be the last to make sure that we have the best scientific information as we move forward to deal with one of the major problems that we face, not only as a Nation, but as a member of the international community.

The scientific information on global climate change has been remarkably consistent. There has really been no major change in the predictions that we have a serious problem. Now, for the people of Maryland, let me talk a little bit about the Chesapeake Bay. The Chesapeake Bay is experiencing radical changes. And it is related to global climate change. Sea level changes, we have seen a lowering of the dissolved oxygen levels, more precipitation, changes in various species and migration patterns, which is jeopardizing not only the economy but the character of my State of Maryland.

So the people of Maryland are concerned about what is happening. And they have a right to expect that this Congress will take up the challenge associated with global climate change.

But the good news is that we all know we have to do something about energy from the point of view of our security. And using less carbon-based energy sources will be good for our economic security. We know that. So this really becomes a win-win situation for our Nation.

So I was proud that President Obama, Madam Chair, last night mentioned that one of his priorities in dealing with our economy is to deal with a carbon cap. Now, I heard Senator Bond and Senator Barrasso talk about the economic impacts of dealing with global climate change. To me, this is a win-win situation. If you reward private companies that can come up with ways to produce energy with emitting less carbon, that is a win. And that is what a carbon cap does. It energizes the private companies to use their ingenuity here in America to lead in technology that will help us not only with a cleaner environment, but with energy security, and will also help our economy by creating more jobs.

And yes, there is a penalty under a carbon cap. If you pollute, you are going to have to pay for the damage you are causing to our economy. To me, that is America. That is what our economy market-based system is based upon that you can make money and help our Country. And that is what the carbon cap is about.

So I heard also the concern about what other countries are doing, and I have heard my colleague talk about it. Well, as President Obama said last night, this is America, we lead. And it is time that we led on this critically important issue.

Now, I congratulate the Chairman, last year for the bill you brought forward, because you recognized the impact that we need to have other countries follow our leadership. And if they produce products that are bad for the environment, with emitting too much greenhouse gases, then there is a price to pay if those products come into America. And I have talked to my friends, parliamentarians from other countries. And we need to work within the WTO, the World Trade Organization, so that we have consistent inter-

national roles to recognize that all of us are citizens of this planet and have a responsibility to reduce carbon emissions.

But if the United States does not lead, it won't get done. That is the responsibility that we hold. And with President Obama's leadership as the President of our United States, we have a unique opportunity, and the world is watching. And I congratulate you, Madam Chair, for holding this hearing, so that our decisions will be based upon the best scientific information.

[The prepared statement of Senator Cardin follows:]

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

Madam Chairman, thank you.

Over the last 2 years we have heard testimony from a number of individuals. A little over a year ago, for example, we heard from Dr. Pachauri, and we are grateful that he has come back to provide us with a further update on the science of global warming.

I want to thank Chairman Boxer for her work in keeping the focus on sound science as this debate continues.

While the list of witnesses has included the occasional obligatory nay-sayer, we have seen a steady stream of scientists who have provided a remarkably consistent set of facts regarding:

- the state of the global climate system,
- projections on how the climate system is changing, and
- the likely impacts these changes will have on health and human welfare, agriculture, transportation systems, and important ecosystems like the Chesapeake Bay.

Much of the testimony has been informed by the latest, peer-reviewed science and represents a consensus of the scientific community on the nature of the climate system's warming, the causes for that warming, and the degree to which this warming will continue.

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

It is not only wildlife that are threatened by climate change—the EPA has found that increasing greenhouse gas concentrations poses a threat to human health due to a number of factors including more deaths attributed to heat and the increase in vector-borne diseases. In Baltimore, the EPA projects that a three degree Fahrenheit overall air temperature increase in air temperature could increase the heat-related death toll by 50 percent from 85 to 130 people annually.

The research upon which these findings are based is rooted in an extensive, careful analysis of past and present observations of the atmosphere and ocean coupled with advanced numerical predictive models.

The science record is remarkable in another key aspect. Time is not on our side. The scientific community consistently warns us that the longer we wait to take aggressive action to curb greenhouse gas emissions, the steeper the climb will be to meet our targets.

Thankfully, today we have not simply a strong scientific consensus on the issue. We also have an increasing body of evidence that our efforts to address climate change will result in a number of net positives for America and the world.

- Our national security is enhanced as we reduce our reliance on foreign sources of oil.
- Our economy will be recharged as we move to a sustainable energy system and the thousands of green jobs it will produce in solar, wind and bio-energy development and energy efficiency projects.
- And lowering greenhouse gas pollution will almost certainly also result in a lowering of other air pollutants, meaning our citizens will be breathing cleaner air.

Thankfully, today we have both an Administration in the White House as well as the congressional leadership we will need to tackle this extraordinary challenge.

I look forward to hearing from today's witnesses and learning more about the latest climate science research.

And I look forward to using this hearing as a strong springboard for us as we confront one of the greatest challenges of our age. With your strong leadership, I

look forward to drafting and passing a climate change bill this year. Let's get started.

Thank you, Madam Chairman.

Senator BOXER. Senator, thank you very much.

I see Senator Crapo isn't here. We will go to Senator Whitehouse. If Senator Crapo comes back, we will go to him and then Senator Udall, and then we will move forward.

Senator Whitehouse.

OPENING STATEMENT OF HON. SHELDON WHITEHOUSE, U.S. SENATOR FROM THE STATE OF RHODE ISLAND

Senator WHITEHOUSE. Thank you, Madam Chair,

I am always reminded when we go through this exercise of debate with our colleagues and friends over whether climate change is really happening of the hearing that you held with the head of the health departments of all the States, came here and gave such a strong, unanimous statement. I asked her, where was the minority report; she said there wasn't one. The health directors of Missouri, of Wyoming, of Idaho, of Oklahoma, were all on board. And I asked, what is the difference, why is there disagreement here? And in a very quiet voice she said, well, we did take an oath to protect the health and safety of our people.

This seems to be the last redoubt where the merchants of doubt can still work their obstructive mischief. And it is unfortunate, I think. You can always find someone who disagrees with any proposition, you can find scientists who disagree with scientific propositions. You can find lawyers who disagree with legal propositions.

But responsible humans act on far less information than this. And even flinty-eyed, rough, tough, profit, bottom-line driven Republican-leaning insurance companies are modifying their decisions and their projections based on this. In Rhode Island, our fishermen see different fisheries. Our nurserymen see the seasons changing. They have seen winter blooms that they have never seen before. Hunters, fishers, naturalists, the black-capped chickadee is the State bird of Massachusetts. And it is being replaced by the Carolina chickadee, because the weather is changing.

We seem to have an inability here to grasp the obvious that people who are out there in the environment, working in the real world and the real environment see every single day. I don't know what it is about this place that makes it so. But it saddens me to hear colleagues cloak this question in economic gloom as well as everything else. I think that is an unfair thing, it is so un-optimistic about America to cloak it in those terms. This could be an area where we are creating jobs, where we are creating exports. This is a place where we can lower families' and businesses' and schools' energy costs.

This is an area where we improve our national security. We don't have to cloak it in economic gloom. I think it is false, I think it is unfortunate. I guess it is rhetorically effective. But I really think it is a shame.

And I hope that the witnesses will talk for a moment during the course of their testimony not just about the warming effect of the carbon load that we are putting into our atmosphere, but also about the ocean acidification effect. Because you know what? Even

if the .05 percent or whatever it is of scientific opinion that doesn't recognize that something serious is going on here is correct, and the warming of the planet may not be related, carbon dioxide is going up. It is going up in unprecedented concentrations. The ocean is a sink for carbon dioxide. It is absorbing it. When it does, it changes the chemistry. I think these are known facts.

What we don't know what happens when the chemistry changes, because we are hitting unprecedented ocean chemistries. But it appears that things like the small mollusks and species that make up krill, for instance, the base of the very oceanic food chain, could find themselves in an environment in which they are unable to make the shells that hold them together out of calcium carbonate in the sea. It could well be that the worst effect for humankind of our carbon emissions is not climate change, but it is ocean change. And I hope that you will address that for a moment in your testimony.

I appreciate very much the Senator's persistent leadership through this. I think that as people look back through time and look for responsible behavior at this moment, they will see her efforts as a shining example and others as regrettable.

Senator BOXER. I thank the Senator, and just know, this is a great Committee. We have a lot of support for this position. Last year we had bipartisan support, and I am hoping we will have it again.

We have been joined by Senator Gillibrand, so we are going to hear from Senator Udall and Senator Gillibrand.

OPENING STATEMENT OF HON. TOM UDALL,
U.S. SENATOR FROM THE STATE OF NEW MEXICO

Senator UDALL. Thank you, Madam Chair. I really want to thank you for all of your work on climate change. When I was in the House of Representatives, I followed what you did over here in the Senate. To me, you were really the leader and stepped out. You put a bill on the floor of the U.S. Senate. We had not had in either chamber a bill on the floor, debated, amended, discussed. I think that helps the American people in an impressive way to start understanding this.

Then once again today, you have brought together a very distinguished panel to address the issue and to get these issues out.

Many of the comments I agree with that were made earlier. I just wanted to talk a little bit about the West, and urge the panelists to address some of the western issues in terms of climate change. I come from a western State, the State of New Mexico. As one scientist described to me vividly, what would happen in New Mexico, he said with just the trend, the conservative trend, not the higher trend or the lower trend, but just the conservative trend of where we are headed would be the equivalent in weather of putting, as you all know when you move these clickers around on a computer screen, click onto the State of New Mexico and drag it 300 miles to the south, which means that New Mexico would then have the weather of Chihuahua, Mexico.

Now, if any of you have been to Santa Fe, my home town, or been to northern New Mexico, the 10,000 foot mountains, the snow pack, if you move New Mexico down to Chihuahua, you imme-

diately wipe out the snow pack, which is the entire water cycle for our region. The snow pack occurs in the winter, drains through the spring. For example, the community of Santa Fe is fed by two reservoirs. Forty percent of the water of Santa Fe is from these two reservoirs.

And I am just using Santa Fe as an example, this would happen all across the West to the snow pack. And I want you to talk about that.

I have also heard, and I think it is a fact, that the West is going to be twice as hot in terms of your models than other parts of the Country. So that also is going to have an impact, not only on water, which we know living in an arid State, we know that water is precious, we know that we have to use it wisely and global warming is going to make it so that we are going to have a lot of difficulty with water. And one of our other major industries, agriculture, which uses water, so that is going to1have an impact.

So I am very happy to see Dr. Christopher Field here. He was someone who mentored a member of my staff that worked with me, Johanna Paulsonberg, on climate matters. She has now moved on to other things, but it was wonderful having her on my congressional staff, having the benefit of her knowledge that she gained from you and from her hard study. So it is great to see you here today and I really look forward to hearing the entire panel.

And once again, I congratulate our Chair for pulling together such a distinguished panel, which I think when the American people hear what these folks have to say, they will understand the urgency that we feel for doing something here today. So thank you, and I yield my time.

Senator BOXER. We are getting very close to that moment.

Senator Gillibrand, you will have the last word. Unless Senator Crapo comes back, you will have the last word.

OPENING STATEMENT OF HON. KIRSTEN GILLIBRAND, U.S. SENATOR FROM THE STATE OF NEW YORK

Senator GILLIBRAND. As your junior member, I will be short and sweet.

Thank you for your extraordinary leadership. I am extremely grateful for your voice for change and for holding this hearing. Thank you to our panelists for coming, sharing your expertise with us. As President Obama said last night, this is an era for solutions. We are looking to you for those solutions and for your guidance on how best to tackle climate change.

In New York State, there is no question that climate change exists. You can talk to our hunters in upstate New York, who are very familiar with the migratory patterns of birds. They know when ice is thawing at a different time of the year. They are very much in tune to how our environment has been affected by global climate change. You can also ask our mayors and city council members downstate, when they have seen massive flooding in regions that previously did not have flooding.

There are so many concerns State-wide that are affecting everyone. With regard to flooding, it is an enormous challenge for municipalities, for our sewer systems that are going to overrun. It is costing enormous amounts of money on the local level. But also, it

has resulted in lives lost and businesses lost and homes lost in upstate New York, in Delaware County, where that 100 year flood seems to be coming every summer. It is an extraordinary challenge that we face. So we do need to focus on the solutions.

I was very, very grateful to President Obama last night, because he talked about a vision for energy independence in the next decade. He talked about the investments in green energy, in new manufacturing, in building materials that are carbon-neutral, and in a cap and trade policy. He talked about how we need to stimulate our entrepreneurs and our innovators to invest in new products, build the electric car. It gets the equivalent of 240 miles per gallon. If we had an electric car that cost $25,000 to buy, it would revolutionize the entire industry. It would revolutionize our environment, and it would be the one thing that could combat global climate change tomorrow.

So the opportunities are clear, and the vision of our President and our leaders in the Senate and the House are also clear. So we look forward to that partnership.

I have many grave concerns that I hope you will address. I was in the Bronx earlier this week, and I was meeting with our local elected leaders. The rates of asthma are so high in many of our inner cities because of pollution and because of issues of climate change. I hope that you can address how these issues translate to my community, to lives lost, businesses lost, homes lost because of flooding, how it translates to the health and welfare of our children because of chronic diseases, including asthma and allergies that are being caused by some of these changes.

Thank you for being here. Thank you for your leadership. Thank you, Madam Senator, for your leadership as our Chairman. I appreciate it very much.

Senator BOXER. Thank you for your leadership.

And now, the moment has arrived. We are going to hear from Dr. R.K. Pachauri, Chairman, United Nations Intergovernmental Panel on Climate Change. It is an honor to have you here, sir. Please proceed for 7 minutes.

STATEMENT OF RAJENDRA K. PACHAURI, PH.D., CHAIRMAN, UNITED NATIONS INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Mr. PACHAURI. Honorable Chairperson of the Committee, Senator Barbara Boxer, honorable members of the Committee, colleagues, distinguished ladies and gentlemen, it is indeed a great privilege to be able to testify before this Committee and provide an update on the latest global warming science.

I shall proceed promptly to give you what I wanted to present, Madam Chairperson. This is just a very quick overview of how the IPCC functions. We have the plenary session, which includes all the governments of the world and essentially represented by people who are scientifically aware of the subject; they approve of the outline of a particular assessment. Then we request governments to give us nominations and CVs of the range of experts who would work on the assessment.

When they are selected, we carry out the drafting of the first version of the report. This is reviewed by experts. Then we get to,

on the basis of comments that we receive, which are carefully logged and documented. We either accept those comments, or where they are rejected, we have to give reasons why they are rejected. And this is done very transparently. Then we move to the second draft and so on.

What I want to emphasize is the fact that this is a very objective, open, transparent process whereby we get the best scientists from all over the world to work on each of these assessments. I also want to ensure I mention that the review process ensures scientific integrity, objectivity, openness and transparency.

We also have great satisfaction in noting that the scientific community has endorsed the findings of the Fourth Assessment Report of the IPCC. This includes the National Academy of Science, the American Meteorological Society, the American Geophysical Union, and the American Association for the Advancement of Science.

Climate science has evolved. We now have much deeper understanding. We have much better observations and data on the basis of which I think science has improved and has progressed from one assessment to the other, culminating in the Fourth Assessment Report we just completed in November 2007.

Just to give you an indication of the scale of the human effort that goes into this, in the Fourth Assessment Report we had 450 lead authors. And these are the actual scientists who write the report. We had 800 contributing authors, and these are people who are specialized in some specific aspect or the other, and they provide inputs. And we had something like 2,500 scientific expert reviewers. So it is a mammoth exercise, and each of these persons work on a voluntary basis. Nobody is paid, nobody gets any benefits.

The input from the American scientific community was overwhelming. If you look at these numbers, in each of the working group we had coordinating lead authors, lead authors, review editors, contributing authors and the total was 825. So I would like to express my gratitude on behalf of the IPCC for the enormous contribution that the scientific community in the U.S. has made to its work.

The warming of the climate system is unequivocal. This is a major finding that we came up with. And I believe there is no cause at all for scientific doubt on this. These are observations of temperature changes that have taken place and you will notice there are ups and downs over here, which is clearly on the basis of natural changes, that the climate obviously is influenced by, and human changes.

But what is particularly significant is the fact that if you look at the last 100 years, Madam Chairperson, you will get an increase of 0.74 degrees Celsius. This is clearly a much steeper slope than you will find for the entire 100 years plus that you see on this graph.

Now, if you look at the last 50 years, the rate of increase has been even faster, almost twice of what we had in the 100-year period from this time before. And finally, let me emphasize that 11 of the last 12 years rank among the 12 warmest in the instrumental record of global surface temperature.

Now, here I would like to show you the observations of temperature changes. If you look at what our models have shown, as a result of just natural factors, then you see a major deviation between observations and the projections of these models. But once you add man-made factors, and that is essentially the concentration of greenhouse gases, you get almost a perfect fit. So I want to emphasize that IPCC's work takes into account all the natural factors that affect climate as well as the human dimensions of what we are doing.

This is a familiar figure, so I shan't spend any time on it. But let me talk of the inequity of climate change impacts. In Africa, for instance, by 2020 our projections show that 75 million to 250 million would be affected by water stress on account of climate change, and crop revenues could drop very rapidly. So we are really causing major distortions and disparities in economic development and growth throughout the world.

I would like to emphasize that delayed emission reductions significantly constrain the opportunities to achieve lower stabilization levels, and therefore this is an urgent task that we have to attend to. If you look at the need to stabilize, let's say temperature increase to 2.0 to 2.4 degrees Celsius, we have only up to 2015 as the window of opportunity, because we will have to ensure that CO_2 emissions peak in that year and decline rapidly thereafter.

Now, this is not going to be an expensive proposition, because our estimate is that for this trajectory of stabilization, the total cost to the global economy will not exceed 3 percent of the global GDP in the year 2030. What does that mean? That means essentially if you had no mitigation, this is the kind of increase you would get, but with mitigation this line bends downwards. Essentially this means that we would only delay the level of prosperity that we are likely to achieve by a few months, or at the most a year.

But the good news is that there are huge co-benefits of mitigation, which the honorable Senators have already mentioned, health co-benefits, much greater employment, increased energy security and mitigation can result in near-term co-benefits that could substantially offset the cost of mitigation, in fact, even lead to negative costs.

Now, I would like to just end by giving some quotations. This is what the Secretary General of the United Nations has said, and finally, some quotations from the President of the United States, President Barack Obama.

Thank you very much, Madam Chairperson.

[The prepared statement of Mr. Pachauri follows:]

TESTIMONY BEFORE THE US SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

Submitted by
Dr. R K Pachauri
Chairman, Intergovernmental Panel on Climate Change (IPCC)
February 25, 2009, Washington, DC

Honorable Chairperson of the Committee, Senator Barbara Boxer, Honorable Members of the Committee, colleagues, distinguished ladies and gentlemen. I am grateful for the opportunity to testify before this Committee to provide an "Update on the Latest Global Warming Science". I submit to the Committee this written testimony and other material that I have presented on other occasions, including a presentation I was privileged to make before this very Committee on January 30, 2008.

The IPCC Fourth Assessment Report (AR4), completed in November, 2007, represents the most comprehensive, updated assessment of the science related to climate change in all its dimensions. One of the findings of this report states "Warming of the climate system is unequivocal". The objective and transparent manner in which the IPCC functions, mobilizing the best talent available across the world, should convey conviction on the strength of its findings to all rational persons, and provide the knowledge base for early action to meet this challenge. The AR4 has emphasized that "delayed emission reductions significantly constrain opportunities to achieve lower stabilization levels and increase the risk of more severe climate change impacts". Some examples of these impacts are:

- The number of people living in severely stressed river basins would go up from 1.4 to 1.6 billion in 1995 to 4.3 to 6.9 billion in 2050.

- Roughly 20-30% of species assessed are likely to be at increasingly high risk of extinction as global mean temperatures exceed 2 to 3 degrees C above pre-industrial levels.

- In some countries of Africa, yields from rainfed agriculture could be reduced by 50% by 2020.

Overall, the differential nature of climate change impacts and the existence of other stresses leave the poor of the world particularly vulnerable. The ethical aspects of this reality need to be considered in the context of economic and political choices that we need to exercise today with a sense of urgency. The global record of mitigation of greenhouse gas (GHG) emissions has not been inspiring. Between 1970 and 2004, for instance, there has been an increase of 70% in GHG emissions and 80% in carbon dioxide emissions.

Yet, mitigation of GHG emissions is economically attractive, particularly since it carries several co-benefits apart from the advantage of stabilizing the concentration of GHGs and, hence, the earth's climate. The IPCC has assessed, for instance, that if temperature increase has to be limited to 2.0 to 2.4 degrees C, then carbon dioxide emissions must peak by 2015, and decline thereafter. The cost of this stringent path of mitigation would

not exceed 3% of the global GDP in 2030. And, if we were to add all the co-benefits that would accrue, such a path of mitigation may actually involve negative costs; in other words, such a path may imply a net increase in economic output and employment, with consequent increase in human welfare. Co-benefits associated with mitigation may include lower pollution at the local level with large health benefits, higher energy security, higher yields in agriculture and greater employment, such as through larger use of renewable energy technologies.

Our knowledge of the scientific aspects of climate change, as brought out in the AR4 of the IPCC, clearly establishes the rationale for early action and the benefits associated with it. It also reveals the heavy cost of inaction that human society and all species would have to incur in the form of increasingly serious impacts of climate change. In this context it would be relevant to quote President Barack Obama:

"Now is the time to confront this challenge once and for all. Delay is no longer an option. Denial is no longer an acceptable response."

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Acceptance Speech for the Nobel Peace Prize Awarded to the Intergovernmental Panel on Climate Change (IPCC)

Delivered by

R K Pachauri, Chairman, IPCC

Oslo

10 December 2007

Your Majesties, Your Royal Highnesses, Honourable Members of the Norwegian Nobel Committee, Excellencies, My Colleagues from the IPCC, Distinguished Ladies & Gentlemen.

As Chair of the Intergovernmental Panel on Climate Change (IPCC) I am deeply privileged to present this lecture on behalf of the Panel on the occasion of the Nobel Peace Prize being awarded to the IPCC jointly with Mr Al Gore. While doing so, I pay tribute to the thousands of experts and scientists who have contributed to the work of the Panel over almost two decades of exciting evolution and service to humanity. On this occasion I also salute the leadership provided by my predecessors Prof. Bert Bolin and Dr Robert Watson. One of the major strengths of the IPCC is the procedures and practices that it has established over the years, and the credit for these go primarily to Prof. Bolin for their introduction and to Dr Watson for building on the efforts of the former most admirably. I had requested Professor Bolin to receive this award on behalf of the IPCC, but ill health prevents him from being with us physically. I convey my best wishes to him. My gratitude also to UNEP and WMO for their support, represented here today by Dr. Mostapha Tolba, one of the founders of the IPCC and Dr. Michel Jarraud respectively. I express my deep thanks also to the Vice-Chairs of the IPCC, Professors Izrael, Odingo and Munasinghe for their contributions to the IPCC over the years.

The Fourth Assessment Report of the IPCC has had a major impact in creating public awareness on various aspects of climate change, and the three Working Group reports as part of this assessment represent a major advance in scientific knowledge, for which I must acknowledge the remarkable leadership of the Co-Chairs of the three Working Groups, Dr Susan Solomon, Dr Qin Dahe for Working Group I; Dr Martin Parry and Dr Osvaldo Canziani for Working Group II; and Dr Bert Metz and Dr Ogunlade Davidson for Working Group III respectively. The Synthesis Report, which distills and integrates the major findings from these three reports has also benefited enormously from their valuable inputs.

The IPCC produces key scientific material that is of the highest relevance to policymaking, and is agreed word-by-word by all governments, from the most skeptical to the most confident. This difficult process is made possible by the tremendous strength of the underlying scientific and technical material included in the IPCC reports.

The Panel was established in 1988 through a resolution of the UN General Assembly. One of its clauses was significant in having stated, "Noting with concern that the emerging evidence indicates that continued growth in atmospheric concentrations of "greenhouse" gases could produce global warming with an eventual rise in sea levels, the effects of which could be disastrous for mankind if timely steps are not taken at all levels". This means that almost two decades ago the UN was acutely conscious of the possibility of disaster consequent on climate change through increases in sea levels. Today we know much more, which provides greater substance to that concern.

This award being given to the IPCC, we believe goes fundamentally beyond a concern for the impacts of climate change on peace. Mr Berge Furre expressed eloquently during the Nobel Banquet on 10 December 2004 an important tenet when he said "We honour the earth; for bringing forth flowers and food – and

trees... The Norwegian Nobel Committee is committed to the protection of the earth. This commitment is our vision – deeply felt and connected to human rights and peace". Honouring the IPCC through the grant of the Nobel Peace Prize in 2007 in essence can be seen as a clarion call for the protection of the earth as it faces the widespread impacts of climate change. The choice of the Panel for this signal honour is, in our view, an acknowledgement of three important realities, which can be summed up as:

1) The power and promise of collective scientific endeavour, which, as demonstrated by the IPCC, can reach across national boundaries and political differences in the pursuit of objectives defining the larger good of human society.

2) The importance of the role of knowledge in shaping public policy and guiding global affairs for the sustainable development of human society.

3) An acknowledgement of the threats to stability and human security inherent in the impacts of a changing climate and, therefore, the need for developing an effective rationale for timely and adequate action to avoid such threats in the future.

These three realities encircle an important truth that must guide global action involving the entire human race in the future. Coming as I do from India, a land which gave birth to civilization in ancient times and where much of the earlier tradition and wisdom guides actions even in modern times, the philosophy of "Vasudhaiva Kutumbakam", which means the whole universe is one family, must dominate global efforts to protect the global commons. This principle is crucial to the maintenance of peace and order today as it would be increasingly in the years ahead, and as the well-known columnist and author Thomas Friedman has highlighted in his book "*The World is Flat*".

Neglect in protecting our heritage of natural resources could prove extremely harmful for the human race and for all species that share common space on planet earth. Indeed, there are many lessons in human history which provide adequate warning about the chaos and destruction that could take place if we remain guilty of myopic indifference to the progressive erosion and decline of nature's resources. Much has been written, for instance, about the Maya civilization, which flourished during 250–950 AD, but collapsed largely as a result of serious and prolonged drought. Even earlier, some 4000 years ago a number of well-known Bronze Age cultures also crumbled extending from the Mediterranean to the Indus Valley, including the civilizations, which had blossomed in Mesopotamia. More recent examples of societies that collapsed or faced chaos on account of depletion or degradation of natural resources include the Khmer Empire in South East Asia, Eastern Island, and several others. Changes in climate have historically determined periods of peace as well as conflict. The recent work of David Zhang has, in fact, highlighted the link between temperature fluctuations, reduced agricultural production, and the frequency of warfare in Eastern China over the last millennium. Further, in recent years several groups have studied the link between climate and security. These have raised the threat of dramatic population migration, conflict, and war over water and other resources as well as a realignment of power among nations. Some also highlight the possibility of rising tensions between rich and poor nations, health problems caused particularly by water shortages, and crop failures as well as concerns over nuclear proliferation.

One of the most significant aspects of the impacts of climate change, which has unfortunately not received adequate attention from scholars in the social sciences, relates to the equity implications of changes that are occurring and are likely to occur in the future. In general, the impacts of climate change on some of the poorest and the most vulnerable communities in the world could prove extremely unsettling. And, given the inadequacy of capacity, economic strength, and institutional capabilities characterizing some of these communities, they

would remain extremely vulnerable to the impacts of climate change and may, therefore, actually see a decline in their economic condition, with a loss of livelihoods and opportunities to maintain even subsistence levels of existence. Since the IPCC by its very nature is an organization that does not provide assessments, which are policy prescriptive, it has not provided any directions on how conflicts inherent in the social implications of the impacts of climate change could be avoided or contained. Nevertheless, the Fourth Assessment Report provides scientific findings that other scholars can study and arrive at some conclusions on in relation to peace and security. Several parts of our reports have much information and knowledge that would be of considerable value for individual researchers and think tanks dealing with security issues as well as governments that necessarily are concerned with some of these matters. It would be particularly relevant to conduct in-depth analysis of risks to security among the most vulnerable sectors and communities impacted by climate change across the globe.

Peace can be defined as security and the secure access to resources that are essential for living. A disruption in such access could prove disruptive of peace. In this regard, climate change will have several implications, as numerous adverse impacts are expected for some populations in terms of:

- access to clean water,
- access to sufficient food,
- stable health conditions,
- ecosystem resources,
- security of settlements.

Climate change is expected to exacerbate current stresses on water resources. On a regional scale, mountain snowpack, glaciers, and small ice caps play a crucial role in fresh water availability. Widespread mass losses from glaciers and

reductions in snow cover over recent decades are projected to accelerate throughout the 21st century, reducing water availability, hydropower potential, and the changing seasonality of flows in regions supplied by meltwater from major mountain ranges (e.g. Hindu-Kush, Himalaya, Andes), where more than one-sixth of the world's population currently lives. There is also high confidence that many semi-arid areas (e.g. the Mediterranean Basin, western United States, southern Africa, and northeastern Brazil) will suffer a decrease in water resources due to climate change. In Africa by 2020, between 75 and 250 million people are projected to be exposed to increased water stress due to climate change.

Climate change could further adversely affect food security and exacerbate malnutrition at low latitudes, especially in seasonally dry and tropical regions, where crop productivity is projected to decrease for even small local temperature increases (1–2 °C). By 2020, in some African countries, yields from rain-fed agriculture could be reduced by up to 50%. Agricultural production, including access to food, in many African countries is projected to be severely compromised.

The health status of millions of people is projected to be affected through, for example, increases in malnutrition; increased deaths, diseases, and injury due to extreme weather events; increased burden of diarrhoeal diseases; increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone in urban areas related to climate change; and the altered spatial distribution of some infectious diseases.

Climate change is likely to lead to some irreversible impacts on biodiversity. There is medium confidence that approximately 20%–30% of species assessed so far are likely to be at increased risk of extinction if increases in global average warming exceed 1.5–2.5 °C, relative to 1980—99. As global average temperature exceeds about 3.5 °C, model projections suggest significant extinctions (40%–

70% of species assessed) around the globe. These changes, if they were to occur would have serious effects on the sustainability of several ecosystems and the services they provide to human society.

As far as security of human settlements is concerned, vulnerabilities to climate change are generally greater in certain high-risk locations, particularly coastal and riverine areas, and areas whose economies are closely linked with climate-sensitive resources. Where extreme weather events become more intense or more frequent with climate change, the economic and social costs of those events will increase.

Some regions are likely to be especially affected by climate change.

- The Arctic, because of the impacts of high rates of projected warming on natural systems and human communities,
- Africa, because of low adaptive capacity and projected climate change impacts,
- Small islands, where there is high exposure of population and infrastructure to projected climate change impacts,
- Asian and African megadeltas, due to large populations and high exposure to sea level rise, storm surges, and river flooding.

The IPCC Fourth Assessment Report concludes that non-climate stresses can increase vulnerability to climate change by reducing resilience and can also reduce adaptive capacity because of resource deployment towards competing needs. Vulnerable regions face multiple stresses that affect their exposure and sensitivity to various impacts as well as their capacity to adapt. These stresses arise from, for example, current climate hazards, poverty, and unequal access to resources, food insecurity, trends in economic globalization, conflict, and incidence of diseases such as HIV/AIDS.

Within other areas, even those with high incomes, some people (such as the poor, young children, and the elderly) can be particularly at risk.

Migration and movement of people is a particularly critical source of potential conflict. Migration, usually temporary and often from rural to urban areas, is a common response to calamities such as floods and famines. But as in the case of vulnerability to the impacts of climate change, where multiple stresses could be at work on account of a diversity of causes and conditions, so also in the case of migration, individuals may have multiple motivations and they could be displaced by multiple factors.

Another issue of extreme concern is the finding that anthropogenic factors could lead to some impacts that are abrupt or irreversible, depending on the rate and magnitude of climate change. For instance, partial loss of ice sheets on polar land could imply metres of sea level rise, major changes in coastlines, and inundation of low-lying areas, with greatest effects in river deltas and low-lying islands.

Global average warming above about 4.5 °C relative to 1980–99 (about 5 °C above pre-industrial) would imply:

- Projected decreases of precipitation by up to 20% in many dry tropical and subtropical areas.
- Expected mass loss of Greenland's ice if sustained over many centuries (based on all current global climate system models assessed) leading to sea level rise up to 4 metres and flooding of shorelines on every continent.

The implications of these changes, if they were to occur would be grave and disastrous. However, it is within the reach of human society to meet these

threats. The impacts of climate change can be limited by suitable adaptation measures and stringent mitigation of greenhouse gas emissions.

Societies have a long record of adapting to the impacts of weather and climate. But climate change poses novel risks often outside the range of experience, such as impacts related to drought, heat waves, accelerated glacier retreat, and hurricane intensity. These impacts will require adaptive responses such as investments in storm protection and water supply infrastructure, as well as community health services. Adaptation measures essential to reduce such vulnerability, are seldom undertaken in response to climate change alone but can be integrated within, for example, water resource management, coastal defence, and risk-reduction strategies. The global community needs to coordinate a far more proactive effort towards implementing adaptation measures in the most vulnerable communities and systems in the world.

Adaptation is essential to address the impacts resulting from the warming which is already unavoidable due to past emissions. But, adaptation alone is not expected to cope with all the projected effects of climate change, and especially not in the long run as most impacts increase in magnitude.

There is substantial potential for the mitigation of global greenhouse gas emissions over the coming decades that could offset the projected growth of global emissions or reduce emissions below current levels. There are multiple drivers for actions that reduce emissions of greenhouse gases, and they can produce multiple benefits at the local level in terms of economic development and poverty alleviation, employment, energy security, and local environmental protection.

The Fourth Assessment Report has assessed the costs of mitigation in the coming decades for a number of scenarios of stabilisation of the concentration of these gases and associated average global temperature increases at equilibrium. A stabilisation level of 445–590 ppm of CO2 equivalent, which corresponds to a global average temperature increase above pre-industrial at equilibrium (using best estimate climate sensitivity) of around 2.0–2.4 °C would lead to a reduction in average annual GDP growth rate of less than 0.12% up to 2030 and beyond up to 2050. Essentially, the range of global GDP reduction with the least-cost trajectory assessed for this level of stabilisation would be less than 3% in 2030 and less than 5.5% in 2050. Some important characteristics of this stabilisation scenario need careful consideration:

- For a CO2-equivalent concentration at stabilization of 445–490 ppm, CO2 emissions would need to peak during the period 2000–15 and decline thereafter. We, therefore, have a short window of time to bring about a reduction in global emissions if we wish to limit temperature increase to around 2 °C at equilibrium.
- Even with this ambitious level of stabilisation the global average sea level rise above pre-industrial at equilibrium from thermal expansion only would lie between 0.4–1.4 metres. This would have serious implications for several regions and locations in the world.

A rational approach to management of risk would require that human society evaluates the impacts of climate change inherent in a business-as-usual scenario and the quantifiable costs as well as unquantifiable damages associated with it, against the cost of action. With such an approach the overwhelming result would be in favour of major efforts at mitigation. The impacts of climate change even with current levels of concentration of greenhouse gases would be serious enough to justify stringent mitigation efforts. If the concentration 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. Subsequent temperature projections

depend on specific emission scenarios. Those systems and communities, which are vulnerable, may suffer considerably with even small changes in the climate at the margin.

Science tells us not only that the climate system is changing, but also that further warming and sea level rise is in store even if greenhouse gases were to be stabilized today. That is a consequence of the basic physics of the system. Social factors also contribute to our future, including the 'lock-in' due, for example, to today's power plants, transportation systems, and buildings, and their likely continuing emissions even as cleaner future infrastructure comes on line. So the challenge before us is not only a large one, it is also one in which every year of delay implies a commitment to greater climate change in the future.

It would be relevant to recall the words of President Gayoom of the Maldives at the Forty Second Session of the UN General Assembly on the 19 October 1987:

"As for my own country, the Maldives, a mean sea level rise of 2 metres would suffice to virtually submerge the entire country of 1,190 small islands, most of which barely rise 2 metres above mean sea level. That would be the death of a nation. With a mere 1 metre rise also, a storm surge would be catastrophic, and possibly fatal to the nation."

On 22 September 1997, at the opening of the thirteenth session of the IPCC at Male, the capital of the Maldives, President Gayoom reminded us of the threat to his country when he said, "Ten years ago, in April 1987, this very spot where we are gathered now, was under two feet of water, as unusually high waves inundated one third of Male, as well as the Male International Airport and several other islands of our archipelago." Hazards from the impacts of climate change are, therefore, a reality today in some parts of the world, and we cannot hide under global averages and the ability of affluent societies to deal with climate-

related threats as opposed to the condition of vulnerable communities in poor regions of the globe.

The successive assessment reports published by the IPCC since 1990 demonstrate the progress of scientific knowledge about climate change and its consequences. This progress has been made possible by the combined strength of growing evidence of the observations of changes in climate, dedicated work from the scientific community, and improved efforts in communication of science. We have now more scientific evidence of the reality of climate change and its human contribution. As stated in the Fourth Assessment Report, "warming of the climate system is unequivocal", and "most of the global average warming over the past 50 years is very likely due to anthropogenic greenhouse gases increases".

Further progress in scientific assessment needs however to be achieved in order to support strong and adequate responses to the threats of climate change, including adaptation and mitigation policies.

There is also notable lack of geographic data and literature on observed changes, with marked scarcity in developing countries. Future changes in the Greenland and Antarctic ice sheet mass are another major source of uncertainty that could increase sea level rise projections. The need for further scientific input calls for continued trust and cooperation from policymakers and society at large to support the work needed for scientific progress.

How climate change will affect peace is for others to determine, but we have provided scientific assessment of what could become a basis for conflict. When Mr. Willy Brandt spoke at the acceptance of the Nobel Peace Prize in 1971, he said, "...we shall have to know more about the origins of conflicts. ... As I see it,

next to reasonable politics, learning is in our world the true credible alternative to force."

At a fundamental level the world now has to create knowledge and practice on a path of development which is not resource degrading and carbon intensive. Human ingenuity and strength are capable of meeting this challenge. Dr. Gro Harlem Brundtland told us 20 years ago of the importance of sustainable development as the path to peace and prosperity. We need to commit ourselves to that path today before it is too late.

The thirteenth Conference of the Parties to the UN Framework Convention on Climate Change is being held in Bali right now. The world's attention is riveted on that meeting and hopes are alive that unlike the sterile outcome of previous sessions in recent years, this one will provide some positive results. The work of the IPCC has helped the world to learn more on all aspects of climate change, and the Nobel Peace Prize Committee has acknowledged this fact. The question is whether the participants in Bali will support what Willy Brandt referred to as "reasonable politics". Will those responsible for decisions in the field of climate change at the global level listen to the voice of science and knowledge, which is now loud and clear? If they do so at Bali and beyond then all my colleagues in the IPCC and those thousands toiling for the cause of science would feel doubly honoured at the privilege I am receiving today on their behalf.

Thank you!

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Speech by Mr Rajendra K. Pachauri

at the Opening Ceremony of the UNFCCC COP 14, Poznán, Poland
(1 December 2008)

Honorable Prime Ministers, Excellencies, Distinguished Ladies and Gentlemen,

I'm here to submit that there is a wealth of information in the Fourth Assessment Report of the IPCC, a large part of which has still not received adequate attention and precise understanding. Hence, impacts of climate change are still seen as distant and undefined. But science has given us precise answers and robust conclusions.

May I in this context inform you of the unique nature of the IPCC. The Panel mobilizes thousands of the best scientists in the world for its assessment of various aspects of climate change. This work is carried out with complete transparency and objectivity in all the procedures followed and peer reviews carried out at each stage of the process by experts as well as governments; the approval and acceptance of the Summary for Policymakers involves all the governments, which gives them direct participation in the process and a full sense of ownership in the work of the IPCC.

From the Fourth Assessment Report we now know the serious impacts of climate change, which would accrue as a result of inaction. We also know the nature of their worldwide implications.

Some examples of these impacts are:

- the number of people living in severely stressed river basins would go up from 1.4 to 1.6 billion in 1995 to 4.3 to 6.9 billion in 2050.

- Roughly 20-30% of species assessed are likely to be at increasingly high risk of extinction as global mean temperatures exceed 2°-3° above pre-industrial levels. We are getting close to that range.

- Abrupt and irreversible changes are possible, such as collapse of the Greenland or West Antarctic ice sheets, which can lead to Sea Level Rise of several meters. For Greenland, the temperature threshold for breakdown is estimated to be about 1.1° to 3.8° C above today's global average temperature. Again we are close to that range too.

- Climate change currently contributes to the global burden of disease and premature deaths. Adverse health impacts will be greatest in low income countries.

- Smallholder and subsistence farmers, who are generally dependent on rainfed agriculture, pastoralists and artisan fisherfolk are likely to suffer complex, localized impacts of climate change.

- Small islands, whether located in the tropics or higher latitudes, have characteristics which make them especially vulnerable to the effects of climate change, sea level rise and extreme events.

- In some countries of Africa, yields from rainfed agriculture could be reduced by 50% by 2020. At the local level many people are likely to suffer additional losses to their livelihoods when climate change and variability occur together with other stresses, such as conflict.

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- If current warming rates are maintained, Himalayan glaciers could decay at very rapid rates. Decline in river flows as a result could affect 500 million people in South Asia and 250 million in China.

The differential nature of climate change impacts and the existence of other stresses leave the poor of the world particularly vulnerable. The ethical aspects of this reality need to be accepted in devising the implementing mitigation actions.

Our collective record of mitigation of GHG emissions has not been very inspiring. Global greenhouse gas emissions have grown, of course, since pre-industrial times, but there has been an increase of 70% between 1970 and 2004. Hence, the record of global action at mitigation has been very weak, even though the UN Framework Convention on Climate Change (UNFCCC) was agreed on in 1992. This record goes against the spirit and intent of the UNFCCC.

Mitigation of emissions of GHGs has various merits and is in itself desirable and feasible in several respects.

If global mean temperature increase is to be stabilized between 2.0-2.4°C, then CO2 emissions must peak by 2015. The cost of such a stringent path of stabilization of the earth's climate would be very modest, if at all a cost would be incurred. For instance, for this trajectory the cost to the global economy would at most be less than 3% of the global GDP in 2030. In fact there are so many co-benefits from such action that if these were to be fully accounted for then these might actually result in a negative cost, or a net increase in economic output and economic welfare.

Large co-benefits of mitigation would include health benefits on account of lower air pollution at the local level, higher energy security, higher yields in agriculture, and greater employment opportunities. The record of those countries that have proactively pursued greater use of renewable energy major improvements in energy efficiency have been able to increase employment in the economy.

But even the trajectory of stabilisation described above would leave some serious problems in the nature of impacts of climate change. We would need to consider whether the effort to limit increase in global mean temperature to about 2 degrees C would be adequate because sea level rise due to thermal expansion alone with this trajectory would be between 0.4 to1.4 meters. Add to this the melting of ice bodies, and we would have serious effects of sea level rise on low lying coastal areas and small islands.

My plea to this august body would be to please listen to and reflect on the voice of science, and please act with determination and a sense of urgency. We in the IPCC do not prescribe any specific action, but action is a must.

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DSDS 2009: Setting the theme
February 5, 2009
Dr R K Pachauri
Director-General, TERI

We are meeting at a critical moment in global developments. The world is going through a serious economic downturn, the like of which has probably not been experienced for seventy five years. At the same time we face the daunting challenge of climate change, which the Secretary General of the UN Mr Ban Ki-Moon has rightly described as "the defining challenge of our age". The Kyoto Protocol which was required to implement the spirit and intent of the UN Framework Convention on Climate Change has clearly fallen short of original expectations. At the same time the scientific evidence of climate change has become stronger and more compelling.

It was in November 2007 that the Synthesis Report as part of the Fourth Assessment Report of the IPCC was released in Valencia, Spain, and the New York Times in a detailed article described it as the "final and most powerful report" brought out by the IPCC. Indeed, this report had a profound effect in shaping the discussions and the final declaration in the Bali Conference of the Parties. Since then, unfortunately, it seems there has been a steady shift in attention from the powerful scientific evidence and findings of this report to a limiting approach that essentially marks "do nothing" positions, so that countries afraid of taking on specific burdens would risk nothing by avoiding an ambitious and effective global agreement. But the burden is already on us and no country in the world can escape the mounting impacts of climate change, which would get progressively worse if we do not tackle the problem at its roots. Our record of reducing emissions of greenhouse gases in very simple terms is far less than satisfactory, if not alarming. Between 1970 and 2004 the increase in GHG emissions globally amounted to 70% and in the case of carbon dioxide, emissions grew by 80% in the same period.

At the same time we are now aware that anthropogenic warming could lead to some impacts that are abrupt or irreversible depending upon the rate and magnitude of climate change. Partial loss of ice sheets on polar land and/or the thermal expansion of seawater over very long time scales could imply meters of sea level rise, major changes in coastlines and inundation of low-lying areas, with greatest effects in river deltas and low-lying islands. We could, therefore, alter the geography of this planet and the spread of human habitation as we see it today. We also know that approximately 20 to 30% of species assessed so far are likely to be at increased risk of extinction if increases in global average warming exceed 1.5 to 2.5°C (relative to 1980-1999). Yet we are focusing our attention to limiting global average temperature increase to between 2° and 2.4°C. The IPCC has clearly brought out some of the negative impacts of even this range of temperature increase if it were to take place. In fact, with stabilization of concentration of GHGs whereby temperature increase would be limited to this range, sea level rise on account of thermal expansion alone would be 0.4 to 1.4 meters. We have two distinguished leaders of small island states with us today - former President Gayoom of the Maldives and President Anote Tong of Kiribati. Can their island nations sustain this threat of sea level rise between 0.4 to 1.4 meters to which effectively we have already committed the world? Can the 160 million people living in Bangladesh continue to occupy their country with sea level rise of this magnitude? Yet the figure that I have quoted is for thermal expansion alone. Add to this the fact of extensive melting of the bodies of ice across the planet, and the threat becomes far more serious.

May I also emphasize that the impacts of climate change would leave no part of the globe untouched. This week itself we have seen voluminous snowfall in Great Britain, as a result of which life came to a halt in several parts of that country. This may not have been the result of human induced climate change, but the IPCC's assessment of an increase in extreme

precipitation events would certainly replicate what has happened in Britain several times over and in several locations. Australia last week had a severe heatwave in several locations, as a result of which people lost their lives. This isolated event again may not be the result of human induced climate change, but the aggregation of such events has the unmistakable signature of human influence on the earth's climate. The IPCC also projects in the case of Australia a decline from production of agriculture and forestry over much of its Southern and Eastern regions. In the case of Africa some countries would see agricultural yields being reduced by upto 50% as early as 2020.

The UN Framework Convention on Climate Change had very clearly defined the ultimate objective of the Convention as the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner".

Science cannot provide an answer to what is dangerous. But science has given substantial evidence on the impacts of climate change in different parts of the world and at temperature increases very close to where we are today. Hence, why is it that the global community shies away from defining what would represent a level of dangerous anthropogenic interference? It seems to me that before we arrive at a shared vision on any aspect of climate change we must first develop a clearly articulated and shared vision of what would represent dangerous anthropogenic interference with the climate system using all the scientific evidence & information available. And, in this we should not be looking for an average value for the globe but rather what would be dangerous for the most vulnerable communities on earth. In this respect the ethical and equitable dimensions of the situation, which is the theme of the summit,

must guide the shared vision of all countries and towards the agreement that is concluded in Copenhagen. Those that are prosperous must accept their responsibility and be totally sensitive to the danger confronting the most vulnerable societies on earth, which are also incidentally some of the poorest communities on the globe. And they are in no way responsible for causing this global problem.

A major scientific reality, which the IPCC Fourth Assessment Report brought out clearly was the unexpectedly low cost of stringent mitigation and the huge co-benefits associated with it. Indeed, if we remove the barriers in implementation, in several cases mitigation can be achieved at negative cost, and with local and national benefits that are disproportionately large. Perhaps President Obama has realized this truth, and is, therefore, focusing on reviving the economy through a process of green growth and what could be termed as redevelopment. Paul Ehrlich divided the world, over twenty years ago, into developing countries, developed countries and mal-developed countries. If we accept his view then the mal-developed countries need to take action by which the first three letters describing them can be shed as rapidly as possible.

So these are some of the issues that must define our approach to an agreement in Copenhagen. Time prevents me from going into greater scientific detail, but I would only end by saying that the evidence is overwhelming, and we must keep that completely in focus to ensure that we do not escape responsibility for action, because the result of inaction would go against the survival of many species, with reduced welfare and possibly enhanced conflict within human society. The scientific evidence has to be placed within a strong & logical framework, which we hope leaders across the world and their negotiators are able to devise such that ethics and equity determine any agreement that we arrive at.

WMO
UNEP
Key findings from the IPCC
Fourth Assessment Report
R K Pachauri
Chairman, IPCC
Director-General, TERI
US Senate Committee on
Environment and Public Works
25th February 2009
IPCC

PLENARY
approves outline
Author
selection
1st
DRAFT
Expert
review
2nd
DRAFT
Expert /
Government
review
FINAL
DRAFT
Government
distribution
PLENARY
Accepted/approved
report
Peer reviewed scientific technical literature
IPCC

Review process of the IPCC assessment reports

1. **Experts** review the first draft of the report
2. **Governments** and **experts** review the second draft of the report and the draft Summary for Policymakers
3. **Governments** review word-by-word the revised draft Summary for Policymakers

➢ **Review process ensures scientific integrity, objectivity, openness and transparency**

Endorsement within the scientific community

Over recent years the IPCC has effectively become the **voice of the mainstream scientific community**

In the US, the IPCC has been repeatedly vetted and endorsed by:

- the National Academy of Science
- the American Meteorological Society
- the American Geophysical Union
- the American Association for the Advancement of Science

Evolution of climate science

Deeper understanding and quantification of the processes governing the climate system have progressed rapidly since the IPCC First Assessment Report (1990)

- These advances have arisen from new data, more sophisticated analyses of data, improvements in understanding and simulation of physical processes and more extensive exploration of uncertainty ranges

The increased confidence in climate science is evident in the **IPCC's Fourth Assessment Report**

The IPCC Fourth Assessment Report (AR4) Process

+2500 scientific expert reviewers
800 contributing authors
450 lead authors from
+130 countries

Authors, Contributors, Reviewers and other Experts

They are selected by the Working Group Bureaus from nominations received from governments and participating organizations or identified directly, because of their special expertise reflected in their publications and works

The composition of lead author teams for chapters of IPCC reports shall reflect a range of views, expertise and geographical representation

They work on a voluntary basis

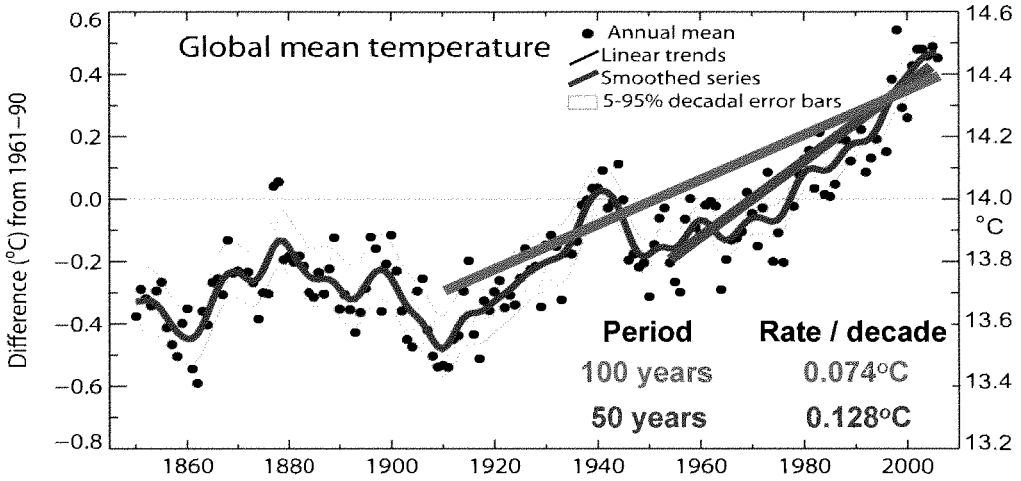
Scientists from the US who worked on the IPCC Fourth Assessment Report

	CLA	LA	RE	CA	Reviewers	Grand Total
WGI	10	32	6	181	188	
WGII	7	15	7	43	209	
WGIII	5	21	3	30	68	
TOTAL	22	68	16	254	465	**825**

Key findings of the IPCC Fourth Assessment Report:

"Warming of the climate system is unequivocal"

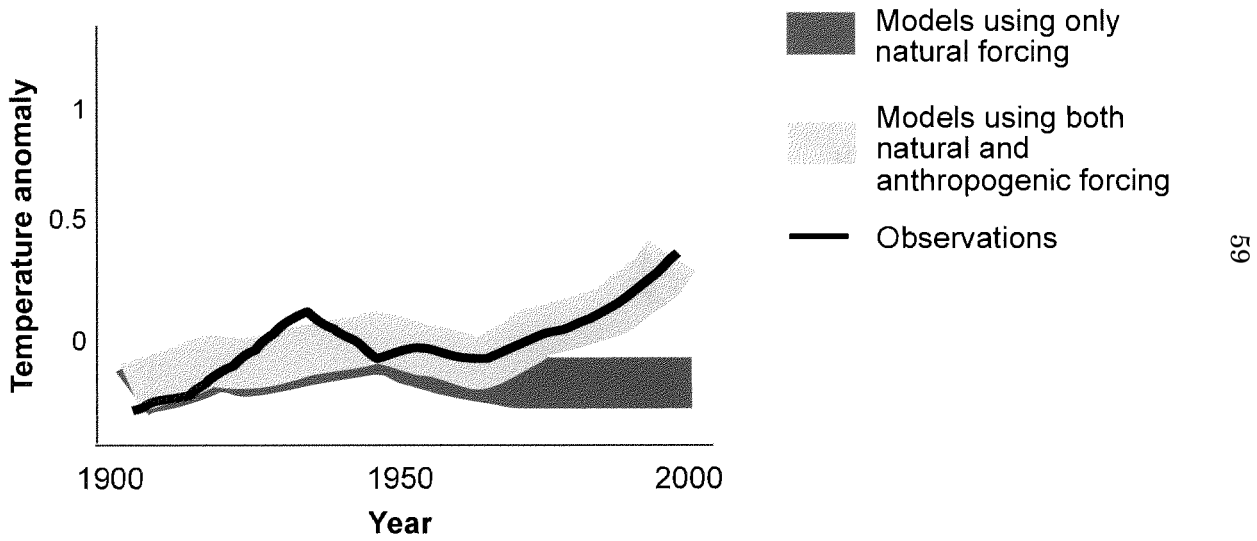
Changes in global average surface temperature



Eleven of the last twelve years rank among the twelve warmest years in the instrumental record of global surface temperature

IPCC

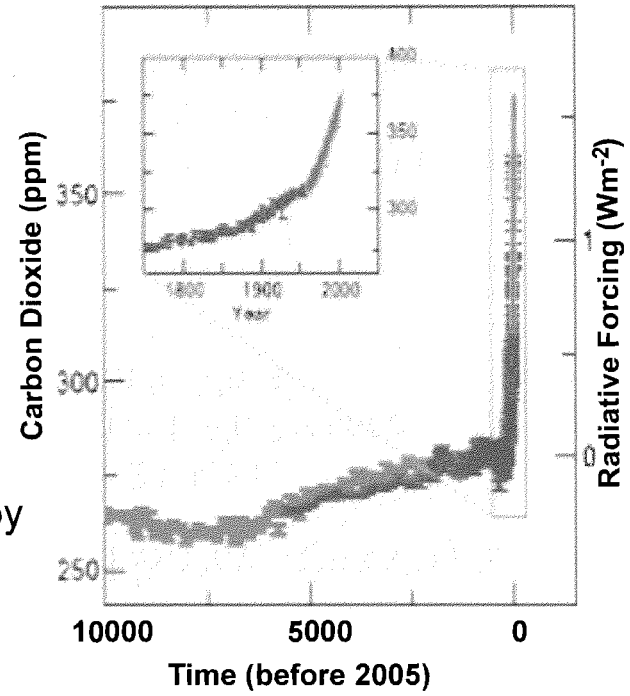
Global temperature change



Carbon dioxide emissions

Global atmospheric concentrations of greenhouse gases (GHG) increased markedly as a result of human activities, with an increase of **70% in 1970-2004**

U.S. emissions have risen by **14.7% in 1990-2006***



*Source: EPA, 2008

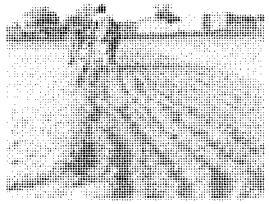
IPCC

Expected impacts on poor regions

People exposed to increased **water stress** by 2020:

- 120 million to 1.2 billion in Asia
- 12 to 81 million in Latin America
- 75 to 250 million in Africa

Possible **yield reduction** in agriculture:



- 30% by 2050 in Central and South Asia
- 30% by 2080 in Latin America
- 50% by 2020 in some African countries

Crop revenues could fall by 90% by 2100 in Africa

Key findings of the IPCC Fourth Assessment Report:

"Delayed emission reductions significantly constrain the opportunities to achieve lower stabilisation levels and increase the risk of more severe climate change impacts"

Stabilisation scenarios

Global mean temp. increase (°C)	Stabilization level (ppm CO_2-eq)	Year CO_2 needs to peak
2.0 – 2.4	445 – 490	2000 – 2015
2.4 – 2.8	490 – 535	2000 – 2020
2.8 – 3.2	535 – 590	2010 – 2030
3.2 – 4.0	590 – 710	2020 – 2060

Costs of mitigation in 2030

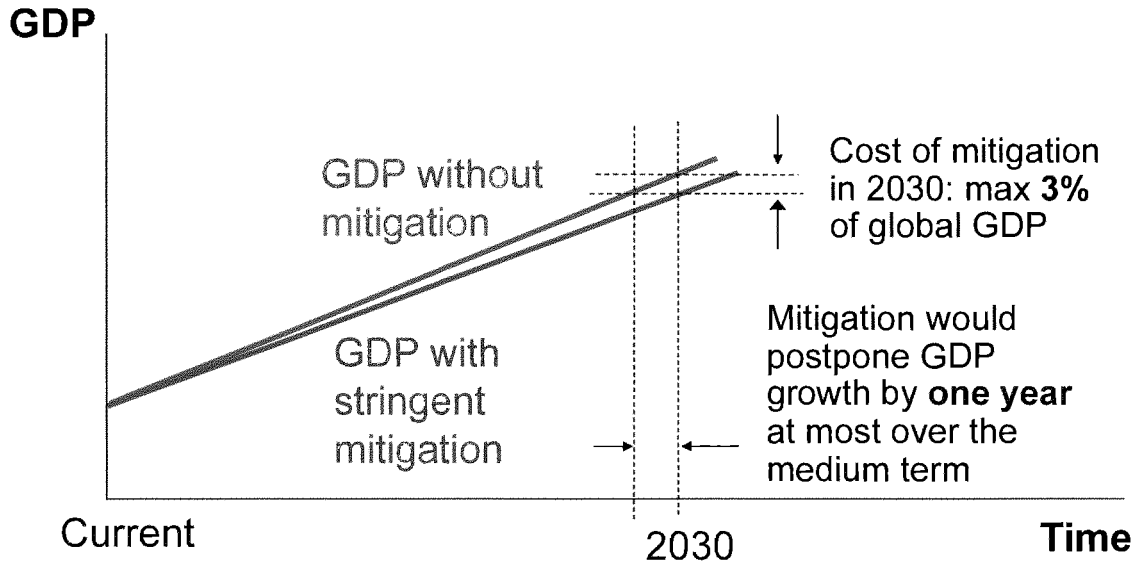
Stabilisation levels (ppm CO2-eq)	Range of GDP reduction (%)	Reduction of average annual GDP growth rates (percentage pts)
445 - 535	< 3	< 0.12
535 - 590	0.2 – 2.5	< 0.1
590 - 710	-0.6 – 1.2	< 0.06

Mitigation measures would induce 0.6% gain to 3% decrease of GDP in 2030

IPCC

Impacts of mitigation on GDP growth

(for stabilisation scenario of 445-535 ppm CO_2-eq)



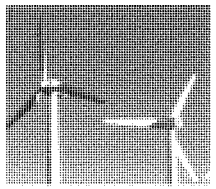
Schematic graph

IPCC

Main co-benefits of mitigation

- ✓ **Health** co-benefits from reduced air pollution
  - Benefits range from 30-50% of estimated mitigation costs up to a factor of 3 to 4
- ✓ More **employment**
  - Solar PV and wind-energy generate 5.7 person-years of employment per 1 million US$ investment (over ten years); while coal industry generates only 4
- ✓ Increased **energy security**

➢ **Mitigation actions can result in near-term co-benefits that may offset a substantial fraction of mitigation costs**



All stabilisation levels assessed can be achieved by deployment of a portfolio of **technologies that are currently available or expected to be commercialised** in coming decades

This assumes appropriate and effective **incentives** are in place for their development, acquisition, deployment and diffusion

"Today, the time for doubt has passed. The IPCC has unequivocally affirmed the warming of our climate system, and linked it directly to human activity"

Mr Ban Ki-moon
Secretary General, United Nations

"Now is the time to confront this challenge once and for all. Delay is no longer an option. Denial is no longer an acceptable response."

"Climate change is real. It is something we have to deal with now, not 10 years from now, not 20 years from now."

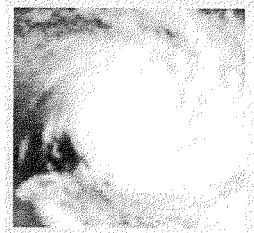
- Barrack Obama

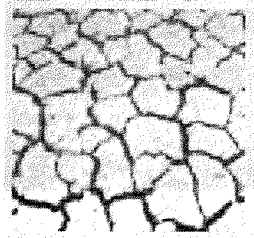
WMO

UNEP

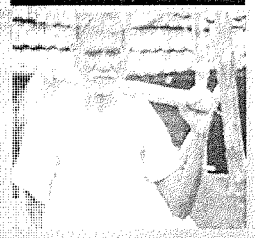
Mitigating Climate Change

R. K. Pachauri
Chairman, IPCC
Director-General, TERI





Senate Environment and Public Works Committee
Washington DC
January 30, 2008



IPCC

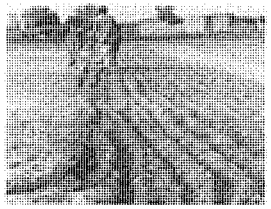
Continued GHG emissions
at or above current rates would cause
further warming and induce
many changes in the global climate
system during the 21st century that
would very likely be **larger than those
observed during the 20th century**

Impacts on poor regions

People exposed to increased water stress by 2020:

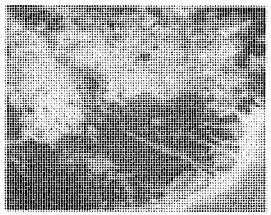
- 120 millions to 1.2 billion in Asia
- 75 to 250 millions in Africa
- 12 to 81 millions in Latin America

Possible yield reduction in agriculture:



- 50% by 2020 in some African countries
- 30% by 2050 in Central and South Asia
- 30% by 2080 in Latin America

Abrupt or irreversible impacts



Partial loss of ice sheets on polar land could imply several metres of sea level rise

20-30% of species are likely to be at risk of extinction if increases in warming exceed 1.5-2.5°C

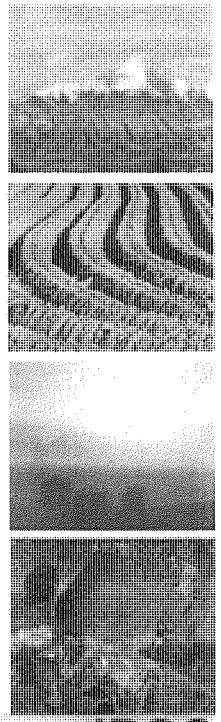
Impacts on North America

Warming in western **mountains** is projected to cause decreased snowpack and reduced summer flows, exacerbating competition for over-allocated water resources

Major challenges are projected for **crops** that are near the warm end of their suitable range or which depend on highly utilized water resources

Increased number, intensity and duration of **heatwaves** will have potential for adverse health impacts

Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution



IPCC

Defining mitigation targets

Climate system inertia: even if GHG concentrations were held constant, further warming trend would occur in the next two decades at a rate of about 0.1°C per decade

Energy system inertia: delayed emission reductions lead to investments that lock in more emission intensive infrastructure and development pathways

Choices about the scale and timing of GHG mitigation involve balancing costs of emission reductions against risks of delay

Stabilisation scenarios

Stabilization level (ppm CO_2-eq)	Global mean temp. increase (°C)	Year CO_2 needs to peak	Global sea level rise above pre-industrial from thermal expansion (m)
445 – 490	2.0 – 2.4	2000 – 2015	0.4 – 1.4
490 – 535	2.4 – 2.8	2000 – 2020	0.5 – 1.7
535 – 590	2.8 – 3.2	2010 – 2030	0.6 – 1.9
590 – 710	3.2 – 4.0	2020 – 2060	0.6 – 2.4

Mitigation efforts over the next two to three decades will have a large impact on opportunities to achieve lower stabilisation levels

IPCC

Co-benefits of mitigation

Health co-benefits from reduced air pollution

Increased **energy security**

More rural **employment**

Increased **agricultural production** and reduced pressure on **natural ecosystems**, due to decreased tropospheric ozone concentrations

Co-benefits of mitigation action offset mitigation costs and provide the opportunity for no-regrets policies

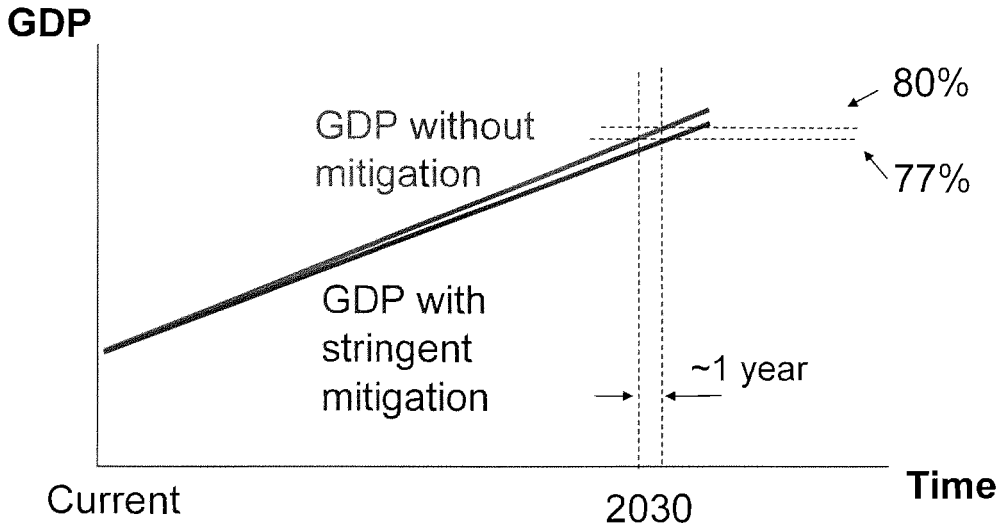
Costs of mitigation in 2030

Stabilisation levels (ppm CO2-eq)	Range of GDP reduction (%)	Reduction of average annual GDP growth rates (percentage pts)
590 - 710	-0.6 – 1.2	< 0.06
535 - 590	0.2 – 2.5	< 0.1
445 - 535	< 3	< 0.12

Mitigation measures would induce 0.6% gain to 3% decrease of GDP in 2030

IPCC

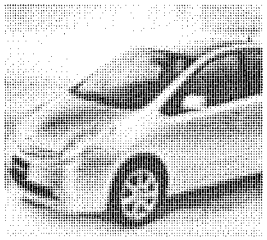
Impacts of mitigation on GDP growth



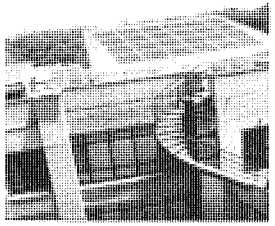
Stringent mitigation would postpone GDP growth of one year at most over the medium term

IPCC

Potential and cost of mitigation



All stabilisation levels assessed can be achieved by deployment of a portfolio of **technologies that are currently available or expected to be commercialised** in coming decades



This assumes that **investment flows, technology transfer and incentives** are in place for technology development

Why adhere to deep cuts in GHG emissions?

Companies that take the lead would meet with success in both business and societal contexts

- ✘ Those that lag behind would suffer from losses in the marketplace and loss of reputation

Nations that show commitment to the growing global consensus would gain prestige

- ✘ Those that stand unmoved would lose political power and influence

The role of the US

US action on mitigation will:

- enable the achievement of global stabilisation targets
- ensure US competitiveness in a world market dominated by low-carbon products
- re-establish confidence in US leadership on critical global issues

Man did not weave the web of life,
he is merely a strand in it.

Whatever he does to the web,
he does to himself.

Chief Seattle, 1854

Environment and Public Works Committee Hearing
February 25, 2009
Follow-Up Questions for Written Submission

Questions for Pachauri

Senator Benjamin L. Cardin

1. The International Energy Association estimates that the world's power demands will rise 60% by 2030. Electricity generators consumed 36 percent of U.S. energy from fossil fuels and emitted 41 percent of the C02 from fossil fuel combustion in 2006. (EPA estimates)

a. Is it feasible to reduce substantially that projected increase through energy conservation strategies in a world economy that is predicated on economic growth?

b. What is your opinion of increasing nuclear power to provide an immediate reduction in greenhouse gas emissions?

2. In her 'Principles for Climate Change Legislation," Chairman Boxer expressed interest in aiding developing countries.

c. What role should the U.S. play in aiding developing nations' carbon mitigation strategies?

d. Would a technology transfer to developing nations for carbon credits be feasible in a cap-and-trade carbon market system?

e. Deforestation releases vast quantities of C02 as trees are removed and burned, and also causes a permanent loss of C02 uptake capacity. Deforestation causes 17.3% of all OHO emissions. By treating preserved forested land as a natural carbon sink, developing countries would have economic incentive to preserve their forest. Could a carbon credits for avoided deforestation scheme work in a cap-and-trade system?

Answers

1(a) The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) clearly establishes the fact that to begin a process of stringent mitigation all the technologies that we need are either available today or likely to be commercialized soon. After the introduction of these technologies and their dissemination we would need innovation and the development of new technologies. For this to happen, a package of policies would need to be put in place to bring about innovation. An appropriate price on carbon would be an important part of such policies.

1(b) The IPCC has projected that nuclear energy use is likely to grow. Of course,

nuclear energy does have associated with it several characteristics which need careful consideration including safety issues, disposal of waste and other risks. It is, however, a technology that can result in substantial reduction of greenhouse gas emissions in relation to fossil fuel based power generation.

2 (c) The US can play an important role in financing incremental costs of mitigation technologies in relation to baseline technologies that would be used in the normal course in developing countries. The US can also assist developing countries in accessing low carbon technologies and support a range of adaptation measures.

2 (d) If developing countries are part of a carbon trading system then they would be able to utilize clean technologies in a cap and trade carbon market system. In this context it would be essential for an agreement in Copenhagen to provide an adequate role for a program such as the Clean Development Mechanism (CDM).

2(e) It is expected that the Copenhagen agreement would include avoided deforestation measure. With appropriate verification, monitoring and measurement of avoided deforestation, it is entirely feasible to provide carbon credits in a cap and trade system. Again the agreement in Copenhagen would have to allow transfer of carbon credits for avoided deforestation to ensure that developed countries regard this as a means to meet part of their own commitments.

Senator Bernard Sanders

1 . I am a firm believer that we should discuss both the harm avoided *and* the benefits gained that come with tackling climate change. There are real, tangible economic opportunities to be realized in reducing greenhouse gases. Your testimony addresses many of the likely benefits of tackling our greenhouse-gas emissions problem. Can you speak specifically to the potential jobs created by enacting strong climate legislation?

Answer

1 Strong climate legislation can lead to the creation of potential jobs, such as in the renewable energy industry. For instance, the experience of Germany is very heartening. In that country a new sector of industrial development has come into place as a result of policies to substitute the use of fossil fuels.

Senator James M. Inhofe

1. Dr. Pachauri, we are continually receiving new data all the time on climate. Just this week we learned that the U.S. National Snow and Ice Data Center underestimated Arctic sea ice by 193,000 square miles – that is an underestimation the size of California. The error was due to a "sensor drift" which showed ice covered sea as "open ocean." Based on your testimony, it also seems now that the IPCC is now touting that the "consensus" also exists on the economics of climate mitigation. However, studies from EPA, EIA, MIT, CRA, etc. all show carbon mitigation imposing economic costs to varying degrees.

Can you explain why the IPCC is different? What model do they use? What assumptions do they make about energy prices, energy supplies, emissions, economic/population growth, etc?

2. Paleoclimate expert Augusto Mangini of the University of Heidelberg in Germany, criticized the UN IPCC summary. "I consider the part of the IPCC report, which I can really judge as an expert, i.e. the reconstruction of the paleoclimate, wrong," Mangini wrote. He added: "The earth will not die."

South African Nuclear Physicist and Chemical Engineer Dr. Philip Lloyd, a UN IPCC co-coordinating lead author who has authored over 150 refereed publications: "The quantity of C02 we produce is insignificant in terms of the natural circulation between air, water and soil... I am doing a detailed assessment of the UN IPCC reports and the Summaries for Policy Makers, identifying the way in which the Summaries have distorted the science."

Victor Manuel Velasco Herrera, a researcher at the Institute of Geophysics of the National Autonomous University of Mexico: "The models and forecasts of the UN IPCC "are incorrect because they only are based on mathematical models and presented results at scenarios."

Indian geologist Dr. Arun D. Ahluwalia at Punjab University and a board member of the UN-supported International Year of the Planet: "The IPCC has actually become a closed circuit; it doesn't listen to others. It doesn't have open minds... I am really amazed that the Nobel Peace Prize has been given on scientifically incorrect conclusions by people who are not geologists."

Dr. Pachuari, does the UN IPCC have a problem with its credibility if even current and former IPCC scientists are openly questioning the conclusions of your group?

3. In 2008, Dr. Nicholas Drapela of the faculty of Oregon State University Chemistry Department described the UN IPCC this way:

"The International Panel on Climate Change is a body of the United Nations. It is not a scientific body; it is a political body."

Dr. John Brignell, a UK Emeritus Engineering Professor at the University of Southampton who held the Chair in Industrial Instrumentation at Southampton, accused the UN of "censorship" on July 23, 2008.

Dr. Brignell wrote: "Here was a purely political body posing as a scientific institution. Through the power of patronage it rapidly attracted acolytes. Peer review soon rapidly evolved from the old style refereeing to a much more sinister imposition of The Censorship. As [past Chairman of the National Academy of Sciences Committee on Theoretical and Applied Statistics Dr. Edward] Wegman demonstrated, new circles of like-minded propagandists formed, acting as judge and jury for each other. Above all, they acted in concert to keep out alien and hostile opinion. 'Peer review' developed into a

mantra that was picked up by political activists who clearly had no idea of the procedures of science or its learned societies. It became an imprimatur of political acceptability, whose absence was equivalent to placement on the proscribed list."

Dr. Pachuari, can you comment on this and explain how you ensure that the peer-review process remains objective and transparent?

4. One of your critics, Professor Richard Lindzen of MIT, has stated that "(The IPCC) has decided that they have to convince other people that since no scientist disagrees you shouldn't disagree either. Whenever you hear that in science, it's pure propaganda." How do you respond to this?

5. Another IPCC scientist not happy with your group's process has accused the IPCC of ignoring skeptical comments.

IPCC 2007 Expert Reviewer Madhav Khandekar, a PhD meteorologist, a scientist with the Natural Resources Stewardship Project who has over 45 years experience in climatology, meteorology and oceanography, and who has published nearly 100 papers and reports. "To my dismay, IPCC authors ignored all my comments and suggestions for major changes in the First Order Draft and sent me the Second Order Draft with essentially the same text as the First Order Draft. None of the authors of the chapter bothered to directly communicate with me (or with other expert reviewers with whom I communicate on a regular basis) on many issues that were raised in my review. This is not an acceptable scientific review process."

Dr. Pachuari, how concerned are you about the IPCC scientific review process and how do you plan to fix the problems?

6. A recent report quoted the UN IPCC's William Schlesinger as admitting that only 20% of IPCC scientists deal with climate. Can you explain how the scientific makeup of the IPCC works and why Mr. Schelsinger made such a statement?

Answers

1. The IPCC carries out its assessment on the basis of peer reviewed literature which appears in the leading scientific journals of the world. In doing so we take into account a range of research results, which then lead to robust scientific consensus. The IPCC uses no single model, but an ensemble of the most reliable models used by researchers all over the world. In respect of energy prices, energy supplies, economic and population growth, etc., the IPCC came up nine years ago with a detailed document published as a special report on emissions scenarios. This report which was extensively peer reviewed in keeping with IPCC procedures, has projected a number of diverse scenarios which represent plausible outcomes on the basis of range of assessments on future economic growth, population, energy supplies and prices, etc. For the Fifth Assessment Report, which is due to be taken up by the IPCC very shortly, we would use a new set of future scenarios which the IPCC itself will not develop but which will be produced by the scientific community at large. The IPCC, in keeping with its normal practice assesses a wide range of research results which are published. The studies quoted by the Senator from the EPA, EIA, etc. which if published and available in the public domain will

certainly be utilized by the IPCC in its next Assessment Report.

2. The opinions that have been quoted from the engineers, scientists, etc. are personal opinions which I can hardly comment on. I would humbly suggest that the Honorable Senator also include the positive views and information about the work of the IPCC, which I am sure would be found difficult to fit into a very large volume of paper.

I beg to differ on any questioning of the IPCC's credibility. If there is a problem of credibility it lies with the so called scientists who continue to question facts even in the face of overwhelming evidence and proof. However, we live in a free world and people are at liberty to express their views. Happily the views of this misguided minority are now shrinking rapidly because the world is getting to understand the scientific realities about climate change.

3. I would not dignify the distinguished member of the faculty of the Oregon State University with a response. The work of the IPCC is carried out by the most distinguished experts from all over the world and in my testimony I explained in detail the manner in which the IPCC functions, which is transparent, objective and guided entirely by scientific expertise. Calling the IPCC names will certainly not provoke me into saying anything that would sink to the same level of ignorance and dogma that these comments convey. With due respect, therefore, Senator I would decline any comment on the specific allegations made by these worthy "so called" scientists who you have quoted. I only hope that some time soon they will see the light of day.

4. I would respond similarly to the comments of Prof. Richard Lindzen.

5. All the comments received by expert reviewers are posted on our website clearly indicating which comments have been accepted by authors as well as specific reasons for those that are not accepted. Not accepting a specific comment is guided purely by the scientific judgement of the author and we are fully aware that some may feel slighted and have their egos hurt by rejection of expert reviews provided by them. For the information of the Honorable Senator may I say that in the Fourth Assessment Report of the IPCC approximately 2500 expert reviewers provided their comments. I would like to ask how many of these were unhappy and resorted to calling the IPCC names just because any comment provided by anyone of them was not accepted.

6. I would be happy to send you the CVs of the 450 odd coordinating lead authors and lead authors who participated in the Fourth Assessment Report. I shall do the same if required with those who are selected for the Fifth Assessment Report in future. I hope that would establish that the person you have quoted is completely off the mark when it comes to describing the qualifications of the IPCC scientists.

Senator Mike Crapo

1) In a February 2009 speech, you stated that the "IPCC Fourth Assessment Report brought out clearly the unexpectedly low cost of stringent mitigation and the huge co-benefits associated with it." You also stated that "in several cases mitigation can be achieved at negative costs, and with local and national benefits that are disproportionately

large."

In July 2008 you stated, "India cannot be held for any emission control. They (developed countries) should get off the back of India and China." You also stated, "We are an expanding economy. How can we levy a cap when millions are living with deprivation?

To impose any cap (on India) at a time when others (industrialized countries) are saying that they will reach the 1990 level of emission by 2025 is hazardous."

You also said that you cannot just ask a country to "stop developing."

How do you reconcile the comments that express the positive economic effects of mitigation with the comments you made last July about the negative effects of emission cuts on China and India? How can emission cuts be good for our economic development but bad for China and India?

2) If the U.S. completely shut down its carbon output from the power sector, by the year 2100, China's growth in emissions alone is predicted to surpass the emissions cut from the U.S. power sector. In fact, if the U.S. shut down all of its fossilfueled power, the estimated decrease in temperature by the year 2100 would be a mere .07 degrees Celsius.

How can we then, achieve realistic carbon emission goals without the participation of developing countries like China and India?

Answers

1. The problem of human induced climate change has been caused by the cumulative emissions of greenhouse gases which have taken place historically. Hence, on this basis the historical responsibility for reducing emissions lies essentially with the developed world. Itwas in keeping with this reality that the United Nations Framework Convention on Climate Change (UNFCCC) had a clear provision for "common but differentiated responsibility" requiring the developed world to take the first steps in emissions reduction. In the developing countries there is a widespread continuation of poverty and an urgent need for development, in the course of which consumption of fossil fuels for some time will be inevitable.

Undoubtedly, emission cuts would affect the global atmosphere irrespective of where they take place, whether it is China, India or the U.S. However, there is an issue of fairness and historical responsibility. The developed world has reached its level of prosperity by essentially using up the environmental space in the earth's atmosphere which the developing world has not yet been able to do. In order to allow the removal of poverty the developed world will have to create that space by cutting down on emissions as a first set of measures. In essence, if I could use an analogy in a situation where we have to limit food consumption say in the case of food scarcity we would certainly not ask someone who is undernourished or hungry to accept equal cuts but rather ask those who have a problem of plenty to do so. The space available in the earth's atmosphere can be considered in similar light. May I put forward the fact that there are about a billion people in this earth living on less than a dollar a day. There are about 1.6 billion people in

the earth who have no access to electricity. Many of these live in darkness once the sun goes down. May I also mention that while the U.S. accounts for emissions of over 20 tonnes per capita of greenhouse gases, China accounts for little over 4 and India about 1.1tonnes per capita. Hence the stages of economic development are very different in different parts of the world, and on no ethical, scientific or humanitarian reasons can onejustify equal treatment across the board for all societies in the world.

2. I am not sure of the figures quoted here if the U.S. were to shut down all of its fossil fuel power, the estimated decrease in temperature by the year 2100 would be a mere .07°C. Unless I know the basis of this figure it would be difficult for me to comment on it. But, prima facie I would say this estimate is wrong. The U.S. has increased its emissions substantially in the past few decades and if the same trend continues the impact on the global climate could be destabilizing in different parts of the world. It is also true that the worst impacts of climate change will be felt by some of the poorest communities in the world and hence this is a reality that must guide actions in the U.S.

Senator BOXER. Dr. Christopher Field, Director, Department of Global Ecology, Carnegie Institute for Science, at Stanford. And he was Co-Chair of Working Group II, which looked at the problems that we will be facing in our continent here. So we are very anxious to hear from you, sir.

STATEMENT OF CHRISTOPHER FIELD, PH.D., DIRECTOR, DEPARTMENT OF GLOBAL ECOLOGY, CARNEGIE INSTITUTION FOR SCIENCE, STANFORD UNIVERSITY; CO-CHAIR, WORKING GROUP II, UNITED NATIONS INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Mr. FIELD. Thank you, Madam Chairman and members of the Committee.

It is a pleasure to review the latest updates on the science and to give you a feel for the way that the reports of the Intergovernmental Panel on Climate Change serve as a very strong foundation for new observations that are coming together all the time. These two pieces fit together in a comprehensive and increasingly compelling way.

I want to repeat a couple of the comments that Dr. Pachauri made about the strength of the IPCC process. The numbers of scientists who participate in the IPCC is, of course, very, very large. But what is important about the process is that it represents an incredibly consistent distilling. Every statement that makes its way into the IPCC is challenged, tested, challenged again. And by the time a statement makes it into the IPCC reports, it has really passed an incredibly high threshold. This is to be contrasted with the broader scientific literature, which includes a wide range of results that are interesting ideas and stand the initial test of time but haven't really been exposed to the kind of tests that the IPCC reports are, incredibly important distinction about the value of assessments.

Perhaps the key conclusions from the Fourth Assessment Report released in 2007 is that there has been clear, unequivocal evidence of warming, 1.3 degree Fahrenheit over the last 100 years. I think an even more important conclusion is that now we have increasingly compelling evidence that human actions are very likely responsible for most of the warming over the last 50 years. We have a wide variety of fingerprints, fingerprints that allow us to test whether it is greenhouse gases or some other putative mechanism. What we see consistently with each of these fingerprints is that the quantitative results, the qualitative results, point toward the unequivocal role of the greenhouse gases in driving the warming that has occurred.

There is a question of how much warming will occur in the future. It is clear that the mechanisms that have been put in place by greenhouse gas emissions will continue and without decisive action to reduce CO_2 emissions to the atmosphere, the business as usual type of possibilities result in temperatures at 2100 where, with a low emissions pathway, we could end up with global average warming of somewhere in the range of 2 to 5.2 degrees Fahrenheit. With a high possibility, it could be in the range of 4 to 11. Of course, the recent trajectory of greenhouse gas emissions has even been higher than what is characterized as the highest scenario in

the IPCC reports, leading to the conclusion that we fundamentally haven't tested the consequences of the emission trajectory that we now know we are on.

There are a wide variety of impacts, and they go everywhere from ecosystems to industry to human health. I want to characterize some of the most important findings of the IPCC with regard to impacts on the United States, especially. One of the most compelling is that there is clear evidence that we have already seen, impacts on western water resources. There is earlier peak in the flow of western rivers. There is a decrease in the amount of snow that is stored in the western snow pack. It is up to 30 percent in many years. We are also seeing a decreased springtime and summertime flow in many rivers that are important to the support of ecosystems.

The projections of climate change impact for water resources in the West are really compelling. There is this gigantic tongue of reduced runoff, essentially, severe drought, that runs all the way from California to Oklahoma. The broad swath of the Southwest is basically robbed of the water to have sustainable lifestyles.

It is clear that we are seeing increased areas consumed in wildfire already. The quadrennial fire review just released by the U.S. Federal agencies shows that in the 1980s, there were 50 wildfires, more than 50,000 acres. In the decade starting in 1999, there were 240. The projections are clear that as the time between the melt of the snow in the spring and the first snow in the fall increases, we have greater and greater risk of wildfires and more and more problems associated with fighting wildfires.

It is also clear that many U.S. cities are already seeing increased numbers of heat waves, hot days, hot nights, and extended periods of heat. And there are very many cities, Sacramento is a good example, where just a small amount of warming transitions days that are uncomfortably hot into potentially life-threatening heat waves. So we are very close to a threshold in a very large number of American cities.

It is very difficult to translate the full range of climate impacts into economic costs. The IPCC has attempted to do that, and comes up with a relatively wide range. The range is that the social cost of carbon, the integrated damages across all the sectors could be anywhere from $3 to $95 per ton of CO_2. That could result in, if we take the integrated costs of the CO_2 emitted this year worldwide, anywhere from $110 billion to over $3.6 trillion of cumulative impacts, and if you contrast that with the cost of stabilization, the costs are really quite modest. Several of you have already spoken about the possibility that we might achieve net economic benefits as a consequence of tackling climate change, and the IPCC concludes the same. But there also could be costs that could be as much as 3 percent of GDP going out to 2030.

If you look at new observations, it is clear that things have continued to change, and they have changed very rapidly, mostly in ways that were discussed by the IPCC, but haven't yet been confirmed, because the evidence wasn't yet strong enough. CO_2 emissions have been increasing very, very rapidly. From 2000 to 2007 the annual rate of increase was 3.5 percent per year, contrasted with 0.9 percent per year from 1990 to 1999, over a threefold in-

crease. We have seen rapid shrinkages in the area covered by Arctic ice, so that in 2007, the area of minimum summer ice in September was 37 percent less than the long-term average. It was more than 20 percent less than the previous low in 2005. And just within the last few months, we have seen confirmation that the continent of Antarctica has been warming, and it has been warming at a rate of almost .2 degrees Fahrenheit per decade, comparable in pace to much of the rest of the southern hemisphere.

In some we are seeing a very wide range of documented impacts. We have increased confidence that these are due to humans and the fingerprints are really compelling. Many areas of risk for the United States, and the costs for mitigation appear to be modest in terms of the long-term costs of doing nothing.

Thank you very much.

[The prepared statement of Mr. Field follows:]

Testimony of
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Before the
U.S. Senate
Committee on Environment and Public Works
"Update on the Latest Global Warming Science"

10:00 a.m., February 25, 2009
Room 406, Dirksen Senate Office Building

The Scientific Assessments of the Intergovernmental Panel on Climate Change (IPCC)

The Intergovernmental Panel on Climate Change (IPCC) was formed in November 1988. Its formal origins were in resolutions passed by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) (Bolin 2007). In its first twenty years, the IPCC released four major assessments, in 1990, 1995, 2001, and 2007. Over this time, the reports of the IPCC have served as a gold standard for authoritative assessments of the state of scientific knowledge about climate change. This unique credibility is grounded in four components of the way the IPCC assessment process works. Specifically these are (Skodvin 2000):

1) The IPCC, using a process based in nominations from governments, engages hundreds of the leading scientific experts in climate science, impacts of climate change, and opportunities for mitigating or managing climate change to review and assess the scientific literature. Most of these scientists participate as volunteers.

2) The experts conduct a comprehensive assessment, considering all of the relevant scientific literature, and not only the literature that comes from a particular perspective or uses a particular set of approaches. The assessment summarizes the main findings and assesses the confidence associated with each finding. If a particular response is very likely (defined as 90 to 99% probability), the assessment reports this, but if it is unlikely (10 to 33% probability), it reports this find as well. Stakeholders receive a quantitative assessment, based on findings across the entire scientific literature.

3) The assessments are subjected to a rigorous, multi-stage, monitored review process. In the first stage of outside review, called the "expert" review stage, the draft report is available to experts around the world. These experts comment on every detail of the assessment, including the completeness of the literature review, the thoroughness of the evaluation, and the interpretation of the results. A twenty page chapter often receives hundreds of pages of detailed comments. Author teams are required to prepare an individual response to each comment, explaining how the chapter will be modified in response to the comment or explaining why the comment does not warrant changing the chapter. All of the comments and all of the responses are then evaluated by a set of review editors who make an independent evaluation of whether the responses are sufficient and whether the changes to the chapter conform to the spirit of the response. When this is complete, the next draft of the assessment is sent to the world's governments, who recruit their own experts to conduct another detailed review, focusing on the same issues – comprehensiveness, balance, and accuracy in the interpretations. This second stage of review also receives detailed responses, and both are again evaluated by independent review editors. After two rounds of review, hundreds of pages of comments, and thorough monitoring of the review and response process by outside experts, the chapters consistently address the wide range of relevant scientific information.

4) Before assessment reports are released, they are approved by consensus, by delegations from all of the world's governments that are members of the IPCC. Each Summary for Policymakers (SPM) is evaluated and approved line-by-line, with country delegations frequently challenging aspects of wording, presentation, or substance. Only when there is not a single challenge, from a single one of the more than 120 countries that typically participate in a plenary approval meeting, does a sentence make it into the SPM. The requirement for line-by-line approval by consensus sets a very high standard, largely insuring that the SPM has nothing that can be interpreted as unsubstantiated or carelessly worded. The underlying technical chapters are accepted without this line-by-line approval process, but both country delegations and authors invest a huge amount of effort into insuring that, prior to acceptance, everything in the SPM is consistent with the underlying technical material.

This highly standardized, thoroughly monitored assessment process insures that the assessment reports of the IPCC are based on the underlying scientific information. The assessments of the IPCC have no place for unfounded speculation, politically motivated opinion, or overstated confidence. If a process is poorly known or it more information is needed, the assessment is explicit about this. In fact, within the scientific community the IPCC assessment reports are widely used as one of best sources for crystallizing focus on the scientific challenges for the future.

The 4th assessment report of the IPCC, released in stages through 2007, provides the authoritative picture on the status of climate change science to within a few months of the release of each report. To the maximum extent possible, each report is completely up to date, with the demands of the review, approval, and publication process effectively setting the gap between the newest material in the assessment and the release date.

Findings from the 4th Assessment Report of the IPCC

The Fourth Assessment Report of the IPCC provides a scientifically rich picture of a changing climate, the mechanisms that underlie observed and projected changes, impacts of climate change on individuals, ecosystems, economies, and regions, and the costs and benefits of changing practices to decrease the amount of climate change from a business-as-usual scenario.

Among the important messages from the Fourth Assessment Report of the IPCC are the following. These statements are a verbatim selection from the four SPMs approved line-by-line, by consensus, by all of the delegations present at the approval meeting.

- Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. 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. (IPCC 2007a)

- 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. (IPCC 2007a)

- The understanding of anthropogenic warming and cooling influences on climate has improved since the TAR, leading to very high confidence 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}. (IPCC 2007a)

- 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. (IPCC 2007a)

- Some aspects of climate have not been observed to change. (IPCC 2007a)

- 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. (IPCC 2007a)

- 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. 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. (IPCC 2007a)

- 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. (IPCC 2007a)

- Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century. (IPCC 2007a)

- 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. (IPCC 2007a)

- Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases. (IPCC 2007b)

- Drought-affected areas will likely increase in extent. Heavy precipitation events, which are very likely to increase in frequency, will augment flood risk. (IPCC 2007b)

- Over the course of this century, net carbon uptake by terrestrial ecosystems is likely to peak before mid-century and then weaken or even reverse, thus amplifying climate change. (IPCC 2007b)

- Approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C. (IPCC 2007b)

- Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes. (IPCC 2007b)

- Many millions more people are projected to be flooded every year due to sea-level rise by the 2080s. Those densely-populated and low-lying areas where adaptive capacity is relatively low, and which already face other challenges such as tropical storms or local coastal subsidence, are especially at risk. The numbers affected will be largest in the mega-deltas of Asia and Africa while small islands are especially vulnerable. (IPCC 2007b)

- Many estimates of aggregate net economic costs of damages from climate change across the globe (i.e., the social cost of carbon (SCC), expressed in terms of future net benefits and costs that are discounted to the present) are now available. Peer-reviewed estimates of the SCC for 2005 have an average value of US$43 per tonne of carbon (i.e., US$12 per tonne of carbon dioxide), but the range around this mean is large. For example, in a survey of 100 estimates, the values ran from US$-10 per tonne of carbon (US$-3 per tonne of carbon dioxide) up to US$350 per tonne of carbon (US$95 per tonne of carbon dioxide). (IPCC 2007c)

- The large ranges of SCC are due in the large part to differences in assumptions regarding climate sensitivity, response lags, the treatment of risk and equity, economic and non-economic impacts, the inclusion of potentially catastrophic losses, and discount rates. It is very likely that globally aggregated figures underestimate the damage costs because they cannot include many non-quantifiable impacts. Taken as a whole, the range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time. (IPCC 2007c)

- Non-climate stresses can increase vulnerability to climate change by reducing resilience and can also reduce adaptive capacity because of resource deployment to competing needs. For example, current stresses on some coral reefs include marine pollution and chemical runoff from agriculture as well as increases in water temperature and ocean

acidification. Vulnerable regions face multiple stresses that affect their exposure and sensitivity as well as their capacity to adapt. These stresses arise from, for example, current climate hazards, poverty and unequal access to resources, food insecurity, trends in economic globalisation, conflict, and incidence of diseases such as HIV/AIDS. Adaptation measures are seldom undertaken in response to climate change alone but can be integrated within, for example, water resource management, coastal defense and risk-reduction strategies. (IPCC 2007c)

- Even the most stringent mitigation efforts cannot avoid further impacts of climate change in the next few decades, which makes adaptation essential, particularly in addressing near-term impacts. Unmitigated climate change would, in the long term, be likely to exceed the capacity of natural, managed and human systems to adapt. (IPCC 2007c)

- Global greenhouse gas (GHG) emissions have grown since pre-industrial times, with an increase of 70% between 1970 and 2004 (high agreement, much evidence). (IPCC 2007c)

- With current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades (high agreement, much evidence). (IPCC 2007c)

- Both bottom-up and top-down studies indicate that there is substantial economic potential for the mitigation of global GHG emissions over the coming decades, that could offset the projected growth of global emissions or reduce emissions below current levels (high agreement, much evidence). (IPCC 2007c)

- In 2030 macro-economic costs for multi-gas mitigation, consistent with emissions trajectories towards stabilization between 445 and 710 ppm CO_2-eq, are estimated at between a 3% decrease of global GDP and a small increase, compared to the baseline. However, regional costs may differ significantly from global averages (high agreement, medium evidence). (IPCC 2007c)

- Changes in lifestyle and behaviour patterns can contribute to climate change mitigation across all sectors. Management practices can also have a positive role (high agreement, medium evidence). (IPCC 2007c)

- While studies use different methodologies, in all analyzed world regions near-term health co-benefits from reduced air pollution as a result of actions to reduce GHG emissions can be substantial and may offset a substantial fraction of mitigation costs (high agreement, much evidence). (IPCC 2007c)

- Energy efficiency options for new and existing buildings could considerably reduce CO2 emissions with net economic benefit. Many barriers exist against tapping this potential, but there are also large co-benefits (high agreement, much evidence). (IPCC 2007c)

- In order to stabilize the concentration of GHGs in the atmosphere, emissions would need to peak and decline thereafter. The lower the stabilization level, the more quickly this

peak and decline would need to occur. Mitigation efforts over the next two to three decades will have a large impact on opportunities to achieve lower stabilization levels (high agreement, much evidence). (IPCC 2007c)

- The range of stabilization levels assessed can be achieved by deployment of a portfolio of technologies that are currently available and those that are expected to be commercialised in coming decades. This assumes that appropriate and effective incentives are in place for development, acquisition, deployment and diffusion of technologies and for addressing related barriers (high agreement, much evidence). (IPCC 2007c)

- In 2050 global average macro-economic costs formulti-gas mitigation towards stabilization between 710 and 445 ppm CO_2-eq, are between a 1% gain to a 5.5% decrease of global GDP. For specific countries and sectors, costs vary considerably from the global average. (high agreement, medium evidence). (IPCC 2007c)

- Decision-making about the appropriate level of global mitigation over time involves an iterative risk management process that includes mitigation and adaptation, taking into account actual and avoided climate change damages, co-benefits, sustainability, equity, and attitudes to risk. Choices about the scale and timing of GHG mitigation involve balancing the economic costs of more rapid emission reductions now against the corresponding medium-term and long-term climate risks of delay (high agreement, much evidence). (IPCC 2007c)

- Policies that provide a real or implicit price of carbon could create incentives for producers and consumers to significantly invest in low-GHG products, technologies and processes. Such policies could include economic instruments, government funding and regulation (high agreement, much evidence). (IPCC 2007c)

- The literature identifies many options for achieving reductions of global GHG emissions at the international level through cooperation. It also suggests that successful agreements are environmentally effective, cost-effective, incorporate distributional considerations and equity, and are institutionally feasible (high agreement, much evidence). (IPCC 2007c)

Specific findings for North America are the following (all from (IPCC 2007b)):

- Warming in western mountains is projected to cause decreased snowpack, more winter flooding and reduced summer flows, exacerbating competition for over-allocated water resources.

- In the early decades of the century, moderate climate change is projected to increase aggregate yields of rain-fed agriculture by 5 to 20%, but with important variability among regions.

- Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilised water resources.

- Cities that currently experience heat waves are expected to be further challenged by an increased number, intensity and duration of heat waves during the course of the century, with potential for adverse health impacts.

- Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution.

Impacts of Climate Change on the United States

The United States frequently experiences weather-related challenges, with substantial economic costs from severe storms, drought, flood, extreme heat, and extreme cold (Field et al. 2007). Weather-related impacts are persistent features of the American landscape. Over the last several decades, however, the United States has experienced substantial amounts of warming, especially in Alaska, and recent scientific research documents an increasing number of impacts that appear to be a result of climate changes that have already occurred (Field et al. 2007). For one-time events, like heat waves, drought, or wildfires, it will rarely be possible to say with certainty that a single event was caused by climate change (Hegerl et al. 2007). Nevertheless, several kinds of extremes will likely become more common with climate change. Increasingly, it is possible to assess the probability that a heat wave, wildfire, or drought would have occurred in the absence of climate change (Hegerl et al. 2007).

In recent decades, the United States has experienced an increasing number of stresses projected to increase in a warming climate. Some of these are iconic one-time events like the need to move the Alaskan village of Shishmaref, which is being progressively lost to the sea after 400 years of habitation, a consequence of melting of the permafrost on which it sits and increased wave action related to a decreased period when ice protects the village (http://www.arctic.noaa.gov/detect/human-shishmaref.shtml). Others are more gradual and progressive. Examples include the clear decrease in the season for high-latitude ice roads, the dramatic decrease in water stored in the snowpack of the Western mountains, or the strong increase in the area burned in Western wildfires (Field et al. 2007). Drought is among the largest climate-related concerns for the United States. Many parts of the Western US have limited water security. Some of these are in parts of the country where decreased snowpack is cutting into water storage capacity or where groundwater pumping has led to large drops in the water table (Field et al. 2007). Projected decreases in precipitation (Meehl et al. 2007) could push many of these areas from water insecure to chronically critically short of water.

With climate change in coming decades, the United States will have vulnerable people, businesses, and activities in all regions. The people most vulnerable to impacts of climate change tend to be those who are very young, old, sick, or poor. People who live in communities dependent on single industries based on resources at risk (e.g. fisheries) will likely experience large impacts, especially if they cannot switch activities or relocate (Field et al. 2007). Continuing increases in the value of the infrastructure in the coastal zone exacerbate the risks from sea-level rise. The United States has abundant adaptive capacity with the potential to provide an important measure of protection, but deploying that capacity to effectively provide protection will require mainstreaming adaptation at a level far above the historical norm (Field et al. 2007).

Updates from New Advances in Climate Science

The authoritative reports of the IPCC are released every five to seven years. This is a substantial time in the trajectory of a rapidly developing field like climate science, and many important new results appear between assessments. One of the great strengths of the IPCC is that, in evaluating thousands of papers, it can evaluate the results stand up to independent validation and which do not. Between assessments, it can be more difficult to determine the confidence to associate with any particular result. Those results, however, that use well established methods and focus on extending observations or calculations already assessed in the IPCC can be used with confidence. Several recent results warrant particular attention.

Emissions of carbon dioxide to the atmosphere from fossil fuel combustion have been increasing rapidly. From 2000 to 2007, the annual rate of increase was 3.5% per year, compared to 0.9% per year for the period from 1990 to 1999. Actual emissions since 2000 have been running at the top end of the range in the family of scenarios used by the IPCC (Raupach et al. 2007).

Observed warming has been confirmed for the continent of Antarctica. For many years, temperature measurements over Antarctica were too sparse to allow a confident assessment of temperature trends, and some records indicated that Antactica might be cooling. Recently published data, based on a larger set of measurements than previously available, confirms that the continent is warming at a rate of more than 0.1°C per decade over the last 50 years (Steig et al. 2009).

Sea level rise has risen over the last century. The 4th Assessment report of the IPCC reports an average rate of 1.8 mm per year over the 20th century, increasing to 3.1 mm per year for the period from 1993 to 2003 (IPCC 2007a). New research confirms that most of the rise since 2003 is from the melting of land ice, with contributions from melting glaciers, Greenland, and Antarctica (Cazenave et al. 2008).

Summer sea ice in the Arctic has been decreasing for many years, with good records going back to the late 1970s. The summer of 2007 saw exceptionally low ice cover at the September minimum, with an area of 3.77 million square km or 38% below the long term average. From 1996 to 2007 the summer area minimum decreased at an annual rate of 10.7% per decade, compared to 3% per decade for 1979 to 1996 (Comiso et al. 2008). The minimum area of Arctic ice was only slightly greater than the 2007 minimum in 2008 (http://www.arcus.org/search/seaiceoutlook/summary_report.php).

Increasing evidence points to the possibility of potentially strong feedbacks, amplifying climate change, from terrestrial ecosystems. The 4th assessment report of the IPCC undertook a preliminary assessment of the feedbacks from coupling the carbon cycle and climate. The conclusion of this assessment is that, over the century, coupling increases the emissions of carbon dioxide to the atmosphere. In climate simulations using the highest emission scenario explored in detail by the IPCC (A2), coupling released an additional 100 to 500 billion tons of

carbon to the atmosphere by 2100 (Meehl et al. 2007). New research indicates that substantial amounts of carbon could also be released from melting permafrost (Khvorostyanov et al. 2008), now estimated to be a store of nearly a billion tons of carbon, or almost three times the cumulative release from fossil fuel combustion since the beginning of the industrial revolution (Schuur et al. 2008).

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Update on the Latest Global Warming Science

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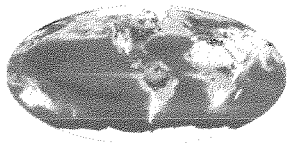


IPCC procedures

- Hundreds of top scientists
- Comprehensive assessment
- Multi-stage, broad-based, monitored review
- Plenary approval line-by-line, by governments

Findings of the AR4

- Warming is unequivocal
  1.3°F over last 100 years

- Most warming over last 50 years very likely due to human influences
  - "fingerprints" for human influences

Findings of the AR4: 2

- Warming will continue

- "No policy" range for 2100
  - Lowest scenario: 2.0-5.2°F
  - Highest scenario: 4.3-11.5°F

Findings of the AR4: 3

- Decreasing water security in the West
- Increased loss to wildfires
- Increased heat waves

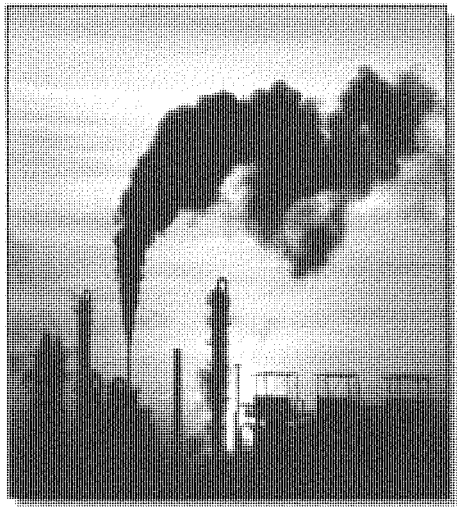
Findings of the AR4: 4

- Damages from climate change
  - \$3 to \$95 per ton CO_2
  - \$110 to \$3,600 billion per year

- Costs of CO_2 stabilization
  - 3% of GDP to a net benefit for GDP

New Observations

- Rapidly increasing CO_2 emissions
- Rapidly shrinking arctic ice
- Warming in Antarctica



Raupach et al. 2007, PNAS
Comiso et al. 2008, GRL
Steig et al. 2009, Nature

In sum

- Wide range of documented impacts
- Increased confidence in human causation
- Critical risk areas for the US
- Modest costs for mitigation

Environment and Public Works Committee Hearing
February 25, 2009
Follow-Up Questions for Written Submission

Questions for Field

Responses from: Christopher Field
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Questions from:

Senator Benjamin L. Cardin

1. The International Energy Association estimates that the world's power demands will rise 60% by 2030. Electricity generators consumed 36 percent of US energy from fossil fuels and emitted 41 percent of the CO2 from fossil fuel combustion in 2006 (EPA estimates)

a. Is it feasible to reduce substantially that projected increase through energy conservation strategies in a world economy that is predicated on economic growth?

The IPCC concludes that conservation and improvements in energy efficiency can be large and important parts of an overall strategy for reducing CO2 emissions. Specifically, the Fourth Assessment Report of the IPCC concludes " Changes in lifestyles and consumption patterns that emphasize resource conservation can contribute to developing a low-carbon economy that is both equitable and sustainable." (Working Group 3 Summary for Policymakers, p 12). Further, the IPCC concludes that in 2030, the costs of a mitigation program involving conservation, efficiency, and new technologies for generating energy could impose macro-economic costs of between a 3% decrease in GDP and a small increase, compared to the baseline (Working Group 3 Summary for Policymakers, p 12). What this means is that aggressive action to stabilize atmospheric CO2 might produce a net benefit for global economic growth, or the overall cost could be a small decrease in economic growth, in effect delaying the expected level of global economic activity in 2030 until 2031 or 2032.

Personally, I am impressed at the wide range of economic opportunities presented by desires to increase conservation and efficiency. I see the potential for the creation of a large number of jobs and a massive quantity of economic activity in improving the efficiency of buildings, vehicles, and manufacturing processes. I think we are at the beginning of an era when many of the most attractive opportunities for business involve products that provide the same or improved services while also using less energy.

b. What is your opinion of increasing nuclear power to provide an immediate reduction in greenhouse gas emissions?

Personally, I consider the challenge of moving to a low-carbon economy to be so serious that it would be irresponsible to a priori *eliminate any technologies from careful consideration. Future expansion of nuclear power should be carefully evaluated from the perspective of cost, risk of accidents, risk of proliferation, and feasibility of waste management. If these challenges can be met, and if nuclear power is still cost competitive when these challenges have been met, then it deserves a place in the energy portfolio. The challenge of meeting the energy needs of a growing world economy are so large that, even if expanding nuclear energy is part of the portfolio, it can be only part, and we will still need to aggressively develop other non-emitting energy sources.*

2. In her "Principles for Climate Change Legislation," Chairman Boxer expressed interest in aiding developing countries.

a. What role should the U.S. play in aiding developing nation's carbon mitigation strategies?

The IPCC provides information that is policy relevant but not policy prescriptive. It does not address questions like the desirability of one nation aiding the carbon mitigation strategies of another. The IPCC does conclude that international markets can provide a way to lower the cost of reducing CO2 emissions (by concentrating expenditures in the places where the decrease in emissions per unit of investment is the greatest) (Working Group 3 Summary for Policymakers, p 22). It further concludes that investments in reducing CO2 emissions can be synergistic with other aspects of sustainable development (Working Group 3 Summary for Policymakers, p 21).

b. Would a technology transfer to developing nations for carbon credits be feasible in a cap-and-trade carbon market system?

In principle, a cap-and-trade system could be configured to treat technology transfers as emissions reductions. This is the general idea of the Clean Development Mechanism (CDM) included in the Kyoto protocol. Under the CDM, one country can assist another country in a project that decreases greenhouse gas emissions, and the country providing the assistance can claim the emissions reduction in its national budget. This kind of international project has the potential to help insure that purchasers have access to the lowest cost strategies for emissions reductions. International projects can pose challenges for accurately accounting the greenhouse gas consequences, but the challenges are not insurmountable.

c. Deforestation releases vast quantities of CO2 as trees are removed and burned, and also causes a permanent loss of CO2 uptake capacity. Deforestation causes 17.3% of all GHG emissions. By treating preserved forested land as a natural carbon sink, developing countries would have economic incentive to preserve their forest. Could a carbon credits for avoided deforestation scheme work in a cap-and-trade system?

Yes, including forest protection in a cap-and-trade system is workable, and it could provide some of the most cost effective options for decreasing CO2 emissions (Working Group 3 Summary for Policymakers, p 16). There are some important challenges in accurately quantifying the emissions reductions from avoided deforestation and other land-use activities, but the tools for addressing these challenges are increasingly available and proven.

Senator Bernard Sanders

1. In your testimony you describe certain types of communities that are likely to have a hard time adapting to changes in climate. What types of communities are probably the most vulnerable and what economic problems are they likely to face?

Four kinds of communities are especially vulnerable to climate change. One is communities that lack the resources to effectively adapt to the changes that cannot be avoided. These are often in poor countries where communities lack the capital, infrastructure, and information to develop effective adaptation strategies. A second set of communities is those in areas where the climate changes are the largest or have the largest impact. First nations communities in the Arctic have already been heavily affected by the climate changes over the last several decades. A significant drop in precipitation over the Southwestern US could lead to profound impacts on communities in that region. A third set of vulnerable communities is those that depend on climate-sensitive resources. These might be maple-sugar producers in Vermont, lobstermen in Maine, or ski resort operators in New Hampshire. A fourth set of vulnerable communities is the kinds of people who tend to be most vulnerable to other environmental and economic dislocations – the very old, the very young, the sick, and the poor. Across these communities, the specific economic hardships caused by climate change will vary from community to community, but the general pattern will be that, in most cases, life becomes more complicated. Sources of income may decline. Risks to health may be more difficult to avoid. Or coping with climate may deplete the funds needed for other activities. In its Fourth Assessment Report, the IPCC concluded that there are vulnerable people and activities in every region.

Senator James M. Inhofe

1. You have made statements that claim the actual trajectory of climate change is more serious than any of the climate predictions in the IPCC's fourth assessment report. In your opinion, have there been any developments at all in the field of climate science that has been good news?

Careful application of the scientific method, combined with thorough peer review and comprehensive assessments like those of the IPCC have provided a much improved understanding of the way the climate works and of the opportunities for preventing dangerous interference with the climate system. This understanding is immensely valuable, providing the world the opportunity to make informed decisions with the potential to save countless lives and vast sums of money. The really good news from climate research is that effective action, undertaken in a timely way, provides a path to avoiding the worst impacts of climate change.

Another way to look at the question is to ask whether new research points to people or activities who are helped by climate change. This is a tricky question, because there are many places (for

example the Upper Midwest in the US, where a small amount of warming would likely increase crop yields but a large warming would lead to serious decreases ((Working Group 2 Summary for Policymakers, p 15). In other locations, warming that is interpreted as beneficial by one community (for example, warming in the Arctic might open routes for ocean shipping) can be strongly damaging for others (for example, eliminating the possibility of using the ice roads needed for Arctic oil and gas exploration).

2. Former Colorado State Climatologist Roger Pielke Sr. analyzed your most recent scientific claims on February 15, 2009. Dr. Pielke suggested that this claim conflicts with real world observations.

He observed that, since mid-2003, there has been no upper ocean global warming; an observation which is not consistent with the GISS model predictions over this time period. The recent and current tropospheric temperatures today are no warmer than they were in 2002. The recent global warming is less than the IPCC models predict, and, even more so, in disagreement with the news articles. Pielke concluded; "When will the news media and others realize that by presenting such biased reports, which are easily refuted by real-world data, they are losing their credibility among many in the scientific community as well as with the public."

Dr. Field, how concerned are you that your statements are not accurate and how concerned are you that the news media is not seeking out scientists with different perspectives to counter your views?

My comments about the trajectory of climate change, reported in the February 15, 2009, Washington Post in an article by Kari Lyderson, were completely accurate. My comment, quoted in the article was "We are basically looking now at a future climate that's beyond anything we've considered seriously in climate model simulations." This is a statement about the forcing of climate change by greenhouse gas emissions. Recent research makes it clear that, from 2000 through 2007, emissions of CO2 from industrial activity increased more rapidly than envisioned in any of the scenarios used by the climate models (Raupach et al. Proceedings of the National Academy of Sciences 104: 1288-1293) (the emissions data for 2008 are not yet available). As a consequence, we are headed on a trajectory of climate change, forced by these higher than expected emissions, that we have not explored with the climate models. Neither I nor anybody else is making specific projections about that trajectory, precisely because it is outside the range that has been explored with the climate models.

Global weather patterns over one or a few years cannot be used as a reliable indicator of trends in climate change. It is well known that the global climate is variable, with warmer years and cooler years, even in a climate that is, over decades, strongly warming. It is very important for effective policy that stakeholders and policymakers not get confused about the relevance of short-term variability for long-term trends. The vast majority of the careful scientific study focused on understanding the sensitivity of climate to forcing by greenhouse gases has confirmed that the climate and the models are both behaving as expected, with increased concentrations of greenhouse gases causing clear warming, in the range that theory predicts.

Senator Mike Crapo

1) The United Nations Intergovernmental Panel on Climate Change's Fourth Assessment report states "in the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fiber, or energy from the forest, will generate the largest sustained mitigation benefit."

Can you discuss what you think the magnitude of the benefit could be and how we can best incent these activities?

Careful stewardship of forest resources can be an important contributor to reducing CO2 emissions at low cost. In addition, these activities can create jobs, help communities adapt to climate changes that cannot be avoided, and contribute to sustainable development (Working Group 3, Summary for Policymakers, p 14). Activities related to reducing CO2 emissions through forestry are very attractive components of a broad portfolio of emissions reduction activities. The magnitude of the benefit from forestry will depend on the range of activities included and on the success with which they are executed. Currently, the clearing of forests, which is occurring mostly in the tropics, contributes 15-20% of the CO2 emissions from human activities. Cutting the rate of tropical deforestation in half could eliminate 7-10% of current emissions and, over the 21st century, keep up to 100 billion tons of carbon out of the atmosphere. Other approaches to increasing the carbon in forests and forest products include replanting areas previously cleared and altering management to increase the carbon in trees and soils. Use of wood as a source of energy can also provide a low carbon alternative to fossil fuels. The maximum benefit from all these strategies is difficult to calculate, because we need to think about a broad land-management system that encourages food production, biodiversity, and varied land use, in addition to forest management for carbon and energy. It is likely, however, that the benefits of forestry for protecting climate can be substantial. Appropriate incentives for forest management for carbon and energy will depend on the region and on the specific goals of the local management system. In some settings, useful incentives might include payments to owners who agree to manage their lands for carbon sequestration. In others, it might be most effective to increase investments in research to boost the efficiency of generators and fermenters for extracting the energy from wood.

Senator BOXER. Thank you very much.

And now, we are going to turn to Dr. Howard Frumkin, Director, National Center for Environmental Health, Centers for Disease Control and Prevention. He is the Director of the Agency for Toxic Substances and Disease Registry.

Thank you very much, Doctor.

STATEMENT OF HOWARD FRUMKIN, M.D., MPH, DR.PH., DIRECTOR, NATIONAL CENTER FOR ENVIRONMENTAL HEALTH, CENTERS FOR DISEASE CONTROL AND PREVENTION; DIRECTOR, AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Dr. FRUMKIN. Madam Chair, members of the Committee, thank you very much for the opportunity to testify today.

It is clear that your eloquence as Senators far outstrips our aptitude as PowerPoint users here on the panel.

[Laughter.]

Dr. FRUMKIN. Dr. Field addressed himself to earth system changes, and drew heavily on the earth and atmospheric sciences to update you. I would like to turn now to the human impacts of climate change and draw on the health sciences to update you. I do this, because climate change is expected to have very real impacts on the health and well-being of real people. That is of great concern to us at the CDC and we think to the entire Nation.

The health science research, as it emerges, is suggesting to us a number of impacts of climate change on health and well-being. They are shown here on this slide, and they are described in more detail in my written testimony. The direct effects of heat can be dangerous to people, especially during heat waves, as we have seen. Severe weather events, both rapid ones like tornadoes and hurricanes, and drawn-out ones, like floods, have a range of impacts on health, as we have seen tragically in recent years in this Country.

Air pollution worsens in several respects under warming scenarios. That has impacts on cardiovascular and respiratory health and on longevity. Allergies are expected to worsen because certain plants that are sources of allergens, from ragweed to poison ivy, seem to thrive under climate change scenarios.

Many vector-borne diseases, traditionally called tropical diseases, in a reminder that these diseases are ecosystem dependent. As ecosystems shift and as the range of these diseases shifts, we expect impacts on human vulnerability and on disease incidence as well. Water-borne diseases are clearly linked to severe rainfall events and to changes in temperature. Threats to the water and food supply can be serious, as agricultural output changes under climate change scenarios. That in turn affects nutrition and health status.

Mental health impacts are considerable. We are now appreciating that one of the longest-lasting and most serious impacts of Hurricane Katrina, for example, has been the mental health impact. We need to attend to that in future climate change scenarios as well. Finally, the possibility of dislocation and migration has public health impacts on those who need to move.

Each of these health impacts teaches us specific lessons that are important to keep in mind. With regard to heat, we have long expe-

rience with heat waves, we have conducted extensive epidemiologic studies, we know who in cities is most vulnerable and we know the steps that we can take to protect the health of people from the effects of the heat wave. This is a good example of how good epidemiology and good preparedness can help us protect the public.

Infectious diseases teach us a different lesson. These are extremely complex phenomena. Climate change is expected to affect the baseline risk of infectious diseases, but many other factors play a role as well, from air conditioning to the presence of screens to underlying health status. We need considerable research to understand best how infectious diseases will unfold. We also need very good surveillance and early warning systems. These are key tools in public health, because we need to recognize these diseases, if and when they change their range.

The mental health outcomes remind us of the need to be very broad-thinking and holistic as we consider the impacts on health. And the question of food is a reminder that we need to look outside the health sector itself and upstream to other sectors whose activities and products affect and determine health. For example, agricultural output—we have evidence emerging now that protein content of certain food crops is diminished under climate change scenarios. That will affect the nutritional value of foods that some people eat, and for some that will have a measurable health impact.

The good news here is that few of these are new problems. Many of these are longstanding problems. Climate change serves not as a revolutionary change, but as an amplifier or multiplier of existing and fairly well understood risks. We have in our public health tool box the tools and strategies that we need in many cases to address these problems and to protect the public. These, after all, are the tools and strategies of public health preparedness.

We need to undertake surveillance and data collection, collecting the baseline information that we need to track trends and to recognize perturbations. We have talked earlier in this panel about modeling and forecasting. We need to downscale modeling and forecasting from the global scale to the regional and even the local scale, where health impacts will play out. And we need to extend existing models to health impacts themselves.

We need to take direct actions to protect the public. For example, heat wave preparedness plans are available for cities to use; GIS systems can identify who is vulnerable, buddy systems can be put in place to reach out to those individuals when heat waves should occur, they can be brought to refuge centers if necessary to protect them during a heat wave, the health care system can be prepared and equipped to deal with hyperthermic health outcomes. We know how to do those plans, and we need to be working on those.

We need effective communication. Using the lessons of health communication, we have great experience in the health sector in delivering tough messages: exercise more, eat better food, quit smoking. Many of the same communication techniques will be useful as applied to climate change, so that people can receive and understand useful information, and not despair, but take constructive action.

We need to undertake training and capacity building, so that at the State and local level, members of our health departments know

how to use these tools, know how to implement them, and can do their job to protect the public. And we need to undertake research, because there is much we still need to learn about climate change, the biomedical and basic biological dimensions of climate change, as they will affect health.

I want to close by pointing to the benefits of taking many of these steps, and these are co-benefits. Indeed, there are sweet spots here. The public health actions we need to take to protect against climate change, ranging from research to surveillance to early warning systems, will have benefits across the entire system of public health, not simply limited to climate change.

In effect, many of the actions that we need to take to address climate change will have benefits for health more broadly. If we shift our transportation patterns to more walking and bicycling and less use of vehicles, those are steps we need to take in an increasingly sedentary and overweight society anyway. And those will also be steps that address climate change.

So the combined health, economic and social benefits of addressing climate change are very much on our mind as we prepare the public health responses to best protect the public. Thank you very much.

[The prepared statement of Dr. Frumkin follows:]

Testimony
Committee on Energy and Public Works
United States Senate

Update on the Latest Global Warming Science: Public Health

Statement of
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U.S. Department of Health and Human Services

CDC
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February 25, 2009

Good morning Chairman Boxer and other distinguished members of the Committee. I am Howard Frumkin, Director of the National Center for Environmental Health at the Centers for Disease Control and Prevention (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR). I am a physician with 27 years of experience in environmental and occupational medicine and epidemiology. I have been Director of NCEH/ATSDR since September 2005. Previously, I served as chairman of the Department of Environmental and Occupational Health at Emory University's Rollins School of Public Health and professor of medicine at Emory Medical School. I am here to speak on our emerging understanding of climate change and its potential impact on health, and to discuss steps needed to protect the public from these potential consequences.

CDC considers climate change a serious public health concern. An effective public health response to climate change can prevent injuries, illnesses, and death while enhancing overall public health preparedness. CDC's approach to climate change is based on the broad scientific consensus reflected in publications of the Intergovernmental Panel on Climate Change, the United States Climate Change Science Program's recent report, *Analyses Of The Effects Of Global Change On Human Health And Welfare And Human Systems* (Synthesis and Assessment Product 4.6 [SAP 4.6]), and the peer-reviewed literature, such as a recent special issue of the *American Journal of Preventive Medicine* that CDC supported. [http://www.ajpm-online.net/issues/contents?issue_key=S0749-3797(08)X0016-9] In this testimony, I will discuss the following dimensions of climate change and public health:

1) The likely public health threats of climate change,

2) The people most vulnerable to these threats, and

3) Public health actions needed to protect the public's health from these anticipated threats.

Climate Change Poses a Public Health Threat

Over the coming years and decades, climate change is likely to have a significant impact on health in the United States and globally. The United States and other developed countries with well-developed health infrastructure and the involvement of government and nongovernmental agencies in disaster planning and response will be better able to address the health effects from climate change than will be countries in the developing world. Nevertheless, Americans may experience difficult challenges, and different regions of the Country may experience these challenges at varying degrees.

The anticipated health impacts of climate change have been well-reviewed and articulated by the Intergovernmental Panel on Climate Change and by the United States Climate Change Science Program through their Synthesis and Assessment Products. While knowledge of the potential public health impacts of climate change will advance in the coming years and decades, these entities have identified the following, which are current best estimates of major anticipated health outcomes, each of which is described in more detail below:

- Direct effects of heat,
- Health effects related to extreme weather events,

- Air pollution-related health effects,
- Water- and food-borne infectious diseases,
- Vector-borne and zoonotic diseases,
- Emerging pathogens susceptible to weather conditions,
- Allergies, and
- Mental health problems.

Heat Stress and Direct Thermal Injury

With climate change, an increase in the severity, duration, and frequency of extreme heat waves is expected in the United States. Heat causes a range of health effects, from mild (heat cramps, heat exhaustion) to severe (such as heat stroke, which can be fatal). Certain populations are especially vulnerable to these effects, including the elderly, those with certain underlying medical conditions, those who are socially isolated, those without air conditioning, and those who are poor. Midwestern and northeastern cities are at greatest risk, as heat-related illness and death appear to be related to exposure to temperatures much hotter than those to which the population is accustomed. This illustrates the need for public health preparedness at the local level.

Extreme Weather Events

Climate change has effects on weather—effects that vary regionally. In some areas, such as the eastern United States, more frequent heavy precipitation events are projected, posing an increased risk of flooding and outbreaks of water-borne infectious diseases. In other areas, such as the southwest, reduced rainfall may be associated with severe drought, reducing availability and quality of water. Moreover, when rainfall

follows a period of drought, vector populations may explode, increasing the risk of infectious diseases such as hantavirus. Drought may increase the frequency and severity of wildfires, reducing air quality—an example of complex system interactions that affect health. Some evidence suggests that hurricanes could become more intense, potentially affecting states of the eastern seaboard and Gulf of Mexico regions.

The health effects of extreme weather events range from loss of life and acute trauma to indirect effects such as loss of home, large-scale population displacement and subsequent mental health effects, damage to sanitation infrastructure (drinking water and sewage systems), interruption of food production, and damage to the health-care infrastructure. Displacement of individuals often results in disruption of health care, of particular concern for those with underlying chronic diseases.

Air Pollution-Related Health Effects

Climate change may affect air quality by modifying local weather patterns and pollutant concentrations, affecting natural sources of air pollution, and promoting the formation of secondary pollutants. For example, higher surface temperatures, especially in urban areas, promote the formation of ground-level ozone. Ozone can irritate the respiratory system, reduce lung function, aggravate asthma, and inflame and damage cells that line the airways. In addition, it may cause permanent lung damage and aggravate chronic lung diseases. There is consistent evidence from models and observations that 21st-century climate change will worsen ozone pollution. Studies suggest that, in the absence of changes in precursor emissions, climate change will increase the frequency of high ozone events by 50% to 100% by 2050. Accordingly,

climate change represents a significant challenge to achieving ozone air quality goals and to preventing associated health impacts.

Water- and Food-borne Infectious Diseases

Altered weather patterns resulting from climate change could 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 purposes. For example, outbreaks of *Vibrio* 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 in the U.S., leading to illness from organisms such as *Cryptosporidium* and *Giardia*. 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. This illustrates the need for effective public health surveillance of water- and food-borne diseases.

Vector-borne and Zoonotic Diseases

Vector-borne and zoonotic diseases, such as Lyme disease, West Nile virus disease, malaria, plague, and hantavirus pulmonary syndrome have been shown to have a distinct seasonal pattern, and in some instances their incidence has been shown to be weather sensitive. Accordingly, climate change-driven ecological changes, such

as variations in rainfall and temperature, could significantly alter the range, seasonality, and incidence of many zoonotic and vector-borne diseases. For example, the range of *Ixodes scapularis,* the tick that transmits Lyme disease, is expected to expand in the United States by more than 200 percent by the 2080s, according to one report. In another example, a recent CDC study found a significant association between increased temperature and precipitation and increased incidence of dengue fever near the U.S.-Mexico border.

The role of climate in vector-borne and zoonotic disease incidence is complex and not fully understood, illustrating the need for further research. While factors such as housing quality, land-use patterns, vector control programs, and proliferation of certain wildlife species are particularly important for the spread of vector-borne and zoonotic disease, climate change could facilitate the establishment of new vector-borne diseases imported into the United States, or alter the geographic ranges of some of these diseases that already exist in this Country.

Emerging Pathogens Susceptible to Weather Conditions

In addition to vector-borne and zoonotic diseases, other pathogens sensitive to weather conditions have emerged. *Cryptococcus gattii,* an organism once restricted to subtropical and tropical environments, was identified within the last decade in the temperate climate zone of the Pacific northwest, where it has caused life-threatening disease of the central nervous system, lung, and skin in humans and animals.

Allergies

Warmer, wetter conditions and higher CO_2 concentrations promote the growth of some plants, including some that produce allergens. For example, ragweed growth is accelerated, and pollen counts are accordingly higher, and poison ivy growth and toxicity are enhanced under these conditions. Such effects could aggravate symptoms in those who suffer from allergies and asthma.

Mental Health Problems

The aftermath of disasters such as severe weather events may include post-traumatic stress and related problems. These may grow out of the experience of the disaster itself and/or elements of the recovery process such as disruption of social networks, economic loss, and displacement. After Hurricane Katrina, rates of severe mental illness (including depression, PTSD, anxiety disorder, panic disorder, and phobias) doubled from 6.1 percent to 11.3 percent among those living in affected regions. This illustrates the need for a comprehensive public health approach to climate change.

Climate Change Vulnerability

The effects of climate change will vary by geographic area and demographic group. With respect to geographic factors, urban centers in the west, southwest, mid-Atlantic, and northeast regions of the United States are expected to experience the largest increases in average temperatures; these areas also may bear the brunt of increases in ground-level ozone and associated airborne pollutants. Populations in midwestern and northeastern cities are expected to experience more heat-related

illnesses as heat waves increase in frequency, severity, and duration. Topography, wetlands destruction, and different rates of coastal erosion are expected to result in dramatically different regional effects of sea level rise. Distribution of animal hosts and vectors may change; in many cases, ranges could extend northward and increase in elevation. The West coast of the United States is expected to experience significant strains on water supplies as regional precipitation declines and mountain snow packs, an important source of summertime water, are reduced.

Some demographic groups are more vulnerable to the health effects of climate change than others. Children are at greater risk of worsening asthma, allergies, and certain infectious diseases. Those with underlying diseases and the elderly are at greater risk for health effects due to heat waves, extreme weather events, and exacerbations of chronic disease. People of lower socioeconomic status are particularly vulnerable to extreme weather events. Alaska Natives are also uniquely vulnerable to the environmental changes from climate change because of their close relationship to and dependence on the land and sea and natural resources for cultural, traditional social, economic and physical well being. The health effects of climate change on a given community depend not only on a community's exposures and demographics, but also on how these characteristics intersect. For example, heat waves are both more likely to occur in urban areas and more likely to affect certain populations: the home-bound, elderly, poor, and minority populations, and those living in areas with less green space and with fewer centrally air-conditioned buildings.

Given the differential burden of climate change health effects on certain populations, public health preparedness must include assessments to identify the most vulnerable populations and anticipate their risks. At the same time, health

communication targeting these vulnerable populations must be devised and tested, and early warning systems focused on vulnerable communities should be developed. With adequate notice and a vigorous response, adverse health effects of climate change may be reduced.

Protecting Public Health from Climate Change: A Strong Foundation

Climate change strategies are typically framed by two broad approaches. *Mitigation* corresponds to prevention—efforts to reduce climate change itself. *Adaptation* corresponds to public health preparedness—efforts to reduce harm from those effects of climate change that are inevitable despite mitigation efforts.

While *mitigation* efforts are generally carried out in other sectors "upstream" from public health, such as energy, transportation, and housing, the health sector has several important roles. First, policy choices such as energy strategies should be assessed to help identify health impacts and to help reach decisions that maximally protect health. By providing technical expertise and through the use of tools such as Health Impact Assessments, CDC can serve as an important health resource to agencies in these sectors. Second, the health sector can itself contribute to climate change mitigation by identifying and implementing energy conservation and related strategies. Third, health and risk communication techniques can be highly useful in informing the public about climate change. Effective communication can equip people to make behavioral choices and support policies that address climate change and protect health, while avoiding negative emotional impacts.

Adaptation (or public health preparedness) is highly consistent with traditional public health responsibilities. In fact, most of the health consequences of climate

changes are not new; they represent an intensification of existing, well recognized threats. Accordingly, existing public health tools provide a firm foundation for public health action on climate change. CDC has in place many of the building blocks needed to respond to climate change. Examples include:

- *Surveillance of Water-borne, Food-borne, Vector-borne, and Zoonotic Diseases:* CDC has a long history of surveillance of infectious, zoonotic, and vector-borne diseases. Examples of relevant tracking systems include the national arthropod-borne viral disease tracking system (ArboNet); FoodNet, PulseNet, and OutbreakNet, which rapidly identify and provide detailed data on cases of foodborne illnesses; and the National Outbreak Reporting System for Foodborne and Waterborne Diseases (NORS).

- *Environmental Public Health Tracking:* CDC's Environmental Public Health Tracking Program has funded several states to build a health surveillance system that integrates environmental exposures and human health outcomes. This system includes critical data on environmental trends and on the incidence, trends, and potential outbreaks of diseases, including those affected by climate change.

- *Geospatial Sciences:* CDC has applied Geographic Information Systems (GIS) technology in unique ways to a variety of public health issues, ranging from long-term disease trends to post-disaster applications. This technology represents an invaluable tool for the public health response to climate change. For example, it can provide critical information about short- and long-term climatologic consequences on land by analyzing remote sensing data derived from space.

- *Modeling:* Projections of future climate change can be used as inputs into models that assess the impact of climate change on public health. CDC has a nascent Agency-wide modeling initiative. Work to date includes pandemic influenza, plague, and tularemia modeling, and heat wave modeling for the city of Philadelphia to predict the most vulnerable populations at risk for hyperthermia.

- *Preparedness Planning:* The principles of public health preparedness for terrorism and pandemic influenza also apply to preparedness for the health impacts of climate change. For example, CDC scientists have developed tools for local emergency planners and decision-makers to use in preparing for and responding to urban heat waves in urban areas, and made them available in a multi-agency *Excessive Heat Events Guidebook.*

- *Training and Education of Public Health Professionals*: Preparing for the health consequences of climate change requires that professionals have the skills required to conceptualize the impending threats, integrate a wide variety of public health and other data in surveillance activities, develop and implement preparedness plans, and provide effective health communication. Building on a strong track record in convening experts and communication of scientific and technical information, CDC held a series of workshops beginning in 2006 to explore key dimensions of climate change and public health, including drinking water, heat waves, health communication, and vulnerable populations. In addition, CDC developed and published guidance on the public health approach to climate change.

- *Health Protection Research:* CDC has a strong record of applied public health research. With regard to climate change, initial efforts have included intramural

research on heat waves, and extramural research on the relationship between rainfall and other climactic factors on Hantavirus pulmonary syndrome and plague.

- *Communication*: CDC has expertise in communicating health and risk information to the general public, as applied to areas as diverse as smoking, HIV infection, and cancer screening. Effective communication can alert the public to health risks associated with climate change and encourage constructive protective behaviors.

In preparing for the effects climate change, CDC works closely with a broad array of partners including other Federal agencies, such as the Environmental Protection Agency, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, Department of Agriculture, and National Institutes of Health through the United States Climate Change Science Program; state and local organizations, such as the National Association of County and City Health Officials (NACCHO), Association of State and Territorial Health Officials (ATSHO), and state and local veterinary officials; faith-based organizations; the American Public Health Association; and many other organizations and agencies. In addition, CDC supports efforts to increase awareness of climate change among global health practitioners, incorporate climate change concerns into ongoing global health programs, and align global health program targets with larger climate change frameworks and sustainable development models.

Protecting Public Health from Climate Change: A Path Forward

Based on its existing foundation, CDC has identified key directions for further work in advancing public health prevention and preparedness for climate change:

1) *Strengthen surveillance systems:* Surveillance systems for food-borne, water-borne, vector-borne, zoonotic, and other diseases in cooperation with state and local partners are needed to track key risk factors and disease occurrence, to better understand the impact of climate change on public health, to develop early warning systems, and to protect health.

2) Advance research: Extensive research is needed to develop innovative modeling and forecasting tools, to characterize better the effects of climate change on health, to predict health effects at local scales, to identify the most health-promoting mitigation strategies, to develop and test health protection strategies, and to test communication approaches. CDC is coordinating its research with NIH, EPA, and NOAA. Through enhancements to CDC's scientific expertise in epidemiology, infectious disease ecology, disaster preparedness, modeling and forecasting, climatology and earth science, and communication, CDC could further apply its unique expertise in applied public health research to advance our understanding of health aspects of climate change. In addition, our emerging understanding would be expanded through CDC partnership with academic centers to support needed research.

3) Provide technical assistance: CDC is receiving a steadily increasing volume of requests from state and local health departments and other agencies and organizations for guidance in addressing the public health implications of climate change. Responding to such requests is a core CDC activity, and much of CDC's expertise is implemented through collaboration with such partners.

4) Building public health capacity: Two recent surveys of public health practitioners, conducted by NACCHO and ASTHO, have shown an urgent need to train state and local public health officials to address climate change. Similarly, training

programs in fields ranging from public health to civil engineering need to train future professionals in the principles and practice of public health as applied to climate change. CDC can support such capacity-building both for practitioners and for trainees.

5) Education and outreach: Important audiences for outreach include health professionals, state and local health departments, university environmental studies departments, science teachers, federal, state and local officials, community groups, faith-based organizations, industry, and the public. CDC can provide science-based information to these audiences, based on the principles of health and risk communication.

6) *Global health assistance*: Just as CDC supports global public health efforts to combat infectious and chronic diseases, there is a need for global efforts to protect people from the health effects of climate change. From surveillance to research, from technical assistance to capacity building and communication, CDC can enhance its global health mission by incorporating work on climate change effects.

Conclusion

An effective public health response to climate change can prevent injuries, illnesses, and death while enhancing overall public health preparedness. There is a need to identify and promote co-benefits so that actions that address climate change also yield health, environmental, economic, and social benefits.

Currently CDC supports efforts to: (1) incorporate climate change concerns into ongoing global health programs, (2) strengthen the evidence base, and (3) collaborate with key agencies addressing climate change. CDC's contributions are essential to national and global efforts in both mitigation and adaptation. The activities needed to

protect public health from climate change will provide collateral benefits as they strengthen the overall public health system.

Thank you again for the opportunity to provide this testimony on the potential health effects of global climate change and for your continued support of CDC's essential public health work.

Climate Change and Public Health

United States Senate
Committee on Environment and Public Works
25 February 2009

Howard Frumkin, M.D., Dr.P.H., Director
National Center for Environmental Health /
Agency for Toxic Substances and Disease Registry
Centers for Disease Control and Prevention

Mitigation:
The need for Health Impact Assessment

Potential Health Effects of Climate Change
Climate change:
• Temperature rise
• Sea level rise
• Hydrological extremes
HEAT
SEVERE WEATHER
AIR POLLUTION
ALLERGIES
VECTOR-BORNE DISEASES
WATER-BORNE DISEASES
WATER AND FOOD SUPPLY
MENTAL HEALTH
ENVIRONMENTAL REFUGEES
Heat stroke, cardiovascular failure
Injuries, fatalities
Asthma, cardiovascular disease
Respiratory allergies, pollen season
Malaria, cholera, leishmaniasis, encephalitis, Rift Valley fever
Cholera, cryptosporidiosis
Salmonellosis, leptospirosis
Malnutrition, diarrhea
Mental illness, alcoholism
Anxiety, post-traumatic stress, depression, despair
Forced migration, civil conflict

Heat:
A well understood threat
U. S. Agents in Chicago Track a Subtle Health Hazard: Heat
Heat Related Deaths in Chicago in July 1995
Number of Heat-related Deaths
Maximum Temperature (F) or Max HI
HI
Tmax
7/1/95
7/2/95
7/13/95
7/14/95
7/15/95
7/16/95
7/17/95
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7/20/95
7/21/95
7/22/95
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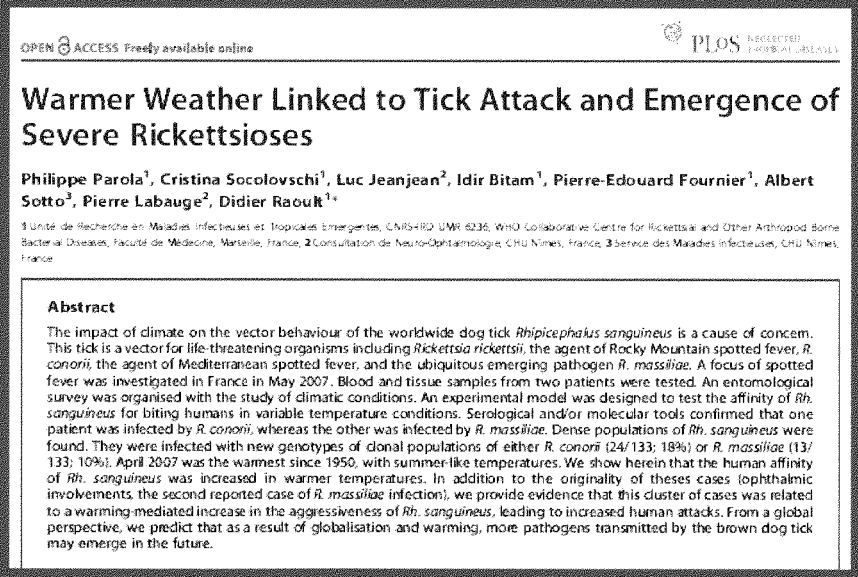
Infectious diseases: Complex, much to learn



OPEN ACCESS Freely available online

PLOS Neglected Tropical Diseases

Warmer Weather Linked to Tick Attack and Emergence of Severe Rickettsioses

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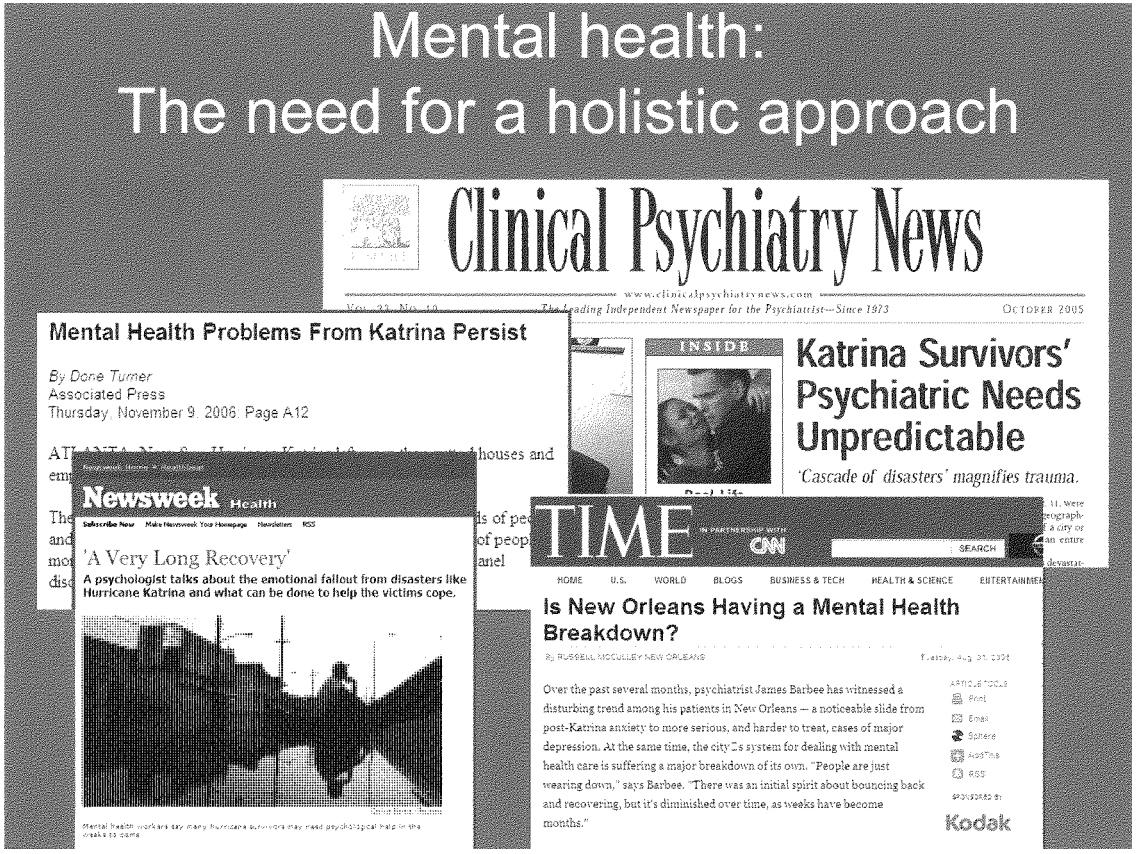
Abstract

The impact of climate on the vector behaviour of the worldwide dog tick *Rhipicephalus sanguineus* is a cause of concern. This tick is a vector for life-threatening organisms including *Rickettsia rickettsii*, the agent of Rocky Mountain spotted fever, *R. conorii*, the agent of Mediterranean spotted fever, and the ubiquitous emerging pathogen *R. massiliae*. A focus of spotted fever was investigated in France in May 2007. Blood and tissue samples from two patients were tested. An entomological survey was organised with the study of climatic conditions. An experimental model was designed to test the affinity of *Rh. sanguineus* for biting humans in variable temperature conditions. Serological and/or molecular tools confirmed that one patient was infected by *R. conorii*, whereas the other was infected by *R. massiliae*. Dense populations of *Rh. sanguineus* were found. They were infected with new genotypes of clonal populations of either *R. conorii* (24/133; 18%) or *R. massiliae* (13/133; 10%). April 2007 was the warmest since 1950, with summer-like temperatures. We show herein that the human affinity of *Rh. sanguineus* was increased in warmer temperatures. In addition to the originality of theses cases (ophthalmic involvements, the second reported case of *R. massiliae* infection), we provide evidence that this cluster of cases was related to a warming-mediated increase in the aggressiveness of *Rh. sanguineus*, leading to increased human attacks. From a global perspective, we predict that as a result of globalisation and warming, more pathogens transmitted by the brown dog tick may emerge in the future.

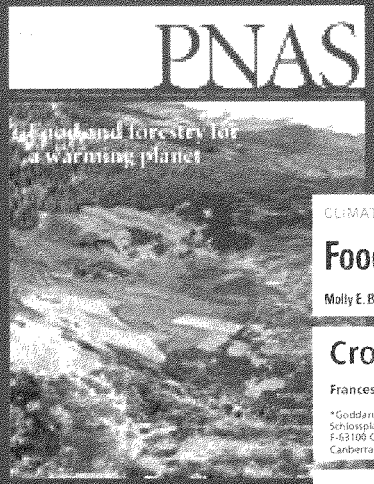
Parola P, Socolovschi C, Jeanjean L, Bitam I, Fournier P-E, et al. (2008) Warmer weather linked to tick attack and emergence of severe rickettsioses. *PLoS Negl Trop Dis* 2(11): e338. doi:10.1371/journal.pntd.0000338

Range of suitable conditions for *Ixodes scapularis*, the Lyme disease vector

Mental health:
The need for a holistic approach



Food:
The need to look "upstream"



CLIMATE

Food Security Under Climate Change

Molly E. Brown and Christopher C. Funk

Food insecurity is likely to increase under climate change, unless early warning systems and development programs are used more effectively.

Crop and pasture response to climate change

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Global food security under climate change

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Public Health Action on Climate Change:
Key Steps
• Surveillance and data collection
• Modelling and forecasting
• Direct actions to protect the public
• Communication
• Training and capacity building
• Research

Environment and Public Works Committee Hearing
February 25, 2009
Responses to Follow-Up Questions for Written Submission

Senator Bernard Sanders

1. In the 2007 IPCC report, we learned a lot about possible increased heat waves, rates of respiratory illnesses and infectious diseases, flooding etc. In your written testimony you indicated that some groups are more at-risk of the expected health effects of climate change than others. Not surprisingly these groups included children and the elderly, who are more vulnerable to many diseases. You also mentioned low-income people as a population particularly vulnerable to the effects of climate change. Could you elaborate on that?

"Vulnerability" is sometimes partly a function of the capabilities and personality of the individual. However, more frequently, vulnerability is a function of the social systems and resources that shape an individual's options and the individual's practical ability to utilize their own inner strength and intelligence to protect themselves in the face of danger or disruption. In that context, low-income populations are vulnerable to the negative health effects of climate change for reasons common to other "environmental justice" concerns: increased exposure to hazards, biological vulnerability due to pre-existing conditions, and decreased resiliency and capacity for recovery after an event.

Low-income populations sustain increased exposures to adverse environmental conditions. For instance, housing in low-lying areas of cities entails increased risk of flooding, substandard housing without air-conditioning increases the risk of heat exposure during heat waves, and residence near industrial facilities or busy thoroughfares increases exposure to air pollutants—all exposures that may be aggravated with climate change. The health effects of these environmental exposures range from drowning to asthma exacerbations to hyperthermia.

There is an increased prevalence of chronic illnesses among low income people, such as obesity, hypertension, asthma, diabetes, and cardiovascular diseases, which heighten vulnerability to some environmental exposures. Furthermore, some segments of the low income population have difficulty accessing those public services designed to reduce vulnerability, because of utilization costs, concerns about social stigmatization, and/or language or other barriers. The most common co-morbidities of the 1995 Chicago Heat Wave's near-fatal heat strokes were hypertension and alcohol abuse (2). A mortality study of Hurricane Katrina found that the third highest cause of death (after drowning and injury) was heart disease (3).

The conditions that increase vulnerability may also decrease the low income population's resiliency and its capacity to recover from environmental challenges. For example, lack of access to medical care may impede recovery from asthma attacks or infectious diseases, and scarcity of resources may hinder rebuilding after severe weather events damage homes, schools, and businesses.

Expected increases in extreme weather events, deteriorating air quality, and rising heat waves under various climate change scenarios will continue to disproportionately burden low income populations. Therefore, public health adaptation must focus on the aspects of vulnerability caused by health and environmental inequities and facilitate behavioral changes to cope with the negative health effects of climate change (4, 5).

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Environment and Public Works Committee Hearing
February 25, 2009
Responses to Follow-Up Questions for Written Submission

Senator Mike Crapo

1. In your testimony, you stated that you expect that with climate change, an increase in the severity, duration, and frequency of extreme heat waves in the U.S. You also predict that will mean a need for public health preparedness to deal with this situation.

In the U.S. 2005 Climate Change and Human Health Impacts report, heat is mentioned fifty-four times and cold just once.

Interestingly, in Europe for example, about two hundred thousand people die from excess heat each year. But about 1.5 million Europeans die annually from excess cold.

How do we know that higher temperatures will not be better, not worse for the human population?

Temperature-related deaths are the lowest when populations operate within an optimal temperature zone. Although these deaths vary by latitude and climatic zone, they do increase when populations find themselves outside their specific comfort zones (1). In addition to locale, social factors also influence temperature related deaths, such as housing codes and the presence of heating/air conditioning units. Although heat waves are the deadliest extreme weather events in the U.S., some countries do experience more cold-related deaths as compared to excessive heat-related deaths (2-8). Despite this trend, studies show that with increasing temperatures, the averted annual cold-related deaths some countries will experience will not be enough to counter the rise in excess annual heat related deaths expected (9).

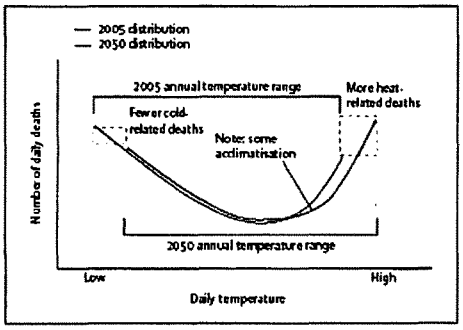

Figure 1: Schematic representation of how an increase in average annual temperature would affect annual total of temperature-related deaths, by shifting distribution of daily temperatures to the right Additional heat-related deaths in summer would outweigh the extra winter deaths averted (as may happen in some northern European countries). Average daily temperature range in temperate countries would be about 5–30°C (9).

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2. There is quite a bit of talk about the threat of certain diseases associated with climate change, such as the increase and proliferation of malaria.

Assuming this would be the case, I assume we would want to find the lowest cost and most effective method for confronting this predicted threat. For example, if we shut down the entire U.S. fossil-fueled power sector, models predict only a .07 degree Celsius lowering in the earth's temperature over the next 100 years.

It costs approximately $7 to buy and distribute a malaria net. Wouldn't this do more to stop the spread of disease?

Vector-borne and zoonotic diseases have many different epidemiologic patterns, risk factors, modes of transmission, and potential approaches for prevention and control. It is not possible to generalize about all of these from a specific single disease such as malaria. Consequently, the overall impact of global warming on the risks for mosquito-borne and other vector-transmitted diseases remains difficult to predict.

For example, malaria infection and illness severity in the population depend on a great number of factors, only some of which would be altered directly by climate change. In addition to a suitable climate, malaria transmission can also be affected by factors such as the underlying immunity to malaria in the population, changes in land use leading to changes in abundance of mosquito breeding sites, housing conditions (such as the presence or absence of window screens), adequacy of malaria control efforts, resistance of mosquitoes to insecticides and malaria parasites to drugs, access to health care, availability of alternative sources for mosquitoes to feed including livestock, and population movements, including those related to conflict or social and economic disruption.

Efforts to control malaria currently focus on proven interventions that can save lives over a relatively short period of time, such as insecticide-treated mosquito nets, prompt detection and diagnosis, effective treatment of illness, intermittent preventive treatment in particular risk groups, and indoor residual application of insecticides. These strategies are having a positive health impact today. This success, however, should not preclude evaluating concerns over the other likely health effects of global climate change. While bed nets provide an inexpensive and effective method for preventing malaria, there are many other very important vector-borne diseases that may be impacted by climate change - such as dengue, Chikungunya, Rift Valley Fever, West Nile Virus infection, and Lyme disease - which are not prevented by bed nets. The impact that global warming may have on these diseases is poorly understood. Consequently, efforts aimed at understanding the ecology of vector-borne and zoonotic diseases and the potential impact of global climate change on disease risk are critical for preparedness, so that future potential climate-related outbreaks of exotic diseases can be averted.

Senator BOXER. Thank you very much.

Dr. William Happer, Professor of Physics, Princeton University. And as I understand it, also Chairman of the George C. Marshall Institute. Welcome.

STATEMENT OF WILLIAM HAPPER, PH.D., CYRUS FOGG BRACKETT PROFESSOR OF PHYSICS, PRINCETON UNIVERSITY

Mr. HAPPER. Thank you.

Let me state clearly where I probably agree with the other witnesses. We have been in a period of global warming, but it has been going on for about 200 years. Also, there have been several periods, like the last 10 years, when the warming has ceased. In fact, there has been a little bit of cooling over the past 10 years. There have even been periods of substantial cooling, for example, from 1940 to 1970. You can see that on Dr. Pachauri's chart.

Atmospheric concentrations of carbon dioxide have increased from about 280 to 380 parts per million over the past 100 years.

The combustion of fossil fuels, coal, oil, natural gases, contributed to this increase in the atmosphere. Finally, increasing concentrations of CO_2 in the atmosphere will cause some warming of the earth's surface. The key question is, will the net effect of the warming and any other effects of CO_2 be good or bad for humanity? I believe the increase of CO_2 will be good.

I predict that future historians will look back on this period much as we now look back on the period just before we passed the 18th Amendment to the U.S. Constitution to prohibit the manufacturing, sale or transportation of intoxicating liquors. At the time, the 18th Amendment seemed to be exactly the right thing to do. It was the 1917 version of saving the planet from the ravages of climate change.

More than half the States enacted Prohibition laws before the 18th Amendment was finally ratified. Only one State, Rhode Island, voted against it, and my hat is off to the Senator from Rhode Island. I am sorry he is not here.

There were many people who thought that prohibition might do more harm than good, but they were completely outmatched by the Temperance movement, whose motives and methods have much in common with the movement to stop climate change. Deeply sincere people felt they were saving humanity from the evils of alcohol, just as many people now sincerely think they are saving humanity from the evils of CO_2.

Prohibition was a mistake, and our Country has probably still not fully recovered from the damage it did. For example, institutions like organized crime got their start in that era. Drastic limitations on CO_2 are likely to damage our Country in an analogous way. There is tremendous opportunity for corruption there.

There is little argument in the scientific community that the direct effect of doubling CO_2 concentrations will be a small increase in the earth's temperature, on the order of 1 degree Centigrade. That is not enough to worry about it. Further increases will cause even less temperature rise.

To get the scary scenarios that we hear about, water vapor and clouds must amplify the direct effects of CO_2. In fact, observations suggest that water vapor and clouds actually diminish the already

small global warming expected from CO_2, not amplify it. The evidence comes from satellite measurements of infrared radiation escaping from the earth into outer space, from measurement of the sunlight reflected from clouds and from measurements of the temperature of the earth's surface.

I keep hearing about the pollutant CO_2, or about poisoning the atmosphere with CO_2. CO_2 is not a pollutant. It is not a poison and we should not corrupt the English language by depriving pollutant and poison of their original meaning. When we exhale, each of us here, our exhaled breath is 4 percent CO_2. That is about 40,000 parts per million, 100 times the current atmospheric concentrations. CO_2 is absolutely essential for life. Commercial greenhouse operators often use CO_2 as a fertilizer to improve the health and growth rate of their plants. Plants and our own primate ancestors evolved when the levels of atmospheric CO_2 were about 1,000 parts per million, a level we will probably not reach by burning fossil fuels. By the way, the oceans did just fine then, at 1,000 parts per million. There was no problem with acidification and lots of coral reefs grew very vigorously.

We are all aware that the green revolution has increased crop yields around the world. Part of this wonderful development comes from improved crop varieties, better use of mineral fertilizers, herbicides, et cetera. But no small part of the yield improvement has come from increased atmospheric levels of CO_2. If we decrease our current levels of CO_2 to those that prevailed a few hundred years ago, I don't know how we would do that, but if we did, we would lose part of the green revolution, and the green revolution has yet to run its course, if we let CO_2 continue to go up.

I often hear there is a consensus behind the idea of impending disaster from climate change that already it may be almost too late to avert this catastrophe, even if we stop burning fossil fuels. Well, first, what is correct in science is not determined by consensus, but by experiment, observation, testing. I can't think of any other branch of science where an international organization is needed to determine the truth. This is the first time this has ever happened.

Second, I don't think there is a consensus about an impending climate crisis. Like the Temperance movement 100 years ago, the climate catastrophe movement has enlisted the mass media, leadership of scientific societies, trustees of charitable foundations, many other influential people to their cause. Even elementary school teachers and writers of children's books terrify our children with the idea of impending climate doom. Children should not be force fed propaganda masquerading as science. Many of you know that in the year 2007, a British court ruled that if Al Gore's book, An Inconvenient Truth, was used in British public schools, that children had to be told of 11 particularly troubling inaccuracies. For example, the court ruled it was not possible to attribute Hurricane Katrina to CO_2. Indeed, if we had taken a small fraction of the many billions of dollars that we spent on climate change research and propaganda and fixed the dikes and pumps around New Orleans, there would have been no disaster.

I regret that climate change issues have become confused with serious problems like secure energy supplies, protecting our environment and figuring out where future generations will get energy

or chemical feedstocks after we have burned all the fossil fuel we can find. I hope we don't confuse these laudable goals with hysterics about carbon footprints. I hope Congress will choose to promote investment in technology that addresses real problems and scientific research that will help us cope with these real problems.

Thank you.

[The prepared statement of Mr. Happer follows:]

CLIMATE CHANGE

Statement of

William Happer
Cyrus Fogg Brackett Professor of Physics
Princeton University

Before the

U.S. Senate Environment and Public Works Committee
Senator Barbara Boxer, Chair

February 25, 2009

Madam Chairman and members, thank you for the opportunity to appear before the Committee on Environment and Public Works to testify on Climate Change. My name is William Happer, and I am the Cyrus Fogg Bracket Professor of Physics at Princeton University. I am not a climatologist, but I don't think any of the other witnesses are either. I do work in the related field of atomic, molecular and optical physics. I have spent my professional life studying the interactions of visible and infrared radiation with

gases – one of the main physical phenomena behind the greenhouse effect. I have published over 200 papers in peer reviewed scientific journals. I am a member of a number of professional organizations, including the American Physical Society and the National Academy of Sciences. I have done extensive consulting work for the US Government and Industry. I also served as the Director of Energy Research at the Department of Energy (DOE) from 1990 to 1993, where I supervised all of DOE's work on climate change. I have come here today as a concerned citizen to express my personal views, and those of many like me, about US climate-change policy. These are not official views of my main employer, Princeton University, nor of any other organization with which I am associated.

Let me state clearly where I probably agree with the other witnesses. We have been in a period of global warming over the past 200 years, but there have been several periods, like the last ten years, when the warming has ceased, and there have even been periods of substantial cooling, as from 1940 to 1970. Atmospheric concentrations of carbon dioxide (CO2) have increased from about 280 to 380 parts per million over past 100 years. The combustion of fossil fuels, coal, oil and natural gas, has contributed to the increase of CO2 in the atmosphere. And finally, increasing concentrations of CO2 in the atmosphere will cause the earth's surface to warm. The key question is: will the net effect of the warming, and any other effects of the CO2, be good or bad for humanity?

I believe that the increase of CO2 is not a cause for alarm and will be good for mankind. I predict that future historians will look back on this period much as we now view the period just before the passage of the 18th Amendment to the US Constitution to prohibit "the manufacturing, sale or transportation of intoxicating liquors." At the time, the 18th amendment seemed to be exactly the right thing to do – who wanted to be in league with demon rum? It was the 1917 version of saving the planet. More than half the states enacted prohibition laws before the 18th amendment was ratified. Only one state, Rhode Island, voted against the 18th amendment. Two states, Illinois and Indiana, never got around to voting and all the rest voted for it. There were many thoughtful people, including a majority of Rhode Islanders, who thought that prohibition might do more harm than good. But they were completely outmatched by the temperance

movement, whose motives and methods had much in common with the movement to stop climate change. Deeply sincere people thought they were saving humanity from the evils of alcohol, just as many people now sincerely think they are saving humanity from the evils of CO2. Prohibition was a mistake, and our country has probably still not fully recovered from the damage it did. Institutions like organized crime got their start in that era. Drastic limitations on CO2 are likely to damage our country in analogous ways.

But what about the frightening consequences of increasing levels of CO2 that we keep hearing about? In a word, they are wildly exaggerated, just as the purported benefits of prohibition were wildly exaggerated. Let me turn now to the science and try to explain why I and many scientists like me are not alarmed by increasing levels of CO2.

The earth's climate really is strongly affected by the greenhouse effect, although the physics is not the same as that which makes real, glassed-in greenhouses work. Without greenhouse warming, the earth would be much too cold to sustain its current abundance of life. However, at least 90% of greenhouse warming is due to water vapor and clouds. Carbon dioxide is a bit player. There is little argument in the scientific community that a direct effect of doubling the CO2 concentration will be a small increase of the earth's temperature -- on the order of one degree. Additional increments of CO2 will cause relatively less direct warming because we already have so much CO2 in the atmosphere that it has blocked most of the infrared radiation that it can. It is like putting an additional ski hat on your head when you already have a nice warm one below it, but your are only wearing a windbreaker. To really get warmer, you need to add a warmer jacket. The IPCC thinks that this extra jacket is water vapor and clouds.

Since most of the greenhouse effect for the earth is due to water vapor and clouds, added CO2 must substantially increase water's contribution to lead to the frightening scenarios that are bandied about. The buzz word here is that there is "positive feedback." With each passing year, experimental observations further undermine the claim of a large positive feedback from water. In fact, observations suggest that the feedback is close to zero and may even be negative. That is, water vapor and clouds may actually diminish the already small global warming expected from CO2, not amplify it. The evidence here comes from satellite measurements of infrared

radiation escaping from the earth into outer space, from measurements of sunlight reflected from clouds and from measurements of the temperature the earth's surface or of the troposphere, the roughly 10 km thick layer of the atmosphere above the earth's surface that is filled with churning air and clouds, heated from below at the earth's surface, and cooled at the top by radiation into space.

But the climate is warming and CO2 is increasing. Doesn't this prove that CO2 is causing global warming through the greenhouse effect? No, the current warming period began about 1800 at the end of the little ice age, long before there was an appreciable increase of CO2. There have been similar and even larger warmings several times in the 10,000 years since the end of the last ice age. These earlier warmings clearly had nothing to do with the combustion of fossil fuels. The current warming also seems to be due mostly to natural causes, not to increasing levels of carbon dioxide. Over the past ten years there has been no global warming, and in fact a slight cooling. This is not at all what was predicted by the IPCC models.

The climate has changed many times in the past with no help by mankind. Recall that the Romans grew grapes in Britain around the year 100, and Viking settlers prospered on small farms in Greenland for several centuries during the Medieval Climate Optimum around 1100. People have had an urge to control the climate throughout history so I suppose it is no surprise that we are at it again today. For example, in June of 1644, the Bishop of Geneva led a flock of believers to the face of a glacier that was advancing "by over a musket shot" every day. The glacier would soon destroy a village. The Bishop and his flock prayed over the glacier, and it is said to have stopped. The poor Vikings had long since abandoned Greenland where the advancing glaciers and cooling climate proved much less susceptible to prayer. Sometimes the obsession for control of the climate got a bit out of hand, as in the Aztec state, where the local scientific/religious establishment of the year 1500 had long since announced that the debate was over and that at least 20,000 human sacrifices a year were needed to keep the sun moving, the rain falling, and to stop climate change. The widespread dissatisfaction of the people who were unfortunate enough to be the source of these sacrifices played an important part in the success of the Spanish conquest of Mexico.

The existence of climate variability in the past has long been an embarrassment to those who claim that all climate change is due to man and that man can control it. When I was a schoolboy, my textbooks on earth science showed a prominent "medieval warm period" at the time the Vikings settled Greenland, followed by a vicious "little ice age" that drove them out. So I was very surprised when I first saw the celebrated "hockey stick curve," in the Third Assessment Report of the IPCC. I could hardly believe my eyes. Both the little ice age and the Medieval Warm Period were gone, and the newly revised temperature of the world since the year 1000 had suddenly become absolutely flat until the last hundred years when it shot up like the blade on a hockey stick. This was far from an obscure detail, and the hockey stick was trumpeted around the world as evidence that the end was near. We now know that the hockey stick has nothing to do with reality but was the result of incorrect handling of proxy temperature records and incorrect statistical analysis. There really was a little ice age and there really was a medieval warm period that was as warm or warmer than today. I bring up the hockey stick as a particularly clear example that the IPCC summaries for policy makers are not dispassionate statements of the facts of climate change. It is a shame, because many of the IPCC chapters are quite good. The whole hockey-stick episode reminds me of the motto of Orwell's Ministry of Information in the novel "1984:" "He who controls the present, controls the past. He who controls the past, controls the future." The IPCC has made no serious attempt to model the natural variations of the earth's temperature in the past. Whatever caused these large past variations, it was not due to people burning coal and oil. If you can't model the past, where you know the answer pretty well, how can you model the future?

Many of us are aware that we are living in an ice age, where we have hundred-thousand-year intervals of big continental glaciers that cover much of the land area of the northern hemisphere, interspersed with relative short interglacial intervals like the one we are living in now. By looking at ice cores from the Greenland and Antarctic ice sheets, one can estimate past temperatures and atmospheric concentrations of CO2. Al Gore likes to display graphs of temperature and CO2 concentrations over the past million years or so, showing that when CO2 rises, the temperature also rises. Doesn't

this prove that the temperature is driven by CO2? Absolutely not! If you look carefully at these records, you find that first the temperature goes up, and then the CO2 concentration of the atmosphere goes up. There is a delay between a temperature increase and a CO2 increase of about 800 years. This casts serious doubt on CO2 as a climate driver because of the fundamental concept of causality. A cause must precede its effect. For example, I hear my furnace go on in the morning about six o'clock, and by about 7 o'clock, I notice that my house is now so warm that I have too many covers on my bed. It is time to get up. It would never occur to me to assume that the furnace started burning gas at 6 o'clock because the house got warm at 7 o'clock. Sure, temperature and gas burning are correlated, just like temperature and atmospheric levels of CO2. But the thing that changes first is the cause. In the case of the ice cores, the cause of increased CO2 is almost certainly the warming of the oceans. The oceans release dissolved CO2 when they warm up, just like a glass of beer rapidly goes flat in a warm room. If not CO2, then what really causes the warming at the end of the cold periods of ice ages? A great question and one of the reasons I strongly support research in climate.

I keep hearing about the "pollutant CO2," or about "poisoning the atmosphere" with CO2, or about minimizing our "carbon footprint." This brings to mind another Orwellian pronouncement that is worth pondering: "But if thought corrupts language, language can also corrupt thought." CO2 is not a pollutant and it is not a poison and we should not corrupt the English language by depriving "pollutant" and "poison" of their original meaning. Our exhaled breath contains about 4% CO2. That is 40,000 parts per million, or about 100 times the current atmospheric concentration. CO2 is absolutely essential for life on earth. Commercial greenhouse operators often use CO2 as a fertilizer to improve the health and growth rate of their plants. Plants, and our own primate ancestors evolved when the levels of atmospheric CO2 were about 1000 ppm, a level that we will probably not reach by burning fossil fuels, and far above our current level of about 380 ppm. We try to keep CO2 levels in our US Navy submarines no higher than 8,000 parts per million, about 20 time current atmospheric levels. Few adverse effects are observed at even higher levels.

We are all aware that "the green revolution" has increased crop yields around the world. Part of this wonderful development is due to improved crop varieties, better use of mineral fertilizers, herbicides, etc. But no small part of the yield improvement has come from increased atmospheric levels of CO2. Plants photosynthesize more carbohydrates when they have more CO2. Plants are also more drought-tolerant with more CO2, because they need not "inhale" as much air to get the CO2 needed for photosynthesis. At the same time, the plants need not "exhale" as much water vapor when they are using air enriched in CO2. Plants decrease the number of stomata or air pores on their leaf surfaces in response to increasing atmospheric levels of CO2. They are adapted to changing CO2 levels and they prefer higher levels than those we have at present. If we really were to decrease our current level of CO2 of around 400 ppm to the 270 ppm that prevailed a few hundred years ago, we would lose some of the benefits of the green revolution. Crop yields will continue to increase as CO2 levels go up, since we are far from the optimum levels for plant growth. Commercial greenhouse operators are advised to add enough CO2 to maintain about 1000 ppm around their plants. Indeed, economic studies like those of Dr. Robert Mendelsohn at Yale University project that moderate warming is an overall benefit to mankind because of higher agricultural yields and many other reasons.

I remember being forced to read Voltaire's novel, Candide, when I was young. You recall that Dr. Pangloss repeatedly assured young Candide that he was living in "the best of all possible worlds," presumably also with the best of all CO2 concentrations. That we are (or were) living at the best of all CO2 concentrations seems to be a tacit assumption of the IPCC executive summaries for policy makers. Enormous effort and imagination have gone into showing that increasing concentrations of CO2 will be catastrophic, cities will be flooded by sea-level rises that are ten or more times bigger than even IPCC predicts, there will be mass extinctions of species, billions of people will die, tipping points will render the planet a desert. A few months ago I read that global warming will soon bring on a devastating epidemic of kidney stones. If you write down all the ills attributed to global warming you fill up a very thick book.

Much is made about tropical diseases like malaria and yellow fever devastating the populations of temperate climates because of the burning of fossil fuels and the subsequent warming of the earth. Many people who actually work with tropical diseases, notably Dr. Paul Reiter, a specialist on tropical diseases, have pointed out how silly all of this is. Perhaps I can add a few bits of history to illustrate this point. One of the first military expenditures of the Continental Congress in 1775 was $300 to purchase quinine for the Continental Army and to mitigate the effects of malaria. The Continental Congress moved from the then Capital of the United States , Philadelphia, to my home town of Princeton, New Jersey, in the summer of 1783 for two reasons. The first was that the Congress had not yet paid many soldiers of the Revolutionary War their promised wages, and disgruntled veterans were wandering up and down the streets of Philadelphia. Secondly, there were outbreaks of malaria in cities as far north as Boston. The Congress knew you were less likely to catch malaria in Princeton than in Philadelphia. In 1793 there was not only malaria, but a horrendous outbreak of yellow fever in Philadelphia. Many thousands of people died in a city with a population of about 50,000. And I should point out that Philadelphia was a bit cooler then than now, since the little ice age was just coming to an end. Controlling tropical diseases and many other diseases has little to do with temperature, and everything to do with curtailing the factors that cause the spread – notably mosquitoes in the case of malaria and yellow fever.

Many of the frightening scenarios about global warming come from large computer calculations, "general circulation models," that try to mimic the behavior of the earth's climate as more CO2 is added to the atmosphere. It is true that climate models use increasingly capable and increasingly expensive computers. But their predictions have not been very good. For example, none of them predicted the lack of warming that we have experienced during the past ten years. All the models assume the water feedback is positive, while satellite observations suggest that the feedback is zero or negative.

Modelers have been wrong before. One of the most famous modeling disputes involved the physicist William Thompson, later Lord Kelvin, and the naturalist Charles Darwin. Lord Kelvin was a great believer in models and differential equations. Charles

Darwin was not particularly facile with mathematics, but he took observations very seriously. For evolution to produce the variety of living and fossil species that Darwin had observed, the earth needed to have spent hundreds of millions of years with conditions not very different from now. With his mathematical models, Kelvin rather pompously demonstrated that the earth must have been a hellish ball of molten rock only a few tens of millions of years ago, and that the sun could not have been shining for more than about 30 million years. Kelvin was actually modeling what he thought was global and solar cooling. I am sorry to say that a majority of his fellow physicists supported Kelvin. Poor Darwin removed any reference to the age of the earth in later editions of the "Origin of the Species." But Darwin was right the first time, and Kelvin was wrong. Kelvin thought he knew everything but he did not know about the atomic nucleus, radioactivity and nuclear reactions, all of which invalidated his elegant modeling calculations.

This brings up the frequent assertion that there is a consensus behind the idea that there is an impending disaster from climate change, and that it may already be too late to avert this catastrophe, even if we stop burning fossil fuels now. We are told that only a few flat-earthers still have any doubt about the calamitous effects of continued CO2 emissions. There are a number of answers to this assertion.

First, what is correct in science is not determined by consensus but by experiment and observations. Historically, the consensus is often wrong, and I just mentioned the incorrect consensus of modelers about the age of the earth and the sun. During the yellow fever epidemic of 1793 in Philadelphia the medical consensus was that you could cure almost anything by bleeding the patient. Benjamin Rush, George Washington's Surgeon General during the War of Independence, and a brave man, stayed in Philadelphia throughout the yellow fever epidemic. He worked tirelessly to save the stricken by bleeding them, the consensus treatment of the day. A few cautious observers noticed that you were more likely to survive the yellow fever without the services of the great man. But Dr. Rush had plenty of high level-friends and he was backed up by the self-evident consensus, so he went ahead with his ministrations. In summary, a consensus is often wrong.

Secondly, I do not think there is a consensus about an impending climate crisis. I personally certainly don't believe we are facing a crisis unless we create one for ourselves, as Benjamin Rush did by bleeding his patients. Many others, wiser than I am, share my view. The number of those with the courage to speak out is growing. There may be an illusion of consensus. Like the temperance movement one hundred years ago the climate-catastrophe movement has enlisted the mass media, the leadership of scientific societies, the trustees of charitable foundations, and many other influential people to their cause. Just as editorials used to fulminate about the slippery path to hell behind the tavern door, hysterical op-ed's lecture us today about the impending end of the planet and the need to stop climate change with bold political action. Many distinguished scientific journals now have editors who further the agenda of climate-change alarmism. Research papers with scientific findings contrary to the dogma of climate calamity are rejected by reviewers, many of whom fear that their research funding will be cut if any doubt is cast on the coming climate catastrophe. Speaking of the Romans, then invading Scotland in the year 83, the great Scottish chieftain Calgacus is quoted as saying "They make a desert and call it peace." If you have the power to stifle dissent, you can indeed create the illusion of peace or consensus. The Romans have made impressive inroads into climate science. Certainly, it is a bit unnerving to read statements of Dr. James Hansen in the Congressional Record that climate skeptics are guilty of "high crimes against humanity and nature."

Even elementary school teachers and writers of children's books are enlisted to terrify our children and to promote the idea of impending climate doom. Having observed the education of many children, including my own, I am not sure how effective the effort will be. Many children seem to do just the opposite of what they are taught. Nevertheless, children should not be force-fed propaganda, masquerading as science. Many of you may know that in 2007 a British Court ruled that if Al Gore's book, "An Inconvenient Truth," was used in public schools, the children had to be told of eleven particularly troubling inaccuracies. You can easily find a list of the inaccuracies on the internet, but I will mention one. The court ruled that it was not possible to attribute hurricane Katrina to CO2. Indeed, had we taken a few of the many billions of dollars we have been spending on climate change research and propaganda and fixed the dykes

and pumps around the New Orleans, most of the damage from Hurricane Katrina could have been avoided.

The sea level is indeed rising, just as it has for the past 20,000 years since the end of the last ice age. Fairly accurate measurements of sea level have been available since about 1800. These measurements show no sign of any acceleration. The rising sea level can be a serious local problem for heavily-populated, low-lying areas like New Orleans, where land subsidence compounds the problem. But to think that limiting CO2 emissions will stop sea level rise is a dangerous illusion. It is also possible that the warming seas around Antarctica will cause more snowfall over the continent and will counteract the sea-level rise. In any case, the rising sea level is a problem that needs quick local action for locations like New Orleans rather than slow action globally.

In closing, let me say again that we should provide adequate support to the many brilliant scientists, some at my own institution of Princeton University, who are trying to better understand the earth's climate, now, in the past, and what it may be in the future. I regret that the climate-change issue has become confused with serious problems like secure energy supplies, protecting our environment, and figuring out where future generations will get energy supplies after we have burned all the fossil fuel we can find. We should not confuse these laudable goals with hysterics about carbon footprints. For example, when weighing pluses and minuses of the continued or increased use of coal, the negative issue should not be increased atmospheric CO2, which is probably good for mankind. We should focus on real issues like damage to the land and waterways by strip mining, inadequate remediation, hazards to miners, the release of real pollutants and poisons like mercury, other heavy metals, organic carcinogens, etc. Life is about making decisions and decisions are about trade-offs. The Congress can choose to promote investment in technology that addresses real problems and scientific research that will let us cope with real problems more efficiently. Or they can act on unreasonable fears and suppress energy use, economic growth and the benefits that come from the creation of national wealth.

Questions for Happer

Questions from:

Senator James M. Inhofe

1. Dr. Happer, you butted heads with former Vice President Al Gore during the first Clinton-Gore administration. Would you care to detail your clash with Gore over science?

The issue was environmental extremism. For example, I had tried to use funds from the Department of Energy, where I was the Director of Energy Research, to set up a network of well calibrated sensors of UVB radiation at ground level. At the time, the few functioning instruments we had in the United States indicated that UVB levels at the earth's surface were decreasing, not increasing as one would expect if stratospheric ozone were decreasing. The Gore camp did not like the idea of direct measurements that might contradict their alarmist modeling and rhetoric about the effects of Freon. So we still have no good measurements of UVB in the United States. In spite of the elimination of almost all uses of Freon, the ozone hole over Antarctica has not gone away, and it is not clear what role, if any, Freon played in producing the hole.

2. How would you describe the current scientific climate in terms of supporting challenges to the prevailing orthodoxy and encouraging dissent?

I sense a great deal of fear in the scientific community. Research on climate is unlike most other research areas, where there is a lively debate about competing ideas. In climate science, any dissent from the dogma presented by the IPCC summaries, is regarded as heresy. It is difficult to get papers published in scientific journals if they do not support the party line of impending climate catastrophe. Editors have been fired for publishing "heretical" papers.

3. How does the UN IPCC process impact climate science?

The main chapters of the IPCC reports are often well-written summaries of the chapter topic. The problem has been the summaries for policy makers, which exaggerate the dangers of climate change and ignore most caveats from the main chapters.

4. Will you respond to the comment from Professor Richard Lindzen of MIT, that "(The IPCC) has decided that they have to convince other people that since no scientist disagrees you shouldn't disagree either. Whenever you hear that in science, it's pure propaganda."

Of course Professor Lindzen is correct. And there are plenty of very competent scientists who disagree with the IPCC alarmism, including some authors of IPCC chapters.

Senator BOXER. Thank you very much.

I just want to put into the record a list of the various foundations that the ExxonMobil gives money to, and note that Dr. Happer, your George C. Marshall Institute receives almost a million dollars over the past 10 years from Exxon.

Your words are very alarming to me, sir, because you are basically saying to these three gentlemen that they are feeding us propaganda. And I have read other things you have said which compares people who are talking about climate change to the Germans during the Nazi era. I have that, I will put that in the record.

[The referenced information follows:]

Exxon Mobil Corporation
2007 Worldwide Contributions and Community Investments

Public Information and Policy Research

Financial Executives Research Foundation, Inc.*, Florham Park, New Jersey	
Project Support	$ 35,000
Research Program	15,000
Foreign Policy Association*, New York, New York	
Annual Dinner	30,000
Foundation for Public Affairs*, Washington, D.C.	5,000
Foundation for Research on Economics and the Environment*, Bozeman, Montana	30,000
Foundation for the Center for Energy, Marine Transportation and Public Policy at Columbia University*, New York, New York	100,000
Foundation of the International Association of the Defense Counsel*, Chicago, Illinois	
Project Support	10,000
Frontiers of Freedom Institute*, Oakton, Virginia	
Energy Literacy	90,000
Fund for Peace*, Washington, D.C.	
Human Rights & Business Roundtable	15,000
George C. Marshall Institute*, Washington, D.C.	
Energy Literacy	50,000
General Operating Support	65,000
George C. Marshall Research Foundation*, Lexington, Virginia	
Award Dinner	10,000
George Mason University Foundation, Inc., Fairfax, Virginia	
Law & Economics Center	30,000
Law & Economics Center*	10,000
George Washington University*, D.C.	
Middle East Policy Forum	25,000
Georgetown University, Center for Contemporary Arabic Studies, Washington, D.C.	30,000
Georgetown University*, Washington, D.C.	50,000
Headwaters Resource Conservation and Development Area Inc.*, Butte, Montana	
Montana Economic Development Summit	10,000
Henry L. Stimson Center*, Washington, D.C.	25,000
Heritage Foundation*, Washington, D.C.	40,000
Independent Institute, Inc.*, Oakland, California	15,000
Institute for Energy Research*, Houston, Texas	
Energy Literacy	45,000
General Operating Support	50,000
Institute for Research on the Economics of Taxation*, Washington, D.C.	
Membership	10,000
Institute of Internal Auditors Research Foundation*, Altamonte Springs, Florida	
Research Program	5,000
International Accounting Standards Committee Foundation*, New York, New York	150,000
International Conservation Caucus Foundation*, Washington, D.C.	25,000
International Foundation for Election Systems, Washington, D.C.	
Program Support	10,000
International Institute for Conflict Prevention & Resolution*, New York, New York	
Membership Support	10,000
John P. Ellbogen Foundation*, Casper, Wyoming	5,000

2006

Exxon Mobil Corporation"'
2006 Contributions and Community Investments"!
($ Millions)

	United States	*Canada*	*Africa & Middle East*	*Asia Pacific*	*Europe, Russia, & Caspian*	*Latin America*	*Totals*
Arts and Culture	3.3	.9	.1	.4	.5	–	5.2
Civic and Community	16.6	1.9	6.2	3.6	11.7	.9	40.9
Environment	1.9	.5	.6	1.6	1.6	.3	6.5
Health	3.9	.7	11.0	.4	2.7	.3	19.0
Education:							
Higher Education	32.0	.8	.5	.6	.9	.3	35.1
Pre-College[3]	10.1	1.2	2.9	.5	3.6	.6	18.9
Total Education	42.1	2.0	3.4	1.1	4.5	.9	54.0
Policy Research	6.1	–	.2	.1	.1	–	6.5
United Appeals	5.4	1.0	–	–	.1	–	6.5
Total	79.3	7.0	21.5	7.2	21.2	2.4	138.6

(1) Includes donations from Exxon Mobil Corporation its divisions and affiliates and ExxonMobil Foundation

(23 Includes contributions to nonprofit and NGO urganizabons. direct spending on community serving projects. social bonus projects required under agreements with host governments by Exxon Mobil Corporation, its divisions and affiliates. and ExxonMobil s share of community expenditures paid by joint venture: operated by other companies

(3j Includes in-kind donation in the United States of $225,000

Fund for Peace*, Washington, D.C.	
Human Rights & Business Roundtable	$ 15,000
George C. Marshall Institute*, Washington, D.C.	
General Support and Annual Dinner	85,000
George Mason University Foundation, Inc., Fairfax, Virginia	
Law & Economics Center	30,000
George Washington University, D.C.	
Research & Education	25,000
Georgetown University, Center Contemporary Arabic Studies, Washington, D.C.	30,000
Heartland Institute, Chicago, Illinois	
Anniversary Benefit Dinner*	10,000
General Operating Support*	15,000
General Operating Support	90,000
Subtotal	$115,000
Henry L. Stimson Center, Washington, D.C.	20,000
Heritage Foundation*, Washington, D.C.	30,000
Independent Women's Forum*, Washington, D.C.	
Annual Dinner Sponsorship	15,000
Institute for Energy Research*, Houston, Texas	65,000
Institute for International Economics, Washington, D.C.	
US-Indonesia FTA Project	15,000
Institute for Research on the Economics of Taxation*, Washington, D.C.	
Membership	10,000
Institute of Internal Auditors Research Foundation*, Altamonte Springs, Florida	
Research Program	5,000
International Conservation Caucus Foundation*, Alexandria, Virginia	
Inaugural Gala	25,000
International Foundation for Election Systems, Washington, D.C.	10,000
International Institute for Conflict Prevention & Resolution*, New York, New York	
Membership Support	10,000
International Policy Network - North America*, Washington, D.C.	95,000
International QSAR Foundation To Reduce Animal Testing*,	
Two Harbors, Minnesota	
McKim Conference	5,000
Johns Hopkins University, School for Advanced International Studies,	
Washington, D.C.	
20th Anniversary Celebration*	15,000
Energy Club Trip	13,000
SAIS - International Programs	90,000
Subtotal	$118,000
Joint Center for Political and Economic Studies*, Washington, D.C.	
2006 Annual Dinner	15,000
Landmark Legal Foundation, Kansas City, Missouri	
Environmental Accountability Insurance	10,000
Leadership America Inc*, Dallas, Texas	
Sponsorship of Leadership America Reception	5,000
Lindenwood University, St. Charles, Missouri	10,000
Manhattan Institute for Policy Research*, New York, New York	30,000
Media Research Center, Arlington, Virginia	52,500
Mentor Group, Boston, Massachusetts	
Court Forum	30,000
Mercatus Center*, Arlington, Virginia	40,000

2005

Public Information and Policy Research: 2005 Worldwide Giving Report

Acton Institute for the Study of Religion and Liberty, Grand Rapids, Michigan	$ 50,000
Advertising Council, Inc., New York, New York	20,000
AEI-Brookings Joint Center for Regulatory Studies, Washington, D.C.	25,000
Africa Grantmakers Affinity Group*, New York, New York	
Membership	7,500
Africa Society*, Washington, D.C.	25,000
Africare*, Washington, D.C.	10,000
American Conservative Union Foundation, Alexandria, Virginia	50,000
American Council for Capital Formation Center for Policy Research, Washington, D.C.	360,000
American Council on Germany, Inc.*, New York, New York	
John J. McCloy Award Dinner	10,000
American Council on Science and Health, New York, New York	25,000
American Enterprise Institute for Public Policy Research, Washington, D.C.	
Annual Dinner*	5,000
General Operating Support	235,000
American Friends of Lubavitch*, Washington, D.C.	
Annual Benefit Event	5,000
American Legislative Exchange Council, Washington, D.C.	
Annual Conference*	90,000
Energy Sustainability Project	80,000
General Operating Support	71,500
Subtotal	$ 241,500
American Spectator Foundation*, Arlington, Virginia	15,000
Americas Society, Inc.*, New York, New York	
Sponsorship Dinner	10,000
Annapolis Center for Science-Based Public Policy Inc., Maryland	30,000
Arab American Institute Foundation*, Washington, D.C.	
Kahlil Gibran Awards	10,000
Asia Society*, Washington, D.C.	
Annual Dinner	25,000
General Operating (including DC Metro and NY)	45,000
Silver Anniversary Tiger Ball 2005 – Houston, Texas	25,000
Subtotal	$ 95,000
Asian American Journalists Association*, San Francisco, California	
Annual National Convention	5,000
Aspen Institute, Inc.*, Queenstown, Maryland	10,000
Atlas Economic Research Foundation, Arlington, Virginia	100,000
Baker Institute For Public Policy – Rice University*, Houston, Texas	
Energy Forum Membership	50,000
National Oil Companies Study	10,000
Brookings Institution, Washington, D.C.	
General Operating Support*	95,000
Project Support	75,000
Business Council for International Understanding*, New York, New York	
Commercial Diplomacy Program	50,000
Capital Research Center, Washington, D.C.	50,000
Center for American and International Law, Plano, Texas	
CAIL Rogers Award Dinner (February 2006)'	6,000
Institute for Energy Law	8,000
Institute for Transnational Arbitration	6,500
International and Comparative Law	5,000
Other contributions*, each under $5,000	2,500
Other contributions, each under $5,000	100
Subtotal	$ 28,100

George C. Marshall Institute, Washington, D.C.	
Awards Dinner and General Operating Support*	*25,000*
General Operating Support	90,000
George Mason University Foundation, Inc., Fairfax, Virginia	
Law & Economics Center	*30,000*
Georgetown University, Center Contemporary Arabic Studies, Washington, D.C.	*30,000*
Heartland Institute, Chicago, Illinois	
General Operating Support*	90,000
General Operating Support	29,000
Henry L. Stimson Center, Washington, D.C.	10,000
Heritage Foundation, Washington, D.C.	30,000
Hoover Institution, Stanford, California	20.000
Houston Bar Foundation Records Preservation*, Texas	
Historic Court Records Preservation	10,000
Houston Forum*, Texas	6,500
Hudson Institute Inc., Washington, D.C.	10,000
Independent Institute, Inc., Oakland, California	30,000
Independent Women's Forum, Washington, D.C.	15,000
Institute for Energy Research*, Houston, Texas	65,000
Institute for Research on the Economics of Taxation*, Washington, D.C.	5,000
Institute for Senior Studies, Arlington, Virginia	30,000
Institute for the Study of Earth and Man*, Dallas, Texas	
Hollis D. Hedberg Award	10.000
Institute for Trade, Standards, and Sustainable Development, Inc.*,	
Princeton, New Jersey	15,000
Institute of Internal Auditors Research Foundation*, Altamonte Springs, Florida	
Research Program	*5,000*
international Foundation for Election Systems, Washington, D.C.	
Democracy Dinner*	10,000
General Operating Support	10,000
International Policy Network – North America*, Washington, D.C.	130,000
International Republican Institute, Washington, D.C.	10,000
Johns Hopkins University, School for Advanced International Studies,	
Washington, D.C.	*75,000*
Joint Center for Political and Economic Studies*, Washington, D.C.	
2005 Annual Dinner	15,000
Kuwait-America Foundation*, Washington, D.C.	
Benefit Dinner	100,000
Landmark Legal Foundation, Kansas City, Missouri	
EnvironmentalAccountability insurance	10,000
Lindenwood University, St. Charles, Missouri	5,000
Massachusetts Institute of Technology, Cambridge	
Energy Policy Studies	*75,000*
Media Institute, Arlington, Virginia	20,000
Media Research Center, Arlington, Virginia	*50.000*
Mentor Group, Boston, Massachusetts	
Court Forum	30,000
Mexican Cultural Institute*, Washington, D.C.	5,000
Mexico Institute*, Dallas, Texas	5,000
Middle East Institute, Washington, D.C.	
Annual Conference and Banquet*	10,000
General Operating Support	40,000
Middle East Policy Council, Washington, D.C.	20,000
Mosaic Foundation*, McLean, Virginia	
Annual Gala	100,000
National Association of Neighborhoods, Washington, D.C.	25,000
National Association of Women Judges*, Bellaire, Texas	
Annual Conference	10,000

2004

Exxon Mobil Corporation
2004 Worldwide Contributions and Community Investments

Public Information and Policy Research

As a science-based company, ExxonMobil is committed to supporting organizations that research significant domestic and foreign policy issues and promote informed discussion on issues of direct relevance to business and the company's ongoing operations. In 2004, worldwide contributions for Public Information and Policy Research totaled $6.5 million with $6.1 million focused within the United States.

We support programs that foster international understanding and engagement, and help shape U.S. foreign policy. For example, we fund the Council on Foreign Relations to support constructive public and private discussions, and to publish Foreign Affairs, a journal on global issues. Our involvement with the Asia Society, the Africa Society, the Corporate Council on Africa, the Arab American Institute, Mosaic, the Business Council for International Understanding and other similar organizations facilitates American understanding about other societies and cultures.

Organizations dedicated to researching free market solutions to public policy problems also receive support from ExxonMobil. For example, we support the American Enterprise Institute for Public Policy Research and the Competitive Enterprise Institute, both organizations dedicated to strengthening the foundations of freedom and to the principles of free enterprise.

Acton Institute for the Study of Religion and Liberty, Grand Rapids, Michigan	50,000
Advancement of Sound Science Center Inc., Potomac, Maryland	
Climate Change	10,000
Advertising Council, Inc., New York, N.Y.	20,000
AEI-Brookings Joint Center for Regulatory Studies, Washington, D.C.	
General Support (Climate Change)	25,000
Africa Fighting Malaria", Washington, D.C.	
Climate Change Outreach	30,000
Africa Grantmakers' Affinity Group", New York, N.Y.	
Membership	7,500
Africa Society, Washington, D.C.	25,000
Africare*, Washington, D.C.	25,000
American Council for Capital Formation Center for Policy Research, Washington, D.C.	
Climate Change	180,000
General Operating Support	75,000
American Council on Germany, Inc., New York, N.Y.	
John J. McCloy Awards Dinner*	7,500
General Support	10,000
American Council on Science and Health, New York, N.Y.	
Climate Change Issues	15,000

Council of State Governments*, Lexington, Kentucky	5,000
Council on Foreign Relations, Inc.*, New York, N.Y.	
Africa Initiative	50,000
Annual Subscription to Corporate Program	55,000
CPR Institute for Dispute Resolution, Inc.*, New York, N.Y.	10,000
East-West Center*, Washington, D.C.	
Membership: US Asia Pacific Council	15,000
EastWest Institute, New York, N.Y.	5,000
European Institute Inc.*, Washington, D.C.	
Membership	15,000
Federalist Society for Law and Public Policy Studies, Washington, D.C.	15,000
Financial Executives Research Foundation, Inc.*, Florham Park, New Jersey	
Research Program	9,000
Foreign Policy Association*, New York, N.Y.	
Corporate Sponsorship-US. Saudi Arabian Relations Program	30,000
Foundation for Public Affairs*, Washington, D.C.	5,000
Foundation for Research on Economics and the Environment, Bozeman, Montana	
Climate Seminar*	20,000
Federal Judicial Seminars	20,000
General Operating Support	30,000
Subtotal	70,000
Foundation of the International Association of the Defense Counsel, Chicago, Illinois	10,000
Fraser Institute*, Vancouver BC, Canada	
Climate Change	60,000
Free Enterprise Education Institute, Potomac, Maryland	
Research Support	10,000
Frontiers of Freedom Institute, Fairfax, Virginia	
Climate Change Efforts	50,000
Global Climate Change Outreach	90,000
Project Support - Climate Change	40,000
Project Support- Science Center & Climate Change	70,000
Subtotal	**250,000**
Fund for Peace*, Washington, D.C.	
Human Rights and Business Roundtable Membership	11,250
George C. Marshall Institute, Washington, D.C.	
Awards Dinner - Climate Change Activities*	25,000
Climate Change	145,000
George Mason University Foundation, Inc., Fairfax, Virginia	
Law & Economics Center	40,000
George Washington University, Graduate School of Political Management, D.C.	
Global Grassroots Education Program	25,000
Georgetown University, Center Contemporary Arab Studies, Washington, D.C.	30,000
Heartland Institute, Chicago, Illinois	
Climate Change Activities*	10,000
Climate Change Efforts	15,000
General Operating Support	75,000
Subtotal	**100,000**

2003

Public Information and Policy Research

As a science-based company, ExxonMobil is committed to supporting organizations that research significant domestic and foreign policy issues and promote informed discussion on issues of direct relevance to business and the company's ongoing operations. In 2003, worldwide contributions for Public Information and Policy Research totaled $6.8 million.

We support programs that foster international understanding and engagement and help shape U.S. foreign policy. For example, we fund the Council on Foreign Relations to support constructive public and private discussions and to publish *Foreign Affairs*, a journal on global issues. Our involvement with the Asia Society, the Corporate Council on Africa, the Arab American Institute, Mosaic and other similar organizations, facilitates American understanding about societies and cultures of the world.

Organizations dedicated to researching free market solutions to public policy problems also receive support from ExxonMobil. For example, the American Enterprise Institute for Public Policy Research and the Competitive Enterprise Institute, both dedicated to strengthening the foundations of freedom and to the principles of free enterprise, receive our support. Additionally, through various memberships and affiliations, we support the promotion of business views and solutions on a wide range of global economic and business policy issues.

2003 SLC Texas Host State", Austin	
2003 Southern Legislative Conference	*5,000*
Acton Institute for the Study of Religion and Liberty, Grand Rapids, Michigan	
Challenge Grant for International Work	50,000
Advancement of Sound Science Center Inc., Potomac, Maryland	10,000
Advertising Council, Inc., New York, N.Y.	20,000
AEI-Brookings Joint Center for Regulatory Studies, Washington, D.C.	30,000
Africa Society, Washington, D.C.	25,000
American Council for Capital Formation Center for Policy Research, Washington, D.C.	
General Operating Support	95,000
Project Support	50,000
American Council on Germany, Inc., New York, N.Y.	
John J. McCloy Award Dinner*	25,000
General Operating Support	10,000
American Council on Science and Health, New York, N.Y.	25.000
American Enterprise Institute for Public Policy Research, Washington, D.C.	
Annual Dinner*	5,000
General Operating Support	225,000
American Inns of Court Foundation, Alexandria, Virginia	
Circuit Professionalism Awards	*5,000*
Others, each under $5,000	2,000
American Institute of Chemical Engineers*, New York, N.Y.	
Center for Chemical Process Safety	30,000

Foundation for Public Affairs*, Washington, D.C.	5,000
Foundation for Research on Economics and the Environment, Bozeman, Montana	30,000
Fraser Institute*, Vancouver BC, Canada	
Climate Change	60,000
Free Enterprise Action Institute, Potomac, Maryland	
Research Support	50,000
Frontiers of Freedom Institute, Fairfax, Virginia	
Global Climate Change Outreach	95,000
Project Support-Sound Science Center	50,000
Frontiers of Freedom, Fairfax, Virginia	
Global Climate Change Activities	50,000
George Bush School of Government and Public Service*, College Station, Texas	
Conference Series	10,000
George C Marshall Research Foundation*, Lexington, Virginia	
2003 George C. Marshall Foundation Award Dinner	15,000
George C. Marshall Institute, Washington, D.C.	
Global Climate Change Program	95,000
George Mason University Foundation, Inc., Fairfax, Virginia	
Law & Economics Center	20,000
George Washington University, D.C.	
Global Grassroots Education Program	25,000
Georgetown University, Center Contemporary	30,000
Arabic Studies, Washington, D.C.	
Heartland Institute, Chicago, Illinois	
19th Anniversary Benefit Dinner*	7,500
General Operating Support	85,000
Henry L. Stimson Center, Washington, D.C.	10,000
Heritage Foundation, Washington, D.C.	95,000
Hoover Institution, Stanford, California	
Global Climate Change Projects	30,000
Houston Forum*, Texas	
2004 Annual Luncheon	5,000
General Operating Support	6,500
Houston International Protocol Alliance, Texas	
Emergency Preparedness Exchange Program between Houston and Baku, Azerbaijan	5,000
Houston Junior Chamber of Commerce Foundation, Inc.*, Texas	
52nd Consular Ball	10,000
Independent Institute, Inc., Oakland, California	10,000
Independent Women's Forum, Washington, D.C.	15,000
Institute for Civil Justice*, Santa Monica, California	85,000
Institute for East West Studies, New York, N.Y.	10,000
Institute for Energy Research, Houston, Texas	37,000
Institute for Policy Innovation, Lewisville, Texas	7,500
Institute for Research on the Economics of Taxation*, Washington, D.C.	
Membership	5,000
Institute for the Study of Earth and Man*, Dallas, Texas	10,000
Institute of Internal Auditors Research Foundation*, Altamonte Springs, Florida	
Research Program	5,000

2002

Public Information and Policy Research

ExxonMobil supports organizations that research significant domestic and foreign policy issues and promote informed discussion on issues of direct relevance to business and the company's ongoing operations. In 2002, worldwide contributions for Public Information and Policy Research totaled $5.6 million, with $5.1 million focused within the United States.

We support programs that increase the United States' knowledge of the world and shape U.S. foreign policy. We fund the Council on Foreign Relations to assist them in constructive discussions both in private and in public, and to publish Foreign Affairs, a journal on global issues. To increase the understanding by the people of the United States about societies and cultures of the world, we support a variety of organizations and programs focused on both cultural affairs and public policy programs. The Asia Society and the Corporate Council on Africa are currently funded by ExxonMobil.

Organizations that are dedicated to research on free market solutions to public policy problems receive support from ExxonMobil. The American Enterprise Institute for Public Policy Research and the Competitive Enterprise Institute, organizations dedicated to strengthening the foundations of freedom and to the principles of free enterprise, receive support from ExxonMobil.

Through various memberships and affiliations, we support the promotion of business views and solutions on a wide range of global economic and business policy issues. We fund the United States Council for International Business, International Chamber of Commerce and the National Foreign Trade Council to obtain business-critical information about international policy and regulatory issues.

Acton Institute for the Study of Religion and Liberty, Grand Rapids, Michigan	30,000
Advancement of Sound Science Center, Potomac, Maryland	10,000
Advertising Council, Inc., New York, N.Y.	20,000
AEI-Brookings Joint Center for Regulatory Studies, Washington, D.C.	25,000
Africa Society, Washington, D.C.	25,000
American Council for Capital Formation Center for Policy Research*, Washington, D.C.	
Climate Change Activities	199,523
Washington Diplomatic Outreach Activities	100,000
American Council on Germany, Inc., New York, N.Y.	
John J. McCloy Award Dinner*	25,000
General Support	10,000
American Council on Science and Health, New York, N.Y.	10,000
American Enterprise Institute for Public Policy Research, Washington, D.C.	
Annual Dinner*	5,000
General Operating Support	225,000
Project Support	25,000

Committee for Economic Development, New York, N.Y.	*75,000*
Competitive Enterprise Institute, Washington, D.C.	
Congressional Briefing Program	*50,000*
General Operating Support	125,000
General Operating Support*	140,000
Legal Activities*	60,000
Project Support	30,000
Subtotal	**405,000**
Conference Board, Inc., New York, N.Y.	
Exchange Rate Project ($50k: 2001-2002)	*25,000*
Congressional Black Caucus Foundation, Inc.*, Washington, D.C.	
Annual Legislative Conference Dinner	25,000
Consumer Alert, Inc., Washington, D.C.	10,000
Corporate Council on Africa", Washington, D.C.	10,000
Council of State Governments*	
Lexington, Kentucky	*5,000*
Washington, D.C.	*5,000*
Council on Foreign Relations*, New York, N.Y.	
Annual Subscription to the Corporate Program	*50,000*
CPR Institute for Dispute Resolution, Inc.*, New York, N.Y.	6,000
Duke University, Durham, North Carolina	
Center for Environmental Solutions	45,000
East West Institute, New York, N.Y.	10,000
Environmental Law Institute", Washington, D.C.	
Eli Award Dinner	17,500
Federalist Society for Law and Public Policy Studies, Washington, D.C.	*15,000*
Florida International University, Miami	15,000
Foreign Policy Association*, New York, N.Y.	*75,000*
Foundation for American Communications, Pasadena, California	
25th Anniversary Gala	*25,000*
Science Journalism Program*	150,000
Foundation for Public Affairs*, Washington, D.C.	*5,000*
Foundation for Research on Economics and the Environment, Bozeman, Montana	30,000
Foundation for the Center for Energy, Marine Transportation and Public Policy at Columbia University*, New York, N.Y.	
General Support ($500k: 1999-2003)	200,000
Frontiers of Freedom, Fairfax, Virginia	
Center for Sound Science and Pubic Policy	100,000
Global Climate Change Outreach Activities	97,000
Global Climate Change Science Projects	35,000
George C. Marshall Foundation, Washington, D.C.	
Awards Dinner*	10,000
Global Climate Change Program	80,000
George Mason University, Fairfax, Virginia	
Law & Economics Center	20,000

2001

Public Information and Policy Research

Total Worldwide Public Information and Policy Research Contributions in 2001 were $5.7 million. Funds were assigned to support organizations that address policy alternatives in a balanced, objective, and methodologically sound manner.

The company is interested in encouraging attention to issues of direct relevance to business and to ExxonMobil's ongoing operations. Areas addressed include those that impact foreign relations, international business operations, national laws and regulations, and states or local communities where ExxonMobil has a significant presence or interest. The company is particularly supportive of policy organizations which study issues of direct relevance to the petroleum and petrochemical industries and the role of private businesses and market forces in contributing to the resolution of public issues. Accordingly, the areas addressed are:

- Research and commentary on key public policy issues. ExxonMobil supports programs, via think tanks, universities, associations and business councils, whose intent is to increase the United States' knowledge of the world and contribute ideas towards shaping U.S. foreign policy. We support the Council on Foreign Relations to help them promote constructive discussions both in private and in public, and to publish Foreign Affairs, the leading journal on global issues.

- Innovative policy ideas that emphasize market forces. ExxonMobil seeks organizations that are dedicated to research and to provide free market solutions to today's public policy problems. These organizations not only produce ground breaking research on free market policy but are actively involved in communicating the public policy debate not only to policy makers but also the media and public. The American Enterprise Institute for Public Policy Research and the Competitive Enterprise Institute, organizations dedicated to strengthening the foundations of freedom and to the principles of free enterprise, receive support from ExxonMobil.

- General work that has a market-oriented approach. Through various memberships or affiliations, ExxonMobil is able to support the promotion of business views and solutions on a wide range of global economic and business policy issues. We support the United States Council for International Business, International Chamber of Commerce and the National Foreign Trade Council to obtain business-critical information about international policy and regulatory issues.

- Research and relationships on countries where ExxonMobil does business. To increase understanding by the people of the United States about the societies and the cultures of the world, in which ExxonMobil does business, we support a variety of programs focused on both cultural affairs and public policy programs. The Asia Society and the Corporate Council on Africa are examples of organizations currently funded by ExxonMobil.

Public Information and Policy Research

Acton Institute for the Study of Religion and Liberty, Grand Rapids, Michigan	
Environmental Outreach Initiative	*20,000*
General Support	*15,000*
Advancement of Sound Science Center, Washington, D.C.	10,000
Advertising Council, Inc., New York, N.Y.	*20,000*
American Accounting Association*, Sarasota, Florida	*5,000*
American Assembly, New York, N.Y.	40,000
American Association of Blacks in Energy, Washington, D.C.	*5,000*
American Council for Capital Formation Center for Policy Research, Washington, D.C.	

Exchange Rate Project ($50k: 2001-2002)	*25,000*
Corporate Council on Africa*, Washington, D.C.	
General Operating Support	*5,000*
US-Africa Summit	100,000
Others, each under $5,000	*3,500*
Council for the United States and Italy, Washington, D.C.	
General Support	5,000
Young Leaders Conference	10,000
Council of State Governments*, Lexington, Kentucky	5,000
Council on Foreign Relations, New York, N.Y.	60,000
CPR Institute for Dispute Resolution, Inc.*, New York, N.Y.	
Legal Program	*6,000*
Dallas Bar Foundation, Texas	
Sarah T. Hughes Reading Room	*5,000*
Dallas Council on World Affairs*, Texas	
Mallon Award Dinner	25,000
Membership	5,000
Duke University, Durham, North Carolina	
Center for Environmental Solutions	45,000
Environmental Law institute*, Washington, D.C.	
Eli Award Dinner	10,000
General Operating Support	10,000
Federalist Society for Law and Public Policy Studies, Washington, D.C.	15,000
Florida International University, Miami	
College of Business Administration	*5,000*
Latin American & Caribbean Center	*5,000*
Transnational and Comparative Studies	*5,000*
Foreign Policy Association, New York, N.Y.	
Annual Dinner*	15,000
World Leadership Forum*	50,000
General Support	30,000
Foundation for American Communications, Pasadena, California	
Energy Program for Journalists*	75,000
Science Journalism Program*	150,000
War on Terrorism Project	50,000
Others, each under $5,000	2,500
Foundation for Public Affairs*, Washington, D.C.	5,000
Foundation for Research on Economics and the Environment, Bozeman, Montana	20,000
Foundation for the Center for Energy, Marine Transportation and Public Policy at Columbia University*, New York, N. Y.	
General Operating Support ($500k: 1999-2003)	100,000
Frontiers of Freedom Institute, Arlington, Virginia	40,000
George C. Marshall Institute, Washington, D.C.	
Climate Change Work	60,000
George Mason University, Arlington, Virginia	
Law & Economics Center	20,000
Georgetown University, Center Contemporary Arabic Studies Washington, D.C.	
Arab Energy & Development Program+ ($400k: 1996-2001)	*80,000*
General Support	*30,000*
Georgetown University, Washington, D.C.	
Landegger Program	10,000
Harvard University, Cambridge, Massachusetts	
Azerbaijan Initiative* ($250k: 1999-2001)	*80,000*
David Rockefeller Center for Latin American Studies	10,000

Form **990-PF**

Department of the Treasury
Internal Revenue Service

Return of Private Foundation

or Section 4947(a)(1) Nonexempt Charitable Trust
Treated as a Private Foundation

Note: The organization may be able to use a copy of this return to satisfy state reporting requirements.

OMB No. 1545-0052

2000

Use the IRS label. Otherwise, print or type. See Specific Instructions.	Name of organization: EXXONMOBTL FOUNDATION	A Employer identification number: 13-6082357
	Number and street (or P.O. box number if mail is not delivered to street address): 800 BELL STREET; Room/suite: 2441L	B Telephone number (see page 10 of the instructions): (713)656-6479
	City or town, state, and ZIP code: HOUSTON, TX 77002	C If exemption application is pending, check here ▶ ☐
		D 1. Foreign organizations, check here ▶ ☐ 2. Foreign organizations meeting the 85% test, check here and attach computation ▶ ☐
		E If private foundation status was terminated

H Check type of organization: ☒ Section 501(c)(3) exempt private foundation ☐ Section 4947(a)(1) nonexempt charitable trust ☐ Other taxable private foundation

Revenue	2	Distributions from split-interest trusts				
	3	Interest on savings and temporary cash investments	529,722	529,722	0	
	4	Dividends and interest from securities				
	5a	Gross rents				
	b	(Net rental income or (loss) _____)				
	6a	Net gain or (loss) from sale of assets not on line 10	5,000			
	b	Gross sales price for all assets on line 6a 20,185,000				
	7	Capital gain net income (from Part IV, line 2)		9,625,354		
	8	Net short-term capital gain				
	9	Income modifications			48,322	
	10a	Gross sales less returns and allowances				
	b	Less: Cost of goods sold				
	c	Gross profit or (loss) (attach schedule)				
	11	Other income (attach schedule)				
	12	Total. Add lines 1 through 11	27,084,722	10,155,076	48,322	
Operating and Administrative Expenses	13	Compensation of officers, directors, trustees, etc.				
	14	Other employee salaries and wages				
	15	Pension plans, employee benefits				
	16a	Legal fees (attach schedule)				
	b	Accounting fees (attach schedule)				
	c	Other professional fees (attach schedule)	78,306			78,306
	17	Interest				
	18	Taxes (attach schedule) (see page 14 of the instructions)	170,300			
	19	Depreciation (attach schedule) and depletion				
	20	Occupancy				
	21	Travel, conferences, and meetings				
	22	Printing and publications				
	23	Other expenses (attach schedule)	671,205	671,205	0	0
	24	Total operating and administrative expenses. Add lines 13 through 23	919,811	671,205	0	78,306
	25	Contributions, gifts, grants paid	41,825,983			42,188,567
	26	Total expenses and disbursements. Add lines 24 and 25	42,745,794	671,205	0	42,266,873
	27	Subtract line 26 from line 12:				
	a	Excess of revenue over expenses and disbursements	(15,661,072)			
	b	Net investment income (if negative, enter -0-)		9,483,871		
	c	Adjusted net income (if negative, enter -0-)			48,322	

For Paperwork Reduction Act Notice, see the instructions. Form 990-PF (2000)

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Exxon Mobil Foundation
Schedule of Appropriations and Payments by Program Area
Fiscal Year 2000

Recipient and/or Purpose	Tax Status	Beginning Balance 2000	Newly Allocated 2000	Amended 2000	Amount Paid 2000	Ending Balance 2000
Foundation for Public Relations Research and Education P.O. Box 118400 Gainesville, FL 32611-8400 *General Support* 2,500.00 2000	501(c)(3)	0.00	2,500.00	0.00	2,500.00	0.00
Foundation for Research on Economics and the Environment 943 Technology Boulevard, Suite 101F Bozeman, MT 59718 *General Operating Support* 20,000.00 2000	501(c)(3)	0.00	20,000.00	0.00	20,000.00	0.00
Frontiers of Freedom Institute 1401 Wilson Boulevard Arlington, VA 22209 *Project Support* 40,000.00 2000	501(c)(3)	000	40,000.00	0.00	40,000.00	0.00
Frontiers of Freedom Institute 1401 Wilson Boulevard Arlington, VA 22209 *Project Support* 90,000.00 2000	501(c)(3)	0.00	90,000.00	0.00	90,000.00	0.00
Frontiers of Freedom Institute 1401 Wilson Boulevard Arlington, VA 22209 *Project Support* 15,000.00 2000	501(c)(3)	0.00	15,000.00	0.00	15,000.00	0.00
General Federation of Women's Clubs, Inc. 1734 N Street, NW Washington, DC 20036 *General Support* 30,000.00 2000	501(c)(3)	000	30,000.00	0.00	30,000.00	000
Geochemical Society Department of Chemistry University of Houston Houston, TX 77204 *General Operating Support* 200.00 2000	501(c)(3)	0.00	200.00	0.00	200.00	0.00
George C. Marshall Institute 1750 K Street, N.W., Suite 900 Washington, DC 20006 *General Support* 50,000.00 2000	501(c)(3)	0.00	50,000.00	0.00	50,000.00	0.00
George Mason University 3401 N. Fairfax Drive Arlington, VA 22201-4498 *Law/Economics Center* 40,000.00 2000	501(c)(3)	0.00	40,000.00	0.00	40,000.00	0.00
Georgetown University School of Foreign Service Landegger Program P.O. Box 571024 Washington, DC 20057-0819 *Landegger Program in International Studies* 10,000.00 2000	501(c)(3)	000	10,000.00	000	10,000.00	0.00
Georgetown University, Center for Contemporary Arabic Studies 37th and O Street, NW Washington, DC 20057 *General Operating Support* 20,000.00 2000	501(c)(3)	0.00	20,000.00	0.00	20,000.00	0.00
Harvard University Center for International Development 79 John F. Kennedy Street Cambridge, MA 02138 *General Support* 15,000.00 2000	Other	0.00	15,000.00	0.00	15,000.00	0.00
Harvard University, Center for Middle East Studies 1737 Cambridge Street Cambridge, MA 02138 *General Operating Support* 5,000.00 2000	501(c)(3)	0.00	5,000.00	0.00	5,000.00	0.00

THE DAILY PRINCETONIAN

NEWS | ENVIRONMENT | JAN. 12

Professor denies global warming theory

By RAYMOND GRUSCA
STAFF WRITER
Published Monday, January 12th, 2009

Correction appended

Physics professor William Happer GS '64 has some tough words for scientists who believe that carbon dioxide is causing global warming.

"This is George Orwell. This is the 'Germans are the master race. The Jews are the scum of the earth.' It's that kind of propaganda," Happer, the Cyrus Fogg Brackett Professor of Physics, said in an interview. "Carbon dioxide is not a pollutant. Every time you exhale, you exhale air that has 4 percent carbon dioxide. To say that that's a pollutant just boggles my mind. What used to be science has turned into a cult."

Happer served as director of the Office of Energy Research in the U.S. Department of Energy under President George H.W. Bush and was subsequently fired by Vice President Al Gore, reportedly for his refusal to support Gore's views on climate change. He asked last month to be added to a list of global warming dissenters in a Senate Environment and Public Works Committee report. The list includes more than 650 experts who challenge the belief that human activity is contributing to global warming.

Though Happer has promulgated his skepticism in the past, he requested to be named a skeptic in light of the inauguration of President-elect Barack Obama, whose administration has, as Happer notes, "stated that carbon dioxide is a pollutant" and that humans are "poisoning the atmosphere."

Happer maintains that he doubts there is any strong anthropogenic influence on global temperature.

"All the evidence I see is that the current warming of the climate is just like past warmings. In fact, it's not as much as past warmings yet, and it probably has little to do with carbon dioxide, just like past warmings had little to do with carbon dioxide," Happer explained.

Happer is chair of the board of directors at the George C. Marshall Institute, a nonprofit conservative think tank known for its attempts to highlight uncertainties about causes of global warming. The institute was founded by former National Academy of Sciences president and prominent physicist Frederick Seitz GS '34, who publicly expressed his skepticism of the claim that global warming is caused by human activity. Seitz passed away in March 2008.

In 2007, the Institute reported $726,087 in annual operating expenses, $205,156 of which was spent on climate change issues, constituting the largest portion of its program expenses, according to its I-990 tax exemption form.

In a statement sent to the Senate as part of his request, Happer explained his reasoning for challenging the climate change movement, citing his research and scientific knowledge.

"I have spent a long research career studying physics that is closely related to the greenhouse effect, for example, absorption and emission of visible and infrared radiation, and fluid flow," he said in the statement. "Based on my experience, I am convinced that the current alarm over carbon dioxide is mistaken."

Geosciences professor Michael Oppenheimer, the lead author of the fourth report of the Intergovernmental Panel on Climate Change (IPCC) — whose members, along with Gore, received the 2007 Nobel Peace Prize — said in an interview that Happer's claims are "simply not true."

Oppenheimer, director of the Wilson School's Program in Science, Technology and Environmental Policy, stressed that the preponderance of evidence and majority of expert opinion points to a strong anthropogenic influence on rising global temperatures, noting that he advises Happer to read the IPCC's report and publish a scientific report detailing his objections to its findings.

The University is home to a number of renowned climate change scientists. Ecology and evolutionary biology professor Stephen Pacala and mechanical and aerospace engineering professor Robert Socolow, who are co-chairs of the Carbon Mitigation Initiative (CMI) and the Princeton Environmental Institute, developed a set of 15 "stabilization wedges." These are existing technologies that would, by the year 2054, each prevent 1 billion tons of carbon emissions. They argue that the implementation of seven of these wedges would be needed to reach target emissions levels.

Neither Pacala nor Socolow could be reached for comment.

Happer said that he is alarmed by the funding that climate change scientists, such as Pacala and Socolow, receive from the private sector.

"Their whole career depends on pushing. They have no other reason to exist. I could care less. I don't get a dime one way or another from the global warming issue," Happer noted. "I'm not on the payroll of oil companies as they are. They are funded by BP."

The CMI has had a research partnership with BP since 2000 and receives $2 million each year from the company. In October, BP announced that it would extend the partnership — which had been scheduled to expire in 2010 — by five years.

The Marshall Institute, however, has received at least $715,000 from the ExxonMobil Foundation and Corporate Giving division from 1998 to 2006,

according to the company's public reports. Though Exxon has challenged the scientific models for proving the human link to climate change in the past, its spokesmen have said that the company's stance has been misunderstood. Others say the company has changed its stance.

Happer explained that his beliefs about climate change come from his experience at the Department of Energy, at which Happer said he supervised all non-weapons energy research, including climate change research. Managing a budget of more than $3 billion, Happer said he felt compelled to make sure it was being spent properly. "I would have [researchers] come in, and they would brief me on their topics," Happer explained. "They would show up. Shiny faces, presentation ready to go. I would ask them questions, and they would be just delighted when you asked. That was true of almost every group that came in."

The exceptions were climate change scientists, he said.

"They would give me a briefing. It was a completely different experience. I remember one speaker who asked why I wanted to know, why I asked that question. So I said, you know I always ask questions at these briefings ... I often get a much better view of [things] in the interchange with the speaker," Happer said. "This guy looked at me and said, 'What answer would you like?' I knew I was in trouble then. This was a community even in the early 1990s that was being turned political. [The attitude was] 'Give me all this money, and I'll get the answer you like.' "

Happer said he is dismayed by the politicization of the issue and believes the community of climate change scientists has become a veritable "religious cult," noting that nobody understands or questions any of the science.

He noted in an interview that in the past decade, despite what he called "alarmist" claims, there has not only not been warming, there has in fact been global cooling. He added that climate change scientists are unable to use models to either predict the future or accurately model past events.

"There was a baseball sage who said prediction is hard, especially of the future, but the implication was that you could look at the past and at least second-guess the past," Happer explained. "They can't even do that."

Happer cited an ice age at the time of the American Revolution, when Londoners skated on the Thames, and warm periods during the Middle Ages, when settlers were able to farm southern portions of Greenland, as evidence of naturally occurring fluctuations that undermine the case for anthropogenic influence.

"[Atmospheric carbon dioxide concentration] was exactly the same then. It didn't change at all," he explained. "So there was something that was making the earth warm and cool that modelers still don't really understand."

The problem does not in fact exist, he said, and society should not sacrifice for nothing.

"[Climate change theory has] been extremely bad for science. It's going to give science a really bad name in the future," he said. "I think science is one of the great triumphs of humankind, and I hate to see it dragged through the mud in an episode like this."

Correction: A previous version of this story incorrectly stated that Pacala and Socolow's stabilization wedges would lead to a target level of carbon in the atmosphere. In fact, they would lead to a target level of carbon emissions.

Original URL: http://www.dailyprincetonian.com/2009/01/12/22506/

Senator BOXER. And you also talked about hysterics. Now, the last thing I would say that came out of these three scientists was hysterics. I was wondering when they would actually raise their voice above a very modest level. They are very clear in what they have learned from the science. I haven't heard hysterics.

So I would, because you made that charge, ask each of them to just talk about how you view the scientific consensus on this. Is there a consensus on this, and are people who are saying it is hysterics or saying it is propaganda, are they outliers in terms of the scientific community? And I don't mean particularly Dr. Happer, but just, he is saying things that some outliers and some members of this Committee say.

And I think it is important, I know Dr. Pachauri, you have put forward all the steps that were taken. But if you could just address in just conversational terms whether or not what you have told us today is propaganda or hysterics.

Mr. PACHAURI. Thank you, Madam Chairperson. Let me once again repeat that the IPCC functions on the basis of mobilizing the best talent from across the world. And incidentally, all those that are chosen for carrying out this task are essentially those that have been nominated by governments and then carefully selected on the basis of the record of research that they have carried out.

I also want to state that all the work that the IPCC does is based on peer-reviewed literature. The IPCC itself doesn't carry out any research. It looks at peer-reviewed literature in well-established journals. And therefore, if this doesn't represent a consensus of the best scientific expertise drawn from all over the world, I would like to ask what would.

And I mentioned also, Madam Chairperson, that in the Fourth Assessment Report, we had an overwhelming number of people from the U.S., very distinguished scientists. And these were those who were actually nominated and then subsequently selected by the IPCC. They were nominated by the previous Administration. I am talking about the year 2002, 2003.

And finally, may I also say with all due respect to our distinguished colleague from Princeton—very truly an outstanding institution; I myself have had some association and continue to have a modest association with a somewhat relatively unknown institution called Yale University.

I would like to emphasize this analogy of the Temperance movement. I think if you go down the annals of history, you will find more people have suffered for having opposed conventional thinking on subjects like cosmology, on the laws of gravity. I just want to mention one single name. In the year 1600, there was a person called Giordano Bruno who was burned at the stake simply because he believed that the world is really something that is part of a much larger universe.

So I would like to submit that whenever new knowledge has emerged, there has been resistance, there has been denial and ultimately, thank God, the truth has prevailed. And I would believe the truth exists today.

Senator BOXER. Well, let me do this, because my time is running out. I am going to ask the last question of mine to Dr. Field, and pick up again on what Dr. Happer said. First, he said that there

was a cooling trend, and then he switched and said, I think increases of CO_2 will be good for humanity. So I don't know from that whether he thinks there is a cooling trend or—— but let's forget that.

He said, increases of CO_2 will be good for humanity. So I guess I need to ask Dr. Field and Dr. Frumkin quickly to explain whether they agree with that or not.

Mr. FIELD. Thank you very much. The temperature records for 2008 have just been released by NASA's Goddard Institute for Space Studies; 2008 was the ninth warmest year in the instrumental record. The fact of the matter is that CO_2 does increase the growth of some plants, but not all plants. Some major crops, corn, sugar cane, sorghum, use a different photosynthesis pathway and are not at all stimulated by increased atmospheric CO_2.

Early results on CO_2 as an agriculture fertilizer suggest that it might be quite powerful in increasing yields by maybe 25 to 30 percent, but recently we have developed a series of new technologies called free air CO_2 enrichment that allow us to do genuine field scale tests of how much doubling atmospheric CO_2 increases the growth of major crops. And the evidence is that doubling CO_2 in cooler regions in the United States can increase crop growth maybe 10 to 20 percent. So certainly not a significant amount. And in the context, well, it could be important.

And in the context of the rising temperatures that are caused by the greenhouse effect of CO_2, we basically see downward pressure from the climate change and a small upward pressure from the CO_2. The IPCC conclusion is that in the United States, for the next few decades, we might see those approximately balancing each other out. Once the temperature increase gets to be greater than about 3 degrees Fahrenheit, the warming trend is expected to be the dominant one, with crop yields going down.

Senator BOXER. Thank you.

And Dr. Frumkin, since you are an expert on health, do you agree that CO_2 is going to be good for humanity, an increase in CO_2 is going to be good for humanity?

Dr. FRUMKIN. No, Senator Boxer. The combination of rising CO_2 and the associated earth system changes, such as warmer temperatures, will have a range of impacts on health, as I described earlier. Both the diminished agricultural output, especially in vulnerable parts of the world, and the other impacts, such as worsening air pollution and aggravation of allergies, collectively give us much more concern than reassurance.

Senator BOXER. Senator Inhofe.

Senator INHOFE. Thank you.

Let me share something I was just handed. This is new news that came out apparently today. The U.K. Register has reported that "Japanese scientists have made a dramatic break with the U.N. and western-backed hypotheses of climate change. The IPCC's conclusion that from now on atmospheric temperatures are likely to show a continuous, monotonous increase should be perceived as an unprovable hypothesis."

Dr. Pachauri, you have made several statements in 2003 and 2008 concerning the Flat Earth Society, which I think is fine. t is a type of name calling I suppose that is good. It can get that way.

Many scientists who doubt what you claim are included in our U.S. Senate minority report, the one I referred to. And they have cited you and Al Gore as other characterizations of skeptics as one of the key motivating factors to publicly speak out in dissent. Climate statistician Dr. William M. Briggs is one of those scientists who are not happy with your comments. Briggs specializes in the statistics of forecast evaluation, serves on the American Meteorological Society's Probability and Statistics Committee, and is an associate editor of the Monthly Weather Review. He wrote in 2008, "After reading U.N. IPCC Chairman Pachauri's asinine comment comparing skeptics to Flat Earthers, it is hard to remain quiet."

Paleoclimate expert Augusto Mangini of the University of Heidelberg in Germany criticized the U.N. IPCC summary, "I consider the part of the IPCC report which I can really judge as an expert," in other words, the reconstruction of the paleoclimate, "wrong." He added, "The earth will not die."

South African nuclear physicist and chemical engineer Dr. Philip Lloyd, a U.N. IPCC co-coordinator, lead author who has authored more than 150 publications, stated "The quantity of CO_2 we produce is insignificant in terms of the natural circulation between air, water and soil. I am doing a detailed assessment of the U.N. IPCC's reports and the summary for policymakers identifying the way in which the summaries have distorted the science."

Victor Emmanuel Vacquier, a researcher at the Institute of Geophysics of the University of New Mexico stated "the models and forecasts of the U.N. IPCC are incorrect because they only are based on mathematical models and presented results scenarios." Indian geologists, and you could probably help me with the pronunciation of this name, Dr. Pachauri, but it is Arun Ahluwalia, of Punjab University, and a board member of the U.N.-supported International Year of the Planet, "The IPCC has actually become a closed-circuit. It doesn't listen to others. It doesn't have open minds. I am really amazed that the Nobel Peace Prize is being given on scientifically incorrect conclusions by people who are not geologists."

Dr. Nicholas Drapela of the faculty of the Oregon State University chemistry department described the U.N. IPCC this way: "The Intergovernmental Panel on Climate Change is a body of the United Nations, it is not a scientific body, it is a political body." Dr. John Rignold, a U.K. emeritus engineering professor at the University of Southampton, who held the chair in industry instrumentation at Southampton, accused the U.N. of censorship on July 23d of 2008, just last year. Dr. Rignold wrote, "Here was a purely political body posing as a scientific institution. They acted in concert to keep out alien or hostile opinion. Peer review developed into a mantra that was picked up by political activists who clearly had no idea of the procedures of science or its learning societies."

Another one of the IPCC scientists not happy with your group's process accused the IPCC of ignoring skeptical comments. The IPCC 2007 expert reviewer, Medhav Chandakar, a Ph.D meteorologist, a scientist with the Natural Resources Stewardship Process, who has over 45 years' experience in climatology, meteorology, oceanography, and who has published nearly 100 papers and reports, said "To my dismay, IPCC authors ignored all of my com-

ments and suggestions for major changes in the first order draft and sent me the second order draft with essentially the same text as the first order draft. None of the authors of the chapter bothered to directly communicate with me or with other expert reviewers with whom I communicate on a regular basis on many issues that were raised in my review. This is not an acceptable scientific process."

I want to comment on another one. This is the former Colorado State climatologist, Roger Pielke, Sr., analyzed your most recent, and this is you, Dr. Field, your most recent scientific claims on February 15th, 2009. Dr. Pielke suggested that this claim conflicts with real world observations. He observed that since mid-2003, there have been no upper ocean global average warming and observation which is not consistent with the GISS model predictions. Over this time, the recent and current tropospheric temperature data also shown in the lower tropospheric temperatures today are no lower than they were in 2002. The recent global warming is less than the IPCC models predict and even more so in disagreement. And this is a quote, he said, "When will the news media," this is significant, I agree with this, "When will the news media and others realize that by presenting such biased reports, which are easily refuted by real world data, they are losing their credibility among many of the scientific community as well as the public?"

Let me just say, Dr. Happer, you have had a lot of criticism here by the others. I thought I would take the 2 minutes I have remaining——

Senator BOXER. You had seven. You had seven when we started. So you are out of time.

Senator INHOFE. I hope you will have the opportunity to refute and certainly do that to each and every allegation in perhaps a written communication. Would you do that?

Mr. HAPPER. Well, do I have some time to respond?

Senator BOXER. Well, excuse me. You have run out of your seven minutes. I gave you seven, I had seven.

Senator INHOFE. Thank you, Madam Chairman.

Senator BOXER. So we are going to have to put it off. But I could also say, you spent your entire 7 minutes attacking the rest of the panel, so we will need to have these——

Senator INHOFE. No, I was quoting scientists, Madam Chairman.

Senator BOXER. Who were attacking the IPCC.

Senator INHOFE. That is correct.

Senator BOXER. And I would like to put into the record this Japan Society of Energy and Resources that you broke the news to us, they are dominated by the power companies in Japan, the gas chemical companies. And I put that in the record.

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

Senator BOXER. I would call on Senator Lautenberg.

Senator LAUTENBERG. Thank you very much, Madam Chairman. I want to ask Dr. Pachauri, what are the credentials for membership in the IPCC? Is there a credential that one has to bring to be a member? This is a member association, is it not?

Mr. PACHAURI. May I respond to that, Madam Chairperson?

Senator LAUTENBERG. Yes.

Mr. PACHAURI. Right.

Senator LAUTENBERG. That is my time.

Mr. PACHAURI. Yes, sir. So as I mentioned, what we do is we first, on the basis of——

Senator LAUTENBERG. As short as you can, please.

Mr. PACHAURI. Yes, detailed exercise, scope out the contents of a particular report, then we write to governments to send us nominations of scientists who can work on the report. These are then selected by the bureau of the IPCC purely on the basis of their research record and their CVs. So it is entirely a merit-based system.

Senator LAUTENBERG. How many members presently constitute the organization?

Mr. PACHAURI. Well, there is no permanent membership per se. For each particular report, we mobilize a team of the best scientists that we can get.

Senator LAUTENBERG. How many people contribute to it?

Mr. PACHAURI. Well, like in the last Fourth Assessment report, we had 450 people who actually wrote the report, 2,500 odd who actually reviewed various drafts, and in addition, 800 so-called contributing authors. So I would say roughly 4,000 plus.

Senator LAUTENBERG. Dr. Happer, I have to commend you for courage, even though we radically differ on the view of what is happening.

From 1980 to 1994, it is said by CDC, and correct me, Dr. Frumkin, if I am wrong, that there was a 75 percent increase in the number of cases of asthma and 150 percent increase among children. Now, is that some kind of a coincidental thing, or do you believe that there is any kind of cause that might bring that situation to us? Dr. Happer.

Mr. HAPPER. Oh, for me?

Senator LAUTENBERG. Yes. I am sorry.

Mr. HAPPER. I am glad you asked. I actually started a little company that looks at asthma and lung imaging a few years ago. So I learned a fair amount about that. The people I talk to, physicians, felt that much of it was due to indoor dust and that, especially slum dwellers were exposed to such dust. I am not a physician, but it was believed to be sort of a lifestyle thing.

Now, maybe that is associated with temperature one way or another. Maybe more air conditioning is a bad thing, I don't know. But this is the limit of what I can respond to on this.

Senator LAUTENBERG. Dr. Frumkin.

Dr. FRUMKIN. Asthma is on the rise. The causes are very complex and not fully understood. But what is clear is that once people have asthma, and this is especially an issue for children, some of the effects of climate change especially affect those individuals. They are especially susceptible. So the problems with air pollution, and the problems with allergen production that rise with climate change are especially worrisome for those with asthma, a larger population now than it has been in the past.

Senator LAUTENBERG. Dr. Happer, you dispute the fact that a consensus has validity, do I understand you correctly?

Mr. HAPPER. Consensuses are often wrong in science and in other spheres of human life. For example, in my field, physicists covered themselves with shame 100 years ago when they debated with Darwin how old the earth was. I mentioned some of this in my written

testimony. But there was complete consensus in the physics community the earth couldn't be more than a few tens of millions of years old. They were completely wrong and Darwin was right.

So consensus is not the way to determine the truth.

Senator LAUTENBERG. Do you challenge the findings that were presented here by your colleagues about the growth in warming and the severity of storms, sea rising?

Mr. HAPPER. Yes, I do, actually. If you look at the records of hurricanes, they have not increased at all. That is public knowledge. And as for warming, it is still not as warm as it was when the Vikings settled Greenland. They were not growing potatoes, but they were exporting sheep to Norway. So there have been huge fluctuations in the climate that IPCC doesn't even try to explain.

Senator LAUTENBERG. Do you think there is a conspiracy, Dr. Happer?

Mr. HAPPER. No, no, not at all.

Senator LAUTENBERG. Well, permit me to finish the sentence, please. That this is a, that there is a conspiracy that is presenting this thing that is a hoax that is being delivered to the world at large because of a conspiratorial alliance?

Mr. HAPPER. No. I really respect the people working on this. I think they really think they are doing good, they want to save the world. We all have an urge to do something good. That is why we are put in the world. I think they have made a mistake.

Senator LAUTENBERG. No, but can this, the charge that this is a hoax, that global warming is a hoax, could you say that that is the kind of a joke you could laugh at?

Mr. HAPPER. No, I don't agree that it is a hoax. I said what I thought it was, I think it is a mistake. A hoax means that someone is intentionally trying to deceive you. I don't think that is the case. I don't think that my colleagues are doing that at all.

Senator LAUTENBERG. Thank you very much.

Senator BOXER. Thank you.

Senator Klobuchar.

Senator KLOBUCHAR. Thank you very much, Madam Chairman. Thank you to all of you.

I wanted to ask just some specific scientific questions on the status of the research. We have heard a lot, Dr. Pachauri, about how there has been some changes to the models about concerns about even more immediate and dramatic climate changes. And I have heard some of that is due to the increased levels of methane emissions that may be coming from the melting of the polar ice. Could you enlighten us about this idea that these methane emissions coming from the polar ice are going to create more global warming?

Mr. PACHAURI. Absolutely, Madam Senator. As a matter of fact, there are a number of other factors also which, with further warming, could lead to larger emissions of greenhouse gases. The oceans, for instance, which hold large quantity of carbon dioxide, with warming could lead to a release of some of that carbon dioxide. This is an area which is being studied in considerable detail. But the indications are very clear that, for instance, the permafrost melting will result in other greenhouse gases, and additional greenhouse gases being emitted into the atmosphere.

Senator KLOBUCHAR. So it is more than just the warming started all this, so when, I am just trying to understand this, so when suddenly the ice starts to melt, that actually leads to more of these gases getting out, is what you are saying? OK.

And then, second question I had is just about the timing of this. The next IPCC report is going to be out in 2014, is that right? And I am just thinking, we are doing all this work right now, and is there going to be some kind of preliminary assessment out in between the last one and this one?

Mr. PACHAURI. Actually, to carry out a thorough and reliable assessment of climate change, we really need this kind of period of time, Senator. And this time around, we are also developing some new scenarios of the way economic growth, technology changes and so on will take place. So we really would not be able to come up with anything more than a very preliminary assessment of how things are changing.

Senator KLOBUCHAR. Could you tell me a little, just based on your international work, about how some of the major economies like India and China are interpreting some of the IPCC data and what is happening there?

Mr. PACHAURI. Senator, there is a substantial concern in all the countries of the world about the impacts of climate change. Because some of these nations are going to be impacted, are going to receive the impacts of climate change that would really disrupt not only their economy but their ecosystems and so on.

One point that I would like to mention is that the problem today has been caused not by flows or emissions that are taking place currently but by the stock which has accumulated essentially as a result of development in the industrialized countries. And I think it is for this reason that the framework you mention on climate change talks about common but differentiated responsibility.

And therefore, may I submit—this is purely a personal opinion—I think for a country like the United States to lead is critically important. The number of technologies that you develop over here, whether it is motorcars or something else, will be used by the developing countries as well.

Senator KLOBUCHAR. Exactly. Mr. Field, could you talk about, you talked about your assessments and what is happening and the models. Could you focus a little on the Midwest and what you have seen there? In our State, we seem to have more fires and floods and things in recent years, especially in the warm years. Could you talk about that?

Mr. FIELD. The United States is expected to have diverse impacts of climate. And some of those impacts will be positive. There are deaths that result from cold temperature. And the real challenge in trying to understand the overall effect is to add up the pluses and the minuses and the conclusion of the IPCC and of the scientific assessment process is that the minuses dramatically outweigh the benefits.

In the United States, many of the most serious impacts will be a consequence of changes in water supply and precipitation is one of the things that is difficult to project from the climate models. In the United States, the clearest decreases in expected precipitation are in the West and the Southwest, with uncertain trends in the

upper Midwest. I think the things that we see clear evidence of in the upper Midwest are increased number of heat wave days, even in cities that are relatively cool. The consequences of heat waves vary from place to place, and cooler cities are not necessarily immune from them. There also are a wide range of concerns about sustainability of water resources in the Great Lakes Region and the transportation is subject to relatively modest——

Senator KLOBUCHAR. The barge traffic and——

Mr. FIELD [continuing]. Increases in lake level, which become increasingly difficult to predict in an environment where year to year, variation rainfall increases. And that is one of the clearest consequences of the climate models.

Senator KLOBUCHAR. Thank you very much. I appreciate all of your work.

Senator BOXER. Thank you, Senator.

Senator Merkley.

Senator MERKLEY. Thank you, Madam Chair. One of the contrasts in the testimony that I thought was very stark was the difference between Dr. Pachauri's testimony that 11 of the last 12 years ranked among the 12 warmest years in the record of global surface temperature and Dr. Happer's testimony that the last decade has been a cooling period. Could either of you or anyone else kind of comment on this dramatic difference and what leads you to such starkly opposite conclusions?

Mr. HAPPER. Well, I could take a start. You can look at the satellite record of the temperature, you could click on the Internet, you can find it. And the temperature peaked about 10 years ago, at the time of an El Nino. And since then, it has been slightly trending downward. In fact, it peaked at a time when we were at a peak of the records of temperature.

But they are not very old. For example, we don't have good records of temperature in the 1930s. My guess is it was probably hotter in the 1930s, but it is certainly consistent that the last 10 years could be high temperature years if the record of temperature only goes back 40 years.

Senator MERKLEY. So for me to clarify, you are using the same, we are talking apples to apples, you are talking about the global surface temperature, not in a particular part of the globe and so forth?

Mr. HAPPER. The satellite temperature, yes.

Senator MERKLEY. Dr. Field.

Mr. FIELD. Yes, 2008 was the ninth warmest year in the instrumental record. The two warmest years were 1999 and 2005. It is difficult to tell for sure, because they were about the same. And there is no question that all the warmest years in the record have been recent ones.

There is also no question that the current temperatures are warmer than any time we have seen in the last 400 years, and very likely for the last 2,000 years. It also is very difficult to say that in a domain with strong directional warming, we wouldn't see an occasional warm year. The climate is a very complicated system, and we want to make sure that we don't set people up to be misled by a single exceptionally hot year or a single exceptionally cool year.

Mr. PACHAURI. Senator, I projected a picture of global mean surface temperature going back in time to the middle of the 19th century. And I clearly indicated, unfortunately not adequately due to shortage of time, that there are ups and downs in this record.

But if you look at the last 100 years, for which I showed you a line that essentially shows the slope of changes, and particularly deal with the last 50 years, then the trend is unmistakable. We are on a path of increased warming, and there is no question about it. And we are not talking about predictions of the weather, as Professor Field has rightly said. You could get a terribly cold year, you could get a terribly hot year. But it is the trend, and the pattern that we should really be concerned about.

Senator MERKLEY. Thank you. If I could just follow up on that, I did find your chart very useful. You said the kind of trend line for 100 years is .074 degrees Centigrade per decade, the last 50 years .128 degrees Centigrade per decade. And my, by the estimates of how much the temperature might increase over the next 50 to 100 years, I am assuming that it appears very likely that the number of Centigrade degree increase per decade is very likely to increase substantially beyond that.

If one was to take, for example, and look at just the next decade, where is kind of the estimate for that decade?

Mr. PACHAURI. Well, if we do nothing, Senator, then we would get an increase of about 0.2 degrees Celsius per decade. That is the kind of increase that we see. But this would become much sharper if we don't do anything about the problem, but that is the immediate projection.

Senator MERKLEY. So I want to follow up on one last piece here, which is the line of carbon dioxide parts per million in the atmosphere, going from 280 historically to 380. It sounds like there is a lot of consensus across everyone's testimony in that regard. Is there still substantial belief in the scientific community that if we don't constrain the part per million at about 400 parts per million that we are on a, very difficult to reverse the trend of global warming that we are on? Are we in the, we use the terrorist alert signals if we will, are we on the orange zone or the red zone or just how close are we to a situation where it would be very hard to reverse the impact?

Mr. PACHAURI. Senator, if we want to limit global mean temperature increase to say, 2 to 2.4 degrees Celsius, then we have to stabilize CO_2 equivalent concentration levels at between 445 to 490 parts per million. Now, that is just a little above where we are today. And that is why I said we have just about 6 years left in which we will have to bring about peaking of emissions and then start reducing them thereafter. And we have got, in the IPCC Fourth Assessment Report, several scenarios of reduction that need to be achieved for different levels of temperature increase.

Senator MERKLEY. Dr. Happer, you wanted to respond? Very briefly, because my time has run its course.

Mr. HAPPER. I just wanted to say a few things. Many people don't realize that over geological time, we are really in a CO_2 famine now. Almost never has the CO_2 level been as low as it has been in the Holocene, 280, that is unheard of. Most of the time it is at least 1,000, and it has been quite a bit higher than that. The earth

was just fine in those times. We evolved as a species in those times when the CO_2 levels were three or four times what they are now. And the oceans were fine, plants grew fine, animals grew fine.

So it is baffling to me that we are so frightened of getting nowhere close to where we started.

Senator MERKLEY. My time is up.

Senator BOXER. Take a little extra time, because this is a weird kind of place you have taken us to. Because you are taking us back how many years, Dr. Happer? To when we were fine?

Senator MERKLEY. Pleistocene, I think was the——

Ms. HAPPER. Well, most people think primate evolved about 80 million years ago.

Senator BOXER. OK, there you go. I don't even know how to say this, but a lot has happened since then——

[Laughter.]

Senator BOXER [continuing]. In terms of where people are living and working. We have a society now. So to say go back to those days, I shudder to think of what it means is going to happen. So either I am missing something or you just don't seem to think times have changed.

Mr. HAPPER. Well, I don't think that the laws of nature, physics and chemistry have changed in 80 million years. Eighty million years ago, the earth was a very prosperous place. There is no reason to think it will suddenly become bad now.

Senator BOXER. OK. Dr. Field, if things were to go back the way it was then in terms of the amount of carbon in the air, which Dr. Happer said was wonderful times, how much was in the air then, sir?

Mr. HAPPER. It is a little hard to be sure, but three or four times what we have now.

Senator BOXER. Three or four times more, what would happen to the people here? And could you just talk reality? Because, don't do it from up here, do it from here. And this is not coming off Senator Carper's time. I am going to give him two extra minutes because of this. But I feel this is really the most extraordinary argument I have ever heard, that we could go back to the times that were so long ago and everything would be fine. You need to talk to me about that.

Mr. FIELD. I would like to give you two observations that are well-known from the historical data. We know that the CO_2 concentrations are higher now than they have been at any time in the last 650,000 years. It is not like it was yesterday when they were higher.

We know the last time they were higher for sure was probably about 50 million years ago. I am sorry the Senator from Wyoming isn't here, because 50 million years ago there were crocodiles in Wyoming. We might go back——

Senator CARPER. Some would say there still are.

[Laughter.]

Mr. FIELD [continuing]. To a very, very different world.

Senator BOXER. Well, that is the point. I mean, we are trying to preserve society as we know it and Dr. Happer says, just go back to the way it was 50 million years ago. I am not telling that to my grandkids.

Senator Merkley, since that was your good—I will give you a minute or two and then I will give Tom as much time.

Senator MERKLEY. I want to say a few things. The first is that homo sapiens were not on this planet during the Pleistocene. And so we are indeed talking about ecosystems that have changed dramatically and certainly human civilization having come and been established far more recently.

The second is, I just have to comment on the parallel you drew to Prohibition. It would seem if you draw the parallel to the issue of being concerned about the health impacts of alcohol then the parallel would be, your commentary would be, increased alcohol consumption is not much of an issue, doesn't have a health consequence, might even be beneficial.

After 10 years of testimony in the State of Oregon on the impacts of alcohol consumption on health and the huge toll it takes on families, I say if you really want to exploit that parallel you might come to a very different conclusion about rising temperatures.

Mr. HAPPER. May I respond?

Senator BOXER. We are not going to have responses now. We are going to go to Tom Carper.

Senator CARPER. Thank you, Madam Chair.

That was pretty good, Senator Merkley. Very good.

I was an undergraduate, went to Ohio State University. From time to time I go back and visit my old alma mater. I was last there a little over a year ago, and I spent some time in the Polar Research Center there. It is run by a couple of folks that several of you know, Drs. Lonnie and Ellen Thompson. They were good enough to share with me their research, which involves, I think, climbing tall mountains in places along the equator, going up to the ice caps and trying to measure, collect ice samples and measure levels of CO_2 that go back hundreds of thousands of years, maybe close to a million years.

And my recollection of what they shared with me that day was that if you go back about that far over 500,000, over 600,000, over 7000,000 years, you find that the, and look from back then to the present, you will find that we are going through a period of time where levels of CO_2 are probably higher than any time in all the years represented in their samples. They also show a pretty close correlation to increases in temperature with the increases in CO_2.

Are you all at all familiar with their research and do you have any comment on it? Dr. Field.

Mr. FIELD. There is a very rich body of information that has come from the study of ice cores. The longest ice cores come from Antarctica where there is incredibly deep ice. And those have been incredibly useful in mapping out the trajectory of ice ages and interglacials that we have experienced. Those have also been incredibly important for figuring out how powerful the effect of CO_2 on climate is. Essentially, we know that the ice ages are triggered by small changes in the shape of the earth's orbit, and we can calculate the physics very precisely of how much warming that would cause.

There is information stored in the ice cores that tells us how much warming actually occurred, and then we can use the difference between the amount that the change in the shape of the

orbit should have caused and the amount that actually occurred as one of the most effective ways to figure out powerful a climate forcing agent the CO_2 is, and a lot of the information we have on the climate sensitivity comes from those ice cores.

Senator CARPER. Dr. Pachauri.

Mr. PACHAURI. Senator, I would just like to mention that over the last 650,000 years, as Professor Field has mentioned, we have had remarkable stability in the concentration of carbon dioxide in the earth's atmosphere. And I would also like to mention that about 125,000 years ago, when we had warming more or less at the same level that we are heading toward today, but that was for very different reasons, we had sea level rise of several meters. And I think that is the kind of thing that we might be heading toward that has been brought out very clearly in the IPCC Fourth Assessment Report.

Senator CARPER. Stay on sea level risk if we could for a little bit. Just by a show of hands, has anyone on our panel ever been to Delaware? Oh, good for you. A State not known for its mountains or hills. In fact, I kid people, and I say, I think in my State, the highest point of land in my State is a bridge. We have great beaches, though. And a lot of people do come to our beaches.

We are told that, according to the IPCC, that if global temperature rises I think by about 2 degrees Celsius in the years to come, we are going to see a sea level rise of close to two feet. No, I think it is close to four feet, maybe four to five feet. My understanding is that this would not be a good thing for my State of Delaware. And I say with tongue in cheek that instead of people going to the beaches to swim or surf at Bethany or Rehoboth or Dewey Beach they would go to Dover Beach or Wilmington Beach or Newark Beach, and instead of going to NASCAR racing at Dover Downs, they would go there for sailboat regattas.

I just want to ask, what you, setting aside those thoughts, but the threat of that kind of sea level rise, as much as three or four or five feet, with a rise in temperatures of maybe 2 degrees Celsius, what might that impact be for us on the East Coast? Even around here in Washington, DC?

Mr. PACHAURI. Senator, even with a 2 degree increase in temperature, we have estimated that due to thermal expansion of the oceans alone, worldwide we would get sea level rise, and this is thermal expansion alone, of 0.4 to 1.4 meters. So let's say you are somewhere in the middle of that range. We are talking about at least a two feet increase in sea level.

And this is something that in a sense, the world has already been committed to, so we have to do something to bring about a reduction in that. And quite apart from the impacts on the U.S., may I say that there are several small island states that will be completely wiped out. The country of Bangladesh, which has over 160 million people, will have no place to go, and several other regions of the world.

But I will let Professor Field talk about that, if you permit.

Senator CARPER. Yes, the East Coast, just talk about—I appreciate very much your mentioning the island states and Bangladesh. But the East Coast.

Mr. FIELD. The impacts of a modest sea level rise, and I hate to say modest, because two to four feet is big in terms of impacts, but even a small amount of sea level risk can have big impacts. A specific example, I will start with California and I will get to the East Coast in a minute. In the delta of the Sacramento River, we know that a one foot sea level rise is enough to change the once in a 100 year flood to once every 10 years. That is what we really see. If you look at the damages from sea level that comes from the extremes, and what you see is even a small amount of sea level rise of a few inches, can make the extremes come dramatically more frequent. When you get up to two to four feet, you are seeing the once in a 100 year flood come every year.

The other thing that is really important in the eastern U.S. where there are big estuaries is that sea level increase in the one to two to three feet range can essentially eliminate all the estuaries, and especially important in urbanized areas where you have a squeeze between the developed zone and the open water, essentially the rising sea level just pushes the water right up to the sea walls or whatever the retaining structures are that each community has erected.

Senator CARPER. Thank you both for those comments.

Let me ask, one other question, and that is, well, let me go back to Drs. Ellen and Lonnie Thompson for a moment. If you were a critic of their research and you were trying to poke a hole in the work that they have done, how would you go about doing that? How could their work be discredited? Any ideas?

Mr. PACHAURI. I am sorry, I didn't quite get whose work you would——

Senator CARPER. The people I talked to at Ohio State University, Drs. Lonnie and Ellen Thompson. How would you go about discrediting their work if you were trying to poke holes in it?

Mr. FIELD. Well, I am a great fan of their work, I would certainly never try to discredit it. And as in most areas of science, there are many teams that have drilled these ice cores. The Thompsons are the specialists in high altitude alpine ice cores. And the patterns that they see are in many cases very similar to the patterns that come from other teams that have drilled ice cores in Greenland and other teams that have drilled ice cores in Antarctica. You see a progression of the atmospheric CO_2 varying between about 200 parts per million during the ice ages, about 280 during the interglacials. And I think that in all science, the whole idea is that it should be testable and repeatable. There are many groups that are out there doing the tests. I think that the overall body of information from the ice cores has stood the challenge of a great many tests already.

Senator CARPER. All right, thank you.

Last question I will ask, just a short one. I understand recent studies have shown that sulfur dioxide and black carbon may be global warming agents. And I just wonder, is the IPCC looking at these pollutants and their contributions to climate change?

Mr. PACHAURI. Yes, as a matter of fact, we have looked at that, Senator, even in the Fourth Assessment Report. Undoubtedly this is a factor, but may I submit that this is something that really doesn't have an impact uniformly across the globe. Because the extent of black carbon that you have is largely a localized phe-

nomenon. Of course, it moves from one region to the other. But this is clearly a factor. It would have an impact, for instance, as has been found, on the monsoons in South Asia and in other parts of Asia. It certainly had an impact in China, to some extent.

So it is a very localized phenomenon. And we are finding out more and more about this situation.

Senator CARPER. Our thanks to each of you for joining us today and for your work and your testimony. Thank you.

Senator BOXER. Thank you.

Well, to the panel, you have been very gracious with your time. I am very grateful to all of you for coming, all of you, including our dissenter, because I think we got somewhere today. I now see it clearly. If we decide that more and more carbon dioxide in the atmosphere is fine and it was just great 50 million years ago, when there was three to four times as much, I mean, if we decide that, and we don't mind that things changed dramatically for our people.

I could tell you in California, this is important, that the preliminary analysis from our bill there addressing global warming is going to avoid 400 premature deaths, 11,000 incidences of asthma and lower respiratory symptoms and 67,000 lost work days by 2020. That is something that is good. If we don't do it, people are going to die. Simple. Straightforward. Going to get sick and they are going to die.

Now, if you think going back to all those years ago and those levels and everything is wonderful and fine and that is your view of the future, God bless you. But I don't agree. I will fight you ever step of the way. I view it as uncaring, I view it as irresponsible. If anything we need to do, it is to leave this planet in the condition as good as we got it from our parents.

We are going to work at it in this Committee. We are going to have that choice between my colleagues who say, do nothing, the party of nope, versus do something, the party of hope. And in doing so, we are going to make our Country far more prosperous. I will tell you, this is a great issue for us in this Committee.

And nothing good comes easy. It was hard for this Committee, long before we were here, to pass the Clean Water Act, the Safe Drinking Water Act, the Endangered Species Act, the Superfund Program, this Committee has an amazing, amazing record of stepping up to the plate. And we did it last year, we are going to do it this year.

And we have been challenged by our President. I couldn't be more proud of this Committee. And Senator Inhofe and I, you know, we kid a lot, but we really do have a fondness for each other. On this issue, it is like Dr. Happer and Dr. Pachauri. I mean, it is just, we are definitely coming from a very different place, and as we see today, a very different time.

[Laughter.]

Senator BOXER. I didn't really know it went back that far. But now, this is giving me new energy for this fight.

So thank you to my Committee, both sides. Thank you to this illustrious panel. Maybe you didn't feel like you were helping us, but you really did help us today, all of you. Thank you very, very much, and we stand adjourned.

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

[Additional statement submitted for the record follows:]

STATEMENT OF HON. MIKE CRAPO,
U.S. SENATOR FROM THE STATE OF IDAHO

Ms. Chairwoman, thank you for the opportunity to share a few words. Also, thank you to the witnesses for being here with us today to discuss the science of climate change.

As a new member of the Senate Environment and Public Works Committee, I am looking forward to robust and thorough discussions about the environmental challenges facing our Nation and our world. I am equally hopeful that we will fully explore all available solutions to some of the most pressing issues of our day such as: ending our Nation's foreign dependence on oil, achieving energy security and finding ways to promote clean energy. Solutions to these issues will make our Nation safer, stronger, and provide a cleaner world for our children and grandchildren.

The best way to promote the goals of a clean, healthy environment is through a framework of incentives for clean energy production. Incentives for wind and solar are important, but a realistic goal for the advancement of clean energy must include incentives for nuclear energy production, carbon capture and sequestration, geothermal and hydropower.

In this time of economic turmoil, we need to find a way to promote clean energy faster and cheaper, and I am concerned about the costs of past proposals before this Committee.

For example, the Environmental Protection Agency estimated that S. 3036, the Lieberman-Warner Climate Security Act would cost $6.7 trillion to implement. Yet, the National Association of Manufacturers estimated that this legislation would cost our economy 3–4 million jobs. Passage of this type of legislation would absolutely negate the predicted benefits of the Stimulus package, which President Obama has stated will "save or create" 3.5 million jobs. Therefore we should proceed very cautiously—carefully analyzing the implications of all climate proposals before this Committee.

Since 2001, the United States has spent over $35 billion on global climate change initiatives, more than all other countries combined. This money has been spent on investments in clean technologies, international partnerships, and clean technology usage. We are also beginning to see the fruits of our legislative labor as the Energy Policy Acts of 2005 and 2007 begin to take effect and make a real difference to the Nation's domestic energy portfolio.

Today, there are 17 companies and consortia pursuing licenses for 26 new nuclear reactors, representing an investment of approximately $80 billion to $100 billion and the creation of thousands of jobs. Plans are in place to build cellulosic ethanol plants using loan guarantees and incentives from the 2005 and 2007 Energy Bills, and there has been a significant investment in renewable power sources.

To ensure that we transition to clean energy at the lowest cost to the consumer, we could take steps to create a Clean Electricity Standard that rewards a broad array of advanced clean sources, like: nuclear power, clean coal, hydro-power, efficiency, and renewable sources. We can also focus on improving management of our Nation's forests, allowing the forests to double the current amount of sequestered carbon.

These approaches will ensure American energy independence, create jobs, and grow the U.S. economy. This will also provide a roadmap for others to follow, sharing the best economic and environmental solutions for the U.S. with developing nations around the world.