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ECONOMIC IMPACTS OF GLOBAL WARMING: PART I—INSURANCE

HEARING

BEFORE THE

SELECT COMMITTEE ON
ENERGY INDEPENDENCE
AND GLOBAL WARMING
HOUSE OF REPRESENTATIVES

ONE HUNDRED TENTH CONGRESS

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CONTENTS

	Page
Hon. Edward J. Markey, a Representative in Congress from the Commonwealth of Massachusetts, opening statement	1
Prepared Statement	3
Hon. F. James Sensenbrenner, Jr. a Representative in Congress from the State of Wisconsin, opening statement	5
Hon. Earl Blumenauer, a Representative in Congress from the State of Oregon, opening statement	6
Prepared Statement	7
Hon. Greg Walden, a Representative in Congress from the State of Oregon, opening statement	9
Hon. Hilda Solis, a Representative in Congress from the State of California, opening statement	9
Prepared Statement	11
Hon. John Sullivan, a Representative in Congress from the State of Oklahoma, opening statement	12
Hon. Marsha W. Blackburn, a Representative in Congress from the State of Tennessee, opening statement	13
Prepared Statement	14
Hon. Emanuel Cleaver II, a Representative in Congress from the State of Missouri, Prepared Statement	16

WITNESSES

Mr. John B. Stephenson, Director, Natural Resources and Environment, Government Accountability Office	17
Prepared Testimony	19
Answers to Submitted Questions	00
Mr. Mike Kreidler, Washington State Insurance Commissioner	43
Prepared Testimony	45
Answers to Submitted Questions	00
Mr. Frank Nutter, President, Reinsurance Association of America	54
Prepared Testimony	57
Answers to Submitted Questions	00

SUBMITTED MATERIALS

Hon. Jerry McNerney and Hon. John Shadegg—A report of Working Group I of the Intergovernmental Panel on Climate Change, Summary for Policymakers, 2007	89
Hon. John Sullivan—Report from the American Geophysical Union: Counting Atlantic Tropical Cyclones Back to 1900, May 1, 2007	107
Hon. Edward J. Markey—GAO Report: Climate Change Insurance Risk, March 2007	111

ECONOMIC IMPACTS OF GLOBAL WARMING: PART I—INSURANCE

THURSDAY, MAY 3, 2007

HOUSE OF REPRESENTATIVES,
SELECT COMMITTEE ON ENERGY INDEPENDENCE
AND GLOBAL WARMING,
Washington, DC.

The committee met, pursuant to call, at 3 p.m. In Room 2359, Rayburn House Office Building, Hon. Edward J. Markey [chairman of the committee] Presiding.

Present: Representatives Markey, Blumenauer, Inslee, Solis, Herseth, Cleaver, Hall, McNerney, Sensenbrenner, Shadegg, Walden, Sullivan, Blackburn and Miller.

The CHAIRMAN. Good morning. Thank you for joining us today as we begin to examine the critical issues surrounding the economic impact that global warming will have on our society. The focus of today's hearing is on the potential economic harm from weather-related losses, both insured and uninsured, as our planet heats up from global warming.

Over the last 25 years, extreme weather caused 88 percent of the $320 billion in total insured property losses. Since almost everything that is insured, from property, to crops, to human life and health, is susceptible to severe weather, the insurance industry is one of the most sensitive indicators of the economic repercussions of global warming. From a financial perspective the insurance industry is our canary in the climate coal mine.

Last week the select committee heard testimony from some of the country's leading scientists that we are fast approaching dangerous climate change. Hurricane expert Dr. Judith Curry testified that globally the number of the most severe storms, Category 4 and 5 hurricanes, has nearly doubled since 1970. Scientists are telling us that in the future global warming will cause even more extreme weather events such as droughts, floods, heat waves and more intense storms and hurricanes.

According to testimony we will hear today from the Government Accountability Office, private insurers are increasingly factoring aspects of global warming into the determinations of their overall exposure to catastrophic risk. For many private insurance companies, global warming now means that when determining risk, the past is no longer prologue.

The Federal Government runs two insurance programs, the National Flood Insurance Program and the Federal Crop Insurance Corporation, both of which are vulnerable to global-warming-related losses. In fact, the effect of a growing number of cata-

strophic climate events may be greater on these Federal insurance programs than on many private insurers because they have not yet begun to factor in the increasing risk from global warming.

In addition, the total exposure of the Federal insurance programs has grown dramatically in recent years. The exposure of Federal flood insurance has quadrupled since 1980 to over $1 trillion. Federal crop insurance coverage has expanded almost 26-fold over the same period. This expansion has further increased the threat that extreme weather poses to Federal insurers.

The Federal Government is also vulnerable because it is often the insurer of last resort, providing insurance programs when private insurance markets are insufficient or do not exist, and providing disaster relief to storm-ravaged areas. As losses from severe weather have increased over the last few decades, so have the number of Presidential disaster declarations. For many catastrophic climate events in the future, it could primarily be the Federal Government that will pick up the tab.

Insured losses represent just a fraction of total losses. Insured losses account for no more than 40 percent of the total weather-related losses as most of this damage is uninsured. Therefore, weather's total cost to America since 1980 is most likely greater than $800 billion.

We are just beginning to face the escalation of these losses. Take, for example, Shishmaref, Alaska. It is one of over 100 villages in Alaska facing imminent relocation as a combination of less sea ice and more intense storms wipes out the very land they inhabit. It will cost over $250 million to relocate Shishmaref alone, and that cost will fall on the U.S. taxpayers because these Native villages are the responsibility of the Federal Government. The Congress needs to understand that risk and to implement real solutions to cut global warming pollution.

I now would like to turn and to recognize the Ranking Member of the select committee, the gentleman from Wisconsin, Mr. Sensenbrenner.

[The statement of Mr. Markey follows:]

Opening Statement for Edward J. Markey (D-MA)
"Economic Impacts of Global Warming Part 1 – Insurance"
Select Committee on Energy Independence and Global Warming
May 3, 2007

This hearing is called to order.

Thank you all for joining us today as we begin to examine the critical issues surrounding the economic impacts that global warming will have on our society. The focus of today's hearing is on the potential economic harm from weather-related losses, both insured and uninsured, as our planet heats up from global warming.

Over the last 25 years, extreme weather caused 88 percent of the $320 billion in total insured property losses. Since almost everything that is insured – from property, to crops, to human life and health – is susceptible to severe weather, the insurance industry is one of the most sensitive indicators of the economic repercussions of global warming. From a financial perspective, the insurance industry is our canary in the climate coal mine.

Last week, the Select Committee heard testimony from some of the country's leading scientists that we are fast approaching dangerous climate change. Hurricane expert Dr. Judith Curry testified that globally, the number of the most severe storms, category 4 and 5 hurricanes, has nearly doubled since 1970. Scientists are telling us that in the future, global warming will cause even more extreme weather events such as droughts, floods, heat waves and more intense storms and hurricanes.

According to testimony we will hear today from the Government Accountability Office (GAO), private insurers are increasingly factoring aspects of global warming into the determinations of their overall exposure to catastrophic risk. For many private insurance companies, global warming now means that when determining risk, the past is no longer prologue.

The federal government runs two insurance programs – the National Flood Insurance Program, and the Federal Crop Insurance Corporation – both of which are vulnerable to global warming-related losses. In fact, the effect of a growing number of catastrophic climate events may be greater on these federal insurance programs than on many private insurers, because they have not yet begun to factor in the increasing risk from global warming.

In addition, the total exposure of the federal insurance programs has grown dramatically in recent years. The exposure of federal flood insurance has quadrupled since 1980 to over $1 trillion. Federal crop insurance coverage has expanded almost 26-fold over that same period. This expansion has further increased the threat that extreme weather poses to federal insurers.

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catastrophic climate events in the future, it could primarily be the federal government that will pick up the tab.

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The Congress needs to understand the risk and implement real solutions to cut global warming pollution.

And now I would like to recognize the Ranking Member of the Select Committee, the gentleman from Wisconsin, Mr. Sensenbrenner.

Mr. SENSENBRENNER. Thank you very much, Mr. Chairman. Today's hearing of the select committee brings a series of discussions by this panel on the economic impact of climate change. While there has been much attention paid to climate change science by the media and some politicians, there has been far too little talk of the economic consequences of climate change in the policy proposals that are supposed to address this issue. I know that I, for one, am anxious for this to be. The economic impact is just another topic where alarmists pump a gallon of hysteria out of an ounce of fact.

Today we are looking at how global warming affects hurricanes, insurance rates and payments. The implications are that global warming creates more powerful storms, which in turn cause more damage. Al Gore's movie uses a busy 2005 hurricane season to illustrate the catastrophe that is sure to come the day after tomorrow. Inconveniently for us, however, Mr. Gore's movie fails to provide the larger context and perspective on hurricane cycles, but it is able to juice fear and uncertainty out of people by not giving the whole picture.

As I mentioned, there is an ounce of facts to the alarmist claims. The number of major hurricanes has increased since 1995, but as the University of Colorado at Boulder researcher Roger Pielke, Jr., pointed out in August of 2005, the recent hurricane trend fits perfectly with the multidecade hurricane cycles that have been well documented since at least 1900. In fact, a study released yesterday by Chris Lancey, a scientist at the National Hurricane Center, said that there is absolutely no evidence linking global warming and hurricane strength; repeat, absolutely no evidence linking global warming and hurricane strength. Lancey said, quote, there is no link to global warming that you could see at all, unquote.

But hurricanes with their menacing eye sure make for a scary picture. And, quite frankly, if you are living in a coastal region prone to hurricanes, you should have a healthy fear of these deadly storms. This was as true for the residents of Galveston, Texas, in 1900, the site of the deadliest hurricane in U.S. history, as it is today for millions of people who live in the path of hurricanes along the Atlantic and gulf coast.

It is a fact that hurricanes are causing more damage than they have ever done before. It is also a fact that there are millions more people living in the path of hurricanes today than did so in 1900, and the homes and buildings they occupy are much more expensive. Despite the hysteria, the raise in hurricane-related damage is because more people live in the path of hurricanes. And where did I learn this fact? From the recent report by the U.N.'s World Meteorological Organization, the parent group of the U.N.'s Intergovernment Panel on Climate Change.

The November 2006 report from the International Workshop on Tropical Cyclones said, and I quote, the recent increase in societal impact from tropical cyclones has largely been caused by the rising concentration of population and infrastructure in coastal regions, unquote. This report said that no individual hurricane can be attributed to global warming, and that no firm conclusions can be made as to whether climate change is affecting hurricane activity. And if you don't believe Dr. Pielke, this report also notes that his-

torical multidecade trends in hurricane activity make it difficult to make conclusions about the current hurricane trends.

Fortunately, the GAO report also noted the relationship between development in hurricane-prone areas and increase in damages these storms cause. That is not to make light of hurricanes and the damage they bring, but as we look to ways to recover from weather-related damages, we should focus on the core issues of development and preparation and not be distracted by undocumented hype.

Republicans will insist that any climate change policy include four principles. It must tangibly help the environment, it must support technological advantages, it must protect jobs in the economy, and it must include global participation including China and India.

Preparing for hurricanes is also good policy, but it is not part of climate change policy. I worry that overzealous economic policy designed to fix global warming won't reduce hurricane damage at all, but instead create economic storms that hit not just the residents on the coast, but people all over the country. And I thank the gentleman.

The CHAIRMAN. The gentleman's time is expired.

The Chair recognizes the gentleman from Oregon Mr. Blumenauer.

Mr. BLUMENAUER. Thank you. I appreciate the opportunity to have this discussion today. It is something I have spent a lot of time working on, dealing with flood insurance reform in the past. Regardless of one's perception of global warming, the fact is 75 percent of our population is at risk for one or more natural disasters and is increasing as people move to coastlines and the urban/wildlife interface. Even without climate change we have seen the cost of natural disasters skyrocketing, a fivefold increase during the last decade for disaster relief funding. There has not been a billion-dollar loss before 1989. From 1989 to 1998, there were 10 disasters where the insurance industry suffered a billion dollars or more.

Climate change will make this worse with the intensity of future hurricanes. And as we heard from Dr. Helms at the last hearing, a warmer climate means wildfires are more frequent and intense. It is nobody's business in the Federal Government right now to really look at these big-picture issues in Congress, and, Mr. Chairman, I appreciate your doing this.

Through the prism of global warming, we may be able to encourage some more rational Federal policies in terms of mitigation. A dollar spent in mitigation will save us $4 or more from FEMA costs. We have seen the World Bank suggest that a $40 billion worldwide investment would have saved $280 billion. It is an intersection of flawed government policies, lack of sound land use planning, goofy things where we spend money after the fact to deal with people. We won't spend money before the fact for prevention, and work that we may do with climate change may be the most important preventive acts of all.

I have a somewhat longer statement I would like to put in the record, but I appreciate where we are going with this. Thank you.

The CHAIRMAN. Thank you. The gentleman's time has expired.

[The information follows:]

Opening Statement
Economic Impacts of Global Warming: Part I – Insurance
May 3, 2007

Mr. Chairman, thank you for holding this hearing today. The issue of rising costs of natural disasters is something that I've been working on for years.

I can't underscore how important this topic is. Seventy-five percent of American households are at risk for one or more natural disasters, and this number is increasing as more and more people move to the coast and wildland-urban interface. As we heard from Dr. Judith Curry, a witness at last week's hearing, more than 50% of our population lives within 50 miles of a coastline.

Even without climate change, costs of dealing with natural disasters are sky-rocketing. According to a 2002 study by the Government Accountability Office, disaster relief fund expenditures have increased nearly fivefold during the past decade – and this was before Hurricane Katrina. Prior to 1989, the insurance industry had never suffered a loss of over $1 billion from a single disaster. From 1989 to 1998, 10 disasters exceeded this amount. (Kunreuther, 1998) Private insurer losses from Hurricane Katrina are estimated to be between $40-60 billion (CRS, 2005)

Climate change is going to make this worse. The new IPCC report indicates that with climate change, future hurricanes will become more intense, with larger peak wind speeds and heavier precipitation. As we heard last week from Dr. John Helms, a warmer climate will mean wildfires that are more frequent and intense.

The most important thing we can do, of course, is to take steps to address climate change immediately. At last week's hearing, we learned how dangerous climate change will be and how vulnerable populations around the world are most at risk. This is why I think this Committee and the Speaker's commitment to addressing climate change is so important.

But scientists tell us that even with aggressive action immediately, we are already committed to at least a few degrees change in temperature. So those of us who can will have to adapt. We can do this by paying more attention to where and how we build.

We can help mitigate some of the impacts of climate change by implementing zoning and building codes. Where possible, we can move people out of flood zones, restore wetlands to reduce flooding events, and storm-proof, fire-proof, and earthquake-proof properties.

We know that mitigation works: The World Bank and USGS have estimated that $40 billion invested in risk reduction strategies could have saved as much as $280 billion in worldwide economic losses from disasters during the 1990s. Last year, the Multi-Hazard Mitigation Council (MMC) of the National Institute of Building Sciences report showed

that that on average, a dollar spent by FEMA on hazard mitigation provides the nation in about $4 in future benefits.

Insurance has to be part of this equation. Because insurance companies understand the risk, they can help us send the right signals to people about where is safe to build. I look forward to hearing from the witnesses today about how they are preparing for the consequences of climate change.

But there is also an important Federal role. Not only must the Federal government implement strategies to reduce greenhouse gas emissions. We must also help keep people out of harm's way. I hope that we can have a follow-up hearing so that the National Flood Insurance Program administrator can tell us what he's doing to prepare for and deal with climate change.

The CHAIRMAN. The Chair recognizes the gentleman from Oregon for an opening statement.

Mr. WALDEN. Thank you very much, Mr. Chairman. I will keep mine brief.

I look forward to hearing from our witnesses. I look forward to comments about why insurance claims are up. And I think the Ranking Member made some very eloquent comments that perhaps we have a lot more people living in a lot more expensive homes a lot closer to the water where these hurricanes occur than we had 20, 30, 50, 100 years ago.

My staff had provided me with this most recent study that just came out that indicates that hurricanes, the recent spate of strong hurricanes, can't be linked to global warming because, as it says here, scientists are incapable of determining whether stronger storms appeared at a time when people were unable to report them accurately or measure their strength, according to a study published yesterday in the U.S., which I think other of my colleagues are going to represent.

And I concur with my colleague from Oregon, there are some rational things we can do to deal with—on our part, with climate change. He referenced forest fires. It is an area of incredible interest for me to try to deal with better forest management, both in terms of reducing catastrophic wildfire that burns unnaturally in my part of the world and emits enormous amounts of carbon and other greenhouse gases into the atmosphere, but also deal with the fact that this government has failed the forest time and again. There is a million acres that were burned and never been replanted. And we all know that vegetation makes for pretty good carbon sink. And you got a million acres out there of Federal forestlands that have burned and never been replanted, according to the Government Accountability Office. So maybe we can help spur along some of these other things, too, that I know all of my colleagues care about that; healthy green forests that are more fire resistant and better carbon sink.

So with that, Mr. Chairman, I yield back the balance of my time.

The CHAIRMAN. The gentleman's time is expired.

The Chair recognizes the gentlelady from California Ms. Solis.

Ms. SOLIS. Thank you Mr. Chairman, and thank you for having this hearing and bringing forward these witnesses that we are going to hear from today.

I represent the State of California, and we just experienced a very traumatic freeze that had a devastating effect on our agricultural industry, and we are still assessing what that damage is.

In addition, that hit a lot of poor communities there in California. So I am equally concerned about the impact that we are having on a loss of jobs, insurance, and also what else is occurring in California with respect to drought and firefighters.

In California, in 2003, we had as many as 14 wildfires. About 800,000 acres were burned, 3,300 homes were destroyed, 100,000 residents had to run for their lives, and 22 people died. These are effects that are occurring. And, of course, we want to be very helpful in our role as Members of Congress to see how we can provide assurances that our communities are safe and what we can do in helping to prepare that.

But again, I am very concerned about our economy and the impact that this will have in low-income communities, communities that I represent, for example, and across the country, and look forward to hearing from you and your testimony. Thank you.

[The information follows:]

Opening Remarks of Congresswoman Hilda L. Solis
Select Committee Hearing on Energy Independence and Global Warming
Hearing on "Economic Impacts of Global Warming: Part I Insurance"
May 3, 2007

- Chairman Markey, thank you for holding this hearing today.
- I am pleased we are discussing the economic impacts of climate change, specifically insurance.
- As you all may know, the state of California's agriculture industry suffered catastrophic losses due to recent record setting freeze this past January.
- Despite the significant efforts to protect crops, agricultural communities in California suffered substantial losses and estimates of long-term damages are still in progress.
- Hurricane Katrina destroyed homes, businesses and significant infrastructure of the city of New Orleans.
- The total economic impact to the city of New Orleans and the region in terms of insurance, tourism, cost of repairs to roads, bridges, levees, and water and sewer systems is still being determined.
- With impacts to infrastructure comes impact on the human population and in the case of both the freeze and Hurricane Katrina those disproportionately impacted were poor communities, for a majority of which insurance was their only hope of survival.
- In 2003, as many as 14 wildfires raged out of control in southern California in one weekend, burning over 800,000 acres, 3,300 homes, forcing over 100,000 residents to run for their lives, and killing 22 people.
- The wildfires exposed millions of people to dangerous levels of air pollution for almost a week.
- The lives, homes and businesses lost in these catastrophic events are a reminder of what can occur in any community.
- Scientists expect climate change to create more frequent and violent storms, heat waves, flooding, tornadoes, and cyclones while other areas slip into cold or drought.
- Our nation's economy must be prepared for these situations, including our insurance and re-insurance industry.
- I look forward to discussing policy options to increase insurance preparedness as climate change impacts the frequency and severity of natural disasters with our panelists today.
- Thank you again, I yield back the balance of my time.

The CHAIRMAN. The gentlelady's time is expired. The gentleman from Oklahoma Mr. Sullivan.

Mr. SULLIVAN. Thank you, Mr. Chairman, and thank you for holding this important hearing today where we will hear testimony on the impact of global warming on the insurance industry.

According to a study published Tuesday in the American Geophysical Union's journal, EOS, the recent wave of strong hurricanes cannot be linked to global warming. Scientists are unable to determine whether strong storms, storms on par with Hurricane Katrina and Andrew, occurred earlier in our Nation's history since technology was not advanced enough to determine hurricane strength. The study references charts of the 1933 and the 2005 hurricane season, two of the busiest hurricane seasons on record. In 1933, all the storms only appeared on the satellite image fairly close to land, while in 2005, we were able to watch them develop far off in the Atlantic and move towards the U.S.

By looking at these two charts, we are able to see how our technology has increased in hurricane tracking. While the 2005 hurricane season, when we saw powerful hurricanes Katrina and Rita, was certainly notable, and relatively light in the 2006 season backs up the study's findings, to make the assumption that hurricanes have gotten stronger because of global warming is stretching the truth because we simply do not have the evidence to back it up.

With the total damages of over 80 billion and the Federal disaster declarations covering over 90,000 miles, Hurricane Katrina certainly left her impact on the gulf coast, its residents and the insurance companies. Companies have been forced to either stop offering coverage in the area or have had to dramatically raise their premiums to be able to offer coverage to gulf coast residents.

I look forward to hearing from our witnesses today on how they have been impacted by the storms while we keep in mind that strengthening hurricanes cannot be tied to global warming.

And also, Mr. Chairman, I would like to ask unanimous consent that this report published by the American Geophysical Union could be added to the record. The report is from the National Oceanic and Atmospheric Administration.

The CHAIRMAN. Without objection, it will be included in the record.

The Chair recognizes the gentlelady from South Dakota Ms. Herseth.

Ms. HERSETH. Mr. Chairman, I will reserve my time for the question-and-answer period. Thank you.

The CHAIRMAN. The Chair recognizes the gentleman from New York Mr. Hall.

Mr. HALL. I will also reserve my time, Mr. Chairman. Thank you.

The CHAIRMAN. The Chair recognizes the gentleman from California.

Mr. MCNERNEY. I will reserve my time, Mr. Chairman. Thank you.

The CHAIRMAN. The Chair recognizes the gentleman from Washington State.

Mr. INSLEE. I will reserve my time, but I would like to welcome Mike Kreidler, a former colleague. Whenever he is in D.C., we are

in the Majority, and things are going well, so we appreciate your being here, Mr. Kreidler.

The CHAIRMAN. The Chair recognizes the gentlelady from Tennessee.

Mrs. BLACKBURN. Thank you, Mr. Chairman. I want to thank you for the hearing, and I want to thank our witnesses who have come before us today. And I want to thank you also for the well-planned and prepared testimony that you gave us to have the opportunity to review prior to your coming here today.

And one of the things that I have noted is—it seems to occur time and again—and that is you all continue to present the issue of what the role of government should be and how it should fit in as we look at insurance and the predictability of those offerings.

Over the past couple and a half decades, many people in businesses have experienced disasters that are caused by weather-related events, and the damages have increased tenfold. We see that continually. The main reason for the increases in insurance losses is due to economic development, as has been stated by the Ranking Member; growth, economic growth and development in those disaster-prone areas that experience severe economic loss from disasters or severe weather hazards. Under the free market private insurers exam, their exposure to catastrophic risk can determine the extent of coverage and what rates to impose.

What we are hearing following Katrina, and in more repetitive circumstances, the risk is so great that the private sector deems hazards to be uninsurable or must establish very high rates that the property owners find unaffordable. And when this happens, then we are seeing that land owners and property owners will seek out programs and seek to insure their property through Federal programs or rely on Federal assistance when they do experience a disaster. But these government programs and Federal disaster assistance programs contain two serious weaknesses, and these are my primary concern for today.

First, they fail to address the financial risk and growth and development by assessing and limiting the catastrophic risk strictly within their ability to pay claims on an annual basis. And second, they fail to contain restrictions on whether insurance coverage should be available in areas that have a history, a long-term history, of disasters in severe weather hazards.

Mr. Chairman, I thank you for the hearing. I am looking forward to hearing from our witnesses and will look forward to addressing these two issues.

The CHAIRMAN. Thank you very much.

[The information follows:]

OPENING STATEMENT

Mr. Chairman:

I appreciate the opportunity to serve on this committee and look forward to a healthy and judicious debate over the issue of climate change.

I also appreciate our witnesses for taking time out of their schedules to testify before our committee.

Today, this committee will be hearing testimony on present and future events that may be caused by climate change.

Yet, what I find is that many who advocate for drastic actions to reduce greenhouse gas emissions have failed to include the human element into their policy solutions.

Hurricanes, diseases, and other disasters will happen with or without global warming. But to follow some of the most radical policies such as shutting down power plants will make no one safer but only poorer and with less ability to adapt or deal with present threats. Some of these measures actually seem to be counterproductive.

If people do not have access to energy such as electricity, they will not be able to improve their health, incomes, or their environmental quality and become more productive.

In effect, we will starve the world's poor.

Mr. Chairman, I believe it is our responsibility to take reasonable actions to help poor and developing countries. But closing coal plants and imposing massive energy costs on consumers and developing nations is not the way to do it.

This is especially true when these policies are based on uncertain events and unreliable data.

Instead, we should devote our time through short term actions and mid-term strategies that lead us to long-term solutions to real, immediate threats and problems we can address now.

[Prepared statement of Mr. Cleaver is as follows:]

U.S. Representative Emanuel Cleaver, II
5th District, Missouri
Statement for the Record
House Select Committee on Energy Independence and Global Warming Hearing
"Economic Impacts of Global Warming: Part I - Insurance"
Thursday, May 3, 2007

Chairman Markey, Ranking Member Sensenbrenner, other Members of the Select Committee, good morning.

To our distinguished panel of experts, I would like to join my colleagues in welcoming you to the Select Committee on Energy Independence and Global Warming. I anticipate listening to your testimony today and hearing your suggestions on the impacts global warming and its anticipated effects on the insurance industry.

There is observational evidence, namely in the 2007 report of the Intergovernmental Panel on Climate Change, that rising global temperatures are anticipated to increase the intensity of extreme weather. Dangerous weather events such as hurricanes, floods, and droughts are expected to become stronger and in turn more threatening. These disastrous events will have more serious consequences because of increased populations in coastal communities and higher rates of development in these areas. A rise in residents in susceptible locations increases the already growing risk of loss in life and property because of the effects of climate change. This fact is amplified by the events that unfolded during and after Hurricane Katrina.

My son Evan was at college in New Orleans at the time Katrina made landfall, and he was one of the lucky ones. Evan was able to escape the storm because he had a car, however, thousands of other area residents were not able to leave because they did not have means to do so. The most vulnerable people to extreme weather are low-income, and they lack financial ability to respond properly to an unexpected weather event. Because of Katrina, nearly 228,000 homes were either damaged or destroyed, of which sixty percent were rental units. Response by insurance companies has been slow, and hundreds of claims are still pending nearly two years after the hurricane. This is simply unacceptable.

The impacts of global warming on the insurance industry must be better understood in order to address both environmental changes and coverage and response of insurance claims. An increase of extreme weather events will lead to a higher damage rate for homeowners and renters, and this will cause a greater strain on insurance claims. We can prevent this liability by gaining a better understanding of what the risks are for insurers in terms of unpredictable weather events, like drought and hurricanes. As we get closer to hurricane season and summer, our country will likely experience some of the effects of global warming again. Today our panel of economic and environmental experts will give us suggestions as to how the effects of climate change on the insurance industry can be rectified, and I thank them for their insight.

Thank you.

The CHAIRMAN. And the time has expired for opening statements from Members, and we now turn to our witness panel. And we will turn to our first witness, Mr. John Stephenson, who—Mr. Stephenson is the Director of Natural Resources and Environment Issues for the U.S. Government Accountability Office. He brings a wealth of knowledge and experience on a variety of environmental subjects, including today's topic, global warming.

Mr. Stephenson, welcome, and please begin.

STATEMENT OF JOHN B. STEPHENSON, DIRECTOR, NATURAL RESOURCES AND ENVIRONMENT, GOVERNMENT ACCOUNTABILITY OFFICE

Mr. STEPHENSON. Thank you Mr. Chairman and members of the committee. My testimony today is based on a report we issued last month on the potentially significant risks facing private and Federal insurers as a result of climate change.

One of the most important aspects of our study was to begin to show the significant economic implications of climate change by examining one of the Nation's most important and forward-looking sectors, the insurance industry.

The uncertain and potentially large losses associated with weather-related events are among the biggest risks that property insurers face. Projections by the Intergovernmental Panel on Climate Change, the IPCC, expect warmer surface temperatures to increase the frequency or severity of many damaging weather events, such as flooding and drought. As you know, the IPCC is a large international body of scientists that was established by the World Meteorological Organization and the United Nations Environmental Program in 1988 to synthesize scientific information on the impacts of climate change.

The IPCC is widely recognized as the leading authority on this topic. Its assessments are thoroughly reviewed by hundreds of scientists, approved by member countries, and had been endorsed by both the National Academies of Science and the U.S. Government's Climate Change Science Program. One key IPCC conclusion worth noting is that observed temperature increases during the 20th century cannot be explained by natural variability alone, but are largely attributable to human activities.

To determine the implications of climate change that it may have on the insurance industry, we examined data from several different sources and found that insurers paid claims of more than 320 billion in weather-related losses from 1980 through 2005. Private insurers paid about 75 percent of this total, while the two large Federal insurance programs, the National Flood Insurance Program and the Federal Crop Insurance Corporation, account for the remaining 25 percent.

Importantly, we know that insurance data alone significantly understates the total economic damages wrought by weather-related events. Experts estimate that insurance losses represent only about 40 percent of the total economic damages. They do not account for losses suffered by the un- or underinsured, which often receive direct disaster assistance payments from the Federal Government and others, and for the cost of rebuilding public infrastructure such as highways. Both Federal and private insurers have experienced

a significant growth in total exposure, that is financial risk of loss, over this same period of time due to the increase in the number of policyholders, property value increases and residents in hazard-prone areas.

Indeed, Mr. Chairman, as you have already mentioned, the Federal Government's exposure under the Flood Insurance Program has quadrupled to nearly $1 trillion, and crop insurance has increased 26-fold to 44 billion.

So these ever-increasing levels of exposure and the significant financial risks they pose make the IPCC's predictions about increases in frequency or severity of damaging weather-related events, including hurricanes in coastal areas, but also droughts in the Western Plains, all the more important.

A key finding in our report is that while both private and Federal insurers face similar risks associated with climate change, the two sectors are responding in very different ways. Private insurers are proactively incorporating elements of climate change into their annual and strategic risk management practices and reducing their exposure to the financial risks posed by extreme weather events by, for example, increasing premiums, altering deductibles, and are limiting coverage in specific weather-prone areas.

In contrast, the Federal programs have done little to incorporate the increased likelihood of extreme weather events associated with climate change into their risk management practices. Failure to anticipate the implications that shifting climates could have on Federal insurance programs could open the Federal budget and the taxpayers who fund it to unquantified risk and to serious financial consequences.

We acknowledge in our report that the mandate and operating environment of the major Federal insurance programs are significantly different from that of the private sector. Unlike the private insurers who are expected to turn a profit, the Federal insurers are directed in statute to prioritize broad participation over financial self-sufficiency. Nevertheless they are expected to be sound stewards of the taxpayers' money and should not rely solely on the U.S. Treasury to bail them out.

Accordingly we recommended in our report that both Federal insurance programs analyze the potential long-term fiscal implications of climate change on their respective programs and report their findings to the Congress. We believe that such foresighted information is essential to help the Congress and the Federal agencies manage this emerging high-risk area, one that potentially has significant implications for the Nation's growing fiscal imbalance.

Mr. Chairman, that concludes the summary of my statement. I would be happy to answer questions at the appropriate time.

The CHAIRMAN. Great. We thank you Mr. Stephenson very much.

[The statement of Mr. Stephenson follows:]

United States Government Accountability Office

GAO

Testimony
Before the Select Committee on Energy Independence and Global Warming, U.S. House of Representatives

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CLIMATE CHANGE

Financial Risks to Federal and Private Insurers in Coming Decades are Potentially Significant

Statement of John B. Stephenson, Director
Natural Resources and Environment

GAO-07-820T

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Highlights

Highlights of GAO-07-820T, testimony before the Select Committee on Energy Independence and Global Warming, United States House of Representatives

May 3, 2007

CLIMATE CHANGE

Financial Risks to Federal and Private Insurers in Coming Decades Are Potentially Significant

Why GAO Did This Study

Weather-related events in the United States have caused tens of billions of dollars in damages annually over the past decade. A major portion of these losses is borne by private insurers and by two federal insurance programs—the Federal Emergency Management Agency's National Flood Insurance Program (NFIP), which insures properties against flooding, and the Department of Agriculture's Federal Crop Insurance Corporation (FCIC), which insures crops against drought or other weather disasters.

In this testimony, GAO (1) describes how climate change may affect future weather-related losses, (2) provides information on past insured weather-related losses, and (3) determines what major private insurers and federal insurers are doing to prepare for potential increases in such losses. This testimony is based on a report entitled *Climate Change: Financial Risks to Federal and Private Insurers in Coming Decades are Potentially Significant* (GAO-07-285) released on April 19, 2007.

What GAO Recommends

In its report, GAO recommended that the Secretaries of Agriculture and Homeland Security analyze the potential long-term fiscal implications of climate change for the FCIC and the NFIP, respectively, and report their findings to the Congress. Both agencies expressed agreement with the recommendation.

www.gao.gov/cgi-bin/getrpt?GAO-07-820T.

To view the full product, including the scope and methodology, click on the link above. For more information, contact John Stephenson at (202) 512-3841 or stephensonj@gao.gov.

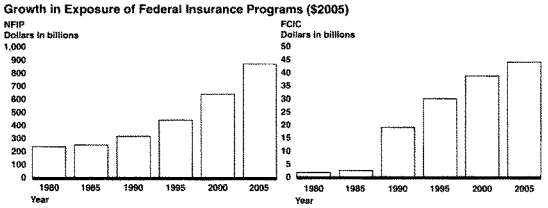
What GAO Found

Key scientific assessments report that the effects of climate change on weather-related events and, subsequently, insured and uninsured losses, could be significant. The global average surface temperature has increased over the past century and climate models predict even more substantial, perhaps accelerating, increases in temperature in the future. Assessments by key governmental bodies generally found that rising temperatures are expected to increase the frequency and severity of damaging weather-related events, such as flooding or drought, although the timing and magnitude are as yet undetermined. Additional research on the effect of increasing temperatures on weather events is expected in the near future.

Taken together, private and federal insurers paid more than $320 billion in claims on weather-related losses from 1980 to 2005. Claims varied significantly from year to year—largely due to the effects of catastrophic weather events such as hurricanes and droughts—but have generally increased during this period. The growth in population in hazard-prone areas and resulting real estate development have generally increased liabilities for insurers, and have helped to explain the increase in losses. Due to these and other factors, federal insurers' exposure has grown substantially. Since 1980, NFIP's exposure nearly quadrupled to nearly $1 trillion in 2005, and program expansion increased FCIC's exposure 26-fold to $44 billion.

Major private and federal insurers are both exposed to the effects of climate change over coming decades, but are responding differently. Many large private insurers are incorporating climate change into their annual risk management practices, and some are addressing it strategically by analyzing its potential long-term industry-wide impacts. In contrast, federal insurers have not developed and disseminated comparable information on long-term financial impacts. GAO acknowledges that the federal insurance programs are not profit-oriented, like private insurers. Nonetheless, a strategic assessment of the potential implications of climate change for the major federal insurance programs would help the Congress manage an emerging high-risk area with significant implications for the nation's growing long-term fiscal imbalance.

Growth in Exposure of Federal Insurance Programs ($2005)



Source: GAO.

Mr. Chairman and Members of the Committee:

I am pleased to be here today to discuss our findings on the potential financial implications of climate change for federal and private insurers. My testimony is based on our report entitled *Climate Change: Financial Risks to Federal and Private Insurers in Coming Decades are Potentially Significant*, released on April 19, 2007.[1] I also presented the findings and recommendations from that report at a hearing before the Senate Homeland Security and Governmental Affairs Committee on the same day. The uncertain and potentially large losses associated with weather-related events are among the biggest risks that property insurers face. Virtually anything that is insured is vulnerable to weather-related events.

The property and casualty segment of the insurance industry, spanning both the private and public sector, bears a large portion of weather-related losses—the dollar value of claims paid on damage attributable to weather-related events.[2] The private sector includes primary insurers that insure individuals and businesses directly, and reinsurers that insure the primary insurers. The public sector includes federal and state programs that were established as an alternative to disaster assistance in markets where private insurance markets did not exist, such as for crop losses, and for losses that private insurers had deemed uninsurable, such as flood damage. The Federal Crop Insurance Corporation (FCIC) was established in 1938 to temper the economic impact of the Great Depression, and was significantly expanded in 1980 to protect farmers from the financial losses brought about by drought, flood, or other natural disasters. The Department of Agriculture's Risk Management Agency (RMA) administers the program in partnership with private insurance companies, which share a percentage of the risk of loss and the opportunity for gain associated with each insurance policy written. The National Flood Insurance Program (NFIP) was established in 1968 to protect communities vulnerable to flood damage. The Federal Emergency Management Agency (FEMA), within the Department of Homeland Security, is responsible for oversight and management of the NFIP. Private insurers administer the program in

[1]GAO, *Climate Change: Financial Risks to Federal and Private Insurers in Coming Decades are Potentially Significant*, GAO-07-285 (Washington, D.C.: Mar. 16, 2007).

[2]Insurers use the term "loss" to refer to the dollar value of approved or settled claims arising from damages incurred by a policyholder. "Loss" does not account for premium or other income, deductibles, co-payments, or damages in excess of coverage.

partnership with the federal government, but the federal government assumes the full liability for losses.

To remain financially solvent, the insurance industry must estimate and prepare for the potential impact of future weather-related events. Any unanticipated changes in the frequency or severity of weather-related events can have financial consequences at the company level and industry-wide. Some infrequent weather-related events—drought or hurricanes, for example—are so severe that they pose unique challenges for insurers and reinsurers. Commonly referred to as extreme or catastrophic events, the unpredictability and sheer size of these events—both in terms of geography and number of insured parties affected—have the potential to overwhelm insurers' and reinsurers' capacity to pay claims.

The earth's climate and weather patterns are dynamic, varying on seasonal, decadal, and longer time scales. Of particular concern, the global average surface temperature has increased by 1.3 degrees Fahrenheit (0.74 degrees Celsius) over the past 100 years, and the National Academy of Sciences (NAS) and other scientific organizations have concluded that available evidence points to continued, perhaps accelerating, increases over the next century. Much research and policy debate of late has centered on the extent to which human activities have contributed to this warming and accompanying changes in climate, and how much is due to natural variability. But in any case, climate change, defined by the Intergovernmental Panel on Climate Change (IPCC) as any change in the climate over time due to either natural variability or as a result of human activity,[3] may affect social and economic activities in potentially profound ways—by raising sea levels, changing precipitation patterns, and altering the frequency or severity of weather-related events.

My testimony summarizes our report, focusing on (1) what is known about how climate change might affect the frequency and severity of damaging weather-related events, (2) the extent of the insured losses incurred by private and federal insurers and reinsurers resulting from weather-related

[3]More specifically, the IPCC definition refers to climate change as a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural factors (e.g., internal processes or external forcings such as solar variations or heavy volcanic activity), or to persistent human-induced changes in the composition of the atmosphere or land use patterns.

events, and (3) what major federal agencies and private insurers and reinsurers are doing to prepare for the potential risk of increased losses.

To describe how climate change might affect insured and uninsured losses, we reviewed and summarized key scientific assessments by reputable international and national research organizations, including the IPCC, NAS, and the multi-federal agency Climate Change Science Program (CCSP). To determine the extent of insured losses, we analyzed key data from 1980 through 2005 from the insurance industry and federal agencies. Comparable data on 2006 losses were not available at the time we completed work on our report. To determine what federal and private insurers are doing to prepare for potential increases in losses, we interviewed agency officials and a subset of the largest insurers and reinsurers operating within the United States. We also interviewed officials from catastrophe modeling firms, insurance industry associations, the National Association of Insurance Commissioners,[4] and universities to provide additional context for respondents' statements. In addition, we reviewed key reports and publications from federal agencies, insurance experts, and selected insurance companies. We performed our work in accordance with generally accepted government auditing standards.

Summary

Assessments by key governmental scientific bodies have found that the effects of climate change on weather-related events could be substantial. IPCC projections, endorsed by NAS and CCSP, expect warmer surface temperatures to increase the frequency and severity of damaging weather-related events (such as flooding or drought), although the timing, magnitude, and duration of these changes are as yet undetermined. Further research on the relationship between increasing temperatures and weather events is ongoing. Of particular note, the IPCC is in the process of releasing its *Fourth Assessment Report* of the state of climate science throughout 2007, and CCSP has undertaken an assessment of the potential changes specific to North America in a report scheduled for release in 2008.

Taken together, private and federal insurers paid more than $320 billion in claims on weather-related losses from 1980 through 2005. In constant 2005 dollars, private insurers paid the largest part of this total, $243.5 billion

[4]The National Association of Insurance Commissioners is an organization of insurance regulators from the 50 states, the District of Columbia, and the five U.S. territories.

(about 76 percent); followed by federal crop insurance, $43.6 billion (about 14 percent); and federal flood insurance, $34.1 billion (about 11 percent). Claims varied significantly from year to year—largely due to the incidence and effects of extreme weather events such as hurricanes and droughts—but generally increased during this period. The growth in population in hazard-prone areas, and resulting real estate development and increasing real estate values, have increased federal and private insurers' total coverage and have helped to explain the increase in losses.

While both major private and federal insurers are exposed to increases in the frequency or severity of weather-related events associated with climate change, the two sectors are responding in different ways. Many major private insurers are incorporating elements of climate change into their annual and strategic risk management practices to reduce their exposure to catastrophic risk—that is, their vulnerability to extreme weather-related events and the associated financial losses. One consequence is that they are transferring some of their exposure to policyholders and to the public sector. Federal insurance programs, on the other hand, have seen their exposure grow significantly—NFIP's total coverage has quadrupled from 1980 to 2005, nearing $1 trillion, and program expansion has increased FCIC's total coverage nearly 26-fold to $44 billion. These escalating exposures to catastrophic weather events are putting the federal government at increased financial risk, but federal insurers have done little to develop and disseminate the kind of information they, and other key decision-makers such as the Congress, need to understand their programs' long-term exposure to the increased financial risks associated with climate change.

While we acknowledge that the mandate and operating environment of the major federal insurance programs is different from that of the private sector, we believe that better information about the federal government's exposure to potential changes in weather-related risk would help the Congress identify and manage this emerging high-risk area—one that potentially has significant implications for the nation's growing fiscal imbalance. Accordingly, our recently released report recommends that the Departments of Agriculture (USDA) and Homeland Security (DHS) assess the potential long-term fiscal implications of climate change for the FCIC and NFIP, respectively, and report their findings to the Congress. During the April 19 hearing, Senators Lieberman and Collins both requested that USDA and DHS notify the Committee of how they plan to implement this recommendation, and offered some guidance on the agencies' approaches in conducting such an assessment.

In commenting on a draft of this report, both USDA and DHS agreed with our recommendation, although USDA took issue with several points made in the report. The Department of Commerce neither agreed nor disagreed with the report's findings, but instead commented on the presentation of several issues in the draft and offered technical comments which we incorporated into this report as appropriate. The Department of Energy elected not to provide comments on the draft.

Background

Insurance is a mechanism for spreading risk over time, across large geographical areas, and among industries and individuals. While private insurers assume some financial risk when they write policies, they employ various strategies to manage risk so that they earn profits, limit potential financial exposure, and build capital needed to pay claims. For example, insurers charge premiums for coverage and establish underwriting standards, such as refusing to insure customers who pose unacceptable levels of risk or limiting coverage in particular geographic areas. Insurance companies may also purchase reinsurance to cover specific portions of their financial risk. Reinsurers use strategies similar to primary insurers to limit their risks.

Under certain circumstances, the private sector may determine that a risk is uninsurable. For example, homeowner policies typically do not cover flood damage because private insurers are unwilling to accept the risk of potentially catastrophic losses associated with flooding. In other instances, the private sector may be willing to insure a risk, but at rates that are not affordable to many property owners. Without insurance, affected property owners must rely on their own resources or seek out disaster assistance from local, state, and federal sources.

In situations where the private sector will not insure a particular type of risk, the public sector may create markets to ensure the availability of insurance. The federal government operates two such programs—the NFIP and the FCIC. NFIP provides insurance for flood damage to homeowners and commercial property owners in more than 20,000 communities. Homeowners with mortgages from federally regulated lenders on property in communities identified as being in high flood risk areas are required to purchase flood insurance on their dwellings. Optional, lower cost flood insurance is also available under the NFIP for properties in areas of lower flood risk. NFIP offers coverage for both the property and its contents, which may be purchased separately. FCIC insures agricultural commodities on a crop-by-crop and county-by-county basis based on farmer demand and the level of risk associated with the

crop in a given region. Major crops, such as grains, are covered in almost every county where they are grown, while specialty crops such as fruit are covered only in some areas. Participating farmers can purchase different types of crop insurance and at different levels.

Climate Change Is Expected to Alter the Frequency or Severity of Damaging Weather-Related Events

Assessments by leading scientific bodies suggest that climate change could significantly alter the frequency or severity of weather-related events, such as drought and hurricanes. Leading scientific bodies report that the Earth warmed during the twentieth century— 1.3 degrees Fahrenheit (0.74 degrees Celsius) from 1906 to 2005 according to a recent IPCC report—and is projected to continue to warm for the foreseeable future.[5] While temperatures have varied throughout history, triggered by natural factors such as volcanic eruptions or changes in the earth's orbit, the key scientific assessments we reviewed have generally concluded that the observed increase in temperature in the past 100 years cannot be explained by natural variability alone. In recent years, major scientific bodies such as the IPCC, NAS, and the United Kingdom's Royal Academy have concluded that human activities are significantly increasing the concentrations of greenhouse gases and, in turn, global temperatures. Assuming continued growth in atmospheric concentration of greenhouse gases, the latest assessment of computer climate models projects that average global temperatures will warm by an additional 3.2 to 7.2 degrees Fahrenheit (1.8 to 4.0 degrees Celsius) during the next century.[6]

Based on model projections and expert judgment, the IPCC reported that future increases in the earth's temperature are likely to increase the frequency and severity of many damaging extreme weather-related events (summarized in table 1). The IPCC recently published summaries of two of

[5]This estimate comes from a recently released summary of a key component of IPCC's *Fourth Assessment Report* of the state of climate science, which reported an updated 100-year linear trend (1906 through 2005) of 1.3 degrees Fahrenheit—larger than the corresponding 1.0 degrees Fahrenheit (0.6 degrees Celsius) reported in the 2001 *Third Assessment Report*.

[6]IPCC narrowed its range of projected warming in its recently released summary from the corresponding range of 2.5 to 10.4 degrees Fahrenheit (1.4 to 5.8 degrees Celsius) reported in the 2001 *Third Assessment Report*. Although these two sets of projections are broadly consistent, they are not directly comparable. IPCC notes in the summary that the new range is more advanced in that it provides best estimates and an assessed likelihood range. It also relies on a larger number of climate models of increasing complexity and realism, as well as new information regarding the nature of feedbacks from the carbon cycle and constraints on climate response from observations.

the three components of its *Fourth Assessment Report*. The first, in which IPCC summarized the state of the physical science, reports higher confidence in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation, and some aspects of extreme events such as drought, heavy precipitation events, and hurricanes. The second, in which IPCC addresses climate impacts and vulnerabilities, reported that the potential societal impacts from changes in temperature and extreme events vary widely across sector and region. For example, although the IPCC projects moderate climate change may increase yields for some rain-fed crops, crops that are near their warm temperature limit or depend on highly-used water resources face many challenges. Additionally, local crop production in any affected area may be negatively impacted by projected increases in the frequency of droughts or floods. Furthermore, the IPCC stated that the economic and social costs of extreme weather events will increase as these events become more intense and/or more frequent. Rapidly-growing coastal areas are particularly vulnerable, and the IPCC notes that readiness for increased exposure in these areas is low. These reports have not been publicly released in their entirety, but are expected sometime after May 2007.

Table 1: Selected IPCC Estimates of Confidence in Projected Changes in Weather-Related Events

Weather-related event	Confidence in projected future changes, 2007	Examples of major projected impacts relevant to property insurers
Warmer and fewer cold days and nights; warmer/more frequent hot days and nights over most land areas	Virtually certain[a]	• Increased crop yields in colder environments • Decreased crop yields in warmer environments • Increased insect outbreaks in agriculture and forestry
Warm spells/heat waves: frequency increases over most land areas	Very likely	• Reduced crop yields in warmer regions due to heat stress • Wildfire danger increases
Heavy precipitation events: frequency increases over most areas	Very likely	• Damage to crops • Soil erosion • Inability to cultivate land due to excessive moisture content of soils • Damage and disruption due to flooding
Area affected by drought increases	Likely	• Land degradation, lower yields and damage or failure of crops • Increased livestock deaths • Increased risk of wildfire • Disruptions due to water shortages
Intense tropical cyclone activity increases	Likely	• Damage to crops and trees • Disruption and damage due to flooding and high winds • Withdrawal of private insurance from vulnerable areas

Source: IPCC, Climate Change 2007: Impacts, Adaptation, and Vulnerability, Summary for Policymakers, 2007.

Note: IPCC uses the following terms to indicate the assessed likelihood of an outcome—"virtually certain" indicates a 99% probability of occurrence; "very likely" indicates a greater than 90% probability of occurrence; and "likely" indicates a greater than 66% probability of occurrence.

[a]Warming of the most extreme days and nights each year.

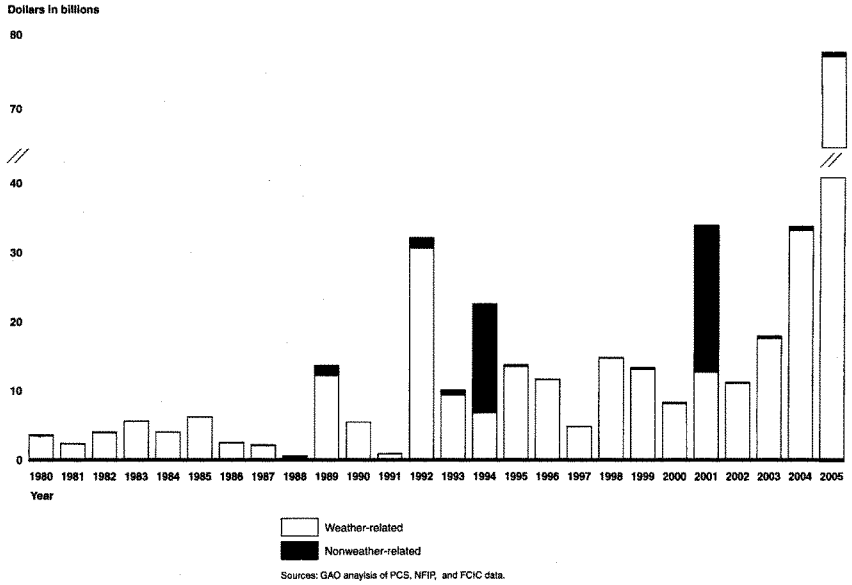
In addition to the IPCC's work, CCSP is assessing potential changes in the frequency or intensity of weather-related events specific to North America in a report scheduled for release in 2008. According to a National Oceanic and Atmospheric Administration official and agency documents, the report will focus on weather extremes that have a significant societal impact, such as extreme cold or heat spells, tropical and extra-tropical storms, and droughts. Importantly, officials have said the report will provide an assessment of the observed changes in weather and climate extremes, as well as future projections.

Weather-Related Insured Losses Totaled More Than $320 Billion between 1980 and 2005 and Appear to Be Increasing

Based on an examination of loss data from several different sources, we found that insurers incurred about $321.2 billion in weather-related losses from 1980 through 2005. In particular, as illustrated in Figure 1, our analysis found that weather-related losses accounted for 88 percent of *all* property losses paid by insurers during this period.[7] All other property losses, including those associated with earthquakes and terrorist events, accounted for the remainder. Weather-related losses varied significantly from year to year, ranging from just over $2 billion in 1987 to more than $75 billion in 2005.

[7]The insured loss totals used in our analysis understate total economic damage associated with weather-related events. Due to data limitations, we did not account for uninsured, underinsured, and self-insured losses. According to data obtained from Munich Re, the type of insured losses we reviewed account for no more than about 40 percent of the total economic losses attributable to weather-related events. Various public and private disaster relief organizations provide assistance to communities and individuals who suffer economic losses that are not insured. Additionally, weather-related events are also responsible for many indirect and non-market impacts that are not wholly accounted for in economic terms, such as environmental damage. This issue is discussed on pages 23-25 of *Climate Change: Financial Risks to Federal and Private Insurers in Coming Decades Are Potentially Significant* (GAO-07-285).

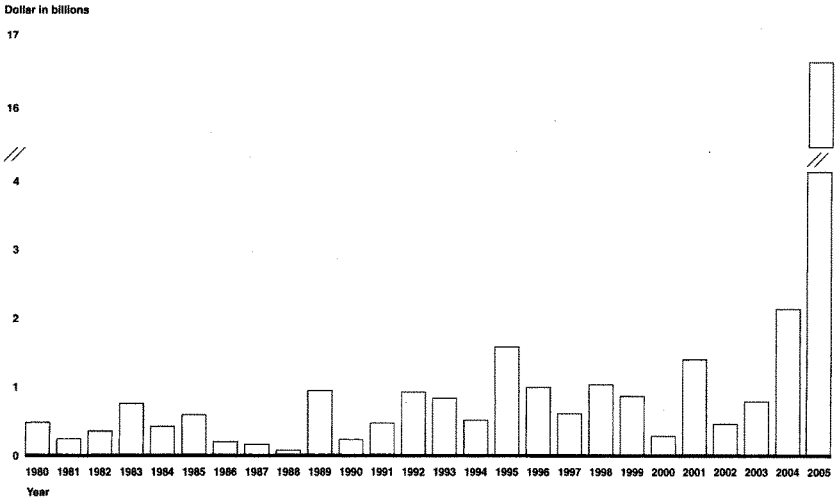
Figure 1: Annual Weather- and Nonweather-Related Insured Losses



Sources: GAO anaylsis of PCS, NFIP, and FCIC data.

Private insurers paid $243.5 billion—over 75 percent of the total weather-related losses we reviewed. The two major federal insurance programs—NFIP and FCIC—paid the remaining $77.7 billion of the $321.2 billion in weather-related loss payments we reviewed. NFIP paid about $34.1 billion, or about 11 percent of the total weather-related loss payments we reviewed during this period. As illustrated in Figure 2, claims averaged about $1.3 billion per year, but ranged from $75.7 million in 1988 to $16.7 billion in 2005.

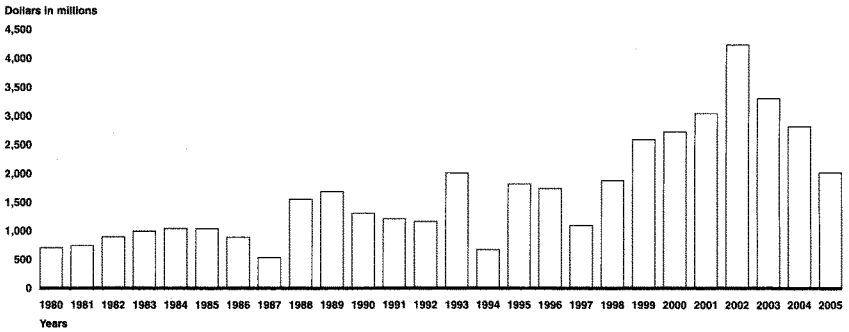
Figure 2: Weather-Related Losses Paid by NFIP



Source: GAO analysis of NFIP data.

Since 1980, FCIC claims totaled $43.6 billion, or about 14 percent of all weather-related claims during this period. As illustrated in Figure 3, FCIC losses averaged about $1.7 billion per year, ranging from $531.8 million in 1987 to $4.2 billion in 2002.

Figure 3: Weather-Related Losses Paid by FCIC



Source: GAO analysis of FCIC data.

The largest insured losses in the data we reviewed were associated with catastrophic weather events. Notably, crop insurers and other property insurers both face catastrophic weather-related risks, although the nature of the events for each is very different. In the case of crop insurance, drought accounted for more than 40 percent of weather-related loss payments from 1980 to 2005, and the years with the largest losses were associated with drought. Taken together, though, hurricanes were the most costly event in the data we reviewed. Although the United States experienced an average of only two hurricanes per year from 1980 through 2005, weather-related claims attributable to hurricanes totaled more than 45 percent of all weather-related losses—more than $146 billion. Moreover, as illustrated in Table 2, these losses appear to have increased during the past three decades.

Table 2: Insured Losses Associated with Hurricanes

	Category 1 & 2	Category 3, 4, & 5	Total
1980s	$807 (11)	$9,905 (6)	**$10,712 (17)**
1990s	$9,039 (11)	$29,099 (8)	**$38,138 (19)**
2000s	$8,072 (7)	$89,210 (7)	**$97,282 (14)**
Total	**$17,918 (29)**	**$128,214 (21)**	**$146,132 (50)**

Source: GAO analysis of PCS and NFIP data; National Oceanic and Atmospheric Administration (hurricane severity classification).

Note: Totals in millions of 2005 dollars. Totals do not include crop losses associated with hurricanes. Number of hurricanes associated with losses is included in parentheses. Hurricane classification was based on peak intensity at landfall.

Several recent studies have commented on the apparent increases in hurricane losses during this time period, and weather-related disaster losses generally, with markedly different interpretations. Some argue that loss trends are largely explained by changes in societal and economic factors, such as population density, cost of building materials, and the structure of insurance policies. Others argue that increases in losses have been driven by changes in climate. To address the issue, Munich Re—one of the world's largest reinsurance companies—and the University of Colorado's Center for Science and Technology Policy Research jointly convened a workshop in Germany in May 2006 to assess factors leading to increasing weather-related losses.[8] The workshop brought together a diverse group of international experts in the fields of climatology and disaster research. Workshop participants agreed that long-term records of disaster losses indicate that societal change and economic development are the principal factors explaining weather-related losses.[9] However, participants also agreed that changing patterns of extreme events are drivers for recent increases in losses, and that additional increases in losses are likely, given IPCC's projections.

The close relationship between the value of the resource exposed to weather-related losses and the amount of damage incurred may have ominous implications for a nation experiencing rapid growth in some of its most disaster-prone areas. AIR Worldwide, a leading catastrophe modeling

[8]Peter Höppe and Roger Pielke, Jr., eds., *Report of the Workshop on Climate Change and Disaster Losses: Understanding and Attributing Trends and Projections*, Hohenkammer, Germany, May 25-26, 2006 (Munich, Germany: October 2006).

[9]Consensus statements agreed to at the workshop are listed in their entirety in appendix IV of GAO-07-285.

firm, recently reported that insured losses should be expected to double roughly every 10 years because of increases in construction costs, increases in the number of structures, and changes in their characteristics. AIR's research estimates that, because of exposure growth, probable maximum catastrophe loss—an estimate of the largest possible loss that may occur, given the worst combination of circumstances—grew in constant 2005 dollars from $60 billion in 1995 to $110 billion in 2005, and it will likely grow to over $200 billion during the next 10 years.

Major Private and Public Insurers Differ in How They Manage Catastrophic Risks Associated with Climate Change

Major private and federal insurers are responding differently to the prospect of increasing weather-related losses associated with climate change. Many large private insurers are incorporating both near and longer-term elements of climatic change into their risk management practices. On the other hand, for a variety of reasons, the federal insurance programs have done little to develop the kind of information needed to understand the programs' long-term exposure to climate change.

Major Private Insurers Prospectively Manage Potential Increases in Catastrophic Risk Associated with Climate Change

Catastrophic weather events pose a unique financial threat to private insurers' financial success because a single event can cause insolvency or a precipitous drop in earnings, liquidation of assets to meet cash needs, or a downgrade in the market ratings used to evaluate the soundness of companies in the industry. To prevent these disruptions, the American Academy of Actuaries (AAA)—the professional society that establishes, maintains, and enforces standards of qualification, practice, and conduct for actuaries in the United States—recommends, among other steps, that insurers measure their exposure to catastrophic weather-related risk. In particular, AAA emphasizes the shortcomings of estimating future catastrophic risk by extrapolating solely from historical losses, and endorses a more rigorous approach that incorporates underlying trends and factors in weather phenomena and current demographic, financial, and scientific data to estimate losses associated with various weather-related events.

In our interviews with eleven of the largest private insurers operating in the U.S. property casualty insurance market, we sought to determine what key private insurers are doing to estimate and prepare for risks associated with potential climatic changes arising from natural or human factors. Representatives from each of the 11 major insurers we interviewed told us they incorporate near-term increases in the frequency and intensity of

hurricanes into their risk estimates. Six specifically attributed the higher frequency and intensity of hurricanes to a 20- to 40-year climatic cycle of fluctuating temperatures in the north Atlantic Ocean, while the remaining five insurers did not elaborate on the elements of climatic change driving the differences in hurricane characteristics.

In addition to managing their aggregate exposure on a near-term basis, some of the world's largest insurers have also taken a longer-term strategic approach to changes in catastrophic risk.[10] Six of the eleven private insurers we interviewed reported taking one or more additional actions when asked if their company addresses climatic change in their weather-related risk management processes. These activities include monitoring scientific research (4 insurers), simulating the impact of a large loss event on their portfolios (3 insurers), and educating others in the industry about the risks of climatic change (3 insurers), among others. Moreover, major insurance and reinsurance companies, such as Allianz, Swiss Re, Munich Re, and Lloyds of London, have published reports that advocate increased industry awareness of the potential risks of climate change, and outline strategies to address the issue proactively.

Major Federal Insurers Have Taken Little Action to Prospectively Assess and Disseminate Information on Potential Increases in Catastrophic Risk Associated with Climate Change

NFIP and FCIC have not developed information on the programs' longer-term exposure to the potential risk of increased extreme weather events associated with climate change as part of their risk management practices. The goals of the key federal insurance programs are fundamentally different from those of private insurers. Whereas private insurers stress the financial success of their business operations, the statutes governing the NFIP and FCIC promote affordable coverage and broad participation by individuals at risk over the programs' financial self-sufficiency by offering discounted or subsidized premiums. Also unlike the private sector, the NFIP and the FCIC have access to additional federal funds during high-loss years.[11] Thus, neither program is required to assess and limit its catastrophic risk strictly within its ability to pay claims on an annual basis. Instead, to the extent possible, each program manages its

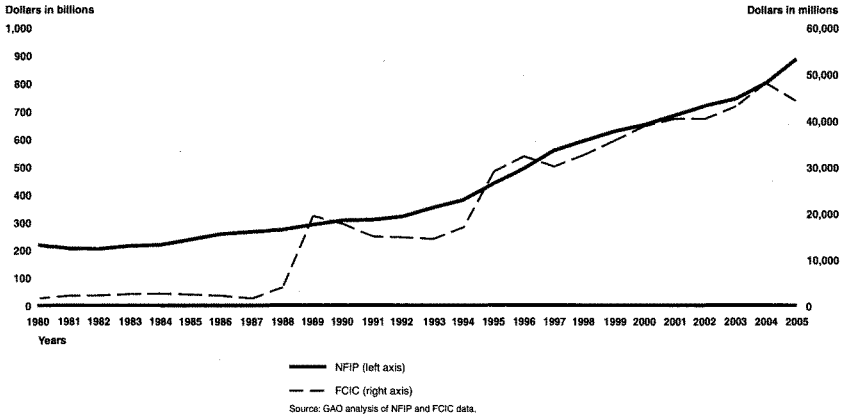
[10]Additionally, concern over the potential impacts of climate change on the availability and affordability of private insurance has led the National Association of Insurance Commissioners to establish a task force to formally address the issue in a report expected this summer.

[11]FCIC receives additional funds for excess losses through USDA's annual appropriations process. The NFIP is authorized to borrow additional funds from the Treasury on an as-needed basis, and repay the borrowed funds with interest.

risk within the context of its broader purposes in accordance with authorizing statutes and implementing regulations.

Nonetheless, an improved understanding of the programs' financial exposure is becoming increasingly important. Notably, the federal insurance programs' liabilities have grown significantly, which leaves the federal government increasingly vulnerable to the financial impacts of catastrophic events. Data obtained from both the NFIP and FCIC programs indicate the federal government has grown markedly more exposed to weather-related losses. Figure 4 illustrates the growth of both program's exposure from 1980 to 2005. For NFIP, the program's total coverage increased fourfold in constant dollars during this time from about $207 billion to $875 billion in 2005 due to increasing property values and a doubling of the number of policies from 1.9 million to more than 4.6 million. The FCIC has effectively increased its exposure base 26-fold during this period. In particular, the program has significantly expanded the scope of crops covered and increased participation. The main implication of the exposure growth for both the programs is that the magnitude of potential claims, in absolute terms, is much greater today than in the past.

Figure 4: Total Coverage of NFIP and FCIC, 1980-2005



Source: GAO analysis of NFIP and FCIC data.

Neither program has assessed the implications of a potential increase in the frequency or severity of weather-related events on program operations, although both programs have occasionally attempted to estimate their aggregate losses from potential catastrophic events. For example, FCIC officials stated that they had modeled past events, such as the 1993 Midwest Floods, using current participation levels to inform negotiations with private crop insurers over reinsurance terms. However, NFIP and FCIC officials explained that these efforts were informal exercises, and were not performed on a regular basis. Furthermore, according to NFIP and FCIC officials, both programs' estimates of weather-related risk rely heavily on historical weather patterns. As one NFIP official explained, the flood insurance program is designed to assess and insure against current—not future—risks. Over time, agency officials stated, this process has allowed their programs to operate as intended. However, unlike private sector insurers, neither program has conducted an analysis of the potential impacts of an increase in the frequency or severity of weather-related events on continued program operations in the long-term.

Information on Federal Agencies' Long-Term Exposure to Catastrophic Risk Could Better Inform Congressional Decision-Making

While comprehensive information on federal insurers' long-term exposure to catastrophic risk associated with climate change may not inform the NFIP's or FCIC's day-to-day operations, it could nonetheless provide valuable information for the Congress and other policy-makers who need to understand and prepare for fiscal challenges that extend well beyond the two programs' near-term operational horizons. We have highlighted the need for this kind of strategic information in recent reports that have expressed concern about the looming fiscal imbalances facing the nation. In particular, we observed that, "Our policy process will be challenged to act with more foresight to take early action on problems that may not constitute an urgent crisis but pose important long-term threats to the nation's fiscal, economic, security, and societal future."[12] The prospect of increasing program liabilities, coupled with expected increases in frequency and severity of weather events associated with climate change, would appear to fit into this category.

Agency officials identified several challenges that could complicate their efforts to assess these impacts at the program level. Both NFIP and FCIC officials stated there was insufficient scientific information on projected impacts at the regional and local level to accurately assess their impact on the flood and crop insurance programs. However, members of the insurance industry have analyzed and identified the potential risks climatic change poses to their business, despite similar challenges. Moreover, as previously discussed, both the IPCC and CCSP are expected to release significant assessments of the likely effect of increasing temperatures on weather events in coming months.

The experience of many private insurers, who must proactively respond to longer-term changes in weather-related risk to remain solvent, suggests the kind of information that needs to be developed to make sound strategic decisions. Specifically, to help ensure their future viability, a growing number of private insurers are actively incorporating the potential for climate change into their strategic level analyses. In particular, some private insurers have run a variety of simulation exercises to determine the potential business impact of an increase in the frequency and severity of weather events. For example, one insurer simulated the impact of multiple large weather events occurring simultaneously. We believe a similar analysis could provide Congress with valuable information about

[12]GAO, *21st Century Challenges: Reexamining the Base of the Federal Government*, GAO-05-325SP (Washington, D.C.: February 2005), 77.

the potential scale of losses facing the NFIP and FCIC in coming decades, particularly in light of the programs' expansion over the past 25 years.

Concluding Observations

We believe that the FCIC and NFIP are uniquely positioned to provide strategic information on the potential impacts of climate change on their programs—information that would be of value to key decision makers charged with a long-term focus on the nation's fiscal health. Most notably, in exercising its oversight responsibilities, the Congress could use such information to examine whether the current structure and incentives of the federal insurance programs adequately address the challenges posed by potential increases in the frequency and severity of catastrophic weather events. While the precise content of these analyses can be debated, the activities of many private insurers already suggest a number of strong possibilities that may be applicable to assessing the potential implications of climate change on the federal insurance programs.

Accordingly, our report recommended that the Secretary of Agriculture and the Secretary of Homeland Security direct the Administrator of the Risk Management Agency and the Under Secretary of Homeland Security for Emergency Preparedness assess the potential long-term implications of climate change for the FCIC and the NFIP, respectively, and report their findings to the Congress. This analysis should use forthcoming assessments from the Climate Change Science Program and the Intergovernmental Panel on Climate Change to establish sound estimates of expected future conditions. Both agencies expressed agreement with this recommendation. In addition, at an April 19, 2007, hearing on our report convened by the Senate Homeland Security and Governmental Affairs Committee, Chairman Joseph Lieberman and Ranking Member Susan Collins directed the agencies to provide the Committee a deadline by which they plan to transmit this assessment to the Congress in fulfillment of this recommendation. Chairman Lieberman also asked the agencies to prepare and disseminate this assessment independent of any annual reports to the Congress.

Mr. Chairman, this concludes my prepared statement. I would be happy to respond to any questions that you or other Members of the Committee may have.

Key Contact and Staff Acknowledgments

For further information about this testimony, please contact me, John Stephenson, at 202-512-3841 or stephensonj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this statement. Contributors to this testimony include Steve Elstein, Assistant Director; Chase Huntley; Micah McMillan; Alison O'Neill; Kate Robertson; and Lisa Van Arsdale.

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The CHAIRMAN. And our next witness is somebody who it is my pleasure to welcome back to Congress, our former colleague. Many of the members on this committee served with Mike in his service here in the United States Congress. He is now the Washington State insurance commissioner. He was first elected to his current post in 2000. He was reelected in 2004. He has been in public service for more than 30 years. The impact of global warming is of particular interest to him because he is one of the coleaders of a task force examining the issue for the National Association of Insurance Commissioners.

Mike, welcome back. It is good to see you again. And whenever you are ready, please begin.

STATEMENT OF MIKE KREIDLER, WASHINGTON STATE INSURANCE COMMISSIONER

Mr. KREIDLER. Thank you very much, Mr. Chairman and members of the committee. It is a pleasure to be here and have an opportunity to speak to this topic.

Let me tell you, Mr. Chairman, that one doesn't have to look very far to see what has happened to insurance as a result of very serious storms, particularly hurricanes, in 2004 and 2005. And you can take a look at insurance companies that have looked at certain areas of the country where, quite frankly, they have chosen to abandon markets and are withdrawing from them, or increasing the kind of costs that effectively represent a lack of availability to people who need them.

The standpoint of the States that are impacted is one where you are going to see some States that are large enough to have the kind of buying power of insurance that they can exercise perhaps more control over the insurance market by virtue of requiring companies to remain in certain markets even when they don't want to or would withdraw, but make it a condition as to being able to sell other products within their particular State.

Obviously, Hurricane Katrina represented the most significant impact from the standpoint of an insurable impact that we have witnessed, but coming from the State of Washington, and I can speak from the standpoint of the Northwest as a whole, and your three Members from the Northwest, hurricanes are not exactly what we are focused on up there. But we are very much focused on what happens when we start to get a great deal more precipitation that doesn't stay around as snow, and when that happens, it has a drastic impact.

We saw an indication of what that can represent in November with record rainfalls that took place, followed by the next month in December with record winds that wreaked considerable damage. Two million people were without power; nearly two dozen people died; serious property losses as a result. Droughts and forest fires, the problems of disease in trees because of the nature of the changing weather can have a very significant impact.

Looking to the world of the insurance community as to what they can do and what they aren't doing, we see that from the standpoint of the reinsurers, particularly international reinsurers, Mr. Nutter will be speaking to that, and you will see that they have been taking a very close look at the problems of climate change and have

become vigorously involved with the issue. Part of it, to be honest, is because of recognizing the kind of threat that it represents to their industry without being engaged in this. But it is also the global aspect of reinsurance and the view that they have.

Primary insurance, or insurance that is sold directly to the purchaser, companies, tends to be much more domestic in the United States, and in the State of Washington for that matter, that you wind up with them not having the same perhaps global view that you have with the reinsurers. Primary insurance in Europe, for example, has become much more engaged with the issues related to climate change than we have seen here in the United States. That is something that I believe reflects perhaps more of the Europeans taking a longer view of what is taking place as opposed to a shorter view that might be more inherent in how we viewed it here in the United States.

Insurance regulators have the opportunity to certainly make sure that the markets out there are viable, that there are products that are still going to be sold, that we are making sure that the products and services that are provided are stood behind by the companies that are licensed and approved to do business in our various States.

Finally, there are some areas where I believe that Congress can take some leading role. Obviously at the local level there are issues related to land use, to zoning and building codes that are clearly ones that can be impacted at the local level. I am a member of a climate action team that has been created in the State of Washington by our Governor. There is also clearly very much a need for a national greenhouse policy to be adopted at the national level, and specifically a program that I look at, which would be the one that deals with the National Flood Insurance Program, where I believe that clearly directing that program and reforming it could have a very pronounced impact on what we are doing.

Clearly, Mr. Chairman, there is an opportunity here to make some changes in how we deal with insurance at the State, at the local, at the national level, and we would be glad to participate in helping develop that. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Mike, very much.

[The statement of Mr. Kreidler follows:]

Testimony of Mike Kreidler
Washington State Insurance Commissioner

Before the
United States House of Representatives
Select Committee on Energy Independence and Global Warming

Regarding:
Economic Impacts of Global Warming—Insurance

May 3, 2007
2359 Rayburn House Office Building
Washington, DC

Testimony of Mike Kreidler
Washington State Insurance Commissioner

Chairman Markey, Ranking Member Sensenbrenner, and members of the Committee, I thank you for the opportunity to testify here today on the economic impact of global warming on the insurance industry.

My name is Mike Kreidler, and I am the elected Insurance Commissioner for the State of Washington. I am active in many of the committees of the National Association of Insurance Commissioners (the "NAIC"). Related to the topic matter of today's hearing, I serve as Co-Chair of the NAIC's Climate Change and Global Warming Task Force.

Today I would like to provide my perspective on how insurers and the economy will be affected by climate change.

- First, the most important job of an insurance commissioner is to protect insurance consumers. This is accomplished by maintaining strong, cooperative regulatory oversight of insurer solvency and monitoring insurer marketing activities so that a healthy competitive marketplace exists to serve consumers.
- Second, global warming will be a real challenge for Americans and the insurance industry.
- Third, global warming will affect different states and different segments of the insurance marketplace in different ways.
- Finally, I will not be presenting any easy solutions to this issue, but will explore some areas that need to be considered and addressed if we are to manage the risks associated with global warming and climate change.

1. Insurance Regulation and Consumer Protection

The most important job of an insurance commissioner is to protect insurance consumers. This is accomplished by maintaining strong, cooperative regulatory oversight of insurer solvency and monitoring insurer marketing activities so that a healthy competitive marketplace exists to serve consumers.

In its simplest form, insurance regulation is about two things. The primary job of an insurance regulator is to ensure that insurance companies remain solvent so that they

can pay claims as they become due, and to ensure that insurers treat their customers and claimants right. An insolvent insurer does not have the resources to pay its claims and, therefore, is of no use to either its policyholders or those with claims against them. An insurer that fails to comply with state consumer protection laws and regulations also can be a problem if it fails to deliver the expected insurance benefits to consumers at times when they are needed the most.

The goal of financial regulation is to protect consumers against excessive insurer insolvency risk. Insurance regulators protect the public interest by requiring insurers to meet certain financial standards, and taking remedial action when needed. This becomes important in the context of climate change when you try to balance the need for consumers to access affordable insurance products with the insurers' ability to deliver the products to the public in a way that minimizes the risk of insolvency.

Regulatory requirements are of little value if there is no mechanism in place to monitor insurers' compliance with the requirements. The purpose of solvency monitoring is to ensure that insurance companies are meeting regulatory standards and to alert regulators if action is needed to protect policyholders' interests. State regulators have established a vast solvency monitoring system that encompasses a range of regulatory activities, including financial reporting, early-warning systems, financial analysis and on-site insurer examinations. Annual and quarterly financial statements filed by insurers serve as the principle source of information to assess insurers' financial positions. Insurers are generally examined every three years. States coordinate the financial examinations through the NAIC association or zone exams process to avoid duplicative or redundant examinations of the same insurer.

Market regulation deals with insurer pricing, product development and market practices. If insurers are able to use their market power to raise prices above competitive levels, then regulators can improve market performance by setting a price ceiling at the competitive price level. This rarely happens because the competitive structure of most markets prevents insurers from acquiring significant market power. Things are different when insurers are faced with catastrophe risk. There are times when insurers believe that certain catastrophe coverages cannot be underwritten profitably. When this conclusion is reached, they react by withdrawing from markets, cancelling policies and introducing coverage limitations. There is evidence that this is occurring in many coastal jurisdictions today.

Market regulation includes the regulation of insurance prices and review of the contractual policy language before it is sold to consumers. This basic consumer protection helps both the insurer and the policyholder by having an expert state employee review the insurance contract before the transaction with the policyholder. Property and casualty insurance contracts are based on state laws and regulations and it helps things go smoother if a person who knows the state civil justice system and requirements enacted by the state legislature reviews the contract for statutory compliance.

2. Global Warming will be a Real challenge for Consumers and the Insurance Industry

Global warming and the resultant climate change will challenge insurers and consumers on many levels. Climate change appears to be impacting weather patterns which, in turn, affect insured property losses. Rising ocean temperatures appear to be affecting hurricane activity. Drought is impacting the health of many of our nation's forests, thus increasing wildfire risk. In 2006, the U.S. recorded the second warmest summer in history. Record windstorms have hit the Pacific Northwest recently. These are but a few of the potential impacts of climate change that could have a profound effect on Americans and insured property losses.

While 2006 was quiet in terms of hurricane activity, we need look no further than 2004 and 2005 to find significant impacts caused by hurricanes in the Gulf and Atlantic Coasts. According to the Insurance Information Institute, eight of the ten most costly catastrophes in the United States have been hurricanes. Of those eight hurricanes, six occurred during the 2004-2005 hurricane seasons. The insured losses from the devastating Hurricane Katrina (2005) alone were larger than Hurricanes Charley, Ivan, Hugo, Rita, and Frances combined.

In the wake of the increased hurricane activity, some insurance companies have stopped writing or restricted the writing of insurance in the Gulf and Atlantic Coasts because of the high risk posed to properties from increased hurricane activity. This is causing availability and affordability problems in some areas as consumers have fewer options. Some insurance companies are looking to use new risk models based on increasing projections of future hurricanes instead of past historical hurricane information. These models predict more hurricane activity, which will likely drive the cost of property insurance in those states even higher. If property insurance is not available, or becomes "practically" unavailable because the cost is so high that consumers cannot

afford it, it will affect the economic development in areas at risk from hurricanes and potentially the national economy as a whole.

While scientists cannot say for sure that all of this increased hurricane activity is attributable to global warming, or climate change in general, it is obvious that something has changed. Scientists generally agree that there is a relationship between warmer ocean temperatures and the intensity of hurricanes. Thus, higher ocean temperatures would be an indication that, while the number of named storms might not increase, the intensity of those storms would be greater. An added complication is that hurricanes could form at higher latitudes, thus exposing a greater number of states to significant hurricane damages.

In Washington State, we are vulnerable to a number of weather-related perils that are impacted by climate change. Flooding, drought, and windstorms are of serious concern.

Last November, western Washington experienced some of the worst flooding in state history. Hundreds of homes were flooded, and roads and bridges were washed away throughout the area. Picturesque Mount Rainier, not too far from my home, received a record 18 inches of rain in 36 hours, and the National Park has sustained damage that will take years to repair.

After the flooding came the wind. Last December, the Pacific Northwest, including western Washington, experienced the most severe windstorm in state history. Over 1.8 million homes lost power, and 18 people were killed. The storm caused hundreds of millions of dollars in damage to homes and property.

Drought is a serious concern in eastern Washington. The lack of precipitation and changing precipitation patterns threaten agriculture, fish habitat and forest health. This impacts the foundation of our state's economy and puts thousands of people at risk from wildfires.

While this may not seem relevant at first, Washington also has significant earthquake risk. Should a shallow fault earthquake in the Seattle area occur, or the massive subduction earthquake predicted for the Cascadia fault 70 miles off our coast, our state would sustain enormous losses. If climate change continues to affect weather losses, factoring in earthquake risk, the combined risks could result in a similar situation, as in the Gulf and Atlantic Coast regions where property insurance can be unaffordable or unavailable.

While property and casualty insurers will have the most identifiable increase in exposure because of climate change, life insurers will face increased challenges as well. Insurers and regulators will have to consider whether increased numbers of catastrophic events may be so overwhelming as to result in a notable increase in mortality. A severe storm or flooding event may cause significant casualties. "Brown outs" and "grid failure," combined with more frequent heat waves, have been identified as a possible outcome of climate change. Increased mortality is a foreseeable result. Evidence for this comes from the experience in Europe in 2003 where record high temperatures led to a health crisis where over 35,000 people perished. The heat wave, coupled with a severe drought caused a crop shortfall in Southern Europe. Given such scenarios, insurers and regulators have to consider the pricing, and perhaps the structure of life insurance policies in light of new environmental conditions.

Human health will be impacted by climate change in ways that are not yet fully understood. Health care delivery mechanisms, including health insurance, will be challenged in ways that we are just beginning to explore. Global warming poses the potential for more frequent and severe epidemics or perhaps pandemics. On a less catastrophic level, basic health care will be challenged by increased respiratory and asthmatic problems resulting from climate change. Heat-related illness might also rise. And on a very basic level, consideration should be given to the increased cost of medical care for persons displaced from their regions by catastrophic events triggered by climate change. These people will need health care outside their traditional provider networks, from providers who do not have their health records. Insurers and regulators must work together to develop responses to these challenges.

3. The Effects of Global Warming will not be Uniform

The most obvious impact of global warming will be on property and casualty insurers. They provide coverage for some of the events that have the most obvious and dramatic outcomes. In particular, hurricanes, more intense thunderstorms, tornadoes, lightning, large hailstorms and wildfires can cause substantial property losses.

The insurance industry collects data on catastrophes. This data is reported to the Insurance Services Office's Property Claims Services or PCS. PCS uses a $25 million threshold to define a catastrophic event that triggers this special data reporting. According to PCS, six of the top ten U.S. catastrophes of all time have occurred since 2004. All of these happened to be hurricanes (Katrina and Wilma in 2005; Charley, Ivan,

Rita and Frances in 2004). Over the last decade, there has been an average of 26 catastrophes per year. Insured losses in 2006 dollars averaged $18.5 billion per year over the period, but ranged from $3.3 billion in 1997 to $63.9 billion in 2005. If 2004 and 2005 are excluded, the average drops to $11.4 billion.

For the first quarter of 2007, the largest catastrophe was the tornadoes that hit Alabama and Georgia in early March, resulting $460 million in insured losses. Total catastrophe losses for the quarter stood at $1.2 billion, covering seven events. Clearly, it is not just hurricanes that cause catastrophic losses.

The event of most concern is the hurricane. Not all jurisdictions experience hurricanes. They are generally a phenomena of the Atlantic and Gulf Coast states. Even within these states, with the possible exception of Florida, the effects of hurricanes are more dramatic within a short distance of the coastline than in the interior parts of the states. Thus, the results and impact of climate change will vary dramatically from state-to-state and within a state. This is particularly true for those states with coastal exposures.

4. There are no Easy Solutions

There are no easy solutions in dealing with the impact that climate change will have on consumers, the insurance industry, and the economy. I believe you have taken an important first step in forming this committee. Once society recognizes there is a problem, we can work together toward finding solutions.

While there are a number of things that can be done at the local, state and federal level, I would like to suggest three areas where we can start: building codes and land use decisions, a national greenhouse gas reduction policy, and reform of the National Flood Insurance Program (NFIP).

We cannot stop natural disasters like hurricanes, wildfires, and windstorms, but there are measures that states and local governments can take to mitigate damage. The first thing we should consider is where we build and how we build there. By mitigation, I mean taking concrete steps to reduce or eliminate risk to property from weather-related hazards and their effects. In practical terms, this involves strengthening building codes for new structures by making them more resistant to hazards such as wind, flood, and

fire. It also means enforcing building codes currently in place, and overcoming the pressure to weaken building codes when natural hazard activity is "quieter" than normal.

We also need to take a careful look at where we develop and redevelop our communities. We need to first ask ourselves, "Is the risk so great from some perils that we should not build here?" Then we must ask the question, "If we decide to build here, what measures should be taken in construction to protect lives and property from the risks they will face?"

I also believe we need to deal with the source of the global warming and resultant climate change problem. Increasing greenhouse gas emissions (GHGs) are significantly contributing to global warming and climate change. As a member of the Washington State Climate Advisory Team (CAT), I learned that 30 of the top 75 world emitters of GHGs are U.S. states. This is a national problem and the federal government needs to take meaningful action to address climate change by creating a national strategy to reduce GHGs. Washington State Governor Chris Gregoire and her colleagues from Arizona, California, Oregon, and New Mexico joined in signing the Western Regional Climate Action Initiative to help reduce GHG emissions. This regional initiative shows great leadership in dealing with global warming and climate change. We can do more, and the federal government should become part of the solution.

And finally, the federal government should consider serious reform of the National Flood Insurance Program (NFIP). From studies I've seen, flooding is significantly impacted by climate change. Whether storm surge from hurricanes in the Gulf Coast or the potential river basin flooding in Washington and other states, we've seen how devastating floods can be. Instead of simply increasing the borrowing authority for the NFIP, the government should accelerate flood map modernization, continue to examine flood rates and underwriting eligibility, enforce flood plain coverage requirements, and study whether or not expanding the NFIP requirement to all mortgages in designated flood plains could help the program and those it serves. The NFIP is an important part of mitigating the potential financial consequences of climate change for millions of property owners, and we need to ensure it remains viable for the future.

Given the variety and complexity of ideas under consideration, I strongly endorse the concept of a National Commission on Catastrophe Preparation to weigh the merits of each idea and develop the best mix of solutions. Clearly, there are a number of forward-thinking ideas that need further consideration, but they should be framed to answer the question, "Will this make insurance for individuals and businesses more available, and

more affordable?" We will work with the Committee to find the right answers to that question. The lessons of recent catastrophes may be the warning we need to start making those decisions, so I thank you for holding this hearing, for inviting me here today, and for your continued interest and leadership on this crucial issue. I'd be happy to answer any questions you may have.

The CHAIRMAN. And our final witness is Frank Nutter. He is the president of the Reinsurance Association of America. Mr. Nutter brings nearly 30 years of experience in the insurance industry to the hearing today. He serves as an advisor to four scientific research institutions and has previously chaired the Natural Disaster Coalition, an effort to develop a program to respond to catastrophic earthquakes, hurricanes and volcanic eruptions in the United States.

Mr. Nutter, welcome, and please begin.

STATEMENT OF FRANKLIN W. NUTTER, PRESIDENT, REINSURANCE ASSOCIATION OF AMERICA

Mr. NUTTER. Mr. Chairman, thank you very much, and thank you for that introduction, Ranking Member Sensenbrenner, members of the committee. Reinsurance is essentially the insurance of insurance companies. Insurance companies lay off risk to the reinsurance community, notably for catastrophic events.

There is no financial services business more dependent on the vagaries of climate and weather than property casualty reinsurers and insurers. The industry is at great risk if it does not understand global climate variability and the frequency and severity of extreme events. Understanding global climate change and integrating that information into the insurance system is an essential part of addressing climate extremes and conveying information to government and the public about the economic consequences of human activity in the face of changing global climate.

The GAO has reported on the extraordinary series of losses paid by private insurers and public insurers in the last few years. In 2005 alone, a record year, the global insurance catastrophe claims were $83 billion, 80 percent of which were from U.S. land-falling hurricanes. As bad as those numbers are, AIR Worldwide estimates that insured natural catastrophe losses could be expected to double every 10 years.

With respect to the impact of climate change alone, the Association of British Insurers concludes that the average annual losses from the three major storm types affecting insurance markets, that would be U.S. hurricanes, Japanese typhoons and European windstorms, could increase by two-thirds by the 2080s. The climate change could increase wind-related insured losses from extreme U.S. hurricane events by three-quarters, the equivalent of two to three Hurricane Andrews annually. It could increase wind-related insured losses from extreme Japanese typhoons by about two-thirds, and the cost of flooding in the U.K. by fifteenfold. Under high emissions scenarios, insurers' capital requirements could increase, the ABI says, by over 90 percent for U.S. hurricanes. Higher capital costs combined with greater annual losses from windstorms alone could result in premium increases of around 60 percent in these markets, the ABI concludes.

It should be noted that the ABI's estimates do not include the likely increase in society's exposure to extreme events due to growing, wealthier populations and increasing assets at risk.

The chief researcher of catastrophe modeler Risk Management Solutions estimates that even when inflation changes in wealth and population growth are taken into account, financial losses from

weather-related catastrophes have increased by an average of 2 percent per year since the 1970s, with climate change a contributing factor.

It is quite clear that the causes behind the dramatic rise in insured catastrophe losses are several: Population growth in high-risk areas, increases in insured coastal values, the insurance industry's own expansion of insurance coverage, government policy which has encouraged weak building codes or failed to enforce building codes, and climate change.

The insurance industry's financial interest is interdependent with climate and weather. It is the risk of natural events which drives the demand for insurance coverage, and yet, if not properly managed, can threaten the viability of an insurer if it is overexposed in high-risk areas.

As a result of Hurricane Andrew, the industry began to recognize that due to unanticipated climate variability, historical data were potentially misleading with respect to future natural catastrophe events. Swiss Re concluded that climate change over time will affect weather and weather patterns.

As has been noted, a number of European insurers and reinsurers have shown great interest in understanding the causes of climate change, including the impact of global warming. U.S. insurers have been more focused on the effect of extreme weather events. The U.S. industry has been more attentive to approaches to mitigate the consequences of natural catastrophes and extreme events. Thus the industry's agenda has included the evaluation of building codes and building code enforcement. And through the Institute for Business and Home Safety, the U.S. industry has greatly enhanced its support for hazard mitigation by conducting research on building designs and building materials.

The initiative most related to scientific assessment of climate change and insurance is the use of computer catastrophe models to integrate that science into the actuarial sciences. These assist an insurer in evaluating its exposure and are used to support insurance rates. Utilizing these models and retracing hurricane events in the past onto current population in today's built environment, potential insured losses are alarming. The Miami hurricane of 1926 would cost $80 billion in insured losses alone. Hurricane Andrew in 1992 would now cost $42 billion; at the time it was an $18 billion event. The 1900 Galveston, Texas, storm, which was mentioned earlier, in today's dollars would be a $33 billion insured loss event. And the 1938 Long Island Express would be $35 billion.

If climate change has increased the intensity of future storms, these numbers will rise. If climate change increases the frequency of extreme events, the consequence is obvious.

In May 2006, the Chief Risk Officer Forum, a group of 13 European insurers, issued a report concluding that climate change has the potential to develop into the greatest environment challenge of the 21st century.

Insurers are in the business of assessing risk, pricing it and providing risk financing or transfer. Its long-term strategy does not include bearing the cost of climate change without a concomitant commitment on the part of society to pursue a mitigation strategy addressing both the causes and consequences of climate change.

Thank you very much.

The CHAIRMAN. Thank you, Mr. Nutter, very much.

[The statement of Mr. Nutter follows:]

RAA

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Testimony

Of

Franklin W. Nutter
Reinsurance Association of America

Economic Impacts of Global Warming:
Part I -- Insurance

Before

Select Committee on Energy Independence
and Global Warming

May 3, 2007

Chairman Markey, Ranking Member Sensenbrenner and Members of the Committee on Energy Independence and Global Warming:

My name is Frank Nutter and I am President of the Reinsurance Association of America (RAA). It is an honor to appear before you on behalf of the RAA. The RAA is a national trade association representing property and casualty organizations that specialize in assuming reinsurance. Together, RAA members and affiliates write over 70% of the reinsurance coverage provided by U.S. property and casualty reinsurers and affiliates.

No financial services business is more dependent on the vagaries of climate and weather than property and casualty insurers. The industry is at great risk if it does not understand global climate variability and the frequency of extreme events. It must be more than a pass-through mechanism for the costs associated with natural disasters. Understanding global climate change and integrating that information into the insurance system is an essential part of addressing climate extremes and conveying information to governments and the public about the economic consequences of human activity in the face of changing global climate.

Climate and Catastrophes

The General Accounting Office reports that from 1980 through 2005 private and Federal insurers paid $320 billion in claims on weather related losses. As noted by the GAO, private insurers paid 76% or $243 billion of this total. The year 2005 alone produced a record: total global insurer catastrophe claims were $83 billion, 80% of which were from US land-falling hurricanes. Even 2006, thought of as a benign catastrophe year, produced 43 insured loss catastrophes in North America out of a global

total of 349. Although some of these catastrophes are earthquake related, over 90% of events causing damage to people and property originated in the atmosphere. Almost 12,000 people lost their lives to storms and floods in 2006. AIR Worldwide estimates that insured natural catastrophe losses should be expected to double roughly every ten years due to increases in construction costs, increases in the number of structures and changes in their characteristics.

With respect to the impact of climate change, the Association of British Insurers concludes as follows:

- Average annual losses from the three major storm types affecting insurance markets (US hurricanes, Japanese typhoons and European windstorms) could increase by two-thirds by the 2080s.
- Focusing on the most extreme storms (losses with a probability of occurring once every 100 to 250 years), by the 2080s climate change could:
    - Increase wind-related insured losses from extreme US hurricanes by around three-quarters (the equivalent of 2 to 3 Hurricane Andrews annually).
    - Increase wind-related insured losses from extreme Japanese typhoons by around two-thirds. The increase alone would be more than twice the cost of the 2004 typhoon season, the costliest in the last 100 years.
    - Increase wind-related insured losses from extreme European storms by at least 5%.
    - Increase the annual costs of flooding in the UK almost 15-fold.

- Under high emissions scenarios, insurers' capital requirements could increase by over 90% for US hurricanes, and by 80% for Japanese typhoons. Higher capital costs combined with greater annual losses from windstorms alone could result in premium increases of around 60% in these markets.

The ABI advises that these loss estimates do not include likely increases in society's exposure to extreme storms, due to growing, wealthier populations, and increasing assets at risk.

Financial losses from weather-related catastrophes have increased by an average of 2% per year since the 1970s, with climate change a contributing factor, according to the chief researcher of catastrophe modeler Risk Management Solutions, Inc. The rate of loss increase holds true even when inflation, changes in wealth and population growth are taken into account. In its latest climate change report, Rapid Climate Change, Lloyd's of London warns that waiting on "definitive scientific pronouncements" on the impact of climate change "seems like an increasingly risky strategy."

The causes behind the dramatic rise in insured catastrophe losses are several:

- Population growth in high-risk areas.
- Dramatic increases in insured coastal values. Florida now has nearly $2 trillion of insured properties. New York has $2 trillion, Louisiana $209 billion and South Carolina $149 billion.
- The insurance industry's own expansion of coverage which had the effect of increasing potential insured damage; deductibles were lowered and full replacement cost added to homeowners' policies in the period 1970-1990.

- Government policy, which either endorsed weak building codes or failed to enforce existing building codes and which has facilitated development in high risk areas.
- Climate change and the incidence of more intense extreme events. Munich Re's Geo-Science Department has concluded that the proportion of severe storms has risen and that of moderate storms has fallen. Three of the ten most intense storms ever recorded in North America were in 2005. Swiss Re advises that "climate change presents an increasing risk to the world economy and social welfare."

The Insurance Industry's Financial Interest

The insurance industry's financial interest is inter-dependent with climate and weather. It is the risk of natural events which drives the demand for insurance coverage and yet, if not properly managed, can threaten the viability of an insurer if it is over-exposed in high risk areas. An insurance company thrives or dies on its ability to make estimates of the economic consequences of future events.

Most insurance coverages are priced based upon historical data which is then trended forward using adjustments for inflation and other economic factors. As a result of Hurricane Andrew, however, a paradigm shift occurred. The industry began to recognize that, due to unanticipated climate variability, historical data were potentially misleading with respect to future natural catastrophe exposure. If climate is now fundamentally changed and is causing changes in weather patterns and cycles, will it lead to more extreme events? Swiss Re notes: "climate change, overtime will affect weather and weather patterns." Citing a recent study by Webster and Holland and noting a trend

toward more intense tropical cyclones, Swiss Re observes that the number of category 4 and 5 storms has doubled since the 1970s.

Insurance and Science

Although a number of European insurers and reinsurers have shown great interest in understanding the causes of climate change, including the impact of global warming, US insurers have been more focused on the effect of extreme weather events. Thus, the US industry has been more attentive to approaches to mitigate the consequences of natural catastrophes and other extreme events; while some European insurers have called upon their governments to reduce the human factors they believe contribute to global warming. In the US, the industry's agenda includes the evaluation of building codes and building code enforcement in every community in the country. Through the Institute for Business & Home Safety, the US industry has greatly enhanced its support for hazard mitigation by conducting research on building design and building materials.

The initiative most related to the scientific assessment of global climate change is the use of catastrophe computer models to integrate scientific knowledge about extreme events into the actuarial sciences. These catastrophe models incorporate scientific assumptions about climate trends and the probability of future extreme events, then produce estimated prospective costs associated with natural catastrophes. They assist an insurer with an analysis of its potential exposure and are used to support rates filed for approval with insurance departments. It is the classic example of using insurance to translate scientific analysis and data into the economic consequences of people's behavior, i.e. where they live and the value and potential loss of properties in those areas. The pure result of the use of catastrophe models is the application of risk-based premiums

and aggregate exposure for insured property. Utilizing these models and retracing past hurricane events onto current population in today's built environment, potential insured losses are alarming: the Miami hurricane of 1926 $80 billion; Hurricane Andrew (1992) $42 billion; 1900 Galveston, Texas $33 billion; 1938 Long Island "express" $35 billion.

If climate change has increased the intensity of future storms, these numbers will rise. If climate change increases the frequency of extreme cyclonic events, the consequence is obvious.

Conclusion

In May 2006 the Chief Risk Officer Forum [CRO], a group of 13 European insurers, issued a report concluding: "Climate change has the potential to develop into the greatest environmental challenge of the 21st century." Stating that insurers need to reflect climate change and the consequent changes in frequency and severity of natural catastrophes in internal analytical models, the CRO Forum identified the industry's adaptive strategy as "limiting exposure, diversifying risks globally and ever sophisticated modeling" in which case the industry could weather the effects of a more active hurricane season. It went on to say, however, that "the sheer magnitude of climate change could impact a large number of industries to such an extent that sustainable insurability may ultimately be put into question."

Insurers are in the business of assessing risk, pricing it and providing risk financing or transfer. The insurance industry's long-term strategy, however, does not include bearing the cost of climate change without a concomitant commitment on the part of society to pursue a mitigation strategy – addressing the causes and consequences of climate change.

The CHAIRMAN. Now we will turn to questions from the subcommittee.

Mr. Nutter, in your testimony you questioned the sustainability of the insurance industry in the face of increasing impacts from global warming. From the reinsurance industry's perspective, what is the potential cost to the economy from global warming in future decades?

Mr. NUTTER. Well, it is obviously a very difficult question to predict the future, which is why I referenced the catastrophe models that I used to cite certain potential insured losses that could come from events that have happened in the past. The reinsurance community, particularly those that study the science that has been published, is concerned that we are seeing not only increased intensity of storms, but perhaps increased frequency of storms. If that is true, and 2004 and 2005 are, in fact, prologue and become the normal hurricane years, it certainly questions the insurability of areas that are recurringly getting hit by these extraordinary loss experiences.

The CHAIRMAN. Mr. Stephenson, the GAO has found that government insurance programs approach risk by looking at the past record as opposed to incorporating new climate science findings or other means of projecting future conditions. How did this rear-view-mirror approach differ from private insurers?

Mr. STEPHENSON. Well, most of the catastrophe models that they use are retrospective. They look in the past and assume that any changes will be incorporated into their projections for this year and next year, for example. The problem with that is, as the insurance industry has indicated, that may not be representative of the future. There may be more events. Their total exposure is increased because of exactly what Mr. Sensenbrenner described: More people moving to the coast, higher property values. That increased exposure makes them more susceptible to higher payments in the future if the IPCC projections are true.

The CHAIRMAN. So what room do you see for FEMA to change the model that it uses?

Mr. STEPHENSON. We don't know—I mean, there are a lot of intricacies in the operation of both Federal insurance programs. The Federal crop insurance is subsidized, of course, by the Federal Government. It is not a total premium-based system. But in general we recommended that they incorporate climate change science into their projections. And Senators Lieberman and Collins asked them to submit a report to their committee on how they intended to do that, although I don't know the timeframe for that report.

The CHAIRMAN. So to each of you, whoever wants to take this, the scientific understanding of the climate system is continually improving. From your perspectives, how is new scientific knowledge effectively being incorporated into the insurance industry, and what would you suggest we as legislators learn from that in terms of laws or regulations that should be on the books?

Mr. STEPHENSON. Are you asking all three of us?

The CHAIRMAN. Any of you.

Mr. STEPHENSON. We think that the first step is for the Federal programs at least to study the issue, look at their programs and see how increased severe weather events might affect those pro-

grams both from an actuarial standpoint and from the number of policies they write and the coverage that they provide. And that is the first step to understanding if anything legislative needs to be done to those two big Federal insurance programs.

The CHAIRMAN. Mike.

Mr. KREIDLER. Mr. Chairman, I would suggest that because of the complexity of the issues and the multiple facets to it, that if there were a national commission that was charged appropriately with the questions to be answered, that part of what would come out of there would be how do you take future risks, changing risk, and make sure that we are not destabilizing the system that we presently have.

The CHAIRMAN. Thank you.

Now Mr. Nutter.

Mr. NUTTER. What I would add to that is this. The insurance mechanism integrates scientific information in its basic actuarial database through these catastrophe models that most insurance companies subscribe to or have within their own processes. Most of the science that goes into those models is really a result of government research programs; the National Science Foundation, NOAA and other programs that the Congress supports financially.

You are correct that there is clearly an improving understanding of climate and weather, and continued research to try and resolve some of the questions that get raised about whether or not a climate-changed environment is affecting the intensity and frequency of storms would be a high priority for government officials and the industry to understand.

The CHAIRMAN. Great. Thank you, Mr. Nutter.

My time is expired. The Chair will recognize the gentleman from Wisconsin Mr. Sensenbrenner.

Mr. SENSENBRENNER. Thank you very much, Mr. Chairman.

On page 2 of Kreidler's testimony he says, quote, still because of global warming and insufficient data as to prior events, the predictive accuracy of catastrophe models has not proven to be as great as once hoped, unquote.

Now, with that statement, which I agree with, and the fact that it is a natural reaction for an insurance company to overcharge their premiums to build up reserves so they don't get wiped out if there is really a catastrophe, Mr. Kreidler, in your role as an insurance regulator for Washington State, have you been able to determine how much of the increase in premiums there has been as a result of what the insurance companies do to make sure that they have a big enough pot of reserves to meet all future predictive claims, and how much of this is actually caused by actual data relating to climate change?

Mr. KREIDLER. Thank you, Mr. Sensenbrenner. That particular issue is very germane because of the nature of how tax policy impacts insurance companies as to the kind of reserving that they do. They tend to be much more responsive to events that have already happened as opposed to what is taking place in the future.

An example of the difference of how that could be dealt with from the standpoint of how companies could do a better job of reserving would be to take a look at how European insurance companies typically are treated by their governments from the standpoint

of tax policy that allows them to do more prospective reserving for future losses. Even the system in our country from the standpoint outside of the tax policy is not positive from the standpoint of allowing those reserves to be there without having an impact on what they then charge in future rates; meaning that if they have those reserves there, they are making reserve income on investments, and you run into a situation where they effectively are being punished or told that their rates cannot be higher as a result of the reserves that they have in accrual. That does not make the kind of thinking of what about the losses that we may incur in the future? We should be able to make sure that companies have the kind of reserves there so they don't artificially raise rates on speculation that they may have losses that they may not be able to sustain.

Mr. SENSENBRENNER. If I were the CEO of an insurance company, and I came before you to get you to sign off on an insurance rate increase due to climatic conditions or things like that, what would you make me demonstrate to you to get approval of the rate increase, aside from me saying that based on our Ouija board, we need to have so much money in reserve to make sure that if something really bad happens, we don't go broke?

Mr. KREIDLER. Mr. Sensenbrenner, I would tell that insurance company executive that we are still in a position right now from the standpoint of you building up these reserves that it is difficult for us as insurance regulators to look at that and say that you are building up those reserves. But there isn't a mechanism right now to make sure that those reserves are only used for those kind of catastrophic losses. At this point there isn't a particular reserving that is catastrophic in its nature that would allow us to treat them separately.

Mr. SENSENBRENNER. So what you would be saying to me is that I need to be much more specific as an insurance company executive in terms of the data that I would submit to you for your review before you would give me the sign-off to raise rates on my customers?

Mr. KREIDLER. That is correct, Mr. Sensenbrenner. We need to wind up making sure that there is some kind of bookends applied to that kind of reserving that takes place that is different than the other kinds of reserving as to solvency standards that are required of an insurance company outside of what might be anticipated in catastrophic losses.

Mr. SENSENBRENNER. So getting back to page 2 of your testimony, the predictive accuracy of these models is not good enough to sustain my asking for you to approve a higher rate if I were running an insurance company?

Mr. KREIDLER. At the present time that is correct.

Mr. SENSENBRENNER. Thank you, Mr. Chairman.

The CHAIRMAN. The gentleman's time is expired.

The Chair recognizes the gentleman from Oregon Mr. Blumenauer.

Mr. BLUMENAUER. Thank you.

I listened with interest to my colleagues on the other side of the dais talk about this most recent report about cyclones and tropical storms going back to 1900. As I read this, just in the first para-

graph, the frequency of tropical cyclones has changed over time and whether that could be linked to global warming.

I am interested in your consensus and that of the scientific community not about the frequency, but about the intensity that with global warming we are going to have more unpredictable weather, that there is going to be greater impact, whether there are more or less, and there are some who think there will be more extreme weather events.

Starting with you, Mr. Stephenson, is there anything that you have heard here today about the frequency maybe being in line with historical patterns that does anything to allay your concern about the impact of the consensus of the scientific community that global warming is going to lead to greater intensity of these storms and their devastation?

Mr. STEPHENSON. Well, GAO is not a science organization, but we do hire a lot of smart analysts who have science backgrounds. Having said that, we sort of hung our hat on the IPCC, which is kind of the source authority for synthesis of science in the world. Their predictions are that intensity and/or frequency of severe storms is likely to increase, and likely means a 66 percent chance of increasing. That is what we based our study on. That is why we feel it is important for the Federal insurance programs to consider this information in their outlooking projections.

Mr. BLUMENAUER. And I would ask the other witnesses if there is any concern that you have in your research that we shouldn't be apprehensive about, increased intensity? Mr. Nutter.

Mr. NUTTER. If I could answer that, I am going to read from a statement by Swiss Re Insurance, which does have scientists on its staff and looks at these things, and they cite a study by Webster and Holland. And I don't have the specific reference, but I will get that for you. It indicates a trend since about 1970 toward more intense tropical cyclones.

Continuing with the Swiss Re statement, in early 1970s, 17 percent of all tropical cyclones were Category 4 or 5. That number has increased to 35 percent and increased two times higher than was just 35 years ago.

So they are citing a scientific study, not an insurance study, that would suggest that we are seeing more intense storms. From my own statement, 3 of the top 10 most intense storms ever recorded in North America were in 2005 alone. It would appear we definitely have a period of increased and more intense storms. In fact, the more moderate storms appear to be declining, and the more intense storms appear to be increasing.

Mr. BLUMENAUER. Thank you, sir. I appreciate it.

Mr. Kreidler, I appreciated your reference to deep concerns in the people that you work with about what government can do. I noted in the work that I did in the aftermath of Katrina, I was stunned to find out that three Louisiana parishes and seven Mississippi counties had no building codes, none. Is there a responsibility for us to link Federal insurance, Federal assistance, to local and State communities that take at least minimal steps to protect their own people and the Federal Treasury?

Mr. KREIDLER. Mr. Blumenauer, that is clearly something that would help to make the world of insurance much more predictable

if, in fact, you had the kind of building code standards and land use policies that were going to be much more predictive of the kind of risks that were involved for losses. The National Flood Insurance Program obviously is one of those that could have a very pronounced and profound impact on those flood-prone areas where flood insurance exists. The Federal Government obviously could have some very significant guideline effects in that program. The other is that if you tie it to mortgage lending and making sure that those policies are renewed so that they keep policies in effect, it would have a very conducive impact.

The same from the standpoint of any Federal housing programs, that the more that it is tied to making sure that there are flood policies in effect or that you wind up with other types of insurance being applied, it is going to be positive.

Mr. BLUMENAUER. Thank you very much.

Thank you, Mr. Chairman.

The CHAIRMAN. All right. The gentleman's time is expired.

The gentleman from Oregon Mr. Walden.

Mr. WALDEN. Thank you, Mr. Chairman. I want to thank our witnesses for their testimony today. It is most helpful.

Mr. Kreidler, being a fellow Westerner, as you know, I represent all of the eastern Oregon. I mentioned in my opening comments about forest fires and certainly the cost, and others have talked about that as well. Do you support changes at the Federal level dealing with how we manage our Federal forests and mitigate against these catastrophic fires we are seeing? These were record levels in the last 3 or 4 years certainly of fires.

Mr. KREIDLER. Mr. Walden, to some degree I see a connection here with insurance and clearly forest fires and their impact, and I think we are going to be forced to take a look at any number of our policies as they currently exist. The disease impact on trees because of the changes that are taking place in weather are profound, much less the problems of drought as we are experiencing them now, meaning that we are much more subject in ways that we had not historically been subject to forest fire and the problems that result from that. I think it is clear that we are going to be challenged to make changes in our forest policy.

Mr. WALDEN. And the same, I assume, with our energy policy. We should encourage renewables and energy production from facilities that have very little, if any, carbon footprint. I mean, is that—maybe that would help, but I realize that is kind of out of the scheme of insurance. But if we are trying to reduce carbon in the atmosphere, then wouldn't it make sense——

Mr. KREIDLER. Mr. Walden, I would agree with that. I was a member of the Northwest Power Planning Council, where we clearly were involved in looking at the Federal dams on the Columbia system; and when I was a Member of Congress I was on the Energy Subcommittee, and carbon sanctions, sequestration were issues that we were dealing with even way back then. I think that it is clear that we are going to have to do a great deal more using alternative energy and developing them to make them economically viable. There is no question about it.

Mr. WALDEN. I appreciate that. I was looking at some data on, for example, if the Snake River dams were to be removed; and then

the trade-off between hauling grain by barge versus truck would be something like an additional 171,000 trucks on the highways, which are clearly more polluting, I would assume, than a barge floating down the river. And, obviously, the energy production that comes from those facilities, while it has its own set of issues involving fish and all, which I respect, and we need to address any replacement powers, most likely is going to have a carbon footprint, right? It is bigger than hydro. I mean—are like the least emitting in terms of the amount of power we consume and produce.

Mr. KREIDLER. There are clearly some catch-22s, Mr. Walden, that are presented because of wanting to make one change to accomplish one particular environmental goal as the trade-off against another; and we clearly see it when it comes to fish as to the increasing amount of release of carbon into the atmosphere. The same can be said when it comes to issues related to nuclear power and how it can be applied as an alternative fuel source.

Mr. WALDEN. Appreciate that. Thanks again for your testimony.

Mr. Stephenson, the IPCC indicated that they really didn't draw a distinction that there were increases in tropical storms related to global change, isn't that correct?

Mr. STEPHENSON. They said that the increase intensity of tropical storms is likely to increase in general. There is an ongoing debate at the direct relationship between climate change and extreme weather events, as was noted by the most recent NOAA study. IPCC has been studying this for 15 years. But renowned scientists all over the world, their studies are peer reviewed. We think they are kind of the source authority. But they did say that the intensity of storms would increase likely.

Mr. WALDEN. That there is no evidence at this point that clearly links the global warming to——

Mr. STEPHENSON. The debate continues.

Mr. WALDEN. Right.

The other issue I have is one I get asked about. We have better technology now to measure these storms, identify these storms. I think if you go back to the 1970s and before, we didn't even have too many satellites that looked at this stuff, right?

Mr. STEPHENSON. We absolutely didn't.

Mr. WALDEN. So how much of—as you have reviewed all of these scientific journals and all, how much of the data that is coming out now is sort of measured against what we didn't know then versus what we know now? I am not asking that clearly. But do you know what I am saying? We didn't have the ability then to know every storm that is out over the ocean. Today, we do, don't we? Is that factored in?

Mr. STEPHENSON. Yes, that is factored in.

Again, we are not a science organization. Our concern is with the increased exposures that the insurance programs have in light of more people moving to the coast, more expensive homes, that if we have, as Mr. Nutter suggested, a repeat of 2005 twice a decade instead of every two decades, that poses extreme financial risk on the Federal insurance programs. That is our concern. We think there is enough scientific information to support that conclusion.

Mr. WALDEN. Appreciate that. Thank you all. Thank you, Mr. Chairman.

The CHAIRMAN. The gentleman's time has expired.

The gentlelady from California, Ms. Solis.

Ms. SOLIS. Thank you, Mr. Chairman.

A question for Mr. Stephenson. In your GAO report you recommended that the Department of Homeland Security and the Department of Agriculture assess fiscal impacts of climate change. Why were those two just singled out? Are there any other agencies we should be including?

Mr. STEPHENSON. Those are the managers of the two large Federal Crop Insurance Corporation and the National Flood Insurance program. That is why we directed our recommendations to those agencies that manage those Federal programs.

Ms. SOLIS. Should we have perhaps some assistance from our other Federal agencies like NOAA, as was mentioned earlier, some of the other scientific agencies that could provide additional support to these agencies that oversee our Federal insurance plans?

Mr. STEPHENSON. I would think that would be—in implementing our recommendations to study the implications, I would expect that they would use all the Federal Government's resources to come up with reports on how their programs might be impacted. So, yes, I would agree with you.

Ms. SOLIS. I am also equally concerned, and this is more a question for Mr. Kreidler regarding health, health care, and the negative impacts that some of these disasters are having on our population, whether it is respiratory, asthmatic. And have we thought or have you and your State looked at combining work from Health and Human Services? Is that something that you may want to look at or we may want to look at?

Mr. KREIDLER. We are in the process right now, an advisory group that has been created in the State of Washington, looking at all aspects and it includes—the Department of Health is a part of that determination. Clearly, it has very significant relevance.

I think the best example or perhaps the worst example is what happened in Europe with the heat wave; and, you know, depending on the numbers they use, 30,000, 40,000 people wound up dying as a result of just heat. But there are other issues, such as disease, that are going to be changed; and it needs to be taken into account. And clearly we are looking at it from the standpoint at the State level. I think it would be important in much the same reasons—for the same reason that we have a review, in having a commission take a look at all aspects to add the questions of health and how they would be impacted.

Ms. SOLIS. Mr. Nutter.

Mr. NUTTER. Yes. If I could supplement that, we don't represent health insurers or reinsurers, but I would refer you to two groups if, going forward, you are going to have hearings that focus on health. One is the Centers for Disease Control has initiated a project looking at climate change and its impact on health; and the second is the Center for Health and the Global Environment, which is part of the Harvard Medical School, has focused for some years on climate and health risks associated with climate. They have excellent expertise and have been at this for some time.

So both of those would be—I would encourage the committee to consult with them.

Ms. SOLIS. Just an additional note, in my experience visiting Mississippi and Louisiana after the flood, a delegation went down, we saw that there were many, for example, refineries and landfills that were actually heavily impacted and, of course, contaminants affecting the population; and I have yet to see the kind of so-called risk management or assessment that needs to be done on not only the land but as well as the population and the devastation that that will have for future generations.

So that is something that I often think about when I look at the shortage of health care facilities there and the impact long lasting in terms of the contaminants that affected the residents there during the flood.

Thank you.

The CHAIRMAN. The gentlelady's time has expired.

The Chair recognizes the gentleman from Oklahoma, Mr. Sullivan.

Mr. SULLIVAN. Thank you, Mr. Chairman; and I want to thank the panelists for being here today. Thank you, and I have a question for all of you—well, different ones for different ones.

Mr. Stephenson, first, just out of curiosity, are there any other comparable programs to our flood insurance program or crop insurance program in other countries? And are they taking possible global warming events into account?

Mr. STEPHENSON. I am sure there are government-sponsored programs in other countries. We did not, however, look at them as part of our study. We were focused on the U.S. Federal Government's insurance programs.

Mr. SULLIVAN. And also, sir, how much of the government exposure on paying out claims is for the repeat claims? For example, someone builds on a flood plain, gets wiped out, then rebuilds only to get wiped out again. How can we work to prevent these cases from repeatedly occurring?

Mr. STEPHENSON. Well, that came up earlier when we were talking about building codes. If you have a federally backed mortgage, you are required to build to the flood insurance codes, but that doesn't exist in every community. So if there was a way to strengthen that global Federal connection so that building codes could be tied to insurance, that would be a good thing.

Mr. SULLIVAN. And also when considering risks for natural disaster damage, weather factors can be taken into account. For example, the condition of local infrastructure such as levies and dams taken into account, the State's ability to respond to the disaster.

Mr. STEPHENSON. All those preventative measures are huge when it comes to insurance payouts for extreme weather events.

Mr. SULLIVAN. And, Mr. Nutter, where do you believe the Federal Government should be in regulating private insurers when it comes to catastrophes or insurance against catastrophes?

Mr. NUTTER. I would suggest that the current system in place is the one that Mr. Kreidler—Commissioner Kreidler represents, and that is really a State-by-State system of insurance regulation at this point. Certainly these events are regionalized, many extreme weather events are regionalized, hurricanes that is distinguished from tornadoes or earthquakes. So at this point, other than the Federal insurance programs and insurance programs you have, we

are not promoting or think that there is any particular role relating to the Federal Government with respect to regulating insurance companies or insurance rates, if I understand your question correctly.

Mr. SULLIVAN. And also, sir, do insurance companies have an economic motivation to make the threat of climate change sound more extreme and dire than it is? And does the creation of extreme scenarios instill fear and thus create a way to increase insurance premiums and, thus, the company's bottom line?

Mr. NUTTER. That is a fair question. But I would suggest that the insurance industry in the Unites States has actually taken a different tact. Its focus has really been on mitigation. It focuses a lot on building codes. It lobbies for improved building codes, and it is focused on research related to building design and building materials to try and improve the resistance of properties to damage by extreme weather events.

The Institute For Business and Home Safety is an insurance-industry-funded organization that does that, so I don't think the industry in the United States really could be accused of doing that. It really has focused more on the consequences of extreme events, not the causes.

Mr. SULLIVAN. Thank you, sir.

And, Mr. Kreidler, given the predictions of large-scale map-altering weather events that folks like the former Vice President are predicting, would you suggest that the Federal Government take over or expand its disaster insurance programs or regulate insurance at the Federal level rather than allow States to do it?

Mr. KREIDLER. I would suggest that expansion would be in order, but I would also probably even more so say that we need reform of these systems so that they act as a coordinated catastrophic program. There is plenty of focus on the local communities from the standpoint of building codes and zoning and the like, but there is a significant part that deals with the infrastructure that exists from the standpoint of making sure that the roads and the levies and all of the infrastructure there is up to standard, and it is a clear question that is deficient at the present time.

I think having a prospective type of catastrophic funding would make a lot of sense; and integrating programs that we currently have, including flood and I would go to say also programs—or perils such as earthquake, should be also incorporated so that we have a comprehensive approach to the challenges that are in front of us.

Mr. SULLIVAN. Thank you, sir; and thank you, gentlemen.

I yield back.

The CHAIRMAN. The gentleman's time has expired.

The Chair recognizes the gentlelady from South Dakota, Ms. Herseth Sandlin.

Ms. HERSETH SANDLIN. Thank you, Mr. Chairman. Thank you to our witnesses today for their insightful testimony.

I do want to focus my questioning on the drought of the western plains. These are a number of people I represent. And I am curious, Mr. Stephenson, on page five of your report it is noted the USDA took issue with several points made in the report, even though they agreed with your recommendation to look at the longer-term effect on the public programs through the Federal Crop

Insurance Corporation. Could you elaborate a little bit on where USDA was taking issue with some of the points in the GAO report?

Mr. STEPHENSON. I think they felt we were focusing more on hurricanes which affect the flood insurance program than the crop insurance program; and that is because the exposure for that particular program is so huge, $1 trillion. But, nevertheless, the IPCC also predicts that increased drought is likely, which means 66 percent confidence that it will occur; and that certainly will affect the crop insurance program.

And, again, they agreed with the recommendation to consider the implications of climate change. However, when we testified in the Senate, they wanted to see a specific report on how they might do that, rather than just insurance.

Ms. HERSETH SANDLIN. I don't want to speculate on all of the concerns USDA may have, but I do think that the focus on hurricanes and when we look at the generalization that it is more costly, but I think in part that may be driven by the population density along the coasts and the private insurers as well.

But when we are dealing with the western plains, did it come up in your conversations, your analysis as it relates to the FCIC and your discussions with USDA that, for example, on page 11 of the report when it looks at weather-related losses paid out, that that could very well have been much higher from 1999 through 2005 given the long-term drought in the western plains, given the fact that there was either inadequate or no insurance products available for rangeland pasture grass for livestock producers versus what was being paid out for grain producers affected in different parts of the country in ag sectors affected by the drought?

Mr. STEPHENSON. We can get into that specifically, but I think your conclusion is correct. It did focus more on grain producers and traditional farming rather than ranching.

Ms. HERSETH SANDLIN. And I just want to point out that there are a number of new pilot programs that are being tested in certain parts of the western plains as it relates to rainfall levels, vegetation cover to deal with the issue of rangeland and grassy pastures. So, if anything, these numbers could go up if indeed this isn't simply a cycle that we have seen before, but even if it is the intensity of which seems to be more severe, as Mr. Blumenauer was pointing out in light of some of the record temperatures as well as the anecdotes of some older people in the western plains who lived through the 1930s as well and comparing that to the drought of the last 6 or 7 years.

I think that that may be all the questions I have.

The GAO then, you didn't do any projections based on—I mean, that is sort of what you are seeking USDA to do for the FCIC projections, including these new pilot projects that may increase participation.

Mr. STEPHENSON. No, that is correct. We looked at the IPCC projections and sort of overlaid those in the Federal insurance programs, understood the Federal Crop Insurance Program, for example, was very retrospective, convinced ourselves that they weren't doing very much prospective looking in. The past may not be a good predictor of the future; and, therefore, we recommended that

they needed to study the issue in more detail than we currently have.

Ms. HERSETH SANDLIN. Okay. Thank you, Mr. Chairman. That is all I have.

The CHAIRMAN. Great. The gentlelady's time has expired.

The Chair recognizes the gentlelady from Michigan.

Mrs. MILLER. Thank you very much, Mr. Chairman; and I think it is appropriate we are talking about global warming. We could use a little bit in this room. I don't know about the rest of you, but I am freezing in here.

My question is going to just be about the National Flood Insurance Program; and I am going to lay out for you some statistics that we have gathered in Michigan and in our office about what I think are huge inequities in that program as far as premiums, claims, et cetera.

As you know, FEMA is currently in this process of remapping the entire Nation, and they are going to be utilizing the much higher technology that we now have available with digital technology, et cetera, and allegedly all of this enhanced data is going to be able to give the National Flood Insurance Program a much more accurate picture about the risks that are posed in various areas, certain areas and theoretically of a more solid foundation on which to base their premiums.

However, I will say this. What we are finding is that, as a result of this entire remapping process that they are going through—and they are pretty much through. For instance, in full transparency, we are talking about Michigan, because we are really looking at this thing. But we are finding our property owners are being forced to pay much, much higher premiums; and I will just give you an example.

In regards to the proposal by FEMA for remapping in the Great Lakes region, they are actually raising the base flood elevation an additional 14 inches, which allegedly will accurately reflect the risk of flooding. However, unfortunately, they are using data that is about 20 years old, which is reflective of a time when we had the highest lake levels ever recorded in the Great Lakes basin. In fact, in Lake St. Claire, which is a lake in between Lake Erie and Lake Huron between the Detroit River and the St. Claire River, actually during that same 20-year period we have experienced water levels that have dropped three feet during that time and are currently about five feet below what is the current flood elevation.

During the last 30 years—and here is the numbers that we have compiled. During the last 30 years, the residents of my State have paid $120 million more in premiums for national flood insurance to the National Flood Insurance Program than they have received in claims, although the remapping plan, as I mentioned, is even going to force more people in Michigan to participate than they already do. They are mapping areas that have never flooded ever and are forcing people into the National Flood Insurance Program.

And I say that because we can compare it to what is happening in the gulf coast as a result of some of the hurricanes, Katrina, Rita, et cetera, where you have billions of dollars being paid in insurance claims. These are to people, of course, who are essen-

tially—who have lived below sea level, unlike what is happening in Michigan.

So if you look at a group of the 10 States which have received actually $1.5 billion more in claims than they have received in premiums—and this is the kicker, I would say—the average premium in this group of States that are receiving these high claims is $223. The average premium in the State of Michigan is $260. So we are paying more on an average into the National Flood Insurance Program than people who are living below the sea level. And I will tell you one thing, in Michigan, we look down at the water, we look down at the water, and yet we are paying these high programs.

In fact, Mr. Kreidler, I have suggested to our State insurance commissioner that Michigan should pull out of the National Flood Insurance Program and completely self-insure. I am not sure we are going to do that. That sounds a little Draconian, I understand. But that is how concerned we are about what we think we are doing. In other words, we feel that we are subsidizing.

So I guess my question is, generally, what are your thoughts about an imbalance like this? And do you think that the National Flood Insurance Program is a viable program? Or is it just administered politically, quite frankly?

Mr. KREIDLER. Thank you. I think that the National Flood Insurance Program has been long overdue ever since its creation I think in 1968. It needs to have a real revamping. I think the last reauthorization of the program was with the idea that that is what the Congress was going to anticipate having a more prolonged, thoughtful consideration of doing and reviewing just exactly how it functions and what it charges and what it is based on. We are all to be part of that review. From my standpoint, I think that that is long overdue.

Just looking at the program, it is a Federal program. I think it is a program that should be incorporated, quite frankly, into all of insurance and not set out as a separate program; and I think that would help in many respects to not address necessarily the cost but certainly from the standpoint of being able to make sure it worked much more efficiently.

The CHAIRMAN. The gentlelady's time has expired.

The chair recognizes the gentleman from California, Mr. McNerney.

Mr. MCNERNEY. Thank you, Mr. Chairman.

Mr. Chairman, without objection, I ask that the IPCC summary for policymakers issued in February of 2000 be included in the record. Specifically, the statement on page 6 that there is observational evidence for increase of intense tropical cyclone activity in the North Atlantic since about 1970, correlated with increases in tropical sea surface temperatures, for the record.

The CHAIRMAN. Without objection, it will be included.

[The information follows on page 89:]

Mr. MCNERNEY. Insurers, more than just about any group, base their decisions on the bottom line and on rigorous probability calculations. Because of this, I feel that the insurance industry is an indication of where we are going with global warming and risk issues associated with that.

Having said that, I would like to point out the risk in my home State of California. Some 23 million people depend on a set of levees in the Sacramento area and not only for their clean water. But not only that, the cities of Sacramento and Stockton have levees that which, if failed, will impact people in urban areas directly. Rising seas and increasing storm intensity, both a consequence of global warming, pose serious threats to our levees.

The reason I bring this up is because many private insurers have either stopped insuring or writing new policies as a result of the Katrina events. Mr. Nutter, can we expect to see this in California? Or can we wait until the catastrophic events?

Mr. NUTTER. That is a difficult question. I can speak for the reinsurance industry.

The global reinsurance industry wants to write catastrophe business as part of its risk portfolio. After Hurricane Katrina, $32 billion of new capital came into the reinsurance business to write business in the gulf coast, in Florida, the east coast; and, frankly, they would think more of California because of its earthquake risk. So from the reinsurance perspective, this is, in fact, an insurable risk that the business wants to write.

It is quite clear that a number of insurance companies have had to reassess the risk exposure they have to extreme weather events and have either sought to raise prices to reflect that risk or to nonrenew or cancel policies in order to bring it in line with their capital requirements from the rating agencies.

I can't speak specifically to Sacramento. I apologize for that. But it is a fair question.

Mr. MCNERNEY. Well, in the 2005–2006 winter we came within about 2 inches of water overrunning the levees in Sacramento. So there is a significant risk, and it is ongoing.

Mr. Stephenson, you mentioned the 66 percent chance of increased weather-related damages. I guess I would like to know when we can see the direct impact of that assessment on our insurance policy rates nationwide.

Mr. STEPHENSON. You are asking the wrong person. You should ask the insurers that. I was just quoting from the IPCC study which you just entered for the record; and that is their statistic, basically.

Mr. NUTTER. There is no question that, following the 2004–2005 storms, that the risk modelers that do assess this risk and advise insurers and government programs about the risk exposure that it caused an increase in risk premiums, particularly in high-risk areas. There was also a reassessment of the construction costs associated with rebuilding. So I would say that the movement toward more risk-based premiums is really already occurring as a result of the wake-up call that the 2004–2005 storms reflected.

Mr. MCNERNEY. One last question, if I have time. Mr. Kreidler, are insurance companies actively involved in influencing national policy in this country toward global warming?

Mr. KREIDLER. In my personal opinion, we have seen too little of it from the standpoint of the American insurance industry. It has been much more of the European insurers as opposed to—and the reinsurers, which tend to be international by their very characteris-

tics, involved in pressuring for and pressing for national policy changes.

I think that when it comes to what we can do with the insurance companies in America, one would be, as a part of a comprehensive study, to look at how they can reserve for future losses so they don't try to build too much of it into their immediate rates they are going to be charging following a particular event or become too responsive to particular risks as they may envision them, such as the levees breaking in the Sacramento River. I think you can do that and lessen the kind of cyclical nature of what you see in rates but also the underwriting patterns that take place by the insurance companies following a significant catastrophic loss or events.

Mr. NUTTER. If I might supplement that, Swiss Reinsurance is a licensed company here in the United States. It is based in Switzerland. They have been proactive in promoting more aggressive U.S. policy with respect to emissions.

I would also note that AIG, obviously a major U.S.-based international insurer, in April, 2007, joined as the first insurer as part of the U.S. Climate Action Partnership. So there is some sign that the industry is becoming more engaged in the debate. The industry as a whole, as suggested by Mr. Kreidler, has been less involved.

Mr. MCNERNEY. Well, thank you for your answers and thanks for coming in today to give your presentations.

The CHAIRMAN. The gentleman's time has expired.

The Chair recognizes the gentleman from Arizona.

Mr. SHADEGG. Thank you, Mr. Chairman.

I want to thank all of our witnesses. I don't believe I have any questions for them.

I want to use this time to put into the record some facts regarding the last hearing and to address an issue which I believe could impeach the credibility of this entire process.

At the last hearing, which was on dangerous climate change, the majority called a witness by the name of Dr. Judith Curry. Dr. Curry had submitted written testimony, and on page one of that testimony she reproduced two paragraphs out of the IPCC summary for policymakers that was just placed into the evidence. Interestingly, she put an ellipsis in between the two paragraphs, making it appear—or in the middle of the long paragraph, making it appear that she had left out at least a sentence, not making it appear that there were two separate paragraphs.

I asked Dr. Curry why she had left out some material, because my staff checked the IPCC report and looked at what the omitted material was. To my surprise, Dr. Curry said—denied. She said she had not left out any language from the IPCC report.

I was stunned at that. It is not often that a witness appears before a congressional committee and fundamentally lies. And so I sought to ask Ms. Curry—I pointed out to Ms. Curry that she, in fact, had left the sentence out. She professed not to know that. I directed her to the sentence, and I was in the process of asking her to read that sentence because I thought it was an extremely important sentence, at which point my time was gaveled to a stop.

The essence of Dr. Curry's testimony was that there are an increased number of hurricanes and that they will do, as a result of our serious consequence, global warming. Interestingly, the sen-

tence that Dr. Curry had left out, which I would like to put into the record now without being interrupted, is a sentence which fundamentally undercut her entire thesis; and that is the sentence which appears at page eight of page 18 of the summary which has just been placed in the record by my colleague on the other side. That sentence says a point that has been re-emphasized here, which is that there is no clear trend in the annual numbers of tropical cyclones. There is no clear trend.

She had previously stated in the report that the risk of increased hurricane activity is arguably the issue of greatest concern to the U.S. public. I think it is very, very serious when a witness appears before this committee and intentionally omits a sentence which impeaches or undercuts their testimony. I think it is much more severe when that witness denies having done that and isn't familiar enough with their work to know that they have left that sentence out, fundamentally lying to this committee because witnesses before this committee are largely under oath.

I wanted to point out, Mr. Chairman, that a further incident occurred that I thought was more troubling and a number of people raised with me after the incident. And that is that, as I was asking and pointing out to this witness that she had left out the sentence which impeached or weakened her own testimony, the Chair gaveled me to a stop and didn't allow me to continue to make that point.

In that hearing earlier I had pointed out to the chairman that there, in fact, was no clock allowing members of this panel to see how much time they had left. Now I presume the chairman of this committee would never intentionally gavel to a silence a member just because that member was making a point that was damaging to that chairman's point of view; and I am certain, Mr. Chairman, that you would never intentionally do that.

But, nonetheless, when I left here, a number of people came to me and said that they were shocked that Dr. Clark had omitted the sentence. They expressed to me that they were even more shocked that Dr. Clark had denied omitting the sentence; and a number of them, Mr. Chairman, said to me they felt that it was completely inappropriate for you to gavel me down right when I was pointing out that she had left out the sentence that impeached her or undermined her testimony and that when I tried to get that sentence into the record that was the point at which the gavel struck and I was not allowed to complete my point.

Now, Mr. Chairman, I understand it is difficult to manage time here, and I am going to assume that that was an unintentional act on your part, but certainly if there were an appearance that this committee was trying to silence members who were simply making a factual point—and I would like to put Dr. Kreidler's testimony back into the record and the IPCC report with the sentence that does undermine her testimony into the record of this hearing. I am certain if people thought that was being done intentionally here, it would undermine the entire purpose of these hearings.

Because I hope the chairman agrees with me that we should have a full and honest debate of all of the issues before this committee, and that if a witness does in fact either omit a sentence which damages or weakens their argument and, more importantly,

that if a witness denies that they did so when it is clear they did in fact do so, this committee would want to know that.

And, with that, Mr. Chairman I yield back.

The CHAIRMAN. Great. The gentleman's time has expired.

And I might note that the gentleman's time, that is, the 5 minutes that he is allocated, had just expired as he was making his point last week in that hearing. And in both instances the gentleman had not appeared to make an opening statement but rather only had 5 minutes of questions and at the conclusion of his 5 minutes then was posing questions which I then allowed to go on for an additional minute, although that was in excess of the time that had been allocated for the gentleman.

At that time, if the gentleman recollects, we had a similar situation where there was a roll call pending. There were members waiting to ask their questions, as there are right now. I was trying to accommodate the other members, and it was in no way intended to have any adverse effect upon the gentleman but, rather, to accommodate the other members.

I will note, however, that Ms. Curry did in fact put an ellipsis in her statement. In other words, she made it clear with that ellipsis that there was missing language. She wasn't trying to misrepresent that there had been no gap in her testimony.

And, similarly, the sentence that you are referring to and have raised does not undermine in any way Dr. Curry's testimony that the intensity of hurricanes is increasing. The missing sentence was about the number of hurricanes, a matter of continuing scientific debate. But the missing language did not in fact undermine her central argument, which was about intensity.

I just wanted to say to the gentleman, in no way was I trying to cut off your statement. All of your time had already expired, and I had given you extra time. I was trying to accommodate, as I am trying to do right now, Mr. Cleaver. But even this conversation is probably going to necessitate us having to adjourn and Mr. Cleaver having to come back after these roll calls. I was trying to get him in before this point. But this conversation again is beginning at the end of your 5 minutes, rather than at a point that would have consumed your 5 minutes.

I will be glad to yield to the gentleman.

Mr. SHADEGG. We will discuss this.

First of all, my entire comments today were devoted to this point. I didn't—my comment saying I was unhappy with how I was treated did not begin at the end. It was the entire essence of it. Besides which her testimony says, "increased hurricane activity," not intensity, activity which can include the number of hurricanes. So it does impeach her statement.

And all I said, as I gave the gentleman the benefit of the doubt, which was I assumed he would not have intentionally cut me off. But the appearance was certainly there, given that it was precisely at that point the gentleman cut me off.

The CHAIRMAN. And, again, I don't mean to cut you off right now, although—for the purposes of recognizing the gentleman from Missouri so that he can ask his questions before we go over for the roll call and not necessitate him having to return and spend another half hour of his time, I apologize to the gentleman from Missouri.

Mr. CLEAVER. Thank you. This is what happened last time.

The CHAIRMAN. Exactly. Okay. So I apologize to the gentleman from Missouri.

Again, I assure the gentleman from Arizona I was only trying to accomplish that for the purpose then, as we did a week ago, as I am trying to accomplish here, and I apologize again, and at this point——

Mr. CLEAVER. The gentleman from Arizona may not have recalled that I was waiting at that hearing as well.

My concern is that my son had just graduated from Dillard University and was staying in New Orleans to do——

The CHAIRMAN. If the gentleman would yield, I think there is only 2 minutes left on the House floor for roll call. I apologize to the gentleman. You can remain here as long as you would like or——

Mr. CLEAVER. No, I think I had better go.

The CHAIRMAN. The committee will adjourn, and we will return in a few minutes.

[Recess.]

The CHAIRMAN. The committee will reassemble, and we apologize to you. And the Chair will, when he is ready to go, recognize the gentleman from Washington State, Mr. Inslee, for his questions.

Mr. INSLEE. Thank you. Thanks for being here. I appreciate Mr. Kreidler's comments about the non-hurricane situation actually causing us some grief, too.

I spent Election Day last November stacking sandbags out on the river in Snohomish County with the chain gang, the Snohomish County Jail chain gang. And I was standing in the mud throwing sandbags, and I was wondering, is this an upfront, personal view of global warming? Well, we can't tell for sure because you can't identify one storm to global warming, but the science is indicative in the Northwest. We will have more frequent, very severe rain events, more frequent weather wind patterns; and 2 weeks later we had a power out for 4 or 5 days.

So I appreciate you bringing it to our attention it is not just the massive hurricanes that has an impact in our personal lives, and also I appreciate you coming all this way to tell the story of economic damage the United States can face due to inaction. You know, many of us think we should take some action, some prudent, reasonable, common-sense action on global climate change; and other people say, well, that will hurt our economy. And it is like they forget that inaction will hurt our economy.

You gentlemen have talked about significant billions and billions of dollar losses we will be suffering if we take no action to deal with it, so I think it is very important you are here, and it is a very important hearing and a very important message, and I appreciate you coming all this way.

Mr. Stephenson, I wonder if you can—we have a situation where the U.S. Congress has dithered and basically done nothing to adapt to climate change. It has adopted the position of the ostrich today as far as climate change; and yet the business community, at least in the private insurance markets, if I understand your testimony correctly, is anticipating the damages and reacting to the damages

and started building it into their business models to really get ready for this, what—the damage that is going to be coming.

Could you try to quantify in dollars at all how much the private markets have moved in response to the oncoming damage of climate change?

Mr. STEPHENSON. The private markets or the Federal?

Mr. INSLEE. Well, we will just say both. Let's lump them together.

Mr. STEPHENSON. The whole point of our report is that the private markets are moving out aggressively to incorporate the impact of climate change on their business, and we don't see similar movement in the Federal insurance program. That is kind of the heart of our report and why we recommended that they need to do so.

Mr. INSLEE. Can you put any dollars on that? Is it millions or billions the people are investing based on the belief that climate change is going to increase damage in the United States?

Mr. STEPHENSON. Well, we are more concerned with the exposure in the future and that there be repeats of 2005, where the National Flood Insurance Program had to borrow $18.5 billion from the Treasury. It is that sort of thing. If we have too many years like that, although the program is not supposed to be completely actuarial sound, it needs to do a better job than that. So that is the concern.

Mr. INSLEE. Mr. Nutter.

Mr. NUTTER. Let me cite from a report that—it is not our report. The Association of British Insurers released a report just last year, and they had the following comment in there which I think is reflective of your question.

Just looking at climate change and holding everything else steady, so not taking into consideration increased populations at risk or properties, that sort of thing, they had the following comment: Higher capital costs for insurance companies, combined with greater annual losses from wind storms alone, could result in premium increases of around 60 percent in those markets, meaning Japan, the U.K. and the U.S.

If that helps you with understanding. The point is, it is considerable.

Mr. INSLEE. So 60 percent, is that on the reinsurance level, the retail level? Is that to the homeowner, is that to the reinsurance market or both?

Mr. NUTTER. The ABI report would be the insurance—the insurance level.

Mr. INSLEE. Is it fair to say that there would be significant costs incurred by the consumer eventually as that works its way down to the market, I assume?

Mr. NUTTER. Well, absolutely. And, as I said, this doesn't even reflect increased construction costs or increased building in these areas. So there is no question the increased severity, frequency of storms is going to drive insurance costs higher.

Mr. INSLEE. So I am trying to put this—it is important to look at it where people really live, their homeowner's premium. You know you could—sitting here, I would say there is a 60 percent—it is probably going to end up as a 60 percent increase to consumers at some point in that order of magnitude. Is that a fair——

Mr. NUTTER. That is a fair interpretation of the Association of British Insurers report, yes.

Mr. INSLEE. I want to make sure I understand that report. I understand that report—the Flood Insurers Association concluded increased wind-related losses from extreme U.S. hurricanes by 2080 would be increased by about three-quarters, the equivalent of two to three hurricane Andrews annually, is that correct?

Mr. NUTTER. That is correct.

Mr. INSLEE. And I want to make sure that that assessment of future damage was not taking into account increased property values or increased population or the fact that we have more people living on the coastline. That is just simply due to the change in the climate, is that my understanding?

Mr. NUTTER. That is also correct.

Mr. INSLEE. So, as I understand, they also said there would be increased wind-related losses from increased Japanese typhoons by about two-thirds. The increase alone would be more than twice the cost of the 2004 season, twice the cost of the last hundred years. That doesn't have anything to do with more people moving to Tokyo. It is just due to the fact of the wind blowing harder.

Mr. NUTTER. Their study just reflected the effect of climate change on those costs.

Mr. INSLEE. And I saw something that was kind of an eye-opener. They also assumed there would be an increase of flooding in the United Kingdom almost 15-fold. We in the Northwest I think have already experienced this in our local regional models, predict it will have increased—significant increased flooding. I am not sure 15-fold, but that is their assessment, right?

Mr. NUTTER. That is U.K., and that is pretty dramatic. I agree.

Mr. INSLEE. So, as I understand again, I think I heard you say that there had been an increase in average weather-related catastrophes since the 1970s at about 2 percent a year, independent of an increased wealth of property or people moving to the coastline but simply due to weather-related losses. Is that the accurate assessment?

Mr. NUTTER. That is correct. And that came from Risk Management Solutions, which is one of these catastrophe modeling firms that I have referenced in the testimony.

Mr. INSLEE. So 2 percent per year, we are talking about over 75 percent increase of losses related just to increased weather events, not to the fact that more people are living on the coastline in nice houses?

Mr. NUTTER. That is correct.

Now they did not attribute all that to climate change, but they did attribute that to an increased incidence of extreme weather events, including the contribution climate change made to that.

Mr. INSLEE. Okay. Mr. Stephenson, you found this dramatic difference between what the private markets are doing, namely, they are responding to this and the government carriers are not. Now I have actually seen, I think, a metaphor for that; and the American businesses are responding. General Electric is making huge investments in clean energy. DuPont is doing the same thing. But the U.S. Congress is dithering around doing nothing, at least to

now. Do you have any explanation as to why the government has not been as responsive as to private markets? Just very briefly.

Mr. STEPHENSON. No. I mean they are not motivated by profit like the private sector is. The Treasury can bail them out if they make a mistake. All those things lead to a little inactivity, in our opinion, on embracing climate change and determining the impact on their prospective jobs and businesses.

Mr. INSLEE. We will try to remedy that. Thank you.

The CHAIRMAN. The gentleman's time has expired.

The gentleman from Missouri, Mr. Cleaver.

Mr. CLEAVER. Thank you, Mr. Chairman. Thank you for bringing such a high quality of witnesses to this committee and also for your patience. I apologize to you for your delay. Your time is valuable, and you have something to say, and some of us just have to say something. So I appreciate your presence.

As I began to say, my son has just graduated from Dillard University, was in New Orleans to do a Shakespeare play at Tulane when Katrina and Rita hit. The one thing that separated my son from the people that the world saw at the Dome was, in spite of the fact he had to spend one night at the Wal-Mart parking lot, he had a car. Only one out of six residents of New Orleans owns a car, and it gives you some example of the poverty of that so-called glitzy city.

If you look at the IPCC report and statements or research by meteorological experts, you have got to come to the conclusion that, with higher global temperatures, we are going to have more floods, more extreme weather. If this happens, the people most vulnerable are the low-income people like those who were left in New Orleans. Is there any suggestion that you might have for ways in which we could provide aid to the lower-income communities in terms of insurance coverage? Because they are going to end up being the most vulnerable. No matter what happens, they are going to get hurt the worst.

Mr. Kreidler.

Mr. KREIDLER. I think that one of the things that clearly can be done is, if you develop a change in how you develop a policy or how you deal with catastrophic events and you can build into how you deal with the kind of insurance that you are requiring homeowners to have, it becomes easier if it is constructed right to be able to offer subsidies so that you don't have gaps of people that are left without insurance.

That clearly presents a real challenge for insurers to come in when they deal with different building codes, different types of—some houses are insured and some of them aren't. In a patchwork, it makes it much more complex and difficult to have a policy as to how you are going to do your insurance in that area. If you have all of the houses insured, everybody has homeowners' insurance, then it is easier to offer a subsidy to those programs where individuals need financial assistance and you can do it thoughtfully, rather than waiting and coming in after a major catastrophe where you essentially are spending money as we have in New Orleans.

Mr. CLEAVER. Yes, Mr. Nutter.

Mr. NUTTER. It is a very good question. Several of the States that we deal with in looking at response to concerns about insurance

costs are trying to address that very thing. I would encourage you to talk to the people in South Carolina, the insurance commissioner and the government.

I was just in Massachusetts yesterday, met with the State Senate president there. A couple things they are looking at are some sort of a tax credit for people that is needs-based or income-based with respect to their insurance premiums, consideration about allowing people—I think a Health Savings Account or an IRA to set aside in a pre-funded way costs related to their recovery. They are also considering tax credits for people who buy materials to either retrofit their homes or when they have to repair their homes.

So I think the States are actually looking at a variety of creative ways and are very focused on the questions you raised.

Mr. CLEAVER. How do you feel about—at least it is in a discussions phase in the Financial Services Committee which I sit on—this all-peril insurance which is designed similar to the Federal flood insurance as we approach more disasters based on the data available?

Mr. NUTTER. Yeah. I know Commissioner Kreidler will want to speak to this as well.

From the insurance industry's perspective—and it has to be concerned about the costs associated with doing that. If you are going to an all-perils policy and you are going to add coverage to these policies that perhaps people don't choose to have now or don't want to have now, you are likely to increase their premiums in areas. And it would just be important in doing that to make sure they are truly risk based, the people are paying for the risks they have taken, whether it is earthquake or hurricane or flood or whatever it would be. But there would be some concern in the industry about expanding the risk portfolio of individual companies as well as the consumers.

Mr. CLEAVER. Thank you.

Mr. KREIDLER. I personally think that moving toward an all-perils policy, particularly for homeowners, for small business, the people who don't have the sophistication and the skills to be able to deal with—well, flood insurance program which may say we are just going to come in and pay this part of it, the rest of you hadn't, figure it out.

If it is integrated, the primary insurance company effectively has to come in, provide the coverage, and then they do the negotiation with, let's say, the National Flood Insurance Program. It would make a lot of sense, and that would be the kind of integration I think that we should see in our insurance.

Mr. CLEAVER. Thank you very much.

Thank you, Mr. Chairman.

The CHAIRMAN. The gentleman's time has expired.

Let me ask a couple of other questions. I know Mr. Hall might come back, and I have asked about Mrs. Blackburn, and there is an indication she might not come back. So I will just keep the hearing going a little bit because of the roll call interruption.

Mr. Stephenson, the GAO notes in its report that, while claims from weather-related losses varied significantly over the last 25 years, they have generally increased during this period. Isn't it very possible if this trend continues that we could see losses during

the next 25 years which exceed the $320 billion insured losses that we have seen over the last 25 years?

Mr. STEPHENSON. Well, again, that is the fear. I mean, a lot of those increased claims are due to increased property values, more people moving towards coastal areas and areas in danger of severe weather events. But, nevertheless, that also means that those Federal insurance programs have greater exposure, and that is the concern, that the predictions in the future need to be accurate. Otherwise, the payouts will far exceed the premiums.

The CHAIRMAN. Have you noted any changes even in the way the insurance industry, for example, looks at the ski industry in terms of the altitude of these ski lodges and re-examining how much it should insure against in terms of loss for that ski lodge if there is no snow that winter? Do any of you have any observations of that one industry, for example? Or other industries that are changing their views of business prospects because of weather?

Mr. NUTTER. One of the curious byproducts of these kinds of things is that the financial markets are often very creative. There are often weather derivatives that companies do buy. It is pretty prominent in the energy industry but in recreational industries as well to buy a derivative that effectively protects against the sort of business interruption that you are talking about. So there is a market, curiously enough, for the downside of climate change; and that is the unexpected things that can happen.

The CHAIRMAN. And is the creation of this new derivative a relatively new phenomenon?

Mr. NUTTER. Relatively new. I would say in the last 10 or 12 years.

The CHAIRMAN. And is it related to the change in weather and the severity of these storms?

Mr. NUTTER. It is certainly related to the willingness of the insurance market to insure certain things but not to insure other things. It doesn't tend to fit the traditional business model of insurance, so financial markets with financial products are creative.

We cite another example. Catastrophe bonds, which are pretty esoteric products, nearly doubled in issuance in 2006 following Hurricane Katrina as insurers were looking for ways to lay off risk to reinsurance market but also to the capital markets. It was something like $5 billion of catastrophe bonds issued, another way of protecting against——

The CHAIRMAN. Which was an increase over what amount.

Mr. NUTTER. It was about that—there were $2½ billion in the preceding year, so it doubled.

The CHAIRMAN. It doubled in 1 year?

Mr. NUTTER. In 1 year.

The CHAIRMAN. And that is unprecedented?

Mr. NUTTER. That is unprecedented, yeah. There are probably $10 billion of outstanding obligations for catastrophe bonds.

The CHAIRMAN. And what is the commentary that accompanied that change in that area? What were the industry leaders saying as to why they needed to do that?

Mr. NUTTER. Well, in some cases it is a function of the dynamics between the reinsurance market that I represent and the capital markets looking for a deeper pool of capital to lay off risk. Rein-

surers, just like insurers, have a risk appetite, and when that is saturated, the question is what more can you do to address client needs? So the capital markets become another vehicle for doing that. The weather derivatives market is somewhat independent of the insurance market, but the catastrophe bond market is very much integrated with the reinsurance market as supplemental capacity.

The CHAIRMAN. Interesting.

Mr. Kreidler.

Mr. KREIDLER. Typically these types of instruments deal with commercial types of insurance, which are largely deregulated at the State level, and not infrequently will also involve the surplus lines market, like Lloyd's of London and the like, where you can always buy it. But what we have seen is that the price of insurance, particularly for let us say the ski resorts are finding that they can always find availability. The affordability is increasingly becoming much more difficult for these lodges, and that obviously makes it more difficult to get investment when you have problems of being able to secure the risk that is involved with that investment.

The CHAIRMAN. So you are saying that for the ski industry in some instances, that increasingly the affordability of the insurance policy is now outweighing the profitability of the operation as a whole for the ski business?

Mr. KREIDLER. Clearly there are indications that that is, in fact, what is taking place. We have seen in Europe in the Alps; we can certainly see it in the State of Washington with the Cascades and the problems we are witnessing right now with the snowpack and the way it comes.

The CHAIRMAN. Can you tell us what is happening in the Alps, to your knowledge?

Mr. KREIDLER. I have to admit, Mr. Chairman, my knowledge there is quite limited, except to say that, in fact, that I have read that the availability of that kind of insurance is becoming much more difficult to secure.

The CHAIRMAN. And it is related to the fact that the snow is no longer as frequent or as deep or predictable, and as a result the insurance premiums have to reflect that?

Mr. KREIDLER. Exactly.

The CHAIRMAN. Let us do this. We thank you. I have one final question, and then I am going to ask each of you to give us kind of your summary statement as to what you want us to remember from this hearing, and we appreciate your testimony.

Impacts from severe weather on homes and property are the most obvious impacts of global warming, but there are others that affect the insurance industry. Congressman Kreidler, in your written testimony you mentioned some of the public health impacts from severe weather. What are the economic repercussions from these public health impacts from global warming, and do you expect to see them grow in the future?

Mr. KREIDLER. Mr. Chairman, I do anticipate that there are going to be increasing health-related challenges. We witnessed that, as I had mentioned earlier, with the statistics on the heat wave when it hit Europe, and some 30 to 40,000 people who wound

up dying as a result of that. That is a very direct impact that we see of health being impacted.

But we also see it from the standpoint of diseases that are going to—much like the changes we see in weather from the standpoint of drought and rain, that you are going to see diseases that have been identified more with much more wet, warm climates moving more to the north. And as that takes place, from a public health aspect it is going to represent some real challenges for us.

The CHAIRMAN. Okay. Great. Any of the others of you who wish to comment on that health-related issue or anything that is related to it?

Mr. NUTTER. If I could just relate to what I said to Representative Solis earlier, and that is that the Centers for Disease Control has initiated a study looking at climate risk and health. The Center for Health and Global Environment is a Harvard Medical School-based organization that focuses on climate change and health risk. I would strongly encourage the committee to at least consult, if not call as witnesses, people from there to talk about it. They are real experts in the field.

The CHAIRMAN. We are planning on doing that, and, in fact, one of our witnesses last week actually wrote the health section for the IPCC report. But we have invited those Harvard experts led by Dr. Epstein to come in and testify before us, which is our intention in the next several weeks.

So that concludes questions from the subcommittee. Now we are going to turn to summary statements from each of the witnesses. We will begin with you, Mr. Stephenson. What do you want this select committee to remember on this question of insurance as we are going forward and making recommendations on legislation this year?

Mr. STEPHENSON. Based solely on this work, we are concerned about the Federal insurance program. So as I mentioned, we testified in the Senate a couple of weeks ago. They agreed to hold the managers' of those Federal insurance programs feet to the fire, and they asked them to submit a specific report on how they intended to implement our recommendations. We will help you monitor their responsiveness to that report.

In addition, the Climate Change Science Program is past due in reporting out its next assessment to the Federal Government, the Climate Change Science Program, that is due in 2008. And we would like you to keep monitoring and make sure that comes out and see its compatibility with the IPCC assessments.

The CHAIRMAN. Great.

Congressman Kreidler.

Mr. KREIDLER. Thank you, Mr. Chairman.

Let me say that I think that this is a very complex interrelationship of insurance and how we can impact it, both from the standpoint of tax policy to investment strategies that really require the kind of thoughtful consideration that a commission, national commission, with the right questions posed to it are going to enable us to get at all the complexities that are involved here from the standpoint of the Federal Government, of certainly the National Flood Insurance Program, but at the local level from the standpoint of land use and building codes, a national policy by the Federal Gov-

ernment on greenhouse gases being integral to this. All of this fits together, and insurance is such an incredibly important, sensitive part about investment and economic development that if you don't take it all into account, you are not going to make sure that insurance is there, affordable and available for people and the economic activity so critical to this country.

The CHAIRMAN. Thank you.

And Mr. Nutter.

Mr. NUTTER. Let me conclude where you started. I do think that insurance is the canary in a coal mine in these areas. The business model for insurance largely has been to take historical data, look backwards and trend it forward. The industry is often characterized as if you were driving a car, it would be like driving it by looking in the rear-view mirror. That is not the case with respect to a change in climate where the industry needs to look forward.

The Congress has been excellent in supporting sound research in this area. There are obviously questions that are still open through the National Science Foundation, through NOAA, through NASA. It is the kind of thing that does help the industry understand the risk and assess it.

The CHAIRMAN. Thank you, Mr. Nutter.

And we thank each of you. This is very, very helpful. And I think it helps put in perspective how the private sector is adjusting here to the changes in weather patterns across the planet, and your testimony has been invaluable. We thank you.

And I think, unfortunately, because of the roll calls, there are a couple of Members who are not going to be able to return in order to ask their questions. But that said, I think it was a very productive hearing, and this hearing is now adjourned. Thank you.

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

A report of Working Group I of the Intergovernmental Panel on Climate Change

Summary for Policymakers

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Introduction

The Working Group I contribution to the IPCC Fourth Assessment Report describes progress in understanding of the human and natural drivers of climate change,[1] observed climate change, climate processes and attribution, and estimates of projected future climate change. It builds upon past IPCC assessments and incorporates new findings from the past six years of research. Scientific progress since the Third Assessment Report (TAR) is based upon large amounts of new and more comprehensive data, more sophisticated analyses of data, improvements in understanding of processes and their simulation in models and more extensive exploration of uncertainty ranges.

The basis for substantive paragraphs in this Summary for Policymakers can be found in the chapter sections specified in curly brackets.

Human and Natural Drivers of Climate Change

Changes in the atmospheric abundance of greenhouse gases and aerosols, in solar radiation and in land surface properties alter the energy balance of the climate system. These changes are expressed in terms of radiative forcing,[2] which is used to compare how a range of human and natural factors drive warming or cooling influences on global climate. Since the TAR, new observations and related modelling of greenhouse gases, solar activity, land surface properties and some aspects of aerosols have led to improvements in the quantitative estimates of radiative forcing.

Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years (see Figure SPM.1). The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture. {2.3, 6.4, 7.3}

- Carbon dioxide is the most important anthropogenic greenhouse gas (see Figure SPM.2). The global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 ppm to 379 ppm[3] in 2005. The atmospheric concentration of carbon dioxide in 2005 exceeds by far the natural range over the last 650,000 years (180 to 300 ppm) as determined from ice cores. The annual carbon dioxide concentration growth rate was larger during the last 10 years (1995–2005 average: 1.9 ppm per year), than it has been since the beginning of continuous direct atmospheric measurements (1960–2005 average: 1.4 ppm per year) although there is year-to-year variability in growth rates. {2.3, 7.3}

- The primary source of the increased atmospheric concentration of carbon dioxide since the pre-industrial period results from fossil fuel use, with land-use change providing another significant but smaller contribution. Annual fossil carbon dioxide emissions[4] increased from an average of 6.4 [6.0 to 6.8][5] GtC (23.5 [22.0 to 25.0] $GtCO_2$) per year in the 1990s to 7.2 [6.9 to 7.5] GtC (26.4 [25.3 to 27.5] $GtCO_2$) per year in 2000–2005 (2004 and 2005 data are interim estimates). Carbon dioxide emissions associated with land-use change

[1] *Climate change* in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change, where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

[2] *Radiative forcing* is a measure of the influence that a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. Positive forcing tends to warm the surface while negative forcing tends to cool it. In this report, radiative forcing values are for 2005 relative to pre-industrial conditions defined at 1750 and are expressed in watts per square metre ($W\ m^{-2}$). See Glossary and Section 2.2 for further details.

[3] ppm (parts per million) or ppb (parts per billion, 1 billion = 1,000 million) is the ratio of the number of greenhouse gas molecules to the total number of molecules of dry air. For example, 300 ppm means 300 molecules of a greenhouse gas per million molecules of dry air.

[4] Fossil carbon dioxide emissions include those from the production, distribution and consumption of fossil fuels and as a by-product from cement production. An emission of 1 GtC corresponds to 3.67 $GtCO_2$.

[5] In general, uncertainty ranges for results given in this Summary for Policymakers are 90% uncertainty intervals unless stated otherwise, that is, there is an estimated 5% likelihood that the value could be above the range given in square brackets and 5% likelihood that the value could be below that range. Best estimates are given where available. Assessed uncertainty intervals are not always symmetric about the corresponding best estimate. Note that a number of uncertainty ranges in the Working Group I TAR corresponded to 2 standard deviations (95%), often using expert judgement.

Changes in Greenhouse Gases from Ice Core and Modern Data

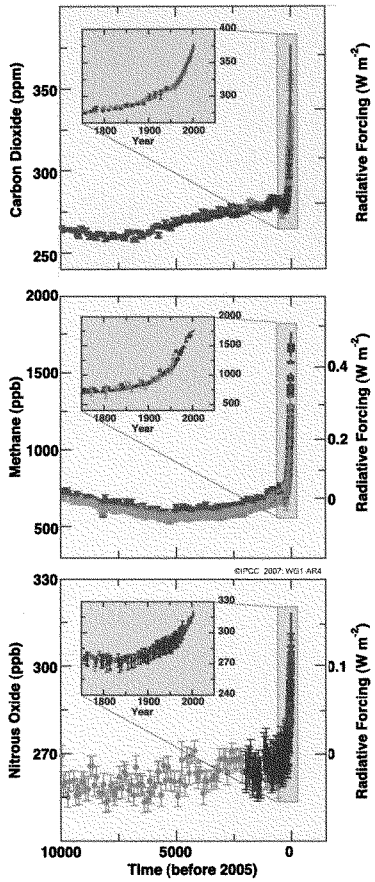

Figure SPM.1. *Atmospheric concentrations of carbon dioxide, methane and nitrous oxide over the last 10,000 years (large panels) and since 1750 (inset panels). Measurements are shown from ice cores (symbols with different colours for different studies) and atmospheric samples (red lines). The corresponding radiative forcings are shown on the right hand axes of the large panels. {Figure 6.4}*

are estimated to be 1.6 [0.5 to 2.7] GtC (5.9 [1.8 to 9.9] $GtCO_2$) per year over the 1990s, although these estimates have a large uncertainty. {7.3}

- The global atmospheric concentration of methane has increased from a pre-industrial value of about 715 ppb to 1732 ppb in the early 1990s, and was 1774 ppb in 2005. The atmospheric concentration of methane in 2005 exceeds by far the natural range of the last 650,000 years (320 to 790 ppb) as determined from ice cores. Growth rates have declined since the early 1990s, consistent with total emissions (sum of anthropogenic and natural sources) being nearly constant during this period. It is *very likely*[6] that the observed increase in methane concentration is due to anthropogenic activities, predominantly agriculture and fossil fuel use, but relative contributions from different source types are not well determined. {2.3, 7.4}

- The global atmospheric nitrous oxide concentration increased from a pre-industrial value of about 270 ppb to 319 ppb in 2005. The growth rate has been approximately constant since 1980. More than a third of all nitrous oxide emissions are anthropogenic and are primarily due to agriculture. {2.3, 7.4}

The understanding of anthropogenic warming and cooling influences on climate has improved since the TAR, leading to *very high confidence*[7] that the global average net effect of human activities since 1750 has been one of warming, with a radiative forcing of +1.6 [+0.6 to +2.4] W m^{-2} (see Figure SPM.2). {2.3., 6.5, 2.9}

- The combined radiative forcing due to increases in carbon dioxide, methane, and nitrous oxide is +2.30 [+2.07 to +2.53] W m^{-2}, and its rate of increase during the industrial era is *very likely* to have been unprecedented in more than 10,000 years (see Figures

[6] In this Summary for Policymakers, the following terms have been used to indicate the assessed likelihood, using expert judgement, of an outcome or a result: *Virtually certain* > 99% probability of occurrence, *Extremely likely* > 95%, *Very likely* > 90%, *Likely* > 66%, *More likely than not* > 50%, *Unlikely* < 33%, *Very unlikely* < 10%, *Extremely unlikely* < 5% (see Box TS.1 for more details).

[7] In this Summary for Policymakers the following levels of confidence have been used to express expert judgements on the correctness of the underlying science: *very high confidence* represents at least a 9 out of 10 chance of being correct; *high confidence* represents about an 8 out of 10 chance of being correct (see Box TS.1)

SPM.1 and SPM.2). The carbon dioxide radiative forcing increased by 20% from 1995 to 2005, the largest change for any decade in at least the last 200 years. {2.3, 6.4}

- Anthropogenic contributions to aerosols (primarily sulphate, organic carbon, black carbon, nitrate and dust) together produce a cooling effect, with a total direct radiative forcing of –0.5 [–0.9 to –0.1] W m^{-2} and an indirect cloud albedo forcing of –0.7 [–1.8 to –0.3] W m^{-2}. These forcings are now better understood than at the time of the TAR due to improved *in situ*, satellite and ground-based measurements and more comprehensive modelling, but remain the dominant uncertainty in radiative forcing. Aerosols also influence cloud lifetime and precipitation. {2.4, 2.9, 7.5}

- Significant anthropogenic contributions to radiative forcing come from several other sources. Tropospheric ozone changes due to emissions of ozone-forming chemicals (nitrogen oxides, carbon monoxide, and hydrocarbons) contribute +0.35 [+0.25 to +0.65] W m^{-2}. The direct radiative forcing due to changes in halocarbons[8] is +0.34 [+0.31 to +0.37] W m^{-2}. Changes in surface albedo, due to land cover changes and deposition of black carbon aerosols on snow, exert

Radiative Forcing Components

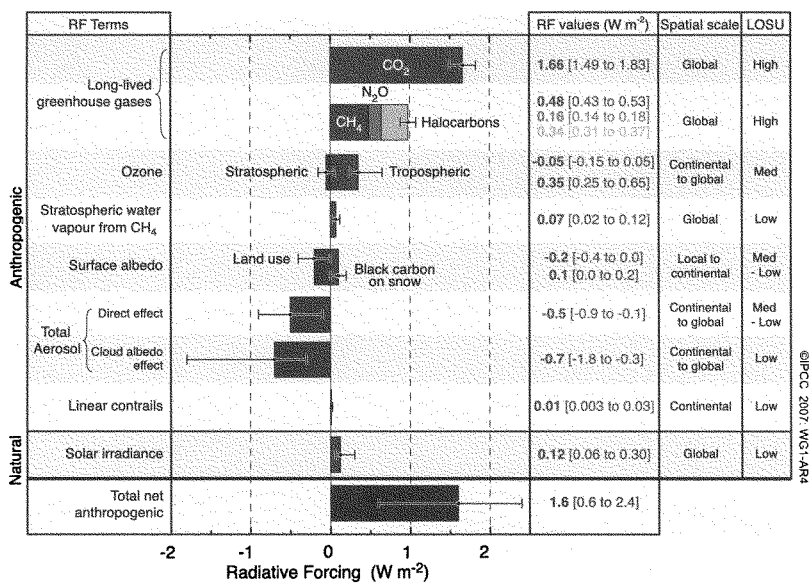

Figure SPM.2. *Global average radiative forcing (RF) estimates and ranges in 2005 for anthropogenic carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). The net anthropogenic radiative forcing and its range are also shown. These require summing asymmetric uncertainty estimates from the component terms, and cannot be obtained by simple addition. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional natural forcing but are not included in this figure due to their episodic nature. The range for linear contrails does not include other possible effects of aviation on cloudiness. {2.9, Figure 2.20}*

[8] Halocarbon radiative forcing has been recently assessed in detail in *IPCC's Special Report on Safeguarding the Ozone Layer and the Global Climate System* (2005).

respective forcings of –0.2 [–0.4 to 0.0] and +0.1 [0.0 to +0.2] W m^{-2}. Additional terms smaller than ±0.1 W m^{-2} are shown in Figure SPM.2. {2.3, 2.5, 7.2}

- Changes in solar irradiance since 1750 are estimated to cause a radiative forcing of +0.12 [+0.06 to +0.30] W m^{-2}, which is less than half the estimate given in the TAR. {2.7}

Direct Observations of Recent Climate Change

Since the TAR, progress in understanding how climate is changing in space and in time has been gained through improvements and extensions of numerous datasets and data analyses, broader geographical coverage, better understanding of uncertainties, and a wider variety of measurements. Increasingly comprehensive observations are available for glaciers and snow cover since the 1960s, and for sea level and ice sheets since about the past decade. However, data coverage remains limited in some regions.

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (see Figure SPM.3). {3.2, 4.2, 5.5}

- Eleven of the last twelve years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature[9] (since 1850). The updated 100-year linear trend (1906 to 2005) of 0.74°C [0.56°C to 0.92°C] is therefore larger than the corresponding trend for 1901 to 2000 given in the TAR of 0.6°C [0.4°C to 0.8°C]. The linear warming trend over the last 50 years (0.13°C [0.10°C to 0.16°C] per decade) is nearly twice that for the last 100 years. The total temperature increase from 1850–1899 to 2001–2005 is 0.76°C [0.57°C to 0.95°C]. Urban heat island effects are real but local, and have a negligible influence (less than 0.006°C per decade over land and zero over the oceans) on these values. {3.2}

- New analyses of balloon-borne and satellite measurements of lower- and mid-tropospheric temperature show warming rates that are similar to those of the surface temperature record and are consistent within their respective uncertainties, largely reconciling a discrepancy noted in the TAR. {3.2, 3.4}

- The average atmospheric water vapour content has increased since at least the 1980s over land and ocean as well as in the upper troposphere. The increase is broadly consistent with the extra water vapour that warmer air can hold. {3.4}

- Observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3000 m and that the ocean has been absorbing more than 80% of the heat added to the climate system. Such warming causes seawater to expand, contributing to sea level rise (see Table SPM.1). {5.2, 5.5}

- Mountain glaciers and snow cover have declined on average in both hemispheres. Widespread decreases in glaciers and ice caps have contributed to sea level rise (ice caps do not include contributions from the Greenland and Antarctic Ice Sheets). (See Table SPM.1.) {4.6, 4.7, 4.8, 5.5}

- New data since the TAR now show that losses from the ice sheets of Greenland and Antarctica have *very likely* contributed to sea level rise over 1993 to 2003 (see Table SPM.1). Flow speed has increased for some Greenland and Antarctic outlet glaciers, which drain ice from the interior of the ice sheets. The corresponding increased ice sheet mass loss has often followed thinning, reduction or loss of ice shelves or loss of floating glacier tongues. Such dynamical ice loss is sufficient to explain most of the Antarctic net mass loss and approximately half of the Greenland net mass loss. The remainder of the ice loss from Greenland has occurred because losses due to melting have exceeded accumulation due to snowfall. {4.6, 4.8, 5.5}

- Global average sea level rose at an average rate of 1.8 [1.3 to 2.3] mm per year over 1961 to 2003. The rate was faster over 1993 to 2003: about 3.1 [2.4 to 3.8] mm per year. Whether the faster rate for 1993 to 2003 reflects decadal variability or an increase in the longer-term trend is unclear. There is *high confidence* that

[9] The average of near-surface air temperature over land and sea surface temperature.

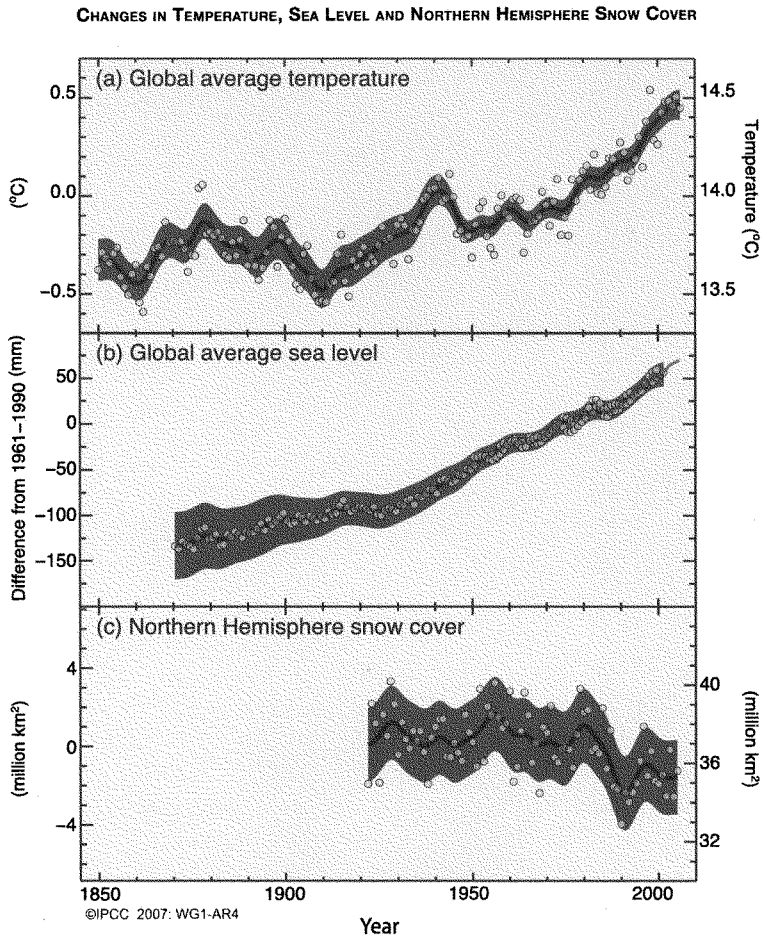

Figure SPM.3. *Observed changes in (a) global average surface temperature, (b) global average sea level from tide gauge (blue) and satellite (red) data and (c) Northern Hemisphere snow cover for March-April. All changes are relative to corresponding averages for the period 1961–1990. Smoothed curves represent decadal average values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series (c). {FAQ 3.1, Figure 1, Figure 4.2, Figure 5.13}*

the rate of observed sea level rise increased from the 19th to the 20th century. The total 20th-century rise is estimated to be 0.17 [0.12 to 0.22] m. {5.5}

- For 1993 to 2003, the sum of the climate contributions is consistent within uncertainties with the total sea level rise that is directly observed (see Table SPM.1). These estimates are based on improved satellite and *in situ* data now available. For the period 1961 to 2003, the sum of climate contributions is estimated to be smaller than the observed sea level rise. The TAR reported a similar discrepancy for 1910 to 1990. {5.5}

At continental, regional and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones.[10] {3.2, 3.3, 3.4, 3.5, 3.6, 5.2}

- Average arctic temperatures increased at almost twice the global average rate in the past 100 years. Arctic temperatures have high decadal variability, and a warm period was also observed from 1925 to 1945. {3.2}
- Satellite data since 1978 show that annual average arctic sea ice extent has shrunk by 2.7 [2.1 to 3.3]% per decade, with larger decreases in summer of 7.4 [5.0 to 9.8]% per decade. These values are consistent with those reported in the TAR. {4.4}
- Temperatures at the top of the permafrost layer have generally increased since the 1980s in the Arctic (by up to 3°C). The maximum area covered by seasonally frozen ground has decreased by about 7% in the Northern Hemisphere since 1900, with a decrease in spring of up to 15%. {4.7}
- Long-term trends from 1900 to 2005 have been observed in precipitation amount over many large regions.[11] Significantly increased precipitation has been observed in eastern parts of North and South America, northern Europe and northern and central Asia. Drying has been observed in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. Precipitation is highly variable spatially and temporally, and data are limited in some regions. Long-term trends have not been observed for the other large regions assessed.[11] {3.3, 3.9}
- Changes in precipitation and evaporation over the oceans are suggested by freshening of mid- and high-latitude waters together with increased salinity in low-latitude waters. {5.2}

Table SPM.1. *Observed rate of sea level rise and estimated contributions from different sources. {5.5, Table 5.3}*

Source of sea level rise	Rate of sea level rise (mm per year) 1961–2003	1993–2003
Thermal expansion	0.42 ± 0.12	1.6 ± 0.5
Glaciers and ice caps	0.50 ± 0.18	0.77 ± 0.22
Greenland Ice Sheet	0.05 ± 0.12	0.21 ± 0.07
Antarctic Ice Sheet	0.14 ± 0.41	0.21 ± 0.35
Sum of individual climate contributions to sea level rise	1.1 ± 0.5	2.8 ± 0.7
Observed total sea level rise	1.8 ± 0.5[a]	3.1 ± 0.7[a]
Difference (Observed minus sum of estimated climate contributions)	0.7 ± 0.7	0.3 ± 1.0

Table note:
[a] Data prior to 1993 are from tide gauges and after 1993 are from satellite altimetry.

[10] Tropical cyclones include hurricanes and typhoons.

[11] The assessed regions are those considered in the regional projections chapter of the TAR and in Chapter 11 of this report.

- Mid-latitude westerly winds have strengthened in both hemispheres since the 1960s. {3.5}

- More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics. Increased drying linked with higher temperatures and decreased precipitation has contributed to changes in drought. Changes in sea surface temperatures, wind patterns and decreased snowpack and snow cover have also been linked to droughts. {3.3}

- The frequency of heavy precipitation events has increased over most land areas, consistent with warming and observed increases of atmospheric water vapour. {3.8, 3.9}

- Widespread changes in extreme temperatures have been observed over the last 50 years. Cold days, cold nights and frost have become less frequent, while hot days, hot nights and heat waves have become more frequent (see Table SPM.2). {3.8}

Table SPM.2. *Recent trends, assessment of human influence on the trend and projections for extreme weather events for which there is an observed late-20th century trend. {Tables 3.7, 3.8, 9.4; Sections 3.8, 5.5, 9.7, 11.2–11.9}*

Phenomenon[a] and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of a human contribution to observed trend[b]	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	*Very likely*[c]	*Likely*[d]	*Virtually certain*[d]
Warmer and more frequent hot days and nights over most land areas	*Very likely*[e]	*Likely (nights)*[d]	*Virtually certain*[d]
Warm spells/heat waves. Frequency increases over most land areas	*Likely*	*More likely than not*[f]	*Very likely*
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*Likely*	*More likely than not*[f]	*Very likely*
Area affected by droughts increases	*Likely* in many regions since 1970s	*More likely than not*	*Likely*
Intense tropical cyclone activity increases	*Likely* in some regions since 1970	*More likely than not*[f]	*Likely*
Increased incidence of extreme high sea level (excludes tsunamis)[g]	*Likely*	*More likely than not*[f,h]	*Likely*[i]

Table notes:

[a] See Table 3.7 for further details regarding definitions.

[b] See Table TS.4, Box TS.5 and Table 9.4.

[c] Decreased frequency of cold days and nights (coldest 10%).

[d] Warming of the most extreme days and nights each year.

[e] Increased frequency of hot days and nights (hottest 10%).

[f] Magnitude of anthropogenic contributions not assessed. Attribution for these phenomena based on expert judgement rather than formal attribution studies.

[g] Extreme high sea level depends on average sea level and on regional weather systems. It is defined here as the highest 1% of hourly values of observed sea level at a station for a given reference period.

[h] Changes in observed extreme high sea level closely follow the changes in average sea level. {5.5} It is *very likely* that anthropogenic activity contributed to a rise in average sea level. {9.5}

[i] In all scenarios, the projected global average sea level at 2100 is higher than in the reference period. {10.6} The effect of changes in regional weather systems on sea level extremes has not been assessed.

- There is observational evidence for an increase in intense tropical cyclone activity in the North Atlantic since about 1970, correlated with increases of tropical sea surface temperatures. There are also suggestions of increased intense tropical cyclone activity in some other regions where concerns over data quality are greater. Multi-decadal variability and the quality of the tropical cyclone records prior to routine satellite observations in about 1970 complicate the detection of long-term trends in tropical cyclone activity. There is no clear trend in the annual numbers of tropical cyclones. {3.8}

Some aspects of climate have not been observed to change. {3.2, 3.8, 4.4, 5.3}

- A decrease in diurnal temperature range (DTR) was reported in the TAR, but the data available then extended only from 1950 to 1993. Updated observations reveal that DTR has not changed from 1979 to 2004 as both day- and night-time temperature have risen at about the same rate. The trends are highly variable from one region to another. {3.2}

- Antarctic sea ice extent continues to show interannual variability and localised changes but no statistically significant average trends, consistent with the lack of warming reflected in atmospheric temperatures averaged across the region. {3.2, 4.4}

- There is insufficient evidence to determine whether trends exist in the meridional overturning circulation (MOC) of the global ocean or in small-scale phenomena such as tornadoes, hail, lightning and dust-storms. {3.8, 5.3}

A Palaeoclimatic Perspective

Palaeoclimatic studies use changes in climatically sensitive indicators to infer past changes in global climate on time scales ranging from decades to millions of years. Such proxy data (e.g., tree ring width) may be influenced by both local temperature and other factors such as precipitation, and are often representative of particular seasons rather than full years. Studies since the TAR draw increased confidence from additional data showing coherent behaviour across multiple indicators in different parts of the world. However, uncertainties generally increase with time into the past due to increasingly limited spatial coverage.

Palaeoclimatic information supports the interpretation that the warmth of the last half century is unusual in at least the previous 1,300 years. The last time the polar regions were significantly warmer than present for an extended period (about 125,000 years ago), reductions in polar ice volume led to 4 to 6 m of sea level rise. {6.4, 6.6}

- Average Northern Hemisphere temperatures during the second half of the 20th century were *very likely* higher than during any other 50-year period in the last 500 years and *likely* the highest in at least the past 1,300 years. Some recent studies indicate greater variability in Northern Hemisphere temperatures than suggested in the TAR, particularly finding that cooler periods existed in the 12th to 14th, 17th and 19th centuries. Warmer periods prior to the 20th century are within the uncertainty range given in the TAR. {6.6}

- Global average sea level in the last interglacial period (about 125,000 years ago) was *likely* 4 to 6 m higher than during the 20th century, mainly due to the retreat of polar ice. Ice core data indicate that average polar temperatures at that time were 3°C to 5°C higher than present, because of differences in the Earth's orbit. The Greenland Ice Sheet and other arctic ice fields *likely* contributed no more than 4 m of the observed sea level rise. There may also have been a contribution from Antarctica. {6.4}

Understanding and Attributing Climate Change

This assessment considers longer and improved records, an expanded range of observations and improvements in the simulation of many aspects of climate and its variability based on studies since the TAR. It also considers the results of new attribution studies that have evaluated whether observed changes are quantitatively consistent with the expected response to external forcings and inconsistent with alternative physically plausible explanations.

Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.[12] This is an advance since the TAR's conclusion that "most of the observed warming over the last 50 years is *likely* to have been due to the increase in greenhouse gas concentrations". Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns (see Figure SPM.4 and Table SPM.2). {9.4, 9.5}

- It is *likely* that increases in greenhouse gas concentrations alone would have caused more warming than observed because volcanic and anthropogenic aerosols have offset some warming that would otherwise have taken place. {2.9, 7.5, 9.4}

- The observed widespread warming of the atmosphere and ocean, together with ice mass loss, support the conclusion that it is *extremely unlikely* that global climate change of the past 50 years can be explained without external forcing, and *very likely* that it is not due to known natural causes alone. {4.8, 5.2, 9.4, 9.5, 9.7}

- Warming of the climate system has been detected in changes of surface and atmospheric temperatures in the upper several hundred metres of the ocean, and in contributions to sea level rise. Attribution studies have established anthropogenic contributions to all of these changes. The observed pattern of tropospheric warming and stratospheric cooling is *very likely* due to the combined influences of greenhouse gas increases and stratospheric ozone depletion. {3.2, 3.4, 9.4, 9.5}

- It is *likely* that there has been significant anthropogenic warming over the past 50 years averaged over each continent except Antarctica (see Figure SPM.4). The observed patterns of warming, including greater warming over land than over the ocean, and their changes over time, are only simulated by models that include anthropogenic forcing. The ability of coupled climate models to simulate the observed temperature evolution on each of six continents provides stronger evidence of human influence on climate than was available in the TAR. {3.2, 9.4}

- Difficulties remain in reliably simulating and attributing observed temperature changes at smaller scales. On these scales, natural climate variability is relatively larger, making it harder to distinguish changes expected due to external forcings. Uncertainties in local forcings and feedbacks also make it difficult to estimate the contribution of greenhouse gas increases to observed small-scale temperature changes. {8.3, 9.4}

- Anthropogenic forcing is *likely* to have contributed to changes in wind patterns,[13] affecting extra-tropical storm tracks and temperature patterns in both hemispheres. However, the observed changes in the Northern Hemisphere circulation are larger than simulated in response to 20th-century forcing change. {3.5, 3.6, 9.5, 10.3}

- Temperatures of the most extreme hot nights, cold nights and cold days are *likely* to have increased due to anthropogenic forcing. It is *more likely than not* that anthropogenic forcing has increased the risk of heat waves (see Table SPM.2). {9.4}

[12] Consideration of remaining uncertainty is based on current methodologies.

[13] In particular, the Southern and Northern Annular Modes and related changes in the North Atlantic Oscillation. {3.6, 9.5, Box TS.2}

Global and Continental Temperature Change

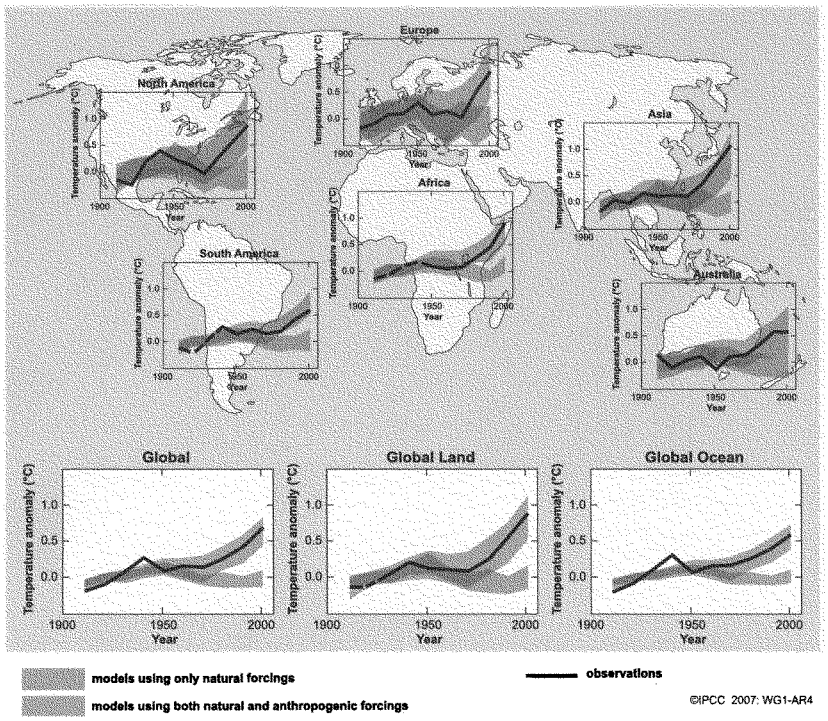

Figure SPM.4. *Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906 to 2005 (black line) plotted against the centre of the decade and relative to the corresponding average for 1901–1950. Lines are dashed where spatial coverage is less than 50%. Blue shaded bands show the 5–95% range for 19 simulations from five climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5–95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings. {FAQ 9.2, Figure 1}*

Analysis of climate models together with constraints from observations enables an assessed *likely* range to be given for climate sensitivity for the first time and provides increased confidence in the understanding of the climate system response to radiative forcing. {6.6, 8.6, 9.6, Box 10.2}

- The equilibrium climate sensitivity is a measure of the climate system response to sustained radiative forcing. It is not a projection but is defined as the global average surface warming following a doubling of carbon dioxide concentrations. It is *likely* to be in the range 2°C to 4.5°C with a best estimate of about 3°C, and is *very unlikely* to be less than 1.5°C. Values substantially higher than 4.5°C cannot be excluded, but agreement of models with observations is not as good for those values. Water vapour changes represent the largest feedback affecting climate sensitivity and are now better understood than in the TAR. Cloud feedbacks remain the largest source of uncertainty. {8.6, 9.6, Box 10.2}

- It is *very unlikely* that climate changes of at least the seven centuries prior to 1950 were due to variability generated within the climate system alone. A significant fraction of the reconstructed Northern Hemisphere inter-decadal temperature variability over those centuries is *very likely* attributable to volcanic eruptions and changes in solar irradiance, and it is *likely* that anthropogenic forcing contributed to the early 20th-century warming evident in these records. {2.7, 2.8, 6.6, 9.3}

Projections of Future Changes in Climate

A major advance of this assessment of climate change projections compared with the TAR is the large number of simulations available from a broader range of models. Taken together with additional information from observations, these provide a quantitative basis for estimating likelihoods for many aspects of future climate change. Model simulations cover a range of possible futures including idealised emission or concentration assumptions. These include SRES[14] illustrative marker scenarios for the 2000 to 2100 period and model experiments with greenhouse gases and aerosol concentrations held constant after year 2000 or 2100.

For the next two decades, a warming of about 0.2°C per decade is projected for a range of SRES emission scenarios. Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected. {10.3, 10.7}

- Since IPCC's first report in 1990, assessed projections have suggested global average temperature increases between about 0.15°C and 0.3°C per decade for 1990 to 2005. This can now be compared with observed values of about 0.2°C per decade, strengthening confidence in near-term projections. {1.2, 3.2}

- Model experiments show that even if all radiative forcing agents were held constant at year 2000 levels, a further warming trend would occur in the next two decades at a rate of about 0.1°C per decade, due mainly to the slow response of the oceans. About twice as much warming (0.2°C per decade) would be expected if emissions are within the range of the SRES scenarios. Best-estimate projections from models indicate that decadal average warming over each inhabited continent by 2030 is insensitive to the choice among SRES scenarios and is *very likely* to be at least twice as large as the corresponding model-estimated natural variability during the 20th century. {9.4, 10.3, 10.5, 11.2–11.7, Figure TS-29}

[14] SRES refers to the *IPCC Special Report on Emission Scenarios* (2000). The SRES scenario families and illustrative cases, which did not include additional climate initiatives, are summarised in a box at the end of this Summary for Policymakers. Approximate carbon dioxide equivalent concentrations corresponding to the computed radiative forcing due to anthropogenic greenhouse gases and aerosols in 2100 (see p. 823 of the TAR) for the SRES B1, A1T, B2, A1B, A2 and A1FI illustrative marker scenarios are about 600, 700, 800, 850, 1250 and 1,550 ppm respectively. Scenarios B1, A1B and A2 have been the focus of model intercomparison studies and many of those results are assessed in this report.

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. {10.3}

- Advances in climate change modelling now enable best estimates and *likely* assessed uncertainty ranges to be given for projected warming for different emission scenarios. Results for different emission scenarios are provided explicitly in this report to avoid loss of this policy-relevant information. Projected global average surface warmings for the end of the 21st century (2090–2099) relative to 1980–1999 are shown in Table SPM.3. These illustrate the differences between lower and higher SRES emission scenarios, and the projected warming uncertainty associated with these scenarios. {10.5}

- Best estimates and *likely* ranges for global average surface air warming for six SRES emissions marker scenarios are given in this assessment and are shown in Table SPM.3. For example, the best estimate for the low scenario (B1) is 1.8°C (*likely* range is 1.1°C to 2.9°C), and the best estimate for the high scenario (A1FI) is 4.0°C (*likely* range is 2.4°C to 6.4°C). Although these projections are broadly consistent with the span quoted in the TAR (1.4°C to 5.8°C), they are not directly comparable (see Figure SPM.5). The Fourth Assessment Report is more advanced as it provides best estimates and an assessed likelihood range for each of the marker scenarios. The new assessment of the *likely* ranges now relies on a larger number of climate models of increasing complexity and realism, as well as new information regarding the nature of feedbacks from the carbon cycle and constraints on climate response from observations. {10.5}

- Warming tends to reduce land and ocean uptake of atmospheric carbon dioxide, increasing the fraction of anthropogenic emissions that remains in the atmosphere. For the A2 scenario, for example, the climate-carbon cycle feedback increases the corresponding global average warming at 2100 by more than 1°C. Assessed upper ranges for temperature projections are larger than in the TAR (see Table SPM.3) mainly because the broader range of models now available suggests stronger climate-carbon cycle feedbacks. {7.3, 10.5}

- Model-based projections of global average sea level rise at the end of the 21st century (2090–2099) are shown in Table SPM.3. For each scenario, the midpoint of the range in Table SPM.3 is within 10% of the

Table SPM.3. *Projected global average surface warming and sea level rise at the end of the 21st century. {10.5, 10.6, Table 10.7}*

	Temperature Change (°C at 2090-2099 relative to 1980-1999)[a]		Sea Level Rise (m at 2090-2099 relative to 1980-1999)
Case	Best estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations[b]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

Table notes:
[a] These estimates are assessed from a hierarchy of models that encompass a simple climate model, several Earth System Models of Intermediate Complexity and a large number of Atmosphere-Ocean General Circulation Models (AOGCMs).
[b] Year 2000 constant composition is derived from AOGCMs only.

Multi-Model Averages and Assessed Ranges for Surface Warming

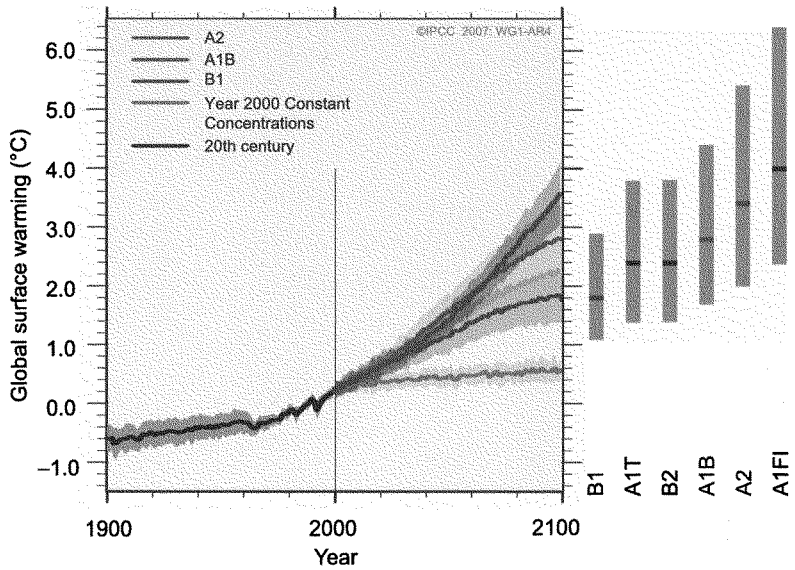

Figure SPM.5. *Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. Shading denotes the ±1 standard deviation range of individual model annual averages. The orange line is for the experiment where concentrations were held constant at year 2000 values. The grey bars at right indicate the best estimate (solid line within each bar) and the* ***likely*** *range assessed for the six SRES marker scenarios. The assessment of the best estimate and* ***likely*** *ranges in the grey bars includes the AOGCMs in the left part of the figure, as well as results from a hierarchy of independent models and observational constraints. {Figures 10.4 and 10.29}*

TAR model average for 2090–2099. The ranges are narrower than in the TAR mainly because of improved information about some uncertainties in the projected contributions.[15] {10.6}

- Models used to date do not include uncertainties in climate-carbon cycle feedback nor do they include the full effects of changes in ice sheet flow, because a basis in published literature is lacking. The projections include a contribution due to increased ice flow from Greenland and Antarctica at the rates observed for 1993 to 2003, but these flow rates could increase or decrease in the future. For example, if this contribution were to grow linearly with global average temperature change, the upper ranges of sea level rise for SRES scenarios shown in Table SPM.3 would increase by 0.1 to 0.2 m. Larger values cannot be excluded, but understanding of these effects is too limited to assess their likelihood or provide a best estimate or an upper bound for sea level rise. {10.6}

- Increasing atmospheric carbon dioxide concentrations lead to increasing acidification of the ocean. Projections based on SRES scenarios give reductions in average global surface ocean pH[16] of between 0.14 and 0.35 units over the 21st century, adding to the present decrease of 0.1 units since pre-industrial times. {5.4, Box 7.3, 10.4}

[15] TAR projections were made for 2100, whereas projections in this report are for 2090–2099. The TAR would have had similar ranges to those in Table SPM.3 if it had treated the uncertainties in the same way.

[16] Decreases in pH correspond to increases in acidity of a solution. See Glossary for further details.

There is now higher confidence in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation and some aspects of extremes and of ice. {8.2, 8.3, 8.4, 8.5, 9.4, 9.5, 10.3, 11.1}

- Projected warming in the 21st century shows scenario-independent geographical patterns similar to those observed over the past several decades. Warming is expected to be greatest over land and at most high northern latitudes, and least over the Southern Ocean and parts of the North Atlantic Ocean (see Figure SPM.6). {10.3}

- Snow cover is projected to contract. Widespread increases in thaw depth are projected over most permafrost regions. {10.3, 10.6}

- Sea ice is projected to shrink in both the Arctic and Antarctic under all SRES scenarios. In some projections, arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century. {10.3}

- It is *very likely* that hot extremes, heat waves and heavy precipitation events will continue to become more frequent. {10.3}

- Based on a range of models, it is *likely* that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases of tropical sea surface temperatures. There is less confidence in projections of a global decrease in numbers of tropical cyclones. The apparent increase in the proportion of very intense storms since 1970 in some regions is much larger than simulated by current models for that period. {9.5, 10.3, 3.8}

Projections of Surface Temperatures

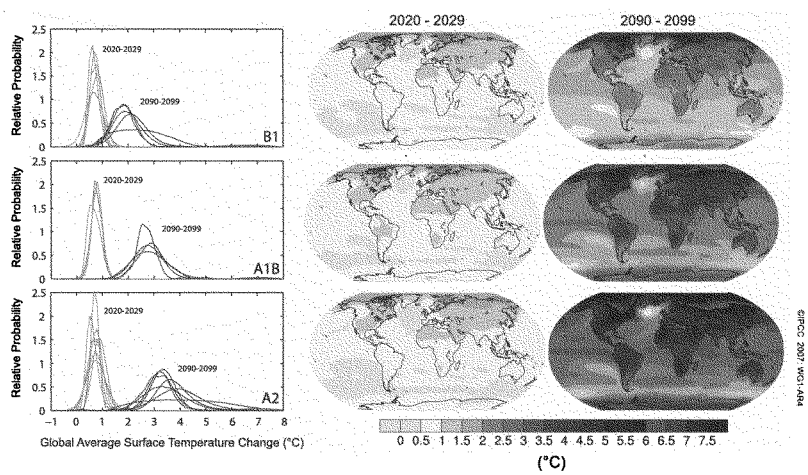

Figure SPM.6. *Projected surface temperature changes for the early and late 21st century relative to the period 1980–1999. The central and right panels show the AOGCM multi-model average projections for the B1 (top), A1B (middle) and A2 (bottom) SRES scenarios averaged over the decades 2020–2029 (centre) and 2090–2099 (right). The left panels show corresponding uncertainties as the relative probabilities of estimated global average warming from several different AOGCM and Earth System Model of Intermediate Complexity studies for the same periods. Some studies present results only for a subset of the SRES scenarios, or for various model versions. Therefore the difference in the number of curves shown in the left-hand panels is due only to differences in the availability of results. {Figures 10.8 and 10.28}*

Projected Patterns of Precipitation Changes

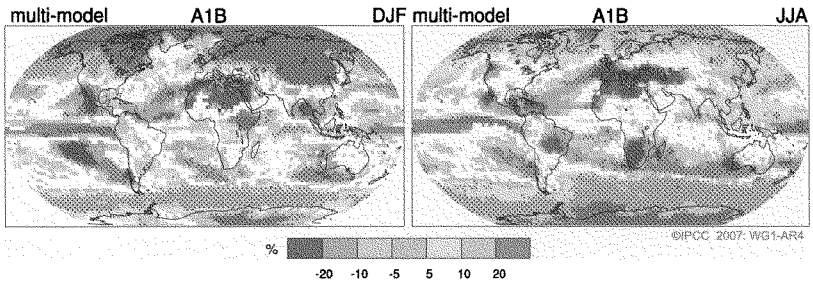

Figure SPM.7. *Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. {Figure 10.9}*

- Extratropical storm tracks are projected to move poleward, with consequent changes in wind, precipitation and temperature patterns, continuing the broad pattern of observed trends over the last half-century. {3.6, 10.3}

- Since the TAR, there is an improving understanding of projected patterns of precipitation. Increases in the amount of precipitation are *very likely* in high latitudes, while decreases are *likely* in most subtropical land regions (by as much as about 20% in the A1B scenario in 2100, see Figure SPM.7), continuing observed patterns in recent trends. {3.3, 8.3, 9.5, 10.3, 11.2 to 11.9}

- Based on current model simulations, it is *very likely* that the meridional overturning circulation (MOC) of the Atlantic Ocean will slow down during the 21st century. The multi-model average reduction by 2100 is 25% (range from zero to about 50%) for SRES emission scenario A1B. Temperatures in the Atlantic region are projected to increase despite such changes due to the much larger warming associated with projected increases in greenhouse gases. It is *very unlikely* that the MOC will undergo a large abrupt transition during the 21st century. Longer-term changes in the MOC cannot be assessed with confidence. {10.3, 10.7}

Anthropogenic warming and sea level rise would continue for centuries due to the time scales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilised. {10.4, 10.5, 10.7}

- Climate-carbon cycle coupling is expected to add carbon dioxide to the atmosphere as the climate system warms, but the magnitude of this feedback is uncertain. This increases the uncertainty in the trajectory of carbon dioxide emissions required to achieve a particular stabilisation level of atmospheric carbon dioxide concentration. Based on current understanding of climate-carbon cycle feedback, model studies suggest that to stabilise at 450 ppm carbon dioxide could require that cumulative emissions over the 21st century be reduced from an average of approximately 670 [630 to 710] GtC (2460 [2310 to 2600] $GtCO_2$) to approximately 490 [375 to 600] GtC (1800 [1370 to 2200] $GtCO_2$). Similarly, to stabilise at 1000 ppm, this feedback could require that cumulative emissions be reduced from a model average of approximately 1415 [1340 to 1490] GtC (5190 [4910 to 5460] $GtCO_2$) to approximately 1100 [980 to 1250] GtC (4030 [3590 to 4580] $GtCO_2$). {7.3, 10.4}

- If radiative forcing were to be stabilised in 2100 at B1 or A1B levels[14] a further increase in global average temperature of about 0.5°C would still be expected, mostly by 2200. {10.7}

- If radiative forcing were to be stabilised in 2100 at A1B levels[14], thermal expansion alone would lead to 0.3 to 0.8 m of sea level rise by 2300 (relative to 1980–1999). Thermal expansion would continue for many centuries, due to the time required to transport heat into the deep ocean. {10.7}

- Contraction of the Greenland Ice Sheet is projected to continue to contribute to sea level rise after 2100. Current models suggest that ice mass losses increase with temperature more rapidly than gains due to precipitation and that the surface mass balance becomes negative at a global average warming (relative to pre-industrial values) in excess of 1.9°C to 4.6°C. If a negative surface mass balance were sustained for millennia, that would lead to virtually complete elimination of the Greenland Ice Sheet and a resulting contribution to sea level rise of about 7 m. The corresponding future temperatures in Greenland are comparable to those inferred for the last interglacial period 125,000 years ago, when palaeoclimatic information suggests reductions of polar land ice extent and 4 to 6 m of sea level rise. {6.4, 10.7}

- Dynamical processes related to ice flow not included in current models but suggested by recent observations could increase the vulnerability of the ice sheets to warming, increasing future sea level rise. Understanding of these processes is limited and there is no consensus on their magnitude. {4.6, 10.7}

- Current global model studies project that the Antarctic Ice Sheet will remain too cold for widespread surface melting and is expected to gain in mass due to increased snowfall. However, net loss of ice mass could occur if dynamical ice discharge dominates the ice sheet mass balance. {10.7}

- Both past and future anthropogenic carbon dioxide emissions will continue to contribute to warming and sea level rise for more than a millennium, due to the time scales required for removal of this gas from the atmosphere. {7.3, 10.3}

The Emission Scenarios of the IPCC Special Report on Emission Scenarios (SRES)[17]

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil-intensive (A1FI), non-fossil energy sources (A1T) or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

An illustrative scenario was chosen for each of the six scenario groups A1B, A1FI, A1T, A2, B1 and B2. All should be considered equally sound.

The SRES scenarios do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.

[17] Emission scenarios are not assessed in this Working Group I Report of the IPCC. This box summarising the SRES scenarios is taken from the TAR and has been subject to prior line-by-line approval by the Panel.

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PAGES 197–208

Counting Atlantic Tropical Cyclones Back to 1900

PAGES 197, 202

Climate variability and any resulting change in the characteristics of tropical cyclones (tropical storms, subtropical storms, and hurricanes) have become topics of great interest and research within the past 2 years [*International Workshop on Tropical Cyclones*, 2006]. An emerging focus is how the frequency of tropical cyclones has changed over time and whether any changes could be linked to anthropogenic global warming.

The Atlantic is the one tropical cyclone basin that has quantitative records back to the mid-nineteenth century for the whole basin (i.e., North Atlantic Ocean, Caribbean Sea, and Gulf of Mexico) [*Jarvinen et al.*, 1984; *Landsea et al.*, 2004]. *Mann and Emanuel* [2006] used this data set to find a positive correlation between sea surface temperatures and Atlantic basin tropical cyclone frequency for the period of 1871–2005. Likewise, *Holland and Webster* [2007] analyzed Atlantic tropical cyclone frequency back to 1855 and found a doubling of the number of tropical cyclones over the past 100 years. Both papers linked these changes directly to anthropogenic greenhouse warming. However, both analyses, with no indication of uncertainty or error bars, presumed that tropical cyclone counts are complete or nearly complete for the entire basin going back in time for at least a century. This article will show that this presumption is not reasonable and that improved monitoring in recent years is responsible for most, if not all, of the observed trend in increasing frequency of tropical cyclones.

Reanalysis of Historical Tropical Cyclone Counts

Mann and Emanuel [2006, p. 238] stated that "although wind estimates prior to the 1940s are problematic, detection of the existence of tropical cyclones is less so, because without aircraft and satellites to warn them off, ships often encountered storms at sea, at least peripherally." *Holland and Webster* [2007] likewise make similar arguments.

By C. W. Landsea

Their assumptions disregarded the recommendations of the original database documentation [*Jarvinen et al.*, 1984] and database extension and reanalysis documentation [*Landsea et al.*, 2004] that tropical cyclones were missed before the mid-twentieth century. In particular, *Landsea et al.* [2004] estimated an undercount bias of zero to six tropical cyclones per year between 1851 and 1885 and zero to four per year between 1886 and 1910. These undercounts roughly take into account the typical size of tropical cyclones, the density of shipping tracks over the Atlantic basin, and the amount of populated coastline. As one goes back further in time, the numbers of ships and shipping lanes decreases and fewer people live in the tropical and subtropical coastal regions. These factors make it increasingly likely that some tropical cyclones would not be counted the farther back in time examined.

Consider the two most active Atlantic hurricane seasons on record (Figure 1): 1933, with 21 tropical cyclones, and 2005, with 28. On the basis of just those cyclones that struck land, 1933 had more impacts (19) than 2005 (17). The difference in frequency between these two years is that there are many more tracks present over the open Atlantic Ocean in 2005 than there were in 1933. Is this evidence of a significant undercount in the historical records?

Here a simple analysis demonstrates the existence of a sizable bias in historical tropical cyclone counts. Figure 2a shows the time series of tropical cyclones going back to 1900, with both multidecadal variations [*Goldenberg et al.*, 2001] and a long-term trend being readily apparent. The data are stratified to indicate which tropical cyclones struck land and which stayed over the open ocean. The former are determined by their center either crossing a coastline or passing within 111 kilometers (60 nautical miles) of a landmass (either island or mainland) as a tropical cyclone.

The year 1900 is chosen as the first in this analysis. It is at about that time that a sufficient number of people lived along the

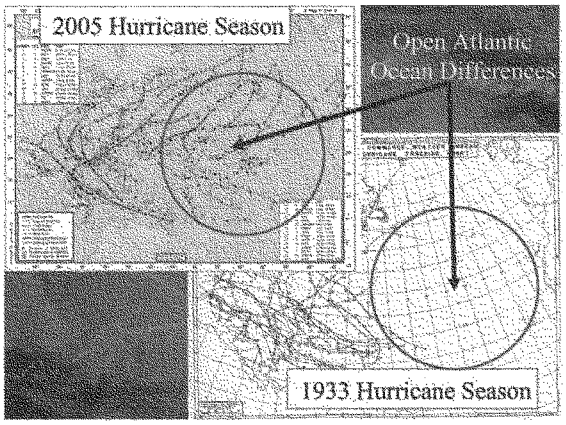

Fig. 1. Track maps of the Atlantic hurricane seasons of 2005 and 1933, the two busiest hurricane years on record for tropical cyclone frequency. The circles highlight large differences in activity that occurred over the open Atlantic Ocean.

Eos, Vol. 88, No. 18, 1 May 2007

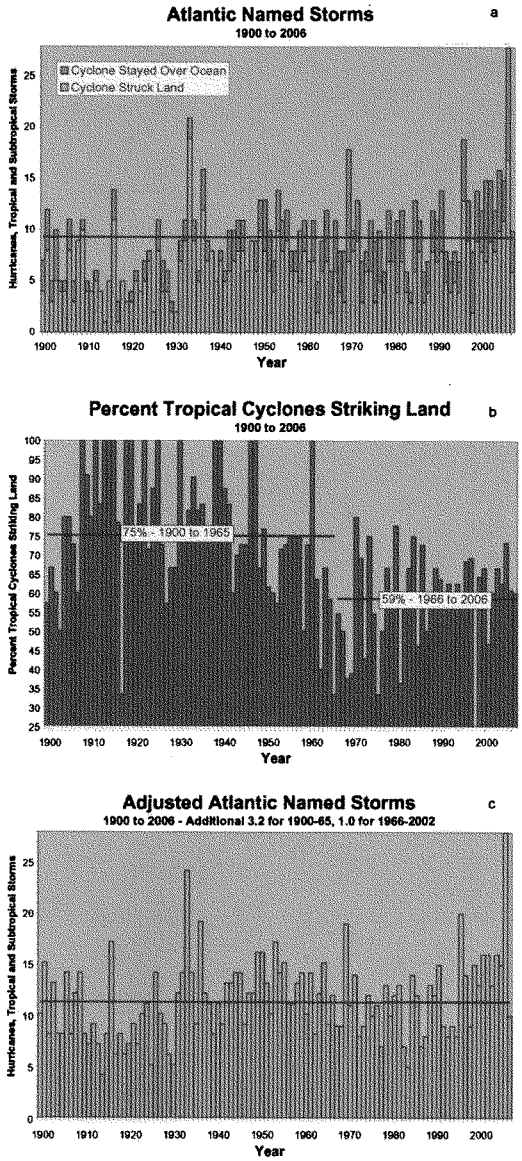

Fig. 2. (a) The 1900–2006 record of number of tropical cyclones in the Atlantic basin, stratified by those that struck land (e.g., as a tropical storm, subtropical storm, or hurricane) versus those that stayed over the open ocean. The solid line is the 1900–2006 long-term mean of 9.2 per year. (b) Percentage of all reported tropical storms, subtropical storms, and hurricanes that struck land. (c) A bias-corrected time series of tropical storms, subtropical storms, and hurricanes to take into account undercounts before the advent of geostationary satellite imagery in 1966 and new technology available since about 2002. The adjusted 1900–2006 long-term mean is 11.5 per year.

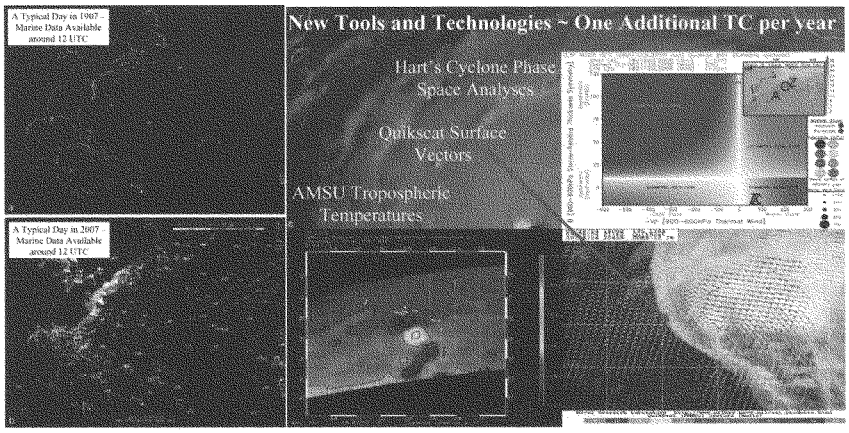

*Fig. 3. (a) Surface marine observations available in the Atlantic basin around 1200 UTC for a typical day in 1907. These observations were based entirely on ship measurements. (b) Same as Figure 3a but for a typical day in 2007. These data include moored and drifting buoys, Quikscat, as well as ship observations. (c) Depiction of new monitoring and analysis technologies (advanced microwave sounding unit tropospheric temperatures [*Brueske and Velden, *2003], Quikscat [*Atlas et al., *2001], and the cyclone phase space analyses [*Hart, *2003]) that have increased Atlantic tropical cyclone counts by about one additional system per year.*

coastline, such that if even a weak tropical storm struck it would likely have been detected and recorded. However, this beginning date of 1900 of having recorded all tropical cyclones that have struck land may be somewhat optimistic, especially for short-lived, relatively weak tropical storms. Consider the detection difficulties of a 1-day tropical cyclone such as Gert, which struck Mexico in 2005 in a sparsely population region of the coast and produced no observed surface tropical storm force winds, caused minimal impact, and was only identified as being a tropical cyclone via satellite imagery and aircraft reconnaissance. Therefore, conclusions from this paper on the number of 'missed' tropical cyclones are likely conservative.

The linear correlation coefficient between the frequency of all tropical storms and those that struck land is a very high 0.87 for 1900–2006. This value might be somewhat surprising given that some years can be quite active yet places such as the continental United States can be relatively untouched (such as what occurred in 2000 and 2001) or seasons that are quiet can have large U.S. impacts (such as 1992 with Hurricane Andrew). The likely reason for such a strong association between the frequency of all tropical cyclones and those that strike land is that taking into consideration all landmasses (i.e., Mexico, Central America, the Caribbean islands, Bermuda, Canada, and the Azores) in addition to the continental United States makes it much more likely that overall busy years will have many landfalls and quiet seasons generally will have fewer tropical cyclone strikes on land.

However, differentiating between the frequency of tropical cyclones that struck land versus those that remained over the open ocean shows that more of the latter were observed in recent decades compared with earlier in the twentieth century (Figure 2a). Figure 2b shows the tropical cyclone data expressed as an annual percentage that make landfall. In the era since geostationary satellite imagery began, in 1966 [*Neumann et al.*, 1999], the average is 59%. While sizable interannual variations are present, this value of slightly more than half is quite stable across the four decades of satellite coverage including periods of both active hurricane seasons (62% from 1995 onward) and a quiet hurricane regime (59% from 1971 to 1994). This value is even steady within the active era between seasons with numerous U.S. landfalling cyclones in 2004 and 2005 (65%) and relative lack of strikes in the United States between 1995 and 2003 (60%). Again, it is likely that the inclusion of tropical cyclones to make landfall in any landmass—in addition to those that just hit the continental United States—minimizes the long-term variability of the percent that strike land caused by genesis location and steering pattern changes.

However, data from the first 66 years, shown in Figure 2b, have a quite different long-term character, with an average of 75% of tropical cyclones striking land. While there were no years with more than 80% striking land from 1966 onward, there were 15 years between 1900 and 1965 in which all (100%) recorded tropical cyclones struck land that season. This difference in the long-term percentage of tropical cyclones that struck land (75% from 1900–1965 versus 59% from 1966–2006) indicates a large bias toward underreporting of tropical cyclones that remained over the open Atlantic Ocean. Even though aircraft reconnaissance began in 1944, this covered only about one half of the Atlantic basin, as systems east of 55°W were generally not monitored or observed with this type of observational platform. Thus aircraft reconnaissance should not have been expected to provide complete monitoring of all tropical cyclone activity in the Atlantic.

'Missed' Cyclones

Assuming that a similar long-term average of about 59% of tropical cyclones actually struck land during 1900–1965, this increases the record by 2.2 additional tropical cyclones per year for this earlier era. Such a broad-brush approach assumes that the amount of shipping remained constant throughout the first two thirds of the twentieth century, which it certainly has not. This technique could, and should, be refined in the future to take into account shipping density variations over time and how this would be manifested in observations of tropical cyclone frequency, duration, and intensity.

The frequency of 'missed' tropical cyclones in the nineteenth century would likely be substantially larger because of the

even sparser coverage from shipping tracks and fewer coastal regions being inhabited. It is to be noted that the late nineteenth century was generally an active period with more recorded tropical cyclones than in the first 25 years of the twentieth century [*Neumann et al.*, 1999; *Landsea et al.*, 2004; *Mann and Emanuel*, 2006], despite fewer observations being available for detecting both coastal and ocean-only tropical cyclones.

The concept that numerous tropical cyclones were missed in the presatellite era should not be surprising given the typical tropical cyclone duration (~1 week), the mesoscale nature of the high winds in a tropical cyclone, and the relative sparse ship-based observations available over the entire North Atlantic Ocean. Figures 3a and 3b demonstrate the vast difference in surface marine observations available today versus those available a century ago.

Moreover, new tools and data sources that have become available just in the past few years are already producing another artificial increase in tropical cyclone frequency (Figure 3c). Quikscat [*Atlas et al.*, 2001], the advanced microwave sounding unit [*Brueske and Velden*, 2003], and the cyclone phase space analyses [*Hart*, 2003] are the primary reasons that the U.S. National Weather Service's National Hurricane Center recognized that Ana of 2003, Otto of 2004, the unnamed subtropical storm of 2005, and the unnamed tropical storm of 2006 (see respective tropical cyclone reports online at http://www.nhc.noaa.gov/pastall.shtml) were tropical cyclones and thus included in the Atlantic tropical cyclone database. These systems would have been considered extratropical cyclones previously and thus not counted as tropical cyclones before the start of the 21st century.

Inclusion of 3.2 additional tropical cyclones per year within 1900–1965 and 1.0 per year from 1966 to 2002 is shown in Figure 2c. Apparent in the adjusted tropical cyclone frequency record are the multidecadal quiet and active periods (quiet up to 1925, active from 1926 to 1970, quiet from 1971 to 1994, and active from 1995 onward) associated with the Atlantic multidecadal oscillation [*Goldenberg et al.*, 2001]. A reanalysis of the trends with the inclusion of these additional tropical cyclones leads to an insignificant trend for both the periods between quiet eras and active eras. This is consistent with the findings of *Solow and Moore* [2002], who did a similar calculation using the U.S. landfalling record.

While efforts are under way to reanalyze the Atlantic hurricane database, which has led to some previously unrecognized tropical cyclones being added into the observational record (averaging 0.9 new tropical cyclones per year between 1886 and 1914 [*Landsea et al.*, 2004]), such efforts will not be able to recover observations of open-ocean tropical cyclones that were just never taken. Researchers cannot assume that the Atlantic tropical cyclone database presents a complete depiction of frequency of events before the advent of satellite imagery in the mid-1960s. Moreover, newly available advanced tools and techniques are also contributing toward monitoring about one additional Atlantic tropical cyclone per year since 2002. Thus large, long-term 'trends' in tropical cyclone frequency are primarily manifestations of increased monitoring capabilities and likely not related to any real change in the climate in which they develop. Obviously, better monitoring in recent decades will also increase our ability to accurately measure tropical cyclone intensity and duration, though these are beyond the scope of this article.

Acknowledgments

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United States Government Accountability Office

GAO

Report to the Committee on Homeland Security and Governmental Affairs, U.S. Senate

March 2007

CLIMATE CHANGE

Financial Risks to Federal and Private Insurers in Coming Decades Are Potentially Significant

GAO-07-285

GAO
Accountability·Integrity·Reliability

Highlights

Highlights of GAO-07-285, a report to the Committee on Homeland Security and Governmental Affairs, U.S. Senate

Why GAO Did This Study

Weather-related events have cost the nation billions of dollars in damages over the past decade. Many of these losses are borne by private insurers and by two federal insurance programs—the National Flood Insurance Program (NFIP), which insures properties against flooding, and the Federal Crop Insurance Corporation (FCIC), which insures crops against drought or other weather disasters.

GAO was asked to (1) describe how climate change may affect future weather-related losses, (2) determine past insured weather-related losses, and (3) determine what major private insurers and federal insurers are doing to prepare for potential increases in such losses. In response, among other things, GAO reviewed key scientific assessments; analyzed insured loss data; and contacted private insurers, NFIP, and FCIC.

What GAO Recommends

GAO is recommending that the Secretaries of Agriculture and Homeland Security analyze the potential long-term fiscal implications of climate change for the FCIC and the NFIP, respectively, and report their findings to the Congress. In commenting on a draft of this report, the two agencies agreed with the recommendation. The Departments of Agriculture and Commerce made comments and suggestions on the presentation of several findings. The Department of Energy elected not to comment.

www.gao.gov/cgi-bin/getrpt?GAO-07-285.

To view the full product, including the scope and methodology, click on the link above. For more information, contact John Stephenson at (202) 512-3841 or stephensonj@gao.gov.

March 2007

CLIMATE CHANGE

Financial Risks to Federal and Private Insurers in Coming Decades Are Potentially Significant

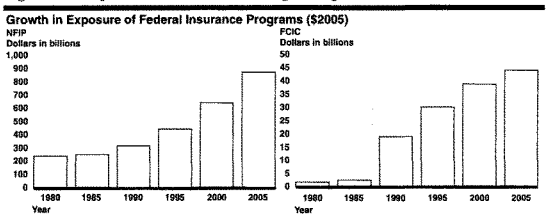
What GAO Found

Key scientific assessments report that the effects of climate change on weather-related events and, subsequently, insured and uninsured losses, could be significant. The global average surface temperature has increased by 0.74 degrees Celsius over the past 100 years and climate models predict additional, perhaps accelerating, increases in temperature. The key assessments GAO reviewed generally found that rising temperatures are expected to increase the frequency and severity of damaging weather-related events, such as flooding or drought, although the timing and magnitude are as yet undetermined. Additional research on the effect of increasing temperatures on weather events is expected in the near future, including a highly anticipated assessment of the state of climate science this year.

Taken together, private and federal insurers paid more than $320 billion in claims on weather-related losses from 1980 to 2005. Claims varied significantly from year to year—largely due to the effects of catastrophic weather events such as hurricanes and droughts—but have generally increased during this period. The growth in population in hazard-prone areas and resulting real estate development have generally increased liabilities for insurers, and have helped to explain the increase in losses. Due to these and other factors, federal insurers' exposure has grown substantially. Since 1980, NFIP's exposure quadrupled, nearing $1 trillion in 2005, and program expansion increased FCIC's exposure 26-fold to $44 billion.

Major private and federal insurers are both exposed to the effects of climate change over coming decades, but are responding differently. Many large private insurers are incorporating climate change into their annual risk management practices, and some are addressing it strategically by assessing its potential long-term industry-wide impacts. The two major federal insurance programs, however, have done little to develop comparable information. GAO acknowledges that the federal insurance programs are not profit-oriented, like private insurers. Nonetheless, a strategic analysis of the potential implications of climate change for the major federal insurance programs would help the Congress manage an emerging high-risk area with significant implications for the nation's growing fiscal imbalance.

Growth in Exposure of Federal Insurance Programs ($2005)



Source: GAO.

Contents

Letter		1
	Results in Brief	3
	Background	6
	Climate Change May Increase Losses by Altering the Frequency or Severity of Weather-Related Events	8
	Insured Weather-Related Losses Have Been Sizeable, and Federal Insurers' Exposure Has Grown Significantly	17
	Major Private and Public Insurers Differ in How They Manage Catastrophic Risks Associated with Climate Change	29
	Conclusions	37
	Recommendation for Executive Action	38
	Agency Comments and Our Evaluation	39
Appendix I	**Scope and Methodology**	41
	Scientific Literature	41
	Insured Loss Data	42
	Interviews with Major Insurers	44
Appendix II	**National Flood Insurance Program**	46
	How the Program Works	47
	Risk Assessment Practices	49
	Program Funding	50
Appendix III	**Federal Crop Insurance Corporation**	51
	How the Program Works	52
	Risk Assessment Practices	53
	Program Funding	55
Appendix IV	**Consensus Statement among Participants at 2006 Munich Re Workshop**	56
Appendix V	**Comments from the U.S. Department of Agriculture**	58
	GAO Comments	61
Appendix VI	**Comments from the Department of Commerce**	63
	GAO Comments	66

Appendix VII **GAO Contact and Staff Acknowledgments** 67

Related GAO Products 68

Tables

Table 1: Selected IPCC Estimates of Confidence in Projected Changes in Weather-Related Events 12
Table 2: Insured Losses Associated with Hurricanes 25
Table 3: Key Policy-Oriented Scientific Assessments Reviewed by GAO 41

Figures

Figure 1: Time Line of Key Scientific Assessments 9
Figure 2: July 1993 Flood Damage at Chesterfield Airport in St. Louis, Missouri 15
Figure 3: Economic Damages by Hurricane Category for U.S. Hurricanes Making Landfall, 1900-2005 16
Figure 4: Annual Weather- and Nonweather-Related Insured Losses 18
Figure 5: Weather-Related Losses Paid by Private Insurers 19
Figure 6: Weather-Related Losses Paid by NFIP 21
Figure 7: Weather-Related Losses Paid by FCIC 22
Figure 8: NFIP Policies and Total Coverage 28
Figure 9: FCIC Total Coverage 29
Figure 10: Modeling Potential Catastrophe Losses 31

Abbreviations

AAA	American Academy of Actuaries
AMO	Atlantic Multidecadal Oscillation
CCSP	Climate Change Science Program
FAIR	Fair Access to Insurance Requirements
FEMA	Federal Emergency Management Agency
FCIC	Federal Crop Insurance Corporation
HUD	Department of Housing and Urban Development
IPCC	Intergovernmental Panel on Climate Change
NAIC	National Association of Insurance Commissioners
NAS	National Academy of Sciences
NFIP	National Flood Insurance Program
NHC	National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
PCS	Property Claim Services
RMA	risk Management Agency
SAP	synthesis and assessment product
SFIP	standard flood insurance policy
USDA	U.S. Department of Agriculture

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United States Government Accountability Office
Washington, DC 20548

March 16, 2007

The Honorable Joseph I. Lieberman
Chairman
The Honorable Susan M. Collins
Ranking Member
Committee on Homeland Security and Governmental Affairs
United States Senate

As the 2004 and 2005 hurricane seasons demonstrated, weather-related events can devastate affected communities and individuals, and are costly to the insurance industry, government disaster assistance programs, and other relief organizations. Apart from the record-setting losses experienced in 2005, weather-related events over the past decade have cost the country tens of billons of dollars each year.

The property and casualty segment of the insurance industry, spanning both the private and public sector, bears a large portion of weather-related losses.[1] The private sector includes primary insurers that insure individuals and businesses directly, and reinsurers that provide insurance to the primary insurers. The public sector includes federal programs—in particular, the National Flood Insurance Program (NFIP), which insures properties at risk of damage from flooding, and the Federal Crop Insurance Corporation (FCIC), which insures crops that are vulnerable to drought, floods, or other natural disasters. Many states also administer insurance pools that provide coverage for losses caused by weather-related events.

The uncertain and potentially large losses associated with weather-related events are among the biggest risks that property insurers face. Virtually anything that is insured—property, crops and livestock, business operations, or human life and health—is vulnerable to weather-related events. To remain financially solvent, the insurance industry must estimate and prepare for the potential impact of weather-related events. As such, any unanticipated changes in the frequency or severity of weather-related

[1]Insurers use the term "loss" to refer to the dollar value of approved or settled claims arising from damages incurred by a policyholder. For the purposes of this report, weather-related loss refers to the dollar value of claims made on damage attributable to weather-related events. "Loss" does not account for premium or other income, deductibles, co-payments, or damages in excess of coverage.

events can have financial consequences at the company level and industry-wide.

The earth's climate and weather patterns are dynamic, varying on seasonal, decadal, and longer time scales. The global average surface temperature has increased by 0..74 degrees Celsius over the past 100 years and climate models predict additional, perhaps accelerating, increases in temperature. While the temperature increases to date may appear small, climate models project that additional changes in temperature may alter social and economic activities in potentially profound ways. Much research and policy debate has centered on the extent to which human activities have contributed to the warming and how much is due to natural variability. For the purposes of this report, *climate change* refers to any change in the climate over time, whether due to natural variability or as a result of human activity.[2] Regardless of the cause, some contend that increasing temperatures—accompanied by changes in other aspects of the climate—may have adverse financial consequences for property insurers, which might slow the growth of the industry and shift more of the burden to governments and individuals.

Concerned about the implications of climate change for weather-related losses incurred by federal agencies and private insurers, you asked us to (1) describe what is known about how climate change might affect insured and uninsured losses, (2) determine insured losses incurred by major federal agencies and private insurers and reinsurers resulting from weather-related events, and (3) determine what major federal agencies and private insurers and reinsurers are doing to prepare for the potential risk of increased losses due to more frequent or more severe weather-related events associated with climate change.

To describe how climate change might affect insured and uninsured losses, we reviewed and summarized key scientific assessments by reputable international and national research organizations, including the Intergovernmental Panel on Climate Change *Third Assessment Report*, National Academy of Sciences reports, and the multifederal agency

[2]More specifically, we used the Intergovernmental Panel on Climate Change definition, which refers to climate change as a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural factors (e.g., internal processes or external forcings such as solar variations or heavy volcanic activity), or to persistent human-induced changes in the composition of the atmosphere or land use patterns.

Climate Change Science Program. To determine insured losses attributable to weather-related events, we analyzed data from 1980 through 2005 from the Department of Homeland Security's Federal Emergency Management Agency (FEMA) for the NFIP; from the Department of Agriculture's Risk Management Agency (RMA) for FCIC; and from the Property Claims Service, a leading source of insurance data. We analyzed changes in weather-related losses since 1980 and supplemented this analysis with a review of existing literature and the views of subject area experts on the key drivers of changes in losses.

To determine what key federal agencies and private insurers are doing to assess and manage the potential for increased losses, we conducted semistructured interviews with officials from the NFIP, RMA, and a sample of the largest private primary insurers and reinsurers in the United States, Europe, and Bermuda. The companies we interviewed represent about 45 percent of the total domestic insurance market but should not be generalized to represent all insurance companies. We also interviewed officials from catastrophe modeling firms, insurance industry associations, the National Association of Insurance Commissioners (NAIC),[3] and universities to provide additional context for respondents' statements. To supplement these interviews, we reviewed documentation of federal agencies' risk management practices, studies by subject area experts, industry reports, insurance company documents, and previous GAO reports. We performed our work between February 2006 and January 2007 in accordance with generally accepted government auditing standards. A more extensive discussion of our scope and methodology appears in appendix I.

Results in Brief

Assessments by the National Academy of Sciences (NAS) and the Intergovernmental Panel on Climate Change (IPCC), a leading source for international climate expertise, report that the effects of climate change on weather-related events and—by extension—weather-related losses could be substantial. IPCC reports that global mean temperatures increased by 0.74 degrees Celsius over the last 100 years and are projected to continue to rise over the next century. Although temperatures have varied throughout history due to natural processes, such as changes in the Earth's orbit and volcanic eruptions, the IPCC and NAS report that the

[3]The National Association of Insurance Commissioners is an organization of insurance regulators from the 50 states, the District of Columbia, and the five U.S. territories.

observed temperature increase during the twentieth century cannot be explained by natural variability alone but is largely attributable to human activities. Warmer surface temperatures are linked to global-scale oceanographic, meteorological, and biological changes. For example, as the earth warms, more water evaporates from oceans and other sources, eventually falling as rain or snow. Key assessments that rely on both observational data and computer models have reported that warmer temperatures are expected to increase the frequency and severity of damaging extreme weather-related events (such as flooding or drought), although the timing, magnitude, and duration of these changes are as yet undetermined. Further research on the effect of increasing temperature on weather events is ongoing. Of particular note, the IPCC is expected to release its fourth assessment of the state of climate science throughout 2007, and the Climate Change Science Program is currently assessing potential changes in the frequency or intensity of weather-related events specific to North America in a report scheduled for release in 2008.

Taken together, private and federal insurers paid more than $320 billion in claims on weather-related losses from 1980 through 2005. In constant dollars, private insurers paid the largest part of the claims during this period, $243.5 billion (about 76 percent); followed by federal crop insurance, $43.6 billion (about 14 percent); and federal flood insurance, $34.1 billion (about 11 percent). Claims varied significantly from year to year—largely due to the incidence and effects of catastrophic weather events such as hurricanes and droughts—but generally increased during this period. In particular, the years with the largest insured losses were generally associated with major hurricanes, which comprised well over one-third of all weather-related losses since 1980. The growth in population in hazard-prone areas, and resulting real estate development and increasing real estate values, have increased federal and private insurers' exposure, and have helped to explain the increase in losses. In particular, heavily-populated areas along the Northeast, Southeast, and Texas coasts have among the highest value of insured properties in the United States and face the highest likelihood of major hurricanes. Due to these and other factors, federal insurers' exposures have grown substantially. Since 1980, NFIP's exposure has quadrupled, nearing $1 trillion, and program expansion has increased FCIC's exposure nearly 26-fold to $44 billion. These escalating exposures to catastrophic weather events are leaving the federal government at increased financial risk. FCIC officials told us, for example, that if the widespread Midwest floods of 1993 were to occur today, losses would be five times greater.

While both major private and federal insurers are exposed to increases in the frequency or severity of weather-related events associated with climate change, the two sectors are responding in different ways. Using computer-based catastrophe models, many major private insurers are incorporating some near-term elements of climate change into their risk management practices. One consequence is that, as these insurers seek to limit their own catastrophic risk exposure, they are transferring some of it to policyholders and to the public sector. In addition, some private insurers are approaching climate change at a strategic level by publishing reports outlining the potential industry-wide impacts and strategies to proactively address the issue. Federal insurance programs, on the other hand, have done little to develop the kind of information needed to understand the programs' long-term exposure to climate change for a variety of reasons. The federal insurance programs are not oriented toward earning profits like private insurers but rather toward increasing participation among eligible parties. Consequently, neither program has had reason to develop information on their long-term exposure to the fiscal risks associated with climate change.

We acknowledge the different mandate and operating environment in which the major federal insurance programs operate, but we believe that better information about the federal government's exposure to potential changes in weather-related risk would help the Congress identify and manage this emerging high-risk area—one which may not constitute an immediate crisis, but which does have significant implications for the nation's growing fiscal imbalance. Accordingly, GAO is recommending that the Secretary of Agriculture and the Secretary of Homeland Security direct the Under Secretary for Farm and Foreign Agricultural Services and the Under Secretary of Homeland Security for Emergency Preparedness to analyze the potential long-term fiscal implications of climate change for the FCIC and the NFIP, respectively, and report their findings to the Congress.

In commenting on a draft of this report, both the Departments of Agriculture (USDA) and Homeland Security (DHS) agreed with our recommendation, and USDA commented on the presentation of several findings in the draft. The Department of Commerce neither agreed nor disagreed with the report's findings, but instead commented on the presentation of several issues in the draft and offered technical comments which we incorporated into this report as appropriate. The Department of Energy elected not to provide comments on the draft.

Background

Insurance is a mechanism for spreading risk over time, across large geographical areas, and among industries and individuals. While insurers assume some financial risk when they write policies, they employ various strategies to manage risk so that they earn profits, limit potential financial exposures, and build capital needed to pay claims.[4] For example, they charge premiums for coverage and establish underwriting standards, such as refusing to insure customers who pose unacceptable levels of risk, or limiting coverage in particular geographic areas. Insurance companies may also purchase reinsurance to cover specific portions of their financial risk. Reinsurers use similar strategies to limit their risks, including charging premiums, establishing underwriting standards, and maintaining close, long-term business relationships with certain insurers.

Both insurers and reinsurers must also predict the frequency and severity of insured losses with some reliability to best manage financial risk.[5] In some cases, these losses may be fairly predictable. For example, the incidence of most automobile insurance claims is predictable, and losses generally do not occur to large numbers of policyholders at the same time. However, some infrequent weather-related events—hurricanes, for example—are so severe that they pose unique challenges for insurers and reinsurers. Commonly referred to as catastrophic or extreme events, the unpredictability and sheer size of these events—both in terms of geography and number of insured parties affected—have the potential to overwhelm insurers' and reinsurers' capacity to pay claims. Catastrophic events may affect many households, businesses, and public infrastructure across large areas, resulting in substantial losses that deplete insurers' and reinsurers' capital.

Given the higher levels of capital that reinsurers must hold to address catastrophic events, reinsurers generally charge higher premiums and restrict coverage for such events. Further, in the wake of catastrophic events, reinsurers and insurers may sharply increase premiums to rebuild capital reserves and may significantly restrict insurance and reinsurance coverage to limit exposure to similar events in the future.

[4]Federal insurance programs are not designed to earn financial profits.

[5]To insure a risk, private insurers must be able to both estimate an event's occurrence and its associated damages and be able to set premiums sufficient to cover their risk and earn a profit. In some cases, insurers may be prevented from charging sufficient premiums due to state regulatory actions.

Under certain circumstances, the private sector may determine that a risk is uninsurable. For example, while homeowner insurance policies typically cover damage and losses from fire and other perils, they usually do not cover flood damage because private insurance companies are largely unwilling to bear the financial risks associated with its potentially catastrophic impact. In other instances, the private sector may be willing to insure a risk, but at rates that are not affordable to many property owners. Without insurance, affected property owners must rely on their own resources or seek out disaster assistance from local, state, and federal sources.

In situations where the private sector will not insure a particular type of risk, the public sector may create markets to ensure the availability of insurance. For example, several states have established Fair Access to Insurance Requirements (FAIR) plans, which pool resources from insurers doing business in the state to make property insurance available to property owners who cannot obtain coverage in the private insurance market, or cannot do so at an affordable rate. In addition, six southern states have established windstorm insurance pools that pool resources from private insurers to make insurance available to property owners who cannot obtain it in the private insurance market.

Similarly, at the federal level, the Congress established the NFIP and the FCIC to provide coverage where voluntary markets do not exist.[6] The Congress established the NFIP in 1968, partly to provide an alternative to disaster assistance for flood damage. Participating communities are required to adopt and enforce floodplain management regulations, thereby reducing the risks of flooding and the costs of repairing flood damage. FEMA, within the Department of Homeland Security, is responsible for, among other things, oversight and management of the NFIP. Under the program, the federal government assumes the liability for covered losses and sets rates and coverage limitations.

The Congress established the FCIC in 1938 to temper the economic impact of the Great Depression and the weather effects of the dust bowl. In 1980, the Congress expanded the program to provide an alternative to disaster assistance for farmers that suffer financial losses when crops are damaged by droughts, floods, or other natural disasters. Farmers' participation is

[6]See appendixes II and III for additional information on how these programs operate, how they assess risk, and how they are funded.

voluntary, but the federal government encourages it by subsidizing their insurance premiums. USDA's RMA is responsible for administering the crop insurance program, including issuing new insurance products and expanding existing insurance products to new geographic regions. RMA administers the program in partnership with private insurance companies, which share a percentage of the risk of loss or the opportunity for gain associated with each insurance policy written.

Climate Change May Increase Losses by Altering the Frequency or Severity of Weather-Related Events

Global temperatures have increased in the last 100 years and are projected to continue to rise over the next century. Using observational data and computer modeling, climatologists and other scientists are assessing the likely effects of temperature rise associated with climate change on precipitation patterns and on the frequency and severity of weather-related events. The key scientific assessments we reviewed generally found that warmer temperatures are expected to alter the frequency or severity of damaging weather-related events, such as flooding or drought, although the timing, magnitude, and duration of these changes are as yet undetermined. Additional research on the effect of increasing temperature on weather events is expected in the near future. Nevertheless, research suggests that the potential effects of climate change on damaging weather-related events could be significant.

Warming Temperatures Are Expected to Alter the Frequency and Severity of Damaging Extreme Weather-Related Events

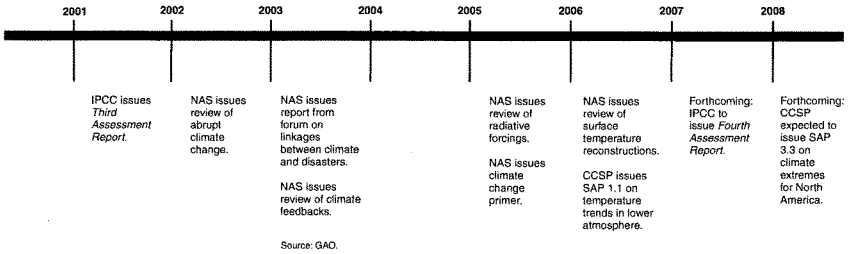
We reviewed the reports released by IPCC, NAS, and the federal Climate Change Science Program (CCSP) that are shown in figure 1.[7] These leading scientific bodies report that the Earth warmed during the twentieth century—0.74 degrees Celsius from 1906 to 2005 according to a recent IPCC report—and is projected to continue to warm for the foreseeable future.[8] IPCC, NAS, CCSP, and other scientific bodies report that this increase in temperature cannot be explained by natural variation alone. IPCC's 2001 assessment of the impact of increasing temperatures on extreme weather events found that it was likely the frequency and severity

[7]Appendix I contains additional information on the specific assessments we reviewed. CCSP is a multiagency effort to coordinate federal climate change science that is responsible for preparing a series of 21 climate science synthesis and assessment products (SAP) for the United States by 2008.

[8]This estimate comes from a recently released summary of a key component of IPCC's *Fourth Assessment Report* of the state of climate science, which reported an updated 100-year linear trend (1906-2005) of 0.74 degrees Celsius—larger than the corresponding 0.6 degrees Celsius reported in the 2001 *Third Assessment Report*.

of several types of events will increase as greenhouse gas emissions continue.[9]

Figure 1: Time Line of Key Scientific Assessments



Source: GAO.

Average Global Temperatures Have Increased and Are Expected to Continue to Rise

The earth's climate system is driven by energy from the sun and is maintained by complex interactions between the atmosphere, the oceans, and the reflectivity of the earth's surface, among other factors. Upon reaching the earth, the sun's energy is either reflected back into space, or is absorbed by the earth and is subsequently reemitted. However, certain gases in the earth's atmosphere—such as carbon dioxide and methane—act like the glass in a greenhouse to trap some of the sun's energy and prevent it from returning to space. While these gases play an important part in maintaining life on earth, their accumulation in the atmosphere can significantly increase global temperatures.

The earth warmed by roughly 0.74 degrees Celsius over the past 100 years, and is projected to continue warming for the foreseeable future. While temperatures have varied throughout history, triggered by natural factors such as volcanic eruptions or changes in the earth's orbit, the key scientific assessments we reviewed have generally concluded that the observed increase in temperature in the past 100 years cannot be explained by natural variability alone. In recent years, major scientific

[9]For the purposes of this report, extreme weather-related events are those with a low frequency of occurrence, but that cause severe damage, such as hurricanes, drought, winter storms, tornadoes, wildfires, and floods, among others.

bodies such as the IPCC, NAS, and the Royal Academy (the United Kingdom's national academy of science) have concluded that human activities, including the combustion of fossil fuels, industrial and agriculture processes, landfills, and some land use changes, are significantly increasing the concentrations of greenhouse gases and, in turn, global temperatures.

Although climate models produce varying estimates of the extent of future changes in temperature, NAS and other scientific organizations have concluded that available evidence points toward continued global temperature rise. Assuming continued growth in atmospheric concentration of greenhouse gases, the latest assessment of computer climate models projects that average global temperatures will warm by an additional 1.8 to 4.0 degrees Celsius during the next century.[10]

Some scientists have questioned the significance of the earth's present temperature rise relative to past fluctuations. To address this issue, the NAS recently assessed the scientific community's efforts to reconstruct temperatures of the past 2,000 years and place the earth's current warming in an historical context.[11] Based on its review, the NAS concluded with a high level of confidence that global mean surface temperature was warmer during the last few decades of the twentieth century than during any comparable period during the preceding 400 years. Moreover, NAS cited evidence that temperatures at many, but not all, individual locations were higher during the past 25 years than any period of comparable length over the past 1,100 years.

[10]IPCC narrowed its range of projected warming in its recently released summary from the corresponding range of 1.4 to 5.8 degrees Celsius reported in the 2001 *Third Assessment Report*. Although these two sets of projections are broadly consistent, they are not directly comparable. IPCC notes in the summary that the new range is more advanced in that it provides best estimates and an assessed likelihood range. It also relies on a larger number of climate models of increasing complexity and realism, as well as new information regarding the nature of feedbacks from the carbon cycle and constraints on climate response from observations.

[11]National Research Council, *Surface Temperature Reconstructions for the Last 2,000 Years* (Washington, D.C.: 2006).

IPCC Expects Continued Warming to Alter Frequency and Severity of Damaging Extreme Weather-Related Events

Determining the precise nature and extent of the relationship between average global temperatures and weather-related events is an exceedingly challenging task. Several key assessments of the state of this science have addressed the large body of work on this topic. Using observational data and computer models, scientists are examining the effects of rising temperatures on precipitation patterns and the frequency and severity of extreme weather-related events. The complexity of weather systems, together with the limited statistical precision of projections of the extent of future temperature change, often produces different model results, and the results themselves represent a range of potential future conditions.

Nonetheless, a key assessment of climate model projections indicates that an increase is likely in the frequency or severity of damaging extreme weather-related events. In 2001, the IPCC, a leading scientific authority on climate science, released its *Third Assessment Report*, which assessed the state of knowledge of, among other things, the potential for global changes in extreme weather-related events. The IPCC described the relationship between temperatures, precipitation, and weather-related events. Increased global mean surface temperatures are linked to global-scale oceanographic, meteorological, and biological changes. For example, as the earth warms, more water evaporates from oceans or lakes, eventually falling as rain or snow. IPCC reported that permafrost is thawing, and the extent of sea ice, snow cover, and mountain glaciers are generally shrinking. The IPCC also noted that global sea level rose between 0.1 and 0.2 meters during the twentieth century through thermal expansion of seawater and widespread loss of land ice, and that this sea level rise could increase the magnitude of hurricane storm surge in some areas. Warming is expected to change rainfall patterns, partly because warmer air holds more moisture.

Based on model projections and expert judgment,[12] the IPCC reported that future increases in the earth's temperature are likely to increase the frequency and severity of many damaging extreme weather-related events (summarized in table 1). For instance, IPCC reported that increased drought is likely across many regions of the globe, including the U.S. Great

[12]Likelihoods for projected changes are defined by the following conditions set by the IPCC: "very likely" indicates that a number of models have been analyzed for such a change, all those analyzed show it in most regions, and it is physically plausible; and "likely" indicates that theoretical studies and those models analyzed show such a change, but only a few models are configured in such a way as to reasonably represent such changes.

Plains. Also, IPCC concluded that the intensity of precipitation events is very likely to increase across almost all regions of the globe and that heavy precipitation events are expected to become more frequent. Compared with projected temperature increases, changes in the frequency and severity of extreme events can occur relatively rapidly, according to the IPCC.

Table 1: Selected IPCC Estimates of Confidence in Projected Changes in Weather-Related Events

Weather-related event	Confidence in projected future changes
Higher maximum temperatures and more hot days over nearly all land areas	Very likely
Higher minimum temperatures and fewer cold and frost days over nearly all land areas	Very likely
More intense precipitation events	Very likely
Increased summer drying and associated risks of drought	Likely[a]
Increase in hurricane peak wind intensities	Likely[b]
Increase in hurricane average and peak precipitation intensities	Likely

Source: IPCC, *Climate Change 2001: The Scientific Basis*, 2001.

[a]Projections for most midlatitude continental interiors. IPCC found a lack of consistent projections in other regions.

[b]IPCC reported that changes in the regional distribution of hurricanes are possible but have not been established.

Much research has been done since the IPCC's *Third Assessment Report*, but there has not been a similarly rigorous assessment of what is known with regard to temperature increase, precipitation, and weather-related events for the United States.[13] However, significant assessments will be completed in the near future. In particular, the IPCC is expected to release its *Fourth Assessment Report* throughout 2007.

[13]The most recent national assessment for the United States, entitled *Climate Change Impacts on the United States*, was forwarded by a federal advisory committee to the Congress and the President in 2000 as required by the Global Change Research Act of 1990. We reported in 2005 that the subsequent assessment was not submitted in November 2004 as required by the act. Instead, according to the Department of Commerce, CCSP has committed to issuing 21 shorter reports by 2008. See GAO, *Climate Change Assessment: Administration Did Not Meet Reporting Deadline*, GAO-05-338R (Washington, D.C.: Apr. 14, 2005).

While we were completing our review, the IPCC released a summary of the first of three components of its *Fourth Assessment Report*, which builds upon past IPCC assessments and incorporates new findings from the physical science research since the *Third Assessment Report*. The summary reports higher confidence in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation, and some aspects of extreme events. In particular, the summary reports that it is very likely that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent. Moreover, based on a range of models, IPCC's summary states that it is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases in tropical sea surface temperatures. IPCC reports less confidence in projections of a global decrease in the number of tropical cyclones, and that the apparent increase in the proportion of very intense storms since 1970 in some regions is much larger than simulated by current models for that period. The full first component report was not publicly released prior to the issuance of our report and is expected some time after May 2007.

The other two components of the *Fourth Assessment Report* will cover impacts, adaptation, and vulnerability, and mitigation. These reports are expected to assess, among other things, key vulnerabilities and risks from climate change, including changes in extreme events. Additionally, the IPCC has committed to producing a capping report that is intended to synthesize and integrate material contained in the forthcoming reports, as well as other IPCC products.

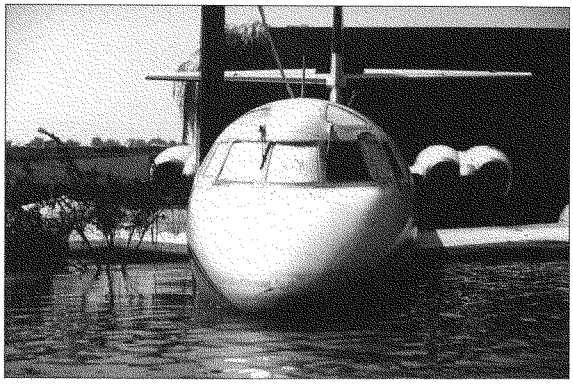
In addition to the IPCC's work, CCSP is assessing potential changes in the frequency or intensity of weather-related events specific to North America in a report scheduled for release in 2008. According to a National Oceanic and Atmospheric Administration (NOAA) official and agency documents, the report will focus on weather extremes that have a significant societal impact, such as extreme cold or heat spells, tropical and extra-tropical storms, and droughts. Importantly, officials have said the report will provide an assessment of the observed changes in weather and climate extremes, as well as future projections.

More Frequent or More Severe Extreme Weather-Related Events Could Significantly Increase Insured Losses

Extreme weather-related events impact communities and economic activity by damaging homes and vehicles (e.g., see fig. 2), interrupting electrical service and business operations, or destroying crops. IPCC reported that the insurance industry—especially the property and casualty segment—are sensitive to the effects of weather-related events. This was highlighted in the Department of Commerce's comments on a draft of this report, which observed that altering either the frequency or severity of high impact extreme weather-related events could result in a significant increase in the risk posed to an insurer. For example, the agency said that what had been considered a 500-year event (i.e., its probability of occurring in a given year is 1 in 500) could shift under climate change to become a 100-year event (i.e., its probability of occurring in a given year is 1 in 100). Consequently, more frequent or more severe events have a greater potential for damage and, in turn, insured losses. As an official from Aon Re Australia, a large global reinsurer, reported, "The most obvious impact of climate change on the insurance sector will be the increase in insured property losses from extreme weather events."[14]

[14]Andrew Dlugolecki, *The Changing Risk Landscape: Implications for Insurance Risk Management* (1999) http://www.aon.com.au/pdf/reinsurance/Aon_Climate_Change.pdf (downloaded Jan. 8, 2007).

Figure 2: July 1993 Flood Damage at Chesterfield Airport in St. Louis, Missouri



Source: FEMA.

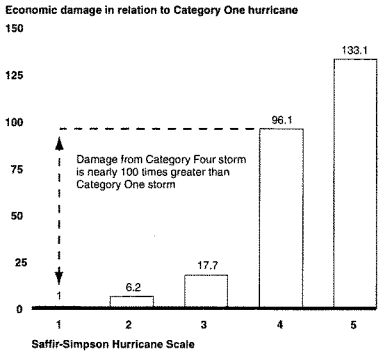
Note: According to FEMA, the depth of the floodwaters underscores the extent of the damage caused by the 1993 Midwest flood. A total of 534 counties in nine states were declared for federal disaster aid.

Notably, the economic damages associated with some extreme weather-related events could increase at a greater rate in comparison with changes in the events themselves. Seemingly small changes in the characteristics of certain weather-related events can lead to substantial increases in damage. For example, recent work on hurricanes by researchers at the University of Colorado, the National Weather Service, and other institutions examined losses associated with hurricanes that made landfall in the United States since 1900.[15] Holding constant the increased population and development in coastal counties during this period, the study compared the economic damage of stronger storms with weaker storms, based on

[15]See Roger Pielke, Jr., et al., *Normalized Hurricane Damages in the United States: 1900-2005* (2007), accessed via http://sciencepolicy.colorado.edu/publications/special/normalized_hurricane_damages.html (downloaded Jan. 8, 2007).

the Saffir-Simpson Hurricane Scale.[16] The researchers found that stronger storms have caused many times more economic damages than weaker storms, as shown in figure 3. These findings are consistent with other independent analyses conducted by insurers and catastrophe modelers.

Figure 3: Economic Damages by Hurricane Category for U.S. Hurricanes Making Landfall, 1900-2005



Source: GAO adaption of Pielke et al. data.

Note: Value of each bar compares the median economic damage associated with hurricanes of that Saffir-Simpson category with the median economic damage of Category One storms. Of the 158 hurricanes reviewed, only three were Category Five.

Moreover, public reports from several of the world's largest reinsurance companies and brokers underscore the potential for substantially increased losses. These reports note that, in addition to greater losses in

[16]The Saffir-Simpson hurricane intensity category system was developed in the 1970s to calculate the destructive force of hurricanes. The scale ranges from Category One to Category Five, with Category Five being the most severe. For example, Category Three hurricanes have winds of 111 to 130 mph, whereas Category Five hurricanes have winds greater than 155 mph.

absolute terms, the potential for greater variability in weather-related events could significantly enhance the volatility of losses.

Insured Weather-Related Losses Have Been Sizeable, and Federal Insurers' Exposure Has Grown Significantly

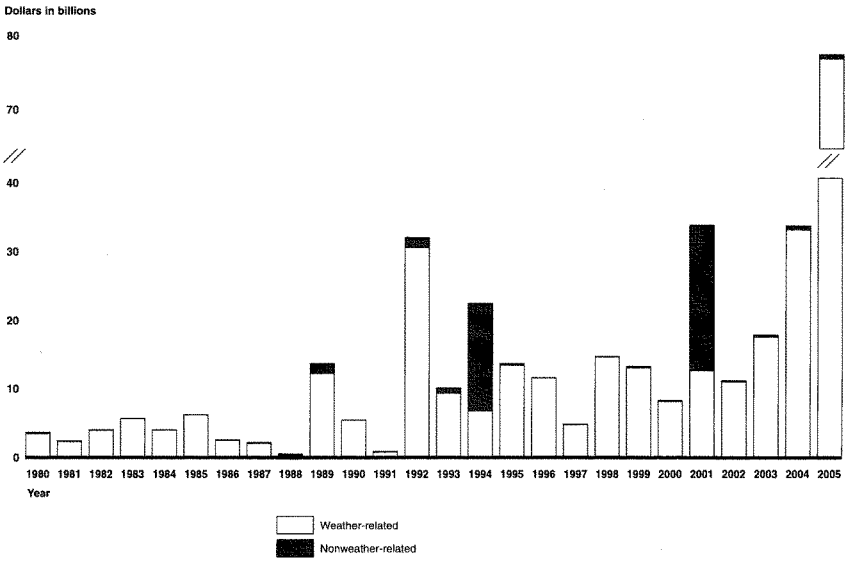
Taken together, insurers paid more than $320 billion in claims for weather-related losses between 1980 and 2005.[17] Claims varied significantly from year to year—largely due to the effects of catastrophic weather events such as hurricanes and droughts—but generally increased during this period. The growth in population in hazard-prone areas, and consequent real estate development and increasing real estate values, have generally increased insurers' exposure to weather-related events and help to explain their increased losses. Due to these and other factors, the federal insurance programs' liabilities have grown significantly, leaving the federal government increasingly vulnerable to the financial impacts of extreme events.

Claims Paid on Weather-Related Losses Totaled More Than $320 Billion between 1980 and 2005

Based on an examination of loss data from several different sources, insurers incurred more than $320 billion in weather-related losses from 1980 through 2005 (see fig. 4). Weather-related losses accounted for 88 percent of *all* property losses paid by insurers during this period. All other property losses, including those associated with earthquakes and terrorist events, accounted for the remainder. Weather-related losses varied significantly from year to year, ranging from just over $2 billion in 1987 to more than $75 billion in 2005.

[17]Data throughout this section are presented in constant 2005 dollars to allow for a comparison of the dollar value of losses over time and are not otherwise adjusted. See appendix I for more information on data used in this report.

Figure 4: Annual Weather- and Nonweather-Related Insured Losses

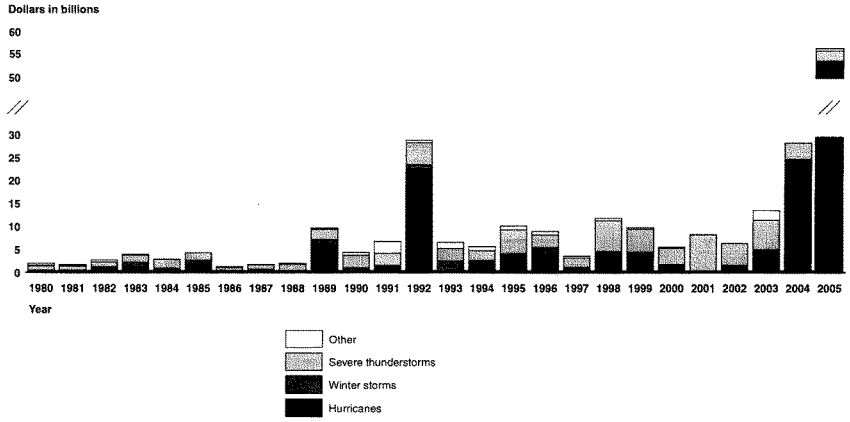


Sources: GAO anaylsis of PCS, NFIP, and FCIC data.

Privately-Insured Losses

Of the $321.2 billion in weather-related loss payments we reviewed, private insurers paid $243.5 billion—over three-quarters of the total.[18] Figure 5 depicts the breakdown of these payments among key weather-related events. Of the $243.5 billion paid by private insurers, hurricanes accounted for $124.6 billion, or slightly more than half. Wind, tornados, and hail associated with severe thunderstorms accounted for $77 billion, or nearly one-third of the private total. Winter storms were associated with $25.1 billion, or about 10 percent.

Figure 5: Weather-Related Losses Paid by Private Insurers



Source: GAO analysis of PCS data.

[18]Property Claim Services (PCS), an authority on insured property losses, maintains a database of estimated losses determined to be "catastrophes"—that is, loss events larger than $25 million that affect a significant number of policyholders. PCS estimates include losses under personal and commercial property insurance policies and typically include payments made on behalf of state-administered risk pools. PCS data are described in greater detail in appendix I.

Federally-Insured Losses

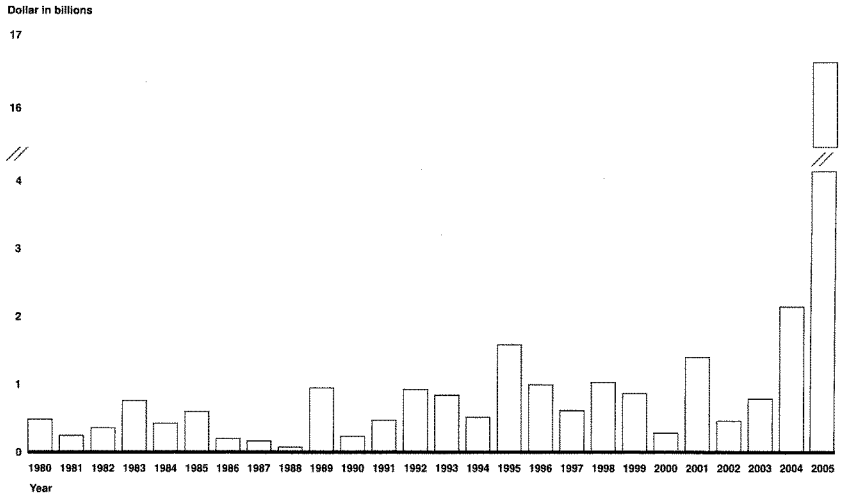
The two major federal insurance programs—NFIP and FCIC—paid the remaining $77.7 billion of the $321.2 billion in weather-related loss payments we reviewed.[19] Although the performance of both NFIP and FCIC is sensitive to weather, the two programs insure fundamentally different risks and operate in very different ways.

NFIP provides insurance for flood damage to homeowners and commercial property owners in more than 20,000 communities. Homeowners with mortgages from federally regulated lenders on property in communities identified as being in high flood risk areas are required to purchase flood insurance on their dwellings. Optional, lower cost flood insurance is also available under the NFIP for properties in areas of lower flood risk. NFIP offers coverage for both the property and its contents, which may be purchased separately.

NFIP claims totaled about $34.1 billion, or about 11 percent of all weather-related insurance claims during this period. As shown in figure 6, NFIP covers only one cause of loss—flooding. Claims averaged about $1.3 billion per year, but ranged from $75.7 million in 1988 to $16.7 billion in 2005.

[19]Appendixes II and III provide additional information about the structure and operation of FCIC and NFIP. Importantly, totals only reflect what was paid during this time—some losses incurred in 2005 may be omitted from this data set.

Figure 6: Weather-Related Losses Paid by NFIP

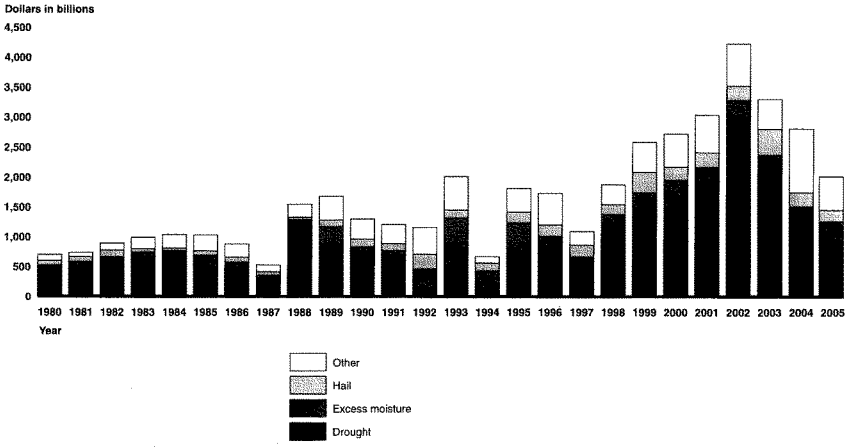


Source: GAO anaylsis of NFIP data.

FCIC insures commodities on a crop-by-crop and county-by-county basis based on farmer demand for coverage and the level of risk associated with the crop in a given region. Over 100 crops are covered by the program. Major crops, such as grains, are covered in almost every county where they are grown, and specialty crops, such as fruit, are covered only in some areas. Participating farmers can purchase different types of crop insurance, including yield and revenue insurance, and at different levels. For yield insurance, participating farmers select the percentage of yield of a covered crop to be insured and the percentage of the commodity price received as payment if the producer's losses exceed the selected threshold. Revenue insurance pays if actual revenue falls short of an assigned target level regardless of whether the shortfall was due to low yield or low commodity market prices.

Since 1980, FCIC claims totaled $43.6 billion, or about 14 percent of all weather-related claims during this period. FCIC losses averaged about $1.7 billion per year, ranging from $531.8 million in 1987 to $4.2 billion in 2002. Figure 7 shows the three causes of loss—drought, excess moisture, and hail—that accounted for more than three-quarters of crop insurance claims. In particular, drought accounted for $18.6 billion in losses, or more than 40 percent of all insured crop losses. Excess moisture totaled $11.2 billion, followed by hail with total claims of $4.2 billion. The remaining $9.6 billion in claims was spread among 27 different causes of loss, including frost and tornados.

Figure 7: Weather-Related Losses Paid by FCIC



Source: GAO analysis of FCIC data.

Insured Losses Understate Total Economic Damage

Importantly, the insured loss totals used in our analysis do not account for all economic damage associated with weather-related events.[20] Specifically, data are not available for several categories of economic losses, including uninsured, underinsured, and self-insured losses. As we reported in 2005, FEMA estimates that one-half to two-thirds of structures in floodplains do not have flood insurance because the uninsured owners either are unaware that homeowners insurance does not cover flood damage, or they do not perceive a serious flood risk.[21] Furthermore, industry analysts estimate that 58 percent of homeowners in the United States are underinsured—that is, they carry a policy below the replacement value of their property—by an average of 21 percent.[22] Finally, some individuals and businesses have the means to "self-insure" their assets by assuming the full risk of any damage.

Various public and private disaster relief organizations provide assistance to communities and individuals who suffer noninsured economic losses, although it was beyond the scope of this report to collect data on these losses. In particular, since 1989, $78.6 billion in federal disaster assistance funds have been obligated through the Disaster Relief Fund administered by FEMA, the largest—but not only—conduit for federal disaster assistance money provided in the wake of presidentially declared disasters and emergencies.

Overall, according to data obtained from Munich Re, one of the world's largest reinsurers, the type of insured losses we reviewed account for no more than about 40 percent of the total losses attributable to weather-related events.[23] NOAA's National Hurricane Center (NHC) uses a similar proportion to produce the agency's estimates of total economic damage

[20]Weather-related damages are also responsible for many indirect and non-market impacts that are not entirely accounted for, if at all, in economic terms, such as environmental damage. See NAS, *The Impacts of Natural Disasters: A Framework for Loss Estimation* (Washington, D.C.: 1999), 55-64.

[21]GAO, *Catastrophe Risk: U.S. and European Approaches to Insure Natural Catastrophe and Terrorism Risks*, GAO-05-199 (Washington, D.C.: Feb. 28, 2005), 61.

[22]Estimate was produced by Marshall & Swift/Boeckh, a leading supplier of local building cost information, residential and commercial property valuation services for the property and casualty insurance sector in the United States. GAO did not independently evaluate the reliability of this estimate.

[23]Munich Re, *Topics 2000: Natural Catastrophes—the Current Position*. Geoscience Research Group (Munich, Germany: 1999).

attributable to hurricanes.[24] Although we did not independently evaluate the reliability of these estimates, subject area experts we spoke with confirmed that it was the best such estimate available and is widely used as an approximation of the relative distribution of losses.

The difficulties we and others faced in accounting for weather-related losses were the subject of the National Academies' *The Impacts of Natural Disasters: A Framework for Loss Estimation.*[25] Reporting how best to account for the costs of natural disasters, including weather-related events, NAS found that there was no system in place in either the public or the private sectors to consistently capture information about the economic impact. Specifically, the NAS report found no widely accepted framework, formula, or method for estimating these losses. Moreover, NAS found no comprehensive clearinghouse for the disaster loss information that is currently collected. To that end, NAS recommended that the Office of Management and Budget, in consultation with FEMA and other federal agencies, develop annual, comprehensive estimates of the payouts for disaster losses made by federal agencies. Reviewing the status of this recommendation was beyond the scope of this report. Nevertheless, our experience with trying to obtain comprehensive information on disaster costs and losses underscores the NAS findings.

Catastrophic Weather-Related Events Help Explain the Significant Year-to-Year Variance in Losses

The largest insured losses in the data we reviewed were associated with catastrophic weather events. These events have a low probability of occurrence, but their consequences are severe. Notably, both crop insurers and other property insurers face the catastrophic risks posed by extreme events, although the nature of the events for each is very different. In the case of crop insurance, drought accounted for more than 40 percent of all insured losses from 1980 to 2005, and the years with the largest losses were associated with drought. Taken together, though, hurricanes were the most damaging event experienced by insurers in the data we reviewed. Although the United States experienced an average of only two hurricanes per year from 1980 through 2005, weather-related claims attributable to hurricanes totaled more than 45 percent of *all* weather-related insured losses—more than $146 billion. Moreover, these losses appear to be increasing.

[24]NHC estimates total losses by extrapolating from insured losses by assuming they account for approximately 50 percent of total losses.

[25]NAS (1999), 1.

In the data we reviewed, the years with the largest insured losses were generally associated with major hurricanes, defined as Category Three, Four, or Five on the Saffir-Simpson Hurricane Scale. Table 2 shows that, while 29 Category One and Two storms account for nearly $18 billion in losses, the 21 major storms account for over $126 billion in losses. In fact, claims associated with major hurricanes comprised 40 percent of all weather-related insured losses since 1980.

Table 2: Insured Losses Associated with Hurricanes

Dollars in thousands

	Categories One, Two	Categories Three, Four, Five	Total
1980s	$807,422 (11)	$9,905,042 (6)	**$10,712,464 (17)**
1990s	9,038,801 (11)	29,099,303 (8)	**38,138,104 (19)**
2000s	8,071,619 (7)	89,210,093 (7)	**97,281,712 (14)**
Total	**$17,917,842 (29)**	**$128,214,438 (21)**	**$146,132,280 (50)**

Sources: GAO analysis of PCS and NFIP data; NOAA (hurricane intensity classification).

Note: Totals do not include crop losses associated with hurricanes. Number of hurricanes associated with losses is included in parentheses. Hurricane classification was based on peak intensity at landfall.

Importantly, hurricane severity is only one factor in determining the size of a particular loss—the location affected by the hurricane is also important. Generally, the more densely populated an area, the greater the extent of economic activity and accumulated value of the building stock. For instance, several studies have reviewed the economic impact of Hurricane Andrew, which tracked over Florida in 1992, in light of the dramatic real estate development that has occurred in the meantime. Researchers have normalized losses associated with the storm to account for societal changes by holding constant the value of building materials, real estate, and other factors so that the storm's impact could be adjusted to reflect contemporary conditions.[26] Hurricane Andrew, which resulted in roughly $25 billion in total economic losses in 1992, would have resulted in more than twice that amount—$55 billion—were it to have occurred in 2005, given current asset values.

[26]A normalization provides an estimate of the damage that would occur if storms from the past affected the same location under the societal conditions of another year.

Several recent studies have commented on the apparent increases in hurricane losses during this time period, and weather-related disaster losses generally, with markedly different interpretations. Some argue that loss trends are largely explained by changes in societal and economic factors, such as population density, cost of building materials, and the structure of insurance policies.[27] Others argue that increases in losses have been driven by changes in climate.[28]

To address this issue, Munich Re and the University of Colorado's Center for Science and Technology Policy Research jointly convened a workshop in Germany in May 2006 to assess factors leading to increasing weather-related loss trends.[29] The workshop brought together a diverse group of international experts in the fields of climatology and disaster research. Among other things, the workshop sought to determine whether the costs of weather-related events were increasing and what factors account for increasing costs in recent decades.

Workshop participants reached consensus on several points, including that analyses of long-term records of disaster losses indicate that societal change and economic development are the principal factors explaining observed increases in weather-related losses.[30] However, participants also agreed that changing patterns of extreme events are drivers for recent increases in losses and that additional increases in losses are likely given IPCC's projected increase in the frequency or severity of weather-related events.

[27]See, for example, Roger A. Pielke, Jr., "Disasters, Death, and Destruction: Making Sense of Recent Calamities," *Oceanography*, vol. 19, no. 2 (2006); Stanley A. Changnon et al., "Human Factors Explain the Increased Losses from Weather and Climate Extremes," *Bulletin of the American Meteorological Society*, vol. 81, no. 3 (2000); and Roger A. Pielke, Jr., and Christopher W. Landsea, "Normalized Hurricane Damages in the United States: 1925–95," *Weather and Forecasting*, vol. 13 (1998).

[28]See, for example, Evan Mills, Richard J. Roth, Jr., and Eugene Lecomte, *Availability and Affordability of Insurance Under Climate Change: A Growing Challenge for the U.S.* (Boston, Mass.: December 2005); Paul Epstein and Evan Mills, eds., *Climate Change Futures: Health, Ecological, and Economic Dimensions* (Boston, Mass.: November 2005); and Cynthia Rosenzweig et al., "Increased Crop Damage in the U.S. from Excess Precipitation Under Climate Change," *Global Environmental Change*, vol. 12 (2002).

[29]Peter Höppe and Roger Pielke, Jr., eds., *Report of the Workshop on Climate Change and Disaster Losses: Understanding and Attributing Trends and Projections*, Hohenkammer, Germany, May 25-26, 2006 (Munich, Germany: October 2006).

[30]Consensus statements agreed to at the workshop are listed in their entirety in appendix IV.

Value at Risk in Federal Insurers' Portfolios Increased Significantly between 1980 and 2005

The growth in population in hazard-prone areas, and consequent real estate development and increasing real estate values, are leaving the nation increasingly exposed to higher insured losses. The close relationship between the value of the resource exposed to weather-related losses and the amount of damage incurred may have ominous implications for a nation experiencing rapid growth in some of its most disaster-prone areas. We reported in 2002 that the insurance industry faces potentially significant financial exposure due to natural catastrophes.[31] Heavily populated areas along the Northeast, Southeast, and Texas coasts have among the highest value of insured properties in the United States and face the highest likelihood of major hurricanes. According to insurance industry estimates, a large hurricane in Miami could cause up to $110 billion in insured losses with total losses as high as $225 billion. Several states—including Florida, California, and Texas—have established programs to help ensure that coverage is available in areas particularly prone to these events.[32]

AIR Worldwide, a leading catastrophe modeling firm, recently reported that insured losses should be expected to double roughly every 10 years because of increases in construction costs, increases in the number of structures, and changes in their characteristics. AIR's research estimates that, because of exposure growth, probable maximum catastrophe loss grew in constant dollars from $60 billion in 1995 to $110 billion in 2005, and it will likely grow to over $200 billion during the next 10 years.

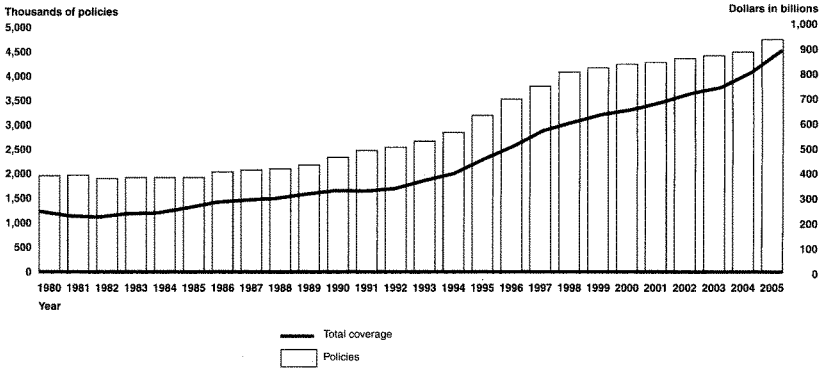
Data obtained from both the NFIP and FCIC programs indicate the federal government has grown markedly more exposed to weather-related losses regardless of the cause. For example, NFIP data show that the number of policyholders and the value of the properties insured have both increased since 1980. Figure 8 shows the growth of NFIP's exposure in terms of both number of policies and the total coverage. The number of policies has more than doubled in this time period, from 1.9 million policies to more than 4.6 million. Moreover, although NFIP limits coverage to $250,000 for a personal structure and $100,000 for its contents, and $500,000 of coverage

[31]GAO, *Catastrophe Insurance Risks: The Role of Risk-Linked Securities and Factors Affecting Their Use*, GAO-02-941 (Washington, D.C.: Sept. 24, 2002), 3.

[32]Past GAO work provided information on the Florida Hurricane Catastrophe Fund, California Earthquake Authority, and the Texas Windstorm Insurance Association. See GAO-02-941 and GAO, *Catastrophe Insurance Risks: Status of Efforts to Securitize Natural Catastrophe and Terrorism Risk*, GAO-03-1033 (Washington, D.C.: Sept. 24, 2003).

for a business structure and $500,000 on its contents, more policyholders' homes are approaching (or exceeding) these coverage limits. Accordingly, the total value covered by the program increased fourfold in constant dollars during this time from about $207 billion to $875 billion in 2005.

Figure 8: NFIP Policies and Total Coverage

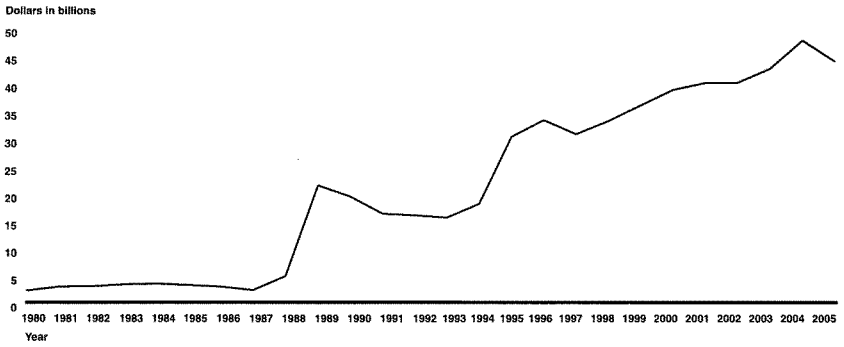


Source: GAO analysis of NFIP data.

Similarly, RMA data show that FCIC has effectively increased its exposure base 26-fold during this period (in constant dollars). In particular, the program has significantly expanded the scope of crops covered and increased participation. Figure 9 shows the growth in FCIC exposure since 1980.[33]

[33]To maintain comparability with other data, GAO did not adjust these data for changes in agricultural prices.

Figure 9: FCIC Total Coverage



Source: GAO analysis of FCIC data.

A senior RMA official told us that the main implication of FCIC's growth is that the magnitude of potential claims, in absolute terms, is much greater today than in the past. For example, if the Midwest floods of 1993 were to occur today, losses would be five times greater than the $2 billion paid in 1993, according to RMA officials.

Major Private and Public Insurers Differ in How They Manage Catastrophic Risks Associated with Climate Change

Although the relative contribution of event intensity versus societal factors in explaining the rising losses associated with weather-related events is still under investigation, both major private and federal insurers are exposed to increases in the frequency or severity of weather-related events associated with climate change. Nonetheless, major private and federal insurers are responding to this prospect differently. Many large private insurers are incorporating some elements of near-term climate change into their risk management practices. Furthermore, some of the world's largest insurers have also taken a long-term strategic approach toward changes in climate. On the other hand, for a variety of reasons, the federal insurance programs have done little to develop the kind of information needed to understand the programs' long-term exposure to climate change. We acknowledge the different mandate and operating environment in which the major federal insurance programs operate but believe that better information about the federal government's exposure to potential changes

in weather-related risk would help the Congress identify and manage this emerging high-risk area; one which may not constitute an immediate crisis but which may pose an important longer term threat to the nation's welfare.

Major Private Insurers Prospectively Manage Potential Increases in Catastrophic Risk Associated with Climate Change

Extreme weather events pose a unique financial threat to private insurers' financial success because a single event can cause insolvency or a precipitous drop in earnings, liquidation of assets to meet cash needs, or a downgrade in the market ratings used to evaluate the soundness of companies in the industry. To prevent these disruptions, the American Academy of Actuaries (AAA)—the professional society that establishes, maintains, and enforces standards of qualification, practice, and conduct for actuaries in the United States—has outlined a five-step process for private insurers to follow to manage their catastrophic risk. These steps include the following:

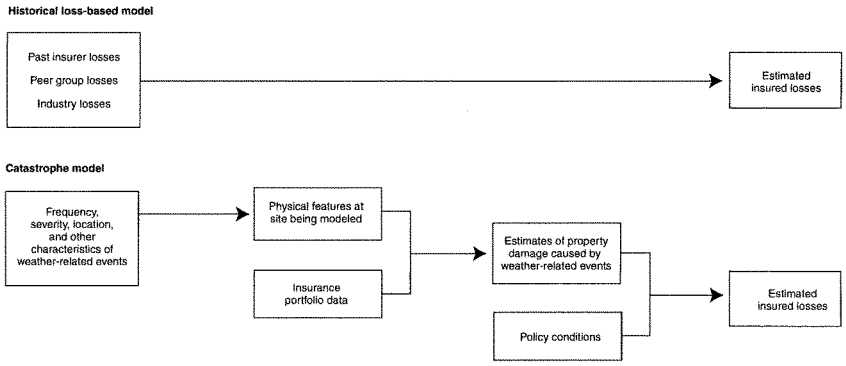
- identifying catastrophic risk appetite by determining the maximum potential loss they are willing to accept;
- measuring catastrophic exposure by determining how vulnerable their total portfolio is to loss, both in absolute terms and relative to the company's risk management goals;
- pricing for catastrophic exposure by setting rates to collect sufficient premiums to cover their expected catastrophic loss and other expenses;
- controlling catastrophic exposure by reducing their policies in areas where they have too much exposure, or transferring risk using reinsurance or other mechanisms; and
- evaluating their ability to pay claims by determining the sufficiency of their financial resources to cover claims in the event of a catastrophe.

Additionally, insurers monitor their exposure to catastrophic weather-related risk using sophisticated computer models called "catastrophe models."[34] AAA emphasizes the shortcomings of estimating future catastrophic risk by extrapolating solely from historical losses and

[34]There are three main catastrophe modeling firms: AIR Worldwide, Risk Management Solutions, and EQECAT. Although many of the insurers we interviewed use models from these firms, two of the eleven insurers have developed their own catastrophe models.

endorses catastrophe models as a more rigorous approach.[35] Catastrophe models incorporate the underlying trends and factors in weather phenomena and current demographic, financial, and scientific data to estimate losses associated with various weather-related events. According to an industry representative, catastrophe models assess a wider range of possible events than the historical loss record alone. These models simulate losses from thousands of potential catastrophic weather-related events that insurers use to better assess and control their exposure and inform pricing and capital management decisions. Figure 10 illustrates the difference between estimating future catastrophic losses using historical data versus catastrophe models.

Figure 10: Modeling Potential Catastrophe Losses



Sources: Adapted from the American Academy of Actuaries and Towers Perrin.

[35] American Academy of Actuaries, *Catastrophe Exposures and Insurance Industry Catastrophe Management Practices* (Washington, D.C.: American Academy of Actuaries, June 10, 2001), http://www.actuary.org/pdf/casualty/catastrophe_061001.pdf (downloaded Jan. 3, 2007), 10-12.

To determine what major private insurers are doing to estimate and prepare for risks associated with potential changes in climate arising from natural or human factors, we contacted 11 of the largest private insurers operating in the U.S. property casualty insurance market. Representatives from each of the 11 major insurers we interviewed told us they use catastrophe models that incorporate a near-term higher frequency and intensity of hurricanes. Of the 11 private insurers, 6 specifically attributed the higher frequency and intensity of hurricanes to the Atlantic Multidecadal Oscillation, which—according to NOAA—is a 20- to 40-year climatic cycle of fluctuating temperatures in the north Atlantic Ocean. The remaining 5 insurers did not elaborate on the elements of climate change driving the differences in hurricane characteristics.

Industry reports indicate that insurance companies' perception of increased risk from hurricanes has prompted them to reduce their near-term catastrophic exposure, in both reinsurance and primary insurance coverage along the Gulf Coast and eastern seaboard. For example, a recent industry analysis from a leading insurance broker reported that reinsurance coverage is substantially limited in the southeastern United States and that reinsurance prices have more than doubled from 2005 to 2006, following a record-setting hurricane season.[36] According to the Insurance Information Institute, a leading source of information about the insurance industry, primary insurance companies have also raised prices in coastal states to cover rising reinsurance costs.[37] Additionally, a recent report co-authored by a major international insurance company cites several examples of large primary insurers either limiting coverage or

[36]Guy Carpenter, *The World Catastrophe Reinsurance Market: Steep Peaks Overshadow Plateaus* (New York, N.Y.: Guy Carpenter, September 2006), http://www.guycarp.com/portal/extranet/insights/reports.html?vid=30 (downloaded Jan. 3, 2007).

[37]Insurance Information Institute, *Catastrophes: Insurance Issues* (New York, N.Y.: Insurance Information Institute, November 2006), http://www.iii.org/media/hottopics/insurance/xxx/ (downloaded Jan. 3, 2007).

withdrawing from vulnerable areas such as Florida,[38] the Gulf Coast, and Long Island.[39]

As private insurers limit their exposure, catastrophic risk is transferred to policyholders and the public sector. Insurance companies transfer risk to policyholders by increasing premiums and deductibles, or by setting lower coverage limits for policies. Insurers can also transfer risk to policyholders by passing along the mandatory participation costs of state-sponsored insurance plans.[40] For example, after the 2004 hurricane season, insurers assessed a surcharge of about 7 percent to every policyholder in Florida to recoup the cost of insurers' participation in the state-sponsored wind insurance plan. The public sector assumes management of weather-related risk at the local, state, and national level by providing disaster relief and recovery, developing mitigation projects, appropriating funds and, ultimately, providing insurance programs when private insurance markets are not sufficient or do not exist.

In addition to managing their aggregate exposure on a near-term basis, some of the world's largest insurers have also taken a long-term strategic approach to changes in catastrophic risk. For example, major insurance and reinsurance companies, such as Allianz, Swiss Re, Munich Re, and Lloyds of London, have published reports that advocate increased industry awareness of the potential risks of climate change and outline strategies to address the issue proactively. Moreover, 6 of the 11 private insurers we interviewed provided one or more additional activities they have undertaken when asked if their company addresses changes in climate through their weather-related risk management processes. These activities include monitoring scientific research (4 insurers), simulating the impact of a large loss event on their portfolios (3 insurers), and educating others

[38]Allianz Group and World Wildlife Fund, *Climate Change and Insurance: An Agenda for Action in the United States* (New York, N.Y.: Allianz Group and World Wildlife Fund, October 2006), http://www.allianz.com/en/allianz_group/sustainability/insight/studies_and_reports/page1.html?hits=reports (downloaded Jan. 4, 2007).

[39]The report notes that these decisions were due, in part, to state restrictions on rate increases that are designed to maintain insurance prices that are affordable, but may not accurately reflect the true potential for loss faced by the insured.

[40]Thirty-one states have FAIR plans, and six southern states have state-sponsored wind insurance plans that pool resources from insurers to cover the cost of coverage for their participants.

in the industry about the risks of climate change (3 insurers), among others.

Furthermore, recent research on insurers' activities to address climate change outlines several other actions that private sector companies are taking, such as developing specialized policies and new products, evaluating risks to company stock investments, and disclosing to shareholders information about company-specific risks due to climate change.[41] Additionally, concern over the potential impacts of climate change on the availability and affordability of private insurance has led state insurance regulators to establish a task force to formally address the issue. The report, issued by the NAIC, is expected to be published in the summer of 2007.

Major Federal Insurers Have Taken Little Action to Prospectively Assess Potential Increases in Catastrophic Risk Associated with Climate Change

The goals of the major federal insurance programs are fundamentally different from those of private insurers. Specifically, whereas private insurers stress the financial success of their business operations, the statutes governing the NFIP and FCIC promote affordable coverage and broad participation by individuals at risk. Although both programs manage risk within their statutory guidelines, unlike the private sector, neither program is required to limit its catastrophic risk strictly within the programs' ability to pay claims on an annual basis. One important implication of the federal insurers' risk management approach is that they each have little reason to develop information on their long-term exposure to the potential risk of increased low-frequency, high-severity weather events associated with climate change.

The statutes governing the NFIP and FCIC promote broad participation over financial self-sufficiency in two ways: (1) by offering discounted or subsidized premiums to encourage participation and (2) by making additional funds available during high-loss years.[42] For example, discounted insurance premiums are available under the NFIP for some older homes situated within high flood risk areas where insurance would

[41]Evan Mills and Eugene Lecomte, *From Risk to Opportunity: How Insurers Can Proactively and Profitably Manage Climate Change* (Boston, MA: Ceres, August 2006), http://www.ceres.org/pub/docs/Ceres_Insurance_Climate_%20Report_082206.pdf (downloaded Jan. 3, 2007), 34.

[42]Note that the federal government covers most, but not all, payments in the event of loss under the FCIC—insurance providers also share in the risk, as described in detail in appendix III.

otherwise have been prohibitively expensive. FEMA is also authorized to borrow additional federal funds for the NFIP on an as-needed basis, subject to statutory limits, to cope with catastrophes.[43] One effect has been that the NFIP's exposure has expanded well beyond the ability to pay claims in high-loss years.

Similar to the discounted premiums offered by the NFIP, the FCIC's subsidized premiums are designed to make crop insurance available and affordable to as many participants as possible. For example, the FCIC is mandated to provide fully subsidized catastrophic coverage for producers in exchange for a minimal administrative fee, as well as partial subsidies for additional levels of coverage. Also like the NFIP, the FCIC is authorized to use additional federal funds on an as-needed basis during high-loss years—although, unlike the NFIP, the FCIC is not required to reimburse those additional funds.

Unlike the private sector, the NFIP and the FCIC can use additional federal funds, and so neither program is required to assess and limit its catastrophic risk strictly within its ability to pay claims on an annual basis. Instead, each program manages its risk to the extent possible, within the context of its broader purposes, in accordance with its authorizing statutes and implementing regulations.[44] For example, the FCIC uses coverage limits, exclusions, and premium rates to meet their statutory goal of a long-term loss ratio no greater than 1.075—including premium subsidies.[45] Although the program has experienced high-loss years that required additional federal funds, over time, these high-loss years have been offset by low-loss years, which have allowed the program to meet its goal and build reserves.[46]

[43]The Congress increased the NFIP's borrowing authority from $1.5 billion to approximately $20.8 billion in the wake of unprecedented losses associated with the 2005 hurricane season.

[44]A detailed description of each program's risk management practices can be found in appendixes II and III for the NFIP and FCIC, respectively.

[45]Loss ratio, an indicator used to evaluate program performance, is calculated by dividing claims paid by total premiums collected. A loss ratio greater than 1.00 indicates that the program paid more in claims than was collected in premiums

[46]The FCIC's average loss ratio from 1995 through 2005 was 0.91. From 1981 through 1994, it was 1.47. See appendix III for more information on the FCIC's performance.

By developing a goal to generate sufficient revenue to pay for an average loss year, the NFIP has also been able to generate a surplus in low-loss years despite borrowing funds in high-loss years. In the past, the program has been able to repay borrowed funds with interest to the Department of the Treasury, however, it is unlikely FEMA will be able to repay the nearly $21 billion borrowed following the 2005 hurricane season based on the program's current premium income.

Although neither program faces the potential of financial ruin like the private sector, both programs have occasionally attempted to estimate their aggregate losses from potential catastrophic events. For example, FCIC officials stated that they had modeled past events, such as the 1993 Midwest floods, using current participation levels to inform negotiations with private crop insurers over reinsurance terms. NFIP and FCIC officials explained that these efforts were informal exercises and were not performed on a regular basis. FCIC officials also said they use a hurricane model developed by NOAA to inform pricing decisions for some commodities such as citrus crops, according to FCIC officials. However, unlike the catastrophic risk faced by private insurers, hurricane damages have not been a primary source of crop insurance claims.

According to NFIP and FCIC officials, their risk management processes adapt to near-term changes in weather as they affect existing data. As one NFIP official explained, NFIP is designed to assess and insure against current—not future—risks. Over time, agency officials stated, this process has allowed their programs to operate as intended. However, unlike the private sector, neither program has conducted an analysis to assess the potential impacts of an increase in the frequency or severity of weather-related events on their program operations over the near- or long-term.

Information on Federal Agencies' Long-term Exposure to Catastrophic Risk Could Better Inform Congressional Decision Making

While comprehensive information on federal insurers' long-term exposure to catastrophic risk associated with climate change may not inform the NFIP's or FCIC's annual operations, it could nonetheless provide valuable information for the Congress and other policymakers who need to understand and prepare for fiscal challenges that extend well beyond the two programs' near-term operational horizons. We have highlighted the need for this kind of strategic information in recent reports that have expressed concern about the looming fiscal imbalances facing the nation. In one report, for example, we observed that, "Our policy process will be

challenged to act with more foresight to take early action on problems that may not constitute an urgent crisis but pose important long-term threats to the nation's fiscal, economic, security, and societal future."[47] The prospect of increasing program exposure, coupled with expected increases in frequency and severity of weather events associated with climate change, would appear to pose such a problem.

Agency officials identified several challenges that could complicate their efforts to assess these impacts at the program level. Both NFIP and FCIC officials stated there was insufficient scientific information on projected impacts at the regional and local levels to accurately assess their impact on the flood and crop insurance programs. However, members of the insurance industry have analyzed and identified the potential risks climate change poses, despite similar challenges. Moreover, as previously discussed, both the IPCC and CCSP are expected to release significant assessments of the likely effect of increasing temperatures on weather events in coming months.

The experience of many private insurers, who must proactively respond to long-term changes in weather-related risk to remain solvent, suggests the kind of information that might be developed to help congressional and other policymakers in assessing current and alternative strategies. Specifically, to help ensure their future viability, a growing number of private insurers are actively incorporating the potential for climate change into their strategic level analyses. In particular, some private insurers have run a variety of simulation exercises to determine the potential business impact of an increase in the frequency and severity of weather events. For example, one insurer simulated the impact of large weather events occurring simultaneously. A similar analysis could provide the Congress with valuable information about the potential scale of losses facing the NFIP and FCIC in coming decades, particularly in light of the programs' expansion since 1980.

Conclusions

Recent assessments by leading scientific bodies provide sufficient cause for concern that climate change may have a broad range of long-term consequences for the United States and its citizens. While a number of key uncertainties regarding the timing, location, and magnitude of impacts

[47]GAO, *21st Century Challenges: Reexamining the Base of the Federal Government*, GAO-05-325SP (Washington, D.C.: February 2005), 77.

remain, climate change has implications for the fiscal health of the federal government, which already faces other significant challenges in meeting its long-term fiscal obligations. NFIP and FCIC are two major federal programs which, as a consequence of both future climate change and substantial growth in exposure, may see their losses grow by many billions of dollars in coming decades.

We acknowledge that to carry out their primary missions, these public insurance programs must focus on the near-term goals of ensuring affordable coverage for individuals in hazard-prone areas. Nonetheless, we believe the two programs are uniquely positioned to provide strategic information on the potential impacts of climate change—information that would be of value to key decision makers charged with such a long-term focus. Most notably, in exercising its oversight responsibilities, the Congress could use such information to examine whether the current structure and incentives of the federal insurance programs adequately address the challenges posed by potential increases in the frequency and severity of catastrophic weather events. While the precise content of these analyses can be debated, the activities of many private insurers already suggest a number of strong possibilities that may be applicable to assessing the potential implications of climate change on the federal insurance programs.

Recommendation for Executive Action

We recommend that the Secretary of Agriculture and the Secretary of Homeland Security direct the Administrator of the Risk Management Agency and the Under Secretary of Homeland Security for Emergency Preparedness to analyze the potential long-term implications of climate change for the Federal Crop Insurance Corporation and the National Flood Insurance Program, respectively, and report their findings to the Congress. This analysis should use forthcoming assessments from the Climate Change Science Program and the Intergovernmental Panel on Climate Change to establish sound estimates of expected future conditions. Key components of this analysis may include: (1) realistic scenarios of future losses under anticipated climatic conditions and expected exposure levels, including both potential budgetary implications and consequences for continued program operation and (2) potential mitigation options that each program might use to reduce their exposure to loss.

Agency Comments and Our Evaluation

We provided a draft of this report to the Departments of Agriculture (USDA), Commerce, Energy, and Homeland Security (DHS) for their review. DHS agreed via email with the report's recommendation, noting that conducting an assessment of the impact of climate change beyond FEMA's current statistical modeling (which is based on historical loss experience) could be helpful if resources were available to pursue such an analysis.

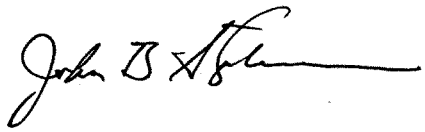
USDA also agreed with the report's recommendation, and commented on the presentation of several findings. (See app. V for the letter from the Under Secretary for Farm and Foreign Agricultural Services and GAO's point-by-point response.) In particular, USDA disagreed that it had thus far taken little action to prospectively assess potential increases in catastrophic risk associated with climate change. USDA explained that RMA does assess both the current and long-term exposure of the crop insurance program to catastrophic weather events, noting specifically that RMA (1) updates and publishes total program liability on a weekly basis and (2) estimates expected changes in liability up to 10 years ahead through its baseline projections. We acknowledge these activities, but believe it is important to note that they are limited in scope, focusing almost exclusively on retrospective measures of performance and not on the potential for increasingly frequent and intense weather-related events. These events, including drought and heavy precipitation events, are the key events acknowledged by USDA as posing catastrophic risk to the crop insurance program. Moreover, other RMA efforts to capture changes in weather-related risk rely on data reflecting what has been experienced in the past, not on what could be experienced in the future.

The Department of Commerce neither agreed nor disagreed with the report's findings, but instead offered several comments on the presentation of several issues in the draft (particularly the depth in which several issues are discussed) as well as technical comments. We have incorporated these comments as appropriate and address them in detail in appendix VI. Notably, the Department of Commerce underscored the vulnerability of high-risk coastal development, stating that such vulnerabilities will only be amplified by climate change-related increases in the frequency or severity of weather-related events.

Finally, the Department of Energy elected not to provide comments on the draft.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies of this report to the Secretaries of Agriculture, Commerce, Energy, and Homeland Security, as well as other interested parties. We also will make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff has any questions regarding this report, please contact me at (202) 512-3841 or stephensonj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors are listed in appendix VII.



John B. Stephenson
Director, Natural Resources and Environment

Appendix I: Scope and Methodology

We were asked us to (1) describe what is known about how climate change might affect insured and uninsured losses, (2) determine insured losses incurred by major federal agencies and private insurers and reinsurers resulting from weather-related events, and (3) determine what major federal agencies and private insurers and reinsurers are doing to assess and manage the potential risk of increased losses due to changes in the frequency and severity of weather-related events associated with climate change.

Scientific Literature

To address the first objective, we reviewed and summarized existing literature from significant policy-oriented scientific assessments from reputable international and national research organizations including the Intergovernmental Panel on Climate Change, National Academy of Sciences, and the multifederal agency U.S. Climate Change Science Program, as specified in table 3. It was beyond the scope of this report to independently evaluate the results of these studies.

Table 3: Key Policy-Oriented Scientific Assessments Reviewed by GAO

Organization	Publication
Intergovernmental Panel on Climate Change (IPCC)	• *Climate Change 2007: The Physical Science Basis, Summary for Policymakers* (2007) • *Climate Change 2001: Synthesis Report* (2001) • *Climate Change 2001: The Scientific Basis* (2001) • *Climate Change 2001: Impacts, Adaptation & Vulnerability* (2001)
Climate Change Science Program (CCSP)	• *Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences, Synthesis and Assessment Product 1.1* (2006)
National Academy of Sciences (NAS)	• *Surface Temperature Reconstructions for the Last 2,000 Years* (2006) • *Understanding and Responding to Climate Change: Highlights of National Academies Reports* (2006) • *Radiative Forcing of Climate Change: Expanding the Concept and Addressing Uncertainties* (2005) • *From Climate to Weather: Impacts on Society and Economy–Summary of a Forum, June 28, 2002, Washington, D.C.* (2003) • *Understanding Climate Change Feedbacks* (2003) • *Abrupt Climate Change: Inevitable Surprises* (2002) • *Climate Change Science: An Analysis of Some Key Questions* (2001)

Source: GAO.

Note: Publication year follows publication title in parentheses.

Insured Loss Data

To address the second objective, we analyzed insured loss data from January 1, 1980, through December 31, 2005, from the Federal Emergency Management Agency (FEMA) for the National Flood Insurance Program (NFIP); the Department of Agriculture's Risk Management Agency (RMA) for the Federal Crop Insurance Corporation (FCIC); and the Property Claim Services (PCS) for private property insurance. Through electronic testing and other means, we assessed the reliability of each of the data sets to determine whether the data were sufficiently reliable for our purposes. Specifically, we interviewed the sources for each of the data sets to gather information on how records were collected, processed, and maintained. Because not all catastrophes are weather-related, we excluded all events attributable to terrorist acts, tsunamis, earthquakes, and other nonweather-related losses, based on discussions with the data provider. To adjust for the general effects of inflation over time we used the chain-weighted gross domestic product price index to express dollar amounts in inflation-adjusted 2005 dollars. We reviewed any changes in data collection methodologies that have occurred over time, and evaluated the effect of any changes on our ability to report losses. We believe that these data are sufficiently reliable for the purpose of describing insured losses. We note, however, that these data likely understate the actual insured losses.

PCS

PCS data are estimates of insured losses, or claims paid by private insurance companies, for catastrophe loss events for the 50 states, as well as the District of Columbia, Puerto Rico, and the U.S. Virgin Islands. PCS defines "catastrophes" as events that, in their estimation, affect a significant number of policyholders and that cause more than $25 million in damages. To identify catastrophes, PCS reviews daily weather reports and wire service news stories to determine if potentially damaging weather has occurred anywhere in the nation. PCS contacts adjusters, insurance claims departments, or public officials to gather additional information about the scope of damage and potential insured losses for events. Damages associated with a single storm event are grouped together as a single catastrophe, even if they are separated by distance. PCS obtains its insured loss data from information reported by insurers. PCS estimates include losses under personal and commercial property insurance policies covering real property, contents, business interruption, vehicles, and boats. PCS estimates also typically include amounts paid by state wind pools, joint underwriting associations, and certain other residual market mechanisms, such as Fair Access to Insurance Requirements (FAIR) plans. However, PCS estimates do not include damage to uninsured or self-insured property including uninsured publicly

owned property and utilities; losses involving agriculture, aircraft and property insured under NFIP or certain specialty lines (such as ocean marine), or loss adjustment expenses. Generally, PCS finalizes its estimates within 6 months of the occurrence of a PCS-identified catastrophe, according to company documents. PCS does not independently verify or audit the accuracy of the reported losses. Thus, loss totals are the best estimates of primary insurers compiled by PCS professionals, and may or may not accurately and completely reflect actual industry-insured losses. Nevertheless, PCS has determined their data to be very close to other independent estimates. PCS officials said that, when compared with state insurance commissioners' estimates based on all loss data from insurance companies following particularly large catastrophes, PCS data are within 3 to 5 percent of actual amounts. For the data used in our review, company officials told us that most estimates included in the data provided to us are final, except the 2005 hurricanes.

NFIP

NFIP data are actual claim payment totals, not estimated amounts. NFIP data represent the budget outlays that satisfy claims submitted by NFIP policyholders to their participating program companies. The companies report these data to the NFIP on a monthly basis. According to a senior program official, the Department of Homeland Security performs periodic audits of company records reported to NFIP. Although nearly all claims in the NFIP data we reviewed are considered closed by the agency (and, therefore, final), a small portion of claims associated with 2004 and 2005 hurricane season are not reflected in data we reviewed, according to the agency's database manager.

FCIC

The loss data provided by FCIC represent the actual amount paid to policyholders, not estimates. FCIC data represent the budget outlays that satisfy claims submitted by policyholders to their participating insurance companies. Participating insurance companies submit claims information for processing through a computerized validation system. Automated processing of claims information occurs annually for a period going back 5 years, but agency officials said that indemnities may have changed after automated processing closed in very specific cases, such as settlement of litigation or arbitration cases.

Identifying Insured Losses Associated with Hurricanes

To determine the insured losses associated with major and nonmajor hurricanes, we identified losses associated with hurricanes in both the PCS and NFIP data sets. We used the name and year of each hurricane to link loss records to information from the National Oceanic and Atmospheric Administration (NOAA) on the peak intensity of each hurricane at or near landfall.

Independent Studies

We supplemented our descriptive analysis with a review of existing literature and the views of subject area experts on the primary drivers of changes in the weather-related loss record in general. Given the data challenges faced by natural hazard researchers, the data sets used in these studies are generally different.

Interviews with Major Insurers

To address the third objective, we conducted semistructured interviews with officials from the NFIP, RMA, and a nonprobability sample of the largest private property/casualty primary insurance and reinsurance companies as defined by national market share. In the private sector, 11 out of 14 potential respondents elected to participate, drawing from companies in the United States, Europe, and Bermuda. Although the results from this sample should not be generalized to represent all insurance companies, the companies we interviewed represent about 45 percent of the total domestic insurance market. In developing our semistructured questionnaire, we reviewed existing literature on risk assessment and management practices, GAO guidance on risk management, and interviewed subject area experts knowledgeable about the insurance industry and federal insurance programs. Insurance industry experts included representatives from insurance brokers, catastrophe modeling firms, industry associations, the Insurance Information Institute, and academics. To reduce response error, we pretested our questions for clarity, relevancy, and sensitivity with representatives from several insurance industry associations, including the American Insurance Association, the National Association of Mutual Insurance Companies, the Property Casualty Insurance Association of America, and the Reinsurance Association of America. On the basis of feedback from the pretests, we modified the questions as appropriate. We distinguished proactive risk management responses to climate change from other responses according to whether insurers indicated that they were adjusting their activities based on projected changes in underlying weather trends rather than adapting only as changes in weather conditions reveal themselves in historical data. During our interviews, some private insurers attributed their actions to changes in the Atlantic Multidecadal Oscillation (AMO).

Because NOAA considers the AMO to be a climatic cycle, we categorized the actions of these insurers as responding to climate change.

We asked the participating federal agencies and private insurance and reinsurance companies to identify individuals knowledgeable about their weather-related risk management practices for our interviews. Based on these criteria, we spoke with a range of senior officials and representatives that included actuaries, underwriters, catastrophe specialists, regulatory affairs and counsel. During the interviews, we asked a series of questions about risk assessment and management practices for weather-related risk, significant drivers of changes to past and future weather-related risk, respondents' perception of and actions to address climate change in their risk management processes, and risk management best practices that might be transferable to federal insurers.

We also interviewed officials from rating agencies, catastrophe modeling firms, insurance industry associations, the National Association of Insurance Commissioners, and universities to provide additional context for respondents' statements. To supplement our interviews, we reviewed documentary evidence of risk management practices from federal agencies, studies from subject area experts, industry reports, publicly available insurance company documents, and previous work from GAO to provide context and support for respondents' statements.

We performed our work between February 2006 and January 2007 in accordance with generally accepted government auditing standards.

Appendix II: National Flood Insurance Program

Floods are the most common and destructive natural disaster in the United States. According to NFIP statistics, 90 percent of all natural disasters in the United States involve flooding. Because of the catastrophic nature of flooding and the inability to adequately predict flood risks, private insurance companies largely have been unwilling to underwrite and bear the risk of flood insurance. As a result, flooding is generally excluded from homeowner policies that cover damages from other types of losses, such as wind, fire, and theft.

The NFIP was established in 1968 to address uninsured losses due to floods. Prior to the establishment of the NFIP, structural flood controls on rivers and shorelines (e.g., dams and levees) and disaster assistance for flood victims were the federal government's primary tools for addressing floods. The Mississippi River Commission, created in 1879 to oversee the development of a levee system to control the river's flow, was the first of these federal efforts to address flooding. Due to the limited effectiveness of structural flood controls, continued development in flood-prone areas, and a desire to reduce postdisaster assistance payments, the Congress began examining the feasibility of prefunding flood disaster costs via federal insurance in the 1950s. Although the first federal flood insurance program authorized by the Congress in 1956 failed due to lack of funding, a series of powerful hurricanes and heavy flooding on the Mississippi River in the early 1960s prompted the Congress to revisit the issue and direct the Department of Housing and Urban Development (HUD) to conduct a feasibility study of a federal flood insurance program. The 1966 HUD feasibility study helped lead to the passage of the National Flood Insurance Act of 1968,[1] which authorized the creation of the NFIP.[2]

Since its inception, the NFIP has undergone several major changes in response to significant flood events. Hurricane Agnes in 1972 led to the mandatory flood insurance requirements on certain persons in flood-prone areas included in the Flood Disaster Protection Act of 1973, which also significantly increased coverage limits in a further effort to increase participation.[3] Following the Midwest floods of 1993, the Congress enacted the National Flood Insurance Reform Act of 1994, which strengthened

[1]Pub. L. No. 90-448, 82 Stat. 573.

[2]Senate Committee on Banking and Currency, *Insurance and Other Programs for Financial Assistance to Flood Victims*, 89th Cong., 2d Sess., 1966, Committee Print.

[3]Pub. L. No. 93-234, 87 Stat. 975 (1973).

lender compliance requirements with mandatory purchase provisions requiring mortgage-holders in flood-prone areas to purchase flood insurance and prohibited flood disaster assistance for properties that had not maintained their mandatory coverage.[4] In 2004, recognizing that losses from repetitive flooding on some insured properties was straining the financial condition of the NFIP, the Congress passed the Flood Insurance Reform Act of 2004, which provided NFIP with additional tools to reduce the number and financial impact of these properties.[5] These tools include: increased authorization of funding for mitigation of repetitive loss properties and statutory authority to penalize policyholders who refuse government assistance to mitigate certain structures that have been substantially or repetitively damaged by flooding, among others. Recently, the Congress has begun exploring additional changes to the NFIP to address the financial and operational challenges presented by the 2005 hurricane season.

How the Program Works

FEMA, within the Department of Homeland Security (DHS), is responsible for the oversight and management of the NFIP.[6] Under this program, the federal government assumes the liability for covered losses and sets rates and coverage limitations, among other responsibilities.

The NFIP combines three elements: (1) property insurance for potential flood victims, (2) mapping to identify the boundaries of the areas at highest risk of flooding, and (3) incentives for communities to adopt and enforce floodplain management regulations and building standards (such as elevating structures) to reduce future flood damage. The effective integration of all three of these elements is needed for the NFIP to achieve its goals of

[4]Pub. L. No. 103-325, 108 Stat. 2255 (1994).

[5]The Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004, Pub. L. No. 108-264, 118 Stat. 712.

[6]In March 2003, FEMA and its approximately 2,500 staff became part of the Department of Homeland Security (DHS). Most of FEMA—including its Mitigation Division, which is responsible for administering the NFIP—is now part of the department's Emergency Preparedness and Response Directorate. However, FEMA retained its name and individual identity within the department. Under a reorganization plan proposed by the current Secretary of DHS, the Emergency Preparedness and Response Directorate would be abolished, and FEMA would report directly to the Undersecretary and Secretary of DHS.

- providing property flood insurance coverage for a high proportion of property owners who would benefit from such coverage,
- reducing taxpayer-funded disaster assistance when flooding strikes, and
- reducing flood damage through floodplain management and the enforcement of building standards.

Over 20,000 communities across the United States and its territories participate in the NFIP by adopting and agreeing to enforce state and community floodplain management regulations to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners and other property owners in these communities. As of 2005, the program had over 4.9 million policyholders, representing about $875 billion in assets. Homeowners with mortgages from federally regulated lenders on property in communities identified to be in high flood risk areas are required to purchase flood insurance on their dwellings. Optional, lower cost coverage is also available under the NFIP to protect homes in areas of low to moderate risk. The mandated coverage protects homeowners' dwellings only; to insure furniture and other personal property items against flood damage, homeowners must purchase separate NFIP personal property coverage.

Prior to the 2005 hurricanes, NFIP had paid about $14.6 billion in flood insurance claims, primarily from policyholder premiums that otherwise would have been paid through taxpayer-funded disaster relief or borne by home and business owners themselves. According to FEMA, every $3 in flood insurance claims payments saves about $1 in disaster assistance payments, and the combination of floodplain management and mitigation efforts save about $1 billion in flood damage each year.

To make flood insurance available on "reasonable terms and conditions to persons who have need for such protection,"[7] the NFIP strikes a balance between the scope of the coverage provided and the premium amounts required to provide that coverage. Policy coverage limits arise from statute and regulation, including FEMA's standard flood insurance policy (SFIP), which is incorporated in regulation and issued to policyholders when they purchase flood insurance. As of 2006, FEMA estimated 26 percent of its policies were subsidized, and 74 percent were charged "full-risk premium"

[7] 42 U.S.C. § 4001(a)(4).

rates. In 1981, FEMA set the operating goal of generating premiums at least sufficient to cover losses and expenses relative to the "historical average loss year." However, the heavy losses from the 2005 hurricane season may increase the historical average loss year to a level beyond the expected long-term average. In light of this, FEMA is currently revisiting the use of the historical average loss year as a premium income target.

Risk Assessment Practices

The NFIP uses hydrologic models to estimate loss exposure in flood-prone areas, based on the method outlined in the 1966 HUD report, *Insurance and Other Programs for Financial Assistance to Flood Victims*.[8] These techniques of analysis were first developed by hydrologists and hydraulic engineers to determine the feasibility of flood protection.

The hydrologic method uses available data on the occurrence of floods and flood damages to establish both the frequency of flood recurrence and the damage associated with a flood of a given height. The NFIP augments available flood data with detailed engineering studies, simulations, and professional judgment to establish the scientific and actuarial basis for its risk assessment process and rates.

Flood-elevation frequency data for specific communities is published in Flood Rate Insurance Maps, which differentiate areas based on their flood risk. These maps are the basis for setting insurance rates, establishing floodplain management ordinances, and identifying properties where flood insurance is mandatory.

To estimate expected annual losses and determine the basis for rate setting, NFIP combines flood-elevation frequency data with depth-damage calculations to estimate a range of flood probabilities and associated damages. Each possible flood is multiplied by the expected damage should such a flood occur, and then each of these is added together. The total of each possible flood's damage provides an expected per annum percentage of the value of property damage due to flooding. This expected damage can then be converted to an expected loss per $100 of property value covered by insurance. This per annum expected loss provides the fundamental component of rate setting. Rates are also adjusted to

[8]Senate Committee on Banking and Currency, *Insurance and Other Programs for Financial Assistance to Flood Victims*.

incorporate additional expense factors, such as adjustment costs and deductibles.

Program Funding

To the extent possible within the context of its broader purposes, the NFIP is expected to pay operating expenses and flood insurance claims with premiums collected on flood insurance policies rather than with tax dollars. However, as we have reported, the program is not actuarially sound by design because the Congress authorized subsidized insurance rates to be made available for policies covering certain structures to encourage communities to join the program. As a result, the program does not collect sufficient premium income to build reserves to meet the long-term future expected flood losses.[9] FEMA has statutory authority to borrow funds from the Department of the Treasury to keep the NFIP solvent.[10] Prior to the 2005 hurricane season, FEMA had exercised its borrowing authority four times, when losses exceeded available fund balances. For example, FEMA borrowed $300 million to pay an estimated $1.8 billion on flood insurance claims resulting from the 2004 hurricane season. Following hurricanes Katrina, Rita, and Wilma, FEMA estimates it will need to borrow nearly $21 billion dollars to cover outstanding claims. Although FEMA has repaid borrowed funds with interest in the past, FEMA does not expect to be able to meet the $1 billion in annual interest payments for these borrowed funds.

[9]GAO, *Flood Insurance: Information on the Financial Condition of the National Flood Insurance Program*, GAO-01-992T (Washington, D.C.: July 19, 2001).

[10]See 42 U.S.C. § 4016.

Appendix III: Federal Crop Insurance Corporation

In general, farm income is determined on the basis of farm production and prices, both of which are subject to wide fluctuations due to external factors. Because a substantial part of farming depends on weather, farm production levels can vary substantially on an annual basis. Commodity prices are also subject to significant swings due to supply and demand on the domestic and international markets. The Congress created FCIC in 1938 to administer a federal crop insurance program on an experimental basis to temper the weather effects of the dust bowl and the economic effects of the Great Depression.[1]

The federal crop insurance program protects participating farmers against financial losses caused by droughts, floods, or other natural disasters. Until 1980, the federal crop insurance program was limited to major crops in the nation's primary production areas. The Federal Crop Insurance Act of 1980 expanded crop insurance both in terms of crops and geographic areas covered.[2] The expansion was designed to allow the disaster assistance payment program provided by the government under previous farm bills to be phased out. To encourage participation, the 1980 act required a 30 percent premium subsidy for producers who purchased coverage up to the 65 percent yield level. Despite the subsidies, program participation remained low, and the Congress authorized several ad hoc disaster payments between 1988 and 1993. Congressional dissatisfaction with the size and frequency of these payments prompted the Congress to pass the Federal Crop Insurance Reform Act of 1994, which mandated participation in the crop insurance program as a prerequisite for other benefits, including agriculture price support payments.[3] The 1994 act also introduced catastrophic risk protection coverage, which compensated farmers for losses exceeding 50 percent of their average yield at 60 percent of the commodity price. Premiums for catastrophic risk protection coverage were completely subsidized, and subsidies for other coverage levels were also increased.

As part of the 1996 Farm Bill, the Congress created the Office of Risk Management under the U.S. Department of Agriculture (USDA), and USDA established RMA to administer the FCIC insurance programs, among other

[1]Federal Crop Insurance Act, tit. V, 52 Stat. 72 (1938) (codified as amended at 7 U.S.C. §§ 1501-1524).

[2]Pub. L. No. 96-365, 94 Stat. 1312 (1980).

[3]Pub. L. No. 103-354, 108 Stat. 3178 (1994).

things.[4] The Congress also required the creation of a revenue insurance pilot project and repealed the mandatory participation provision of the 1994 Act. However, participation in the crop insurance program has not necessarily precluded the need for further disaster assistance. For example, due to low commodity prices in 1997 and multiple years of natural disasters, the Congress enacted an emergency farm financial assistance package totaling almost $6 billion in 1998, which included over $2 billion in crop disaster payments, and an $8.7 billion financial assistance package in 1999 that included $1.2 billion in crop disaster payments.

In 2000, the Congress enacted the Agricultural Risk Protection Act, which further increased subsidies for insurance above the catastrophic risk protection coverage level, subsidized a portion of the cost of revenue insurance products, improved coverage for farmers affected by multiple years of natural disasters, required pilot insurance programs for livestock farmers, and authorized pilot programs for growers of other commodities not currently covered, gave the private sector greater representation on the FCIC Board of Directors, reduced eligibility requirements for permanent disaster payment programs for noninsured farmers, and provided new tools for monitoring and controlling program abuses, among other provisions.[5] These changes required $8.2 billion in additional spending from fiscal years 2001 through 2005.

How the Program Works

RMA has overall responsibility for supervising the federal crop insurance program, which it administers in partnership with private insurance companies. Insurance policies are sold and completely serviced through approved private insurance companies that have their losses reinsured by USDA. These companies share a percentage of the risk of loss or opportunity for gain associated with each insurance policy written. In addition, RMA pays companies a percentage of the premium on policies sold to cover the administrative costs of selling and servicing these policies. In turn, insurance companies use this money to pay commissions to their agents who sell the policies and fees to adjusters when claims are filed. RMA oversees the development of new insurance products and the expansion of existing insurance products to new areas to help farmers reduce the chance of financial loss.

[4]Pub. L. No. 104-127, 110 Stat. 888 (1996).

[5]Pub. L. No. 106-224, 114 Stat. 358 (2000).

The USDA determines whether the federal crop insurance program will insure a commodity on a crop-by-crop and county-by-county basis, based on farmer demand for coverage and the level of risk associated with the crop in the region, among other factors. Over 100 crops are covered; major crops such as grains are covered in almost every county where they are grown, and specialty crops such as fruit are covered in some areas. For many commodities, producers may also purchase revenue insurance. Based on commodity market prices and the producer's production history, producers are assigned a target revenue level. The producer receives a payment if their actual revenue falls short of the target level, whether the shortfall was due to low yield or low prices. Premiums for revenue insurance are subsidized at the same level as traditional crop insurance policies.

Farmers' participation in the federal crop insurance program is voluntary, but the federal government encourages it by subsidizing the insurance premiums. Participating farmers are assigned a "normal" crop yield based on their past production history and a commodity price based on estimated market conditions. The producer selects both the percentage of yield to be covered and the percentage of the commodity price received as payment if the producer's losses exceed the selected threshold. Premium prices increase as levels of yield and price coverage rise. However, all eligible producers can receive fully subsidized catastrophic risk protection coverage that pays producers for losses exceeding 50 percent of normal yield, at a level equal to 55 percent of the estimated market price, in exchange for a $100 administrative fee. Producers who purchase this coverage can buy additional insurance at partially subsidized rates up to 85 percent of their yield and 100 percent of the estimated market price.

As an alternative, the Group Risk Plan provides coverage based on county yields rather than a producer's actual production history. If county yield falls below the producer's threshold yield (a percentage of the historical county yield), then the producer receives a payment.

Risk Assessment Practices

RMA's risk assessment/rate-setting methodology is complex because the risk of growing a particular crop varies by county, farm, and farmer. Because of all the possible combinations involved, hundreds of thousands of rates are in place. Each year, RMA follows a multistep process to establish rates for each crop included in the program. The process involves establishing base rates for each county crop combination and adjusting these basic rates for a number of factors, such as coverage and

production levels. In addition, rates are adjusted to account for the legislated limitations in price increases.

For each crop, RMA extracts data on counties' crop experience from its historical database. The data elements for each crop, crop year, and county include (1) the dollar amount of the insurance coverage sold, (2) the dollar amount of the claims paid, and (3) the average coverage level. The historical data are adjusted to the 65 percent coverage level (the most commonly purchased level of coverage) so that liability and claims data at different coverage levels can be combined to develop rates. Using the adjusted data, FCIC computes the loss-cost ratio for each crop in each county. The loss-cost ratio is calculated by dividing the total claim payments by the total insurance in force; the result is stated as a percentage.[6] To reduce the impact a single year will have on the average loss-cost ratio of each county, RMA caps the adjusted average loss-cost ratio for any single year at 80 percent of all years.[7] To establish the base rate for each county, the average for all the years since 1975 is calculated using the capped loss-cost ratios and a weighting process to minimize the differences in rates among counties.

Rates are further adjusted by: a disaster reserve factor, a surcharge for catastrophic coverage for each crop based on pooled losses at the state level,[8] a prevented planting factor, farm divisions, crop type, and differences in both average yield and coverage levels.[9]

[6]For example, if the claims paid in 1 year totaled $7.36 and the insurance in force was $100, the loss-cost ratio is 7.36 percent. The percentage represents the rate that would need to be charged per $100 of insurance coverage if total premiums are to equal the total claim payments for that year. In this example, the 7.36 percent indicates that a rate of $7.36 was required per $100 of insurance coverage sold.

[7]The excess of losses above the capped amount is pooled at the state level and reallocated to the counties. According to FCIC, this procedure is intended to reduce the variation of rates from one year to the next.

[8]The surcharge is established by pooling the amount of insurance in force and the claim payments for capped years with the highest loss-cost ratios in each county that were not factored into the county unloaded rates at the state level. These data are used to calculate a statewide surcharge for catastrophic coverage (pooled claims payments divided by pooled insurance in force). If the pooled losses at the state level exceed five points, the excess is returned to the counties and included in the county unloaded rate.

[9]Prevented planting factor adds a provision for losses due to crops that were never planted because of external factors not directly related to yield loss.

Program Funding

The crop insurance program is financed primarily through general fund appropriations and farmer-paid premiums. In addition to the premiums paid by producers, FCIC receives an annual appropriation to cover necessary costs for the program's premium subsidies, excess losses, delivery expenses, and other authorized expenses. According to USDA budget documents, for fiscal year 2005, insurance premium and administrative fee revenue from farmers was approximately $2.1 billion, and gross claims equaled almost $3.3 billion. Total government operating costs in fiscal year 2005 were approximately $3 billion.

RMA is required to set crop insurance premiums at actuarially sufficient rates, defined as a long-run loss ratio target of no more than 1.075. From its initial expansion in 1981 through 1994, the crop insurance program had an average loss ratio of 1.47 and paid roughly $3.2 billion in claims excess of subsidized premium income during that period.[10] From 1995 to 2005, the program had an average loss ratio of 0.91, and collected roughly $2.7 billion in subsidized premium excess of claims during that period. Excluding subsidies and measuring performance on the basis of a producer premium, from 1981 to 1994, the crop insurance program averaged a loss ratio of 1.93 and paid roughly $5.2 billion in claims excess of producer premium over that period; from 1995 to 2005, the program averaged a loss ratio of 2.15 and paid roughly $14.2 billion in claims excess of a producer premium during that period.

Generally, producers can purchase crop insurance to insure up to 85 percent of their normal harvest (yield), based on production history. In 2007, the USDA expects the FCIC to provide $48 billion in risk protection on 287 million acres nationwide, which represents approximately 80 percent of the nation's acres planted to principal crops. The USDA estimates this level of coverage will cost the federal government $4.2 billion in 2007.

[10]The Federal Crop Insurance Reform Act of 1994 mandated participation in the program to receive other commodity support payments, although this requirement was rescinded in 1996.

Appendix IV: Consensus Statement among Participants at 2006 Munich Re Workshop

Munich Re, one of the world's largest reinsurance companies, and the University of Colorado jointly convened an international workshop on climate change and disaster loss trends in May 2006 in Hohenkammer, Germany. The workshop brought together 32 experts in the fields of climatology and disaster research from 13 countries. White papers were prepared and circulated by 25 participants in advance of the workshop and formed the basis of the discussions. In the course of the event, participants developed a list of statements that each represent a consensus among participants on issues of research and policy as related to the workshop's two central organizing questions: (1) What factors account for increasing costs of weather related disasters in recent decades? and (2) What are the implications of these understandings, for both research and policy?

Consensus (unanimous) statements of the workshop participants:

1. Climate change is real, and has a significant human component related to greenhouse gases.

2. Direct economic losses of global disasters have increased in recent decades with particularly large increases since the 1980s.

3. The increases in disaster losses primarily result from weather related events, in particular storms and floods.

4. Climate change and variability are factors which influence trends in disasters.

5. Although there are peer reviewed papers indicating trends in storms and floods there is still scientific debate over the attribution to anthropogenic climate change or natural climate variability. There is also concern over geophysical data quality.

6. IPCC (2001) did not achieve detection and attribution of trends in extreme events at the global level.

7. High quality long-term disaster loss records exist, some of which are suitable for research purposes, such as to identify the effects of climate and/or climate change on the loss records.

8. Analyses of long-term records of disaster losses indicate that societal change and economic development are the principal factors responsible for the documented increasing losses to date.

9. The vulnerability of communities to natural disasters is determined by their economic development and other social characteristics.

10. There is evidence that changing patterns of extreme events are drivers for recent increases in global losses.

11. Because of issues related to data quality, the stochastic nature of extreme event impacts, length of time series, and various societal factors present in the disaster loss record, it is still not possible to determine the portion of the increase in damages that might be attributed to climate change due to greenhouse gas emissions.

12. For future decades the IPCC (2001) expects increases in the occurrence and/or intensity of some extreme events as a result of anthropogenic climate change. Such increases will further increase losses in the absence of disaster reduction measures.

13. In the near future the quantitative link (attribution) of trends in storm and flood losses to climate changes related to greenhouse gas emissions is unlikely to be answered unequivocally.

14. Adaptation to extreme weather events should play a central role in reducing societal vulnerabilities to climate and climate change.

15. Mitigation of greenhouse gas emissions should also play a central role in response to anthropogenic climate change, though it does not have an effect for several decades on the hazard risk.

16. We recommend further research on different combinations of adaptation and mitigation policies.

17. We recommend the creation of an open-source disaster database according to agreed upon standards.

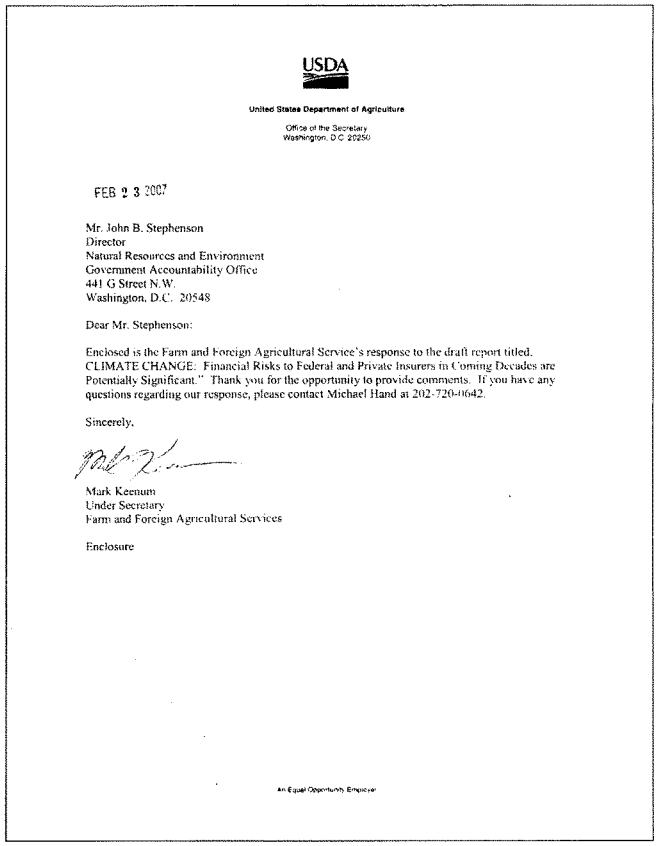
18. In addition to fundamental research on climate, research priorities should consider needs of decision makers in areas related to both adaptation and mitigation.

19. For improved understanding of loss trends, there is a need to continue to collect and improve long-term and homogenous data sets related to both climate parameters and disaster losses.

20. The community needs to agree upon peer reviewed procedures for normalizing economic loss data.

Appendix V: Comments from the U.S. Department of Agriculture

Note: GAO comments supplementing those in the report text appear at the end of this appendix.



USDA

United States Department of Agriculture

Office of the Secretary
Washington, D.C. 20250

FEB 23 2007

Mr. John B. Stephenson
Director
Natural Resources and Environment
Government Accountability Office
441 G Street N.W.
Washington, D.C. 20548

Dear Mr. Stephenson:

Enclosed is the Farm and Foreign Agricultural Service's response to the draft report titled, CLIMATE CHANGE: Financial Risks to Federal and Private Insurers in Coming Decades are Potentially Significant." Thank you for the opportunity to provide comments. If you have any questions regarding our response, please contact Michael Hand at 202-720-0642.

Sincerely,

Mark Keenum
Under Secretary
Farm and Foreign Agricultural Services

Enclosure

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U.S. Department of Agriculture
Response to the
U.S. Government Accountability Office *Draft* Report GAO-07-285
"CLIMATE CHANGE: Financial Risks to Federal and Private Insurers in Coming Decades are Potentially Significant"

February 8, 2007

Weather-related events have caused billions of dollars in damage over the past decade. GAO examined actions taken by private and Federal insurers to address the potential increase in losses. As a result of the study, *GAO recommends that the United States Department of Agriculture (USDA), specifically the Risk Management Agency (RMA), analyze the potential long-term implications of climate change using forthcoming assessments from the Intergovernmental Panel on Climate Change to establish sound estimates of expected future conditions.*

USDA Response

USDA is in general agreement with GAO's recommendation.

Specific Comments

Although USDA agrees with GAO's recommendation, we do not agree with some of the conclusions drawn within the report.

See comment 1.

Much of the focus of this report is with losses related to coastal weather events, especially hurricanes. However, the main cause of catastrophic losses for the crop insurance program is drought in the nation's interior. This is why the loss experience of the crop insurance program is distinct from the loss experience described in the report for the National Flood Insurance Program and property and casualty losses for private insurers.

See comment 2.

The increase in crop insurance indemnities over time reflects the rapid growth of the crop insurance program, not an increase in either the frequency and/or severity of catastrophic weather events. In fact, the severity of loss for the crop insurance program, as measured by the loss ratio, has been generally lower in the 1990's and 2000's than in the 1980's. Thus, if anything, the frequency and severity of catastrophic loss events for the crop insurance program appears to be decreasing.

See comment 3.

USDA does not agree that it has "taken little action to prospectively assess potential increases in catastrophic risk associated with climate change." RMA tracks total program liability – a definitive measure of the total value at risk from climatic weather events. This number is updated on a weekly basis and is available on RMA's public website.

RMA also estimates expected changes in liability up to 10 years ahead through RMA's baseline projections. Therefore, RMA *does* assess the long-term, as well as current, exposure of the crop insurance program to catastrophic weather events.

See comment 4.

GAO's draft report treats the recurring 20- to 40-year Atlantic hurricane cycle as synonymous with climate change. However, other parts of the report describe climate change in terms of a long-run progression, such as global warming, that leads to an increase in frequency and severity of weather events. Referring to the normal cycle of Atlantic hurricanes as climate change appears to be inconsistent with how climate change is described in other parts of the report.

See comment 5.

When GAO surveyed private insurers about what they are doing to estimate and prepare for the risks of climate change, they found that insurers were using catastrophe models that incorporate the hurricane cycle. RMA also incorporates hurricane risk into premium rates for several of its insured commodities. However, rather than focusing on short-term fluctuations in the hurricane cycle, RMA uses historical hurricane data that spans several cycles.

The following are GAO's comments on the U.S. Department of Agriculture's letter dated February 23, 2007.

GAO Comments

1. We agree that the loss experiences of NFIP, FCIC, and private insurers are distinct and sought to reflect these distinctions in our draft report. For example, we acknowledged on page 23 of the draft the specific distinction USDA highlights—that the main cause of catastrophic losses for FCIC is drought in the nation's interior (see pages 24 and 25 of this document). Despite these and other differences, however, we believe the report's findings and underlying message are still applicable to the NFIP, the FCIC, and private insurers.

2. Our analysis of insured losses does not attempt to attribute increases in past losses to changes in the severity of weather events in the data sets we reviewed, as implied by the comment. Moreover, we acknowledge that the increase in FCIC's losses (indemnities) largely reflected the rapid growth of the crop insurance program. However, given the IPCC's projections for potential increase in the frequency and severity of weather-related events—including those that affect crops—we believe that limiting an evaluation of FCIC's *future* weather-related risk to the program's loss ratio—which only captures *historical* performance of the program based on past climatic and market conditions—to be a potentially misleading metric upon which to make a prospective assessment.

3. We acknowledged these activities in the draft report. However, we believe that USDA's actions are limited in scope, focusing almost exclusively on actuarial performance and not on the potential implications of climate change for FCIC's operations (i.e., changes in the frequency and severity of weather-related events, weather variability, growing seasons, and pest infestations). Accordingly, we believe the program should do more to prospectively assess the implications of climate change.

4. We employed the IPCC's definition of climate change, which includes statistically significant variations in climate, brought on by factors that are both internal and external to the earth's climate system, and that persist over time—typically decades or longer. Under this definition, the Atlantic hurricane cycle, as with other significant variations that are understood to be internal to the earth's climate system, can be considered climatic changes. Our use of the definition was corroborated by a senior NOAA scientist.

5. We updated our discussion of FCIC's modeling activities (see page 36) to reflect this hurricane model. However, as stated on page 22, 75 percent of FCIC's claims were associated with drought, excess moisture, and hail from 1980 to 2005, whereas hurricanes were associated with a much smaller portion of FCIC's claims during this period. Accordingly, we believe that if more sophisticated, prospective risk assessment techniques (such as those used in FCIC's hurricane model) were applied to drought, moisture, and hail events, it would allow for a far more useful assessment of the potential implications of climate change for FCIC's operations.

Appendix VI: Comments from the Department of Commerce

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

UNITED STATES DEPARTMENT OF COMMERCE
The Under Secretary of Commerce
for Oceans and Atmosphere
Washington, D.C. 20230

FEB 26 2007

Mr. John B. Stephenson
Director
Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, NW
Washington, D.C. 20548

Dear Mr. Stephenson:

Thank you for the opportunity to review and comment on the Government Accountability Office's draft report entitled *Climate Change: Financial Risks to Federal and Private Insurers In Coming Decades are Potentially Significant* (GAO-07-285). Enclosed is the National Oceanic and Atmospheric Administration's comments on the draft report.

Sincerely,

Conrad C. Lautenbacher, Jr.
Vice Admiral, U.S. Navy (Ret.)
Under Secretary of Commerce for
Oceans and Atmosphere

Enclosure

THE ADMINISTRATOR

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Department of Commerce
National Oceanic and Atmospheric Administration
Comments on the Draft GAO Report Entitled
"Climate Change: Financial Risks to Federal and Private Insurers In Coming Decades are Potentially Significant"
(GAO-07-285/March 2007)

General Comments

The Department of Commerce (DOC) appreciates the opportunity to review this report. The issues covered in the report are very important and reflect the real world intersection between science, policy, and economics.

See comment 1.

We have three major comments on the structure of the report. First, GAO should provide a clear definition of the phrase "climate change" at the beginning of its report. While it is addressed on page 2, DOC recommends the authors refer to the definition provided by the 2007 Intergovernmental Panel on Climate Change (IPCC) Working Group 1:

> **IPCC Working Group 1 Climate Change Definition**
> Climate change refers to a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

See comment 2.

The second comment is directed to page 2 of the report and relates to the discussion of frequency and intensity of weather phenomenon. The authors write:

> "Regardless of the cause, increasing temperatures—accompanied by changes in other aspects of the climate—may impact communities and, by extension, the insurance industry by altering the frequency or severity of weather-related events such as hurricanes, tornadoes, severe thunderstorms and hail events, and wildfires."

While DOC recognizes the IPCC's Fourth Assessment Report was not available at the time of GAO's review, the issue of frequency and intensity has been well discussed in the scientific community, and policy makers would benefit from drawing information from the IPCC's Summary for Policy Makers for Working Group 1. According to page 10 of this summary, "there is insufficient evidence to determine whether trends exist…in small scale phenomena such as tornadoes, hail, lightning, and dust storms." The authors could state the frequency of heavy precipitation events has increased over most land areas… (page 8). On hurricanes, IPCC notes an increase in "intense tropical cyclone activity," but also mentions "there is no clear trend in the annual numbers of tropical cyclones," which refers to frequency. Tropical cyclones projections are addressed on page 16 of the summary, where the IPCC projects future tropical cyclones will become more intense, but there is less confidence in projections of a global decrease in numbers of tropical cyclones.

1

See comment 3.

Further, DOC notes the report could be strengthened by a discussion of what is meant by "altering the frequency or severity of weather-related events" and how this is linked to risk. For example, altering either the frequency or severity of high impact extreme weather-related events could result in a five fold increase in risk for what has been considered a 500-year event (i.e., probability of occurring in a given year = 1/500) shifts under climate change to be a 100-year event (i.e., probability of occurring in a given year = 1/100).

See comment 4.

The third comment is the report should examine coastal development impacts more rigorously. The National Oceanic and Atmospheric Administration (NOAA) has done work that uses data from the Bureau of the Census to show coastal communities have seen population growth of nearly 40 million people from 1970 to 2000. The authors refer to Roger Pielke, Jr.'s work on coastal impacts, but cite it only to show that more intense hurricanes tend to have higher impacts. Pielke, Jr., and others, including Chris Landsea of NOAA and Kerry Emanuel of Massachusetts Institute of Technology, have examined hurricanes, climate change, and development, and found coastal development has increased the vulnerability to winter storm surge, wind damage, and hurricanes. These vulnerabilities, due to high risk coastal development, will only be amplified by climate change related increases in the frequency or severity of high impact extreme weather-related events.

The authors cite anecdotal evidence, such as increased development in the area hit by Hurricane Andrew, but the report lacks analysis of the long term trends and does not quantify what portion of the increase in losses is attributable to societal change and economic development as referenced on page 58 in the Munich Re consensus statement. This would be useful information for policy makers.

2

The following are GAO's comments on the Department of Commerce's letter dated February 26, 2007.

GAO Comments

1. We agree that a clear and accurate definition of *climate change* is a necessary prerequisite for any discussion of the issue. While a variety of definitions for the term are in use, we did not attempt to independently define the term. Rather, we relied upon the IPCC's most current publicly-available definition.

2. We revised the introductory statement referred to in Commerce's comments for editorial purposes (see page 2). To the extent practicable, we also incorporated the Working Group I Summary for Policymakers of the IPCC's *Fourth Assessment Report* into the detailed discussion of the potential changes in the frequency and severity of weather-related events identified in the 2001 *Third Assessment Report* (see pages 8 to 13).

3. We included an elaboration on page 14 of how altering the frequency and severity of weather-related events is linked to risk.

4. It was outside the scope of this report to conduct our own quantitative trend analysis of the relative roles of societal factors (such as development or agricultural prices) and climate change in shaping the increases in weather-related insured losses observed in the data. In response to the comment, however, we clarified which studies we reviewed that addressed this question, both for coastal hazards (such as hurricanes) and inland hazards (such as drought and excess moisture).

Appendix VII: GAO Contact and Staff Acknowledgments

GAO Contact

John Stephenson, (202) 512-3841, or stephensonj@gao.gov

Staff Acknowledgments

In addition to the individual named above, Steve Elstein, Assistant Director; Chase Huntley; Alison O'Neill; Michael Sagalow; and Lisa Van Arsdale made key contributions to this report. Charles Bausell, Jr.; Christine Bonham; Mark Braza; Lawrence Cluff; Arthur James, Jr.; Marisa London; Justin Monroe; and Greg Marchand also made important contributions to this report.

We also wish to give special tribute to our dear friend and colleague, Curtis Groves, who died many years too soon after a long battle with multiple myeloma near the conclusion of our work.

Related GAO Products

National Flood Insurance Program: New Processes Aided Hurricane Katrina Claims Handling, but FEMA's Oversight Should Be Improved. GAO-07-169. Washington, D.C.: December 15, 2006.

Catastrophic Disasters: Enhanced Leadership, Capabilities, and Accountability Controls Will Improve the Effectiveness of the Nation's Preparedness, Response, and Recovery System. GAO-06-618. Washington, D.C.: September 6, 2006.

Crop Insurance: More Needs To Be Done to Reduce Program's Vulnerability to Fraud, Waste, and Abuse. GAO-06-878T. Washington, D.C.: June 15, 2006.

High-Risk Program. GAO-06-497T. Washington, D.C.: March 15, 2006.

Federal Emergency Management Agency: Improvements Needed to Enhance Oversight and Management of the National Flood Insurance Program. GAO-06-119. Washington, D.C.: October 18, 2005.

Crop Insurance: Actions Needed to Reduce Program's Vulnerability to Fraud, Waste, and Abuse. GAO-05-528. Washington, D.C.: September 30, 2005.

Catastrophe Risk: U.S. and European Approaches to Insure Natural Catastrophe and Terrorism Risks. GAO-05-199. Washington, D.C.: February 28, 2005.

21st Century Challenges: Reexamining the Base of the Federal Government. GAO-05-325SP. Washington, D.C.: February 2005.

Climate Change: Information on Three Air Pollutants' Climate Effects and Emissions Trends. GAO-03-25. Washington, D.C.: April 28, 2003.

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