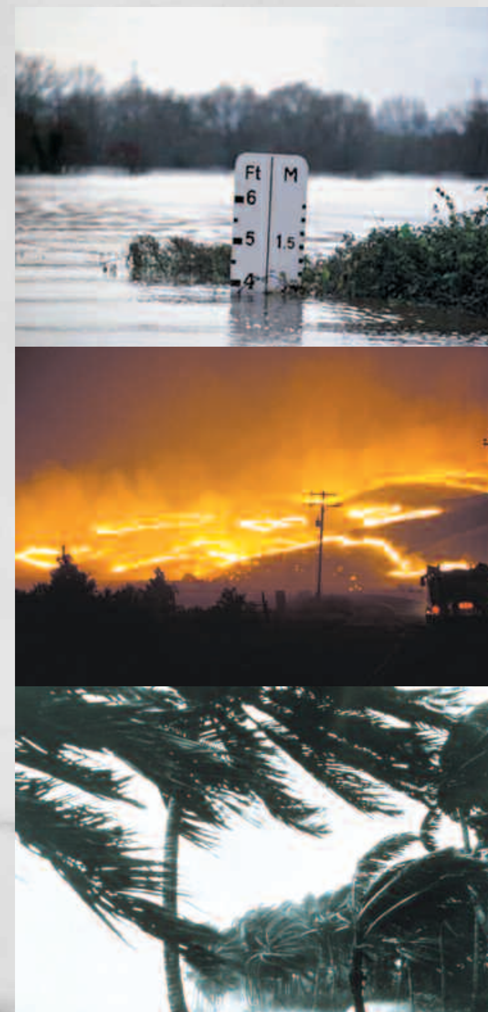
Climate Change and Insurance: An Agenda for Action in the United States



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Climate change poses significant risks throughout the United States, particularly to coastal, flood-prone and fire-prone areas . Allianz and World Wildlife Fund (WWF) are working together to understand and better manage the true risks of global warming.

Without examining how global warming could intensify risk it is impractical for Allianz, WWF and our peers to carry out long term planning to protect assets.

The insurance industry has a two-fold responsibility. On the one hand, it needs to prepare itself for the negative effects that climate change may have on its business and on its customers. On the other hand, it can significantly help mitigate the economic risks and enter the low-carbon economy by providing appropriate products and services.

Allianz Group and WWF have joined forces to produce a report that will advance the debate in the insurance industry, and propose solutions. The report identifies risks for the sector, emerging physical impacts that will likely be amplified with climate change, and develops actions that demonstrate how insurance providers, such as Allianz Group, can respond to these risks in a meaningful and responsible manner. Implementing these actions will mean big steps forward, developing sound practices business for a living planet.

WWF and Allianz Group will work together to implement the actions of this report and to take responsible steps to help solve this global problem. Allianz and WWF strongly believe that companies that are ready to seize these new opportunities will ultimately be able to reap benefits for society and for their shareholders.

This cooperation in the United States between Allianz and WWF is a second milestone since the 2005 launch of *Climate Change & the Financial Sector*: *An Agenda for Action* in London. In markets around the world WWF and Allianz are raising awareness about climate change in the financial industry and fostering a dialogue aimed at improving the management of environmental risks.

New York, October 2006

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Executive Summary

This report builds upon *Climate Change and the Financial Sector: An Agenda for Action* released in Europe in June 2005, and is the first report of its kind that attempts to overlay a detailed distillation of climate change science with U.S. insurance industry activities around climate change. This report aims to go beyond an investigation of only hurricanes to also address the implications for the U.S. insurance industry of other impacts of climate change including forest fires, floods, and storm surge (although storm surge is not commercially insured, this report describes how government insurance backstops interact intimately with commercial insurance products and with consumer perception of risk).

The report finds that U.S. insurers are far ahead of many of their overseas counterparts in assessing current catastrophic (cat) risk through sophisticated cat risk modeling that is based on *historical* weather events; however, U.S. insurers appear to lag behind their European peers who have begun to conduct studies of climate change and are beginning, though slowly, to incorporate *future* climate change scenarios into cat risk models, particularly for flooding.

NATURE OF THE PROBLEM

Within the last two centuries, human activities have led to an increase in greenhouse gases (GHG), such as carbon dioxide (CO_2), in the atmosphere that are trapping the sun's heat like a blanket, warming the Earth's climate and causing "global warming."

Since the industrial revolution, the Earth's average temperatures have increased substantially and rapidly from a historical perspective, and all ten of the hottest years on record have occurred since 1990. 2005 was the hottest year in over a century.[1] Global warming will continue – and is likely to accelerate – as more GHG's accumulate in the atmosphere.

Studies show that rising temperatures in recent years have likely contributed to an increase in the frequency and severity of natural disasters such as tropical storms and hurricanes, of which there were a record 27 in the Atlantic in 2005. These and other changes will have consequences for the United States.

The U.S. business community is beginning to recognize that climate change is likely to cause physical and weather-related risks in the future, as well as regulatory, competitive, and reputational risks. The vice-chairman of Merrill Lynch recently declared "we are conducting an enormous chemical experiment with potentially huge consequences for our environment, for our economies, and for human life."[2] And Goldman Sachs agrees: "We believe climate change is one of the most significant environmental challenges of the 21st century and is linked to other important issues such as economic growth and development, poverty alleviation, access to clean water, and adequate energy supplies."[3]

This report presents:

1) the current state of the science regarding the regional impacts of climate change in the United States, with particular focus on floods, storm surge (with some discussion of related hurricanes), and forest fires, and
2) the impacts on, actions of, and recommendations to insurers and the U.S. insurance industry.

The main findings of this paper are as follows:

SCIENTIFIC FINDINGS

- *Global sea level rise is projected to increase by a minimum average of 0.28 m in this century.* Even small amounts of sea level rise contribute to increasingly dangerous storm surge and more vulnerable levee systems as was seen in New Orleans in 2005. Over the next five centuries, catastrophic sea level rise of up to 6 m could inundate many U.S. coastal cities, and large portions of coastal states.
- *The risk of forest fire is exacerbated by current climatic trends in many parts of the United States.* Higher temperatures, drier conditions, and success in fire suppression over the recent decades have resulted in high fuel loads. Exacerbated by the increased wildland/urban interface all lead to a greater risk of increased losses from wildfires.
- *Climate change is affecting the hydrological cycle, which also affects floods.* Glacial melting is increasing, snowmelt is occurring earlier, and on average, there is an increase in "rain-rather-than-snow" winter precipitation, all factors contributing to early spring floods. Combined with distorted market signals as a result of government subsidized flood insurance, flooding will likely continue to generate major economic losses.
- *Warmer sea temperatures are likely to increase the intensity of hurricanes which are the most devastating form of natural catastrophe in the United States.* Although some scientists contend that the recent rise in intensity of hurricanes is a result of Atlantic Multidecadal Oscillation, more and more studies are linking climate change to the warmer sea temperatures that add fuel to tropical storms escalating them into hurricanes. The cause of warmer sea temperatures is widely considered a result of global warming. Although insurance companies are not directly examining climate change's future impact on sea temperatures, modeling firms are examining recent rises in sea temperatures more and more.
- *There is rapid and substantial population growth and building investments in areas at risk from the hazardous effects of climate change, particularly catastrophic events such as hurricanes, storm surge, and forest fires.* This rapid development significantly compounds the potential physical impacts of climate change. Federal and state run insurance programs, especially the National Flood Insurance Program, have artificially low insurance premiums that have encouraged building in high risk areas by distorting the natural market signal that high risk equals high premiums.
- *The available scientific information predicting the consequences of climate change and changing weather is being underutilized by the U.S. insurance industry to manage the risks and capitalize on the opportunities.* With a few notable exceptions, there is little evidence that industry behavior is changing significantly to adapt to this growing risk of the physical impacts of climate change.

INSURANCE INDUSTRY FINDINGS

- *U.S. insurers have suffered significant losses from catastrophic events.* Catastrophe losses have been doubling every ten years as a result of the surge in building along coastlines and other high-risk areas, and the industry has suffered tens of billions of dollars in payouts and many companies have gone out of business as a result of weather-related losses such as 1992's Hurricane Andrew. Climate change is expected to exacerbate these economic challenges.
- *U.S. insurance companies have sophisticated catastrophic risk modeling tools that could be used to better understand climate change's impacts.* Cat risk models currently use historical and current weather events and indices to form the basis of underwriting and catastrophe planning; however, current science indicates that relatively recent anthropogenic climate change effects are ensuring that the future is going to be significantly different from the past. Thus, historically-based risk modeling is likely to be insufficient for preparation. Cat risk

studies that incorporate scientists' predictions about climate-related changes could provide more insight into future weather events.

- *Insurance and reinsurance companies are already adapting to the consequences of climate change.* U.S. insurers are already raising rates or exiting markets as a result of increased risk in coastal and fire-prone areas. In areas where insurers feel the risk is too great, or their ability to raise premiums is hampered by political or regulatory limitations, the risk burden will be shifted to the public, to asset owners (such as banks and investors), and to government insurance backstops. Federal and state insurance programs distort the market's ability to reflect the true climbing costs of climate change impacts.
- *Some American insurers are beginning to act, and there are numerous solutions available to U.S. insurers and industry associations.* For a number of reasons, American insurance companies, and the industry as a whole, have done less to examine and plan for the implications of climate change than their European counterparts. In May 2006, U.S. insurance giant AIG was the first American company to release a climate change policy statement and develop new products to manage new risks. Fireman's Fund Insurance Company is in the final stages of launching three new "green" products that relate to climate change and energy efficiency, as well as a number of other environmental attributes. The American Insurance Association and the Insurance Information Institute have produced papers on the subject; however, unlike the Association of British Insurers, the U.S. insurance industry or associations have not begun to model various climate change scenarios.
- *Until recently, many barriers have existed that have hindered U.S. companies and associations from acting.* Barriers to American action have included: distorted market signals resulting from local and federal regulatory structures; fragmented political leadership on climate change; public ambivalence towards climate change; public skepticism regarding the soundness of any course of action to address climate change.

RECOMMENDATIONS.

There are many activities that insurance companies or industry associations can take, and different solutions will fit different companies depending on their portfolio of products, corporate culture, and relationship with local and federal regulators. Examples of activities that insurers or industry associations could take to reduce the physical impacts of climate change, or to adapt to these impacts, include:

1 IMPROVE UNDERSTANDING OF THE PROBLEM

- *Commission scenario risk analyses* that incorporate the predictions of leading scientists into existing insurance risk models offered by a number of risk modeling agencies. Such studies would provide new, more accurate information about possible risks to communities, homes, and businesses if climate change plays out as scientists anticipate.
- *Work with modelers and scientists* to increase the accuracy of climate change modeling. By creating a demand for economically relevant science, insurance companies can provide a great service to society and their customers.
- *Build partnerships with environmental NGO's* or other new stakeholders to bring a different perspective and expertise to the issue and build on the strengths of multi-sectoral partnerships.

2 SEND STRONGER SIGNALS OF RISK TO THE PUBLIC

- *Work with government (where appropriate) to allow for adjustment of homeowner insurance rates and flood insurances rates*, and to develop appropriate price and risk signals to consumers and businesses moving into high risk areas. Insurers only exit markets as a last resort; however if governments and regulators do not allow for more pricing flexibility, exiting markets become the last option.
- *Acknowledge and disclose the risks and opportunities of climate change* in annual securities filings and through other corporate communications. More and more institutional investors

and money managers are demanding increased climate change disclosure from insurance companies, and the Investor Network on Climate Risk now represents 50 institutional investors managing $3 trillion.

- *Incentivize the reduction of GHG emissions* that exacerbate climate change through reduced rates for "green" or energy efficient buildings (as Fireman's Fund's new products do) or reduced rates for hybrid or other energy efficient vehicles (as Traveler's Fund does).
- *Take a proactive approach to influencing land use development and planning.*

3 PREPARE AND ADAPT TO CHANGING CLIMATE

- *Continue to adapt to the impacts of climate change* through promotion of and lobbying for appropriate building materials and improved building codes. Building on past efforts and successes on issues such as seat belt and air bag requirements, this is an area that the U.S. insurance industry already has a roadmap.
- *Examine how the physical impacts of climate change may provide business opportunities* through environmental remediation or new product lines.
- *Commit to make internal operations climate neutral.*

Introduction

Climate change may well be one of the great challenges in human history. Current calculations show that the projected economic impacts of a global warming of only 1 degree Celsius (1.8 degree F) could reach $2 trillion worldwide in 2050[4] and at least $300 billion *per year* before that time.[5]

Galvanizing political, social, and corporate action in the United States to tackle this issue has proven to be enormously challenging. Thus, in follow-up to a report released in June 2005 by Allianz and the World Wildlife Fund, *Climate Change and the Financial Sector: An Agenda for Action*, Allianz and WWF-US have joined forces once again to produce this subsequent report, *Climate Change and Insurance: An Agenda for Action in the United States*. The findings presented here build on the work done in 2005 and shed light on the unique physical impacts of climate change to U.S. insurers, how the U.S. insurance industry is managing this challenge, and the ways in which U.S. insurers are uniquely positioned to work with government and consumers to minimize the negative affects of climate change.

Because of differing social, political, and regulatory environments between the E.U. and the U.S., and because climate change is causing different impacts in America compared to Europe, this new report focuses exclusively on how U.S. insurers may be affected by the physical impacts of climate change through forest fires, flooding, storm surges, and hurricanes. It distills current scientific research on this subject, describing both the scientific certainties and uncertainties, and provides recommendations for how the U.S. insurance industry can move forward to continue providing insurance amidst the uncertainty.

This report focuses primarily on the property and casualty impacts of forest fires, flooding, and storm surge. The report discusses wind and hurricane damage to some extent; however, hurricanes have been the primary focus of a number of other reports in the wake of Hurricane Katrina, thus this report attempts to look at other perils. No attempt has been made in this paper to assess the numerous impacts of climate change on human health and survival, as affected by expected increased frequency of heat waves, or the shifting geographic distribution of infectious disease due to climatic and ecological changes. Likewise, no attempt has been made to assess the physical effects and extent of economic damage to sectors such as agriculture, transportation, fisheries, construction, and tourism (the latter accounting for 7% of U.S. economy[6]) or to include potential damage to public infrastructure due to higher temperatures, such as blackouts, that can lead to substantial economic losses. Finally, there is no analysis here of the worst-case future scenarios – one that would involve coincidental or multiple extreme events during a time of weakness in the financial market.

This report is organized into two sections. The first section, *The Science of Climate Change's Physical Impacts*, provides a conservative overview describing what is known and not known about how climate change will affect floods, storm surges, forest fires, and – to some extent – hurricanes in the United States. This is critical background for the U.S. insurance industry, most of which is focused on scientific uncertainties rather than on strong scientific evidence of the risks that climate change poses to the industry.

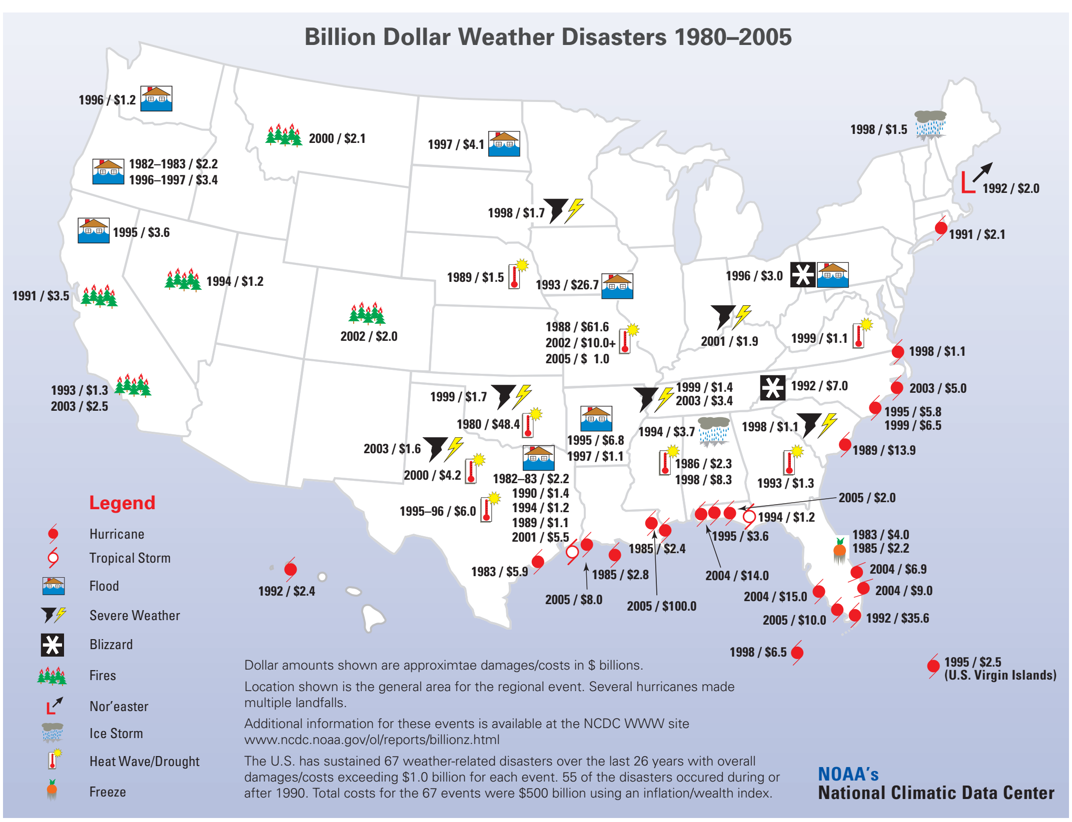
The second section, *U.S. Insurance and the Physical Impacts of Climate Change*, provides details about how floods, forest fires, and storm surges could impact insurance in the United States, particularly given the rampant development and building in high-risk coastal and fire-prone areas in the United States. This section also describes what U.S. insurers are doing and can do to address the risks and opportunities posed by the physical impacts of climate change, and provide a set of recommendations for moving forward.

1
The Science of Climate Change's Physical Impacts

OVERVIEW

There is vast scientific consensus that anthropogenic climate change is occurring, and it will lead to historically significant changes in weather events. The exact nature, location, and intensity of such events remain uncertain – and are likely to continue to remain so – due to the fact that weather related events are impacted by an intricate set of interrelated, yet distinct factors.

The first section of this report aims to provide an overview of the state of climate change science and scientific modeling, with specific review of research on the impacts global warming will have on rising sea level, storm surge, floods, forest fires, and – to some extent – hurricanes. This primary focus on floods, fires, and storm surge is inherently limited in scope and this section will not touch on the broad array of other physical impacts of climate change such as infectious diseases, heat waves, etc.

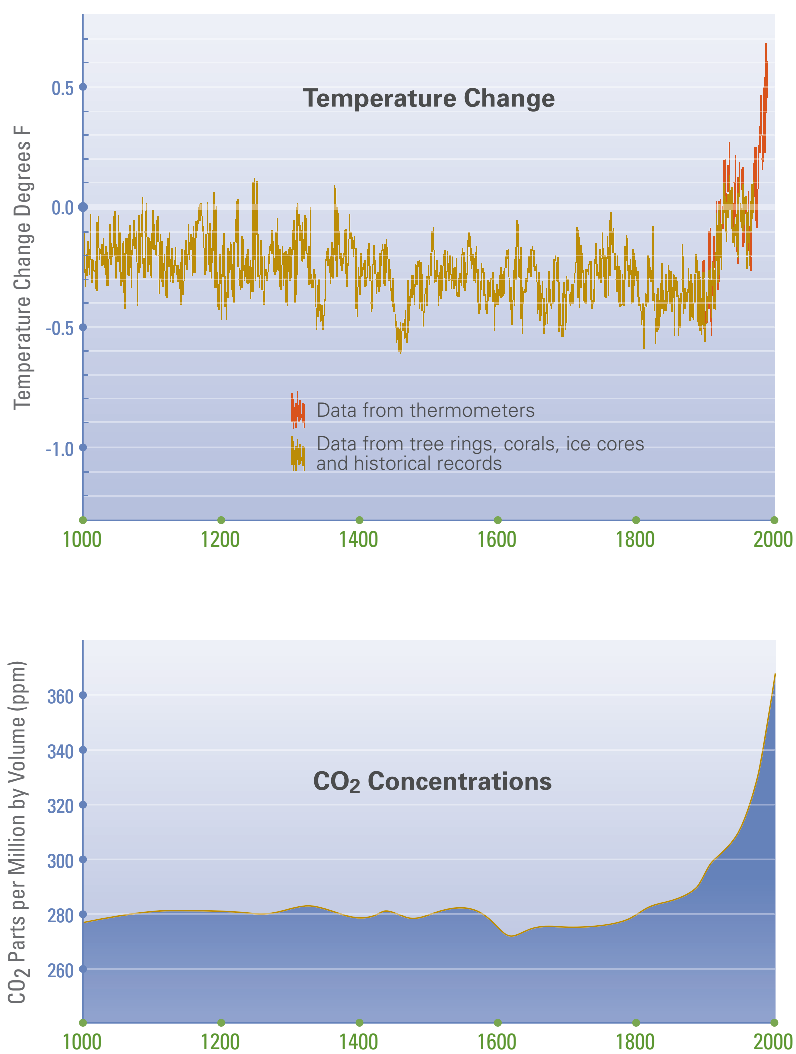


1.1 Climate Change Science

1.1.1 The scientific certainty

Recent research has resulted in broad scientific consensus that the earth's climate is warming and that – although some changes occur on a cyclical basis throughout history – current climate change, or "global warming," is being driven by rising levels of greenhouse gases (GHG) such as carbon dioxide (CO_2) that are trapping the sun's heat like a blanket, warming the Earth's atmosphere, and disrupting its climate system.

Fig. 1
1000 Years of Global CO_2 and Temperature Change
Source: IPCC 2001



The potential impacts of such warming are far reaching and potentially catastrophic. Figure 1 clearly shows that since the industrial revolution, when burning of fossil fuels increased dramatically, the Earth's temperatures have risen sharply.

All ten of the hottest years on record have occurred since 1990, with 2005 being the warmest yet, according to NASA's Goddard Institute. There is compelling evidence, drawing on multiple sources, that the last few decades have been warmer than any other comparable period in the last 400 years.[7] The concentrations of GHG are increasing, and doing so at a faster rate than once projected. GHG in the atmosphere increased from 280 to almost 382 parts per million, a 36 percent increase, since the onset of the industrial age, at an accelerated rate of change that is linked with the ever-increasing use of fossil fuel and other human activities. This accelerated warming has led to a boost in the Earth's average temperature by over half a degree Celsius (0.9 degree F) over the past 30 years.

If these trends continue, global average temperatures could increase by 1.4 to 5.8 degrees Celsius[8] (3.06 to 9.9 degrees F) by the end of the century. Though seemingly small, this is actually an enormous change. The difference between an ice age and the Earth's current climate, which is so well suited for human life, is only about five degrees Celsius (9 degrees F).

Through the Kyoto Protocol, and numerous national and local policies, the industrialized world is largely united in its efforts to slow the increase in atmospheric GHG concentrations.

1.1.2 Regional impacts of climate change

Numerous peer-reviewed studies in recent years have strengthened the link between rising global temperatures and increased severity and frequency of natural catastrophes. Throughout the remainder of this section, we will review the latest certainties and uncertainties of climate science with regard to floods, storm surge, fires, and hurricanes in the United States.

While there is broad consensus that significant shifts in the global climate will alter the earth's weather events, changes in temperature, however small, affect an enormous set of planetary biophysical processes, many of which are complexly interlinked. Thus, uncertainty remains about the exact magnitude of the effects, as well as the precise time frame and location in which the predicted changes will occur.

In the following sections, we have taken a conservative approach in assessing only well-consolidated scientific knowledge, paying minimal attention to the various potentially far-reaching effects of synergistic relationships, feedback loops, and cascading effects of global warming, of which there are too many to address here and are, to a large extent, poorly understood. This is not to imply that mechanisms that are poorly understood should be ignored. For instance, even if our understanding of the carbon cycle is incomplete, we know that warmer weather leads to more frequent, more intense fires, and that fires release carbon, thus contributing to further climate change, or that recent research indicates that thawing soils (e. g. in Alaska) may lead to large-scale release of GHG, as permafrost may contain up to 30 percent of all the carbon stored in soils in the world,[9] also potentially accelerating global warming.[10]

Gaps in understanding the intricacies of various mechanisms do not justify reticence to consider the possible risks of their effects.

1.1.3 Climate change modeling

Scientists rely on explanatory and predictive modeling to assess and predict climate change. A number of models exist, and, because they differ in how they represent various processes involved, they project somewhat different scenarios for the future. However, it is worthwhile to note that scientific models are in agreement that a considerable trend in increasing temperature throughout the United States is occurring (Figure 2).

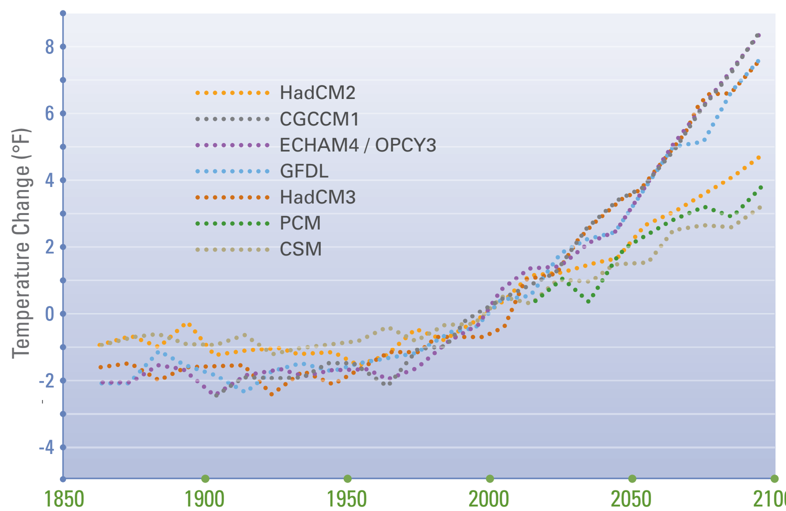


Fig. 2
Simulations by a number of climate models (indicated by the colored lines on Figure 2) all show a rise in temperature change in the U.S. in this century.
Source: National Assessment Synthesis Team 2000

The magnitude of regional effects remains unclear and is currently the focus of intense examination. For instance, the Hadley model predicted a wetter climate in some locales in the U.S., whereas the Canadian model predicted a drier climate in some of those same locales.

The value of the models is that they offer a range of possible and probable scenarios with the differing projections they present. This is a crucial contribution to risk assessment, one that allows for anticipating opportunities as well as setbacks, and planning accordingly.

1.1.4 Climate science and the financial industry

Currently, there are virtually no scientific studies in the U.S. examining the *future* impacts of the physical impacts of climate change on insurance; however, several studies have been conducted on this topic in Europe. Since there has been little demand of scientists for this type of research, funding options for this kind of scientific endeavor have been limited to date. Conversely, industries may be slow to consider climate change effects as a result of the dearth of relevant scientific studies, specifically addressing the link between climate change and the financial services industry.[11]

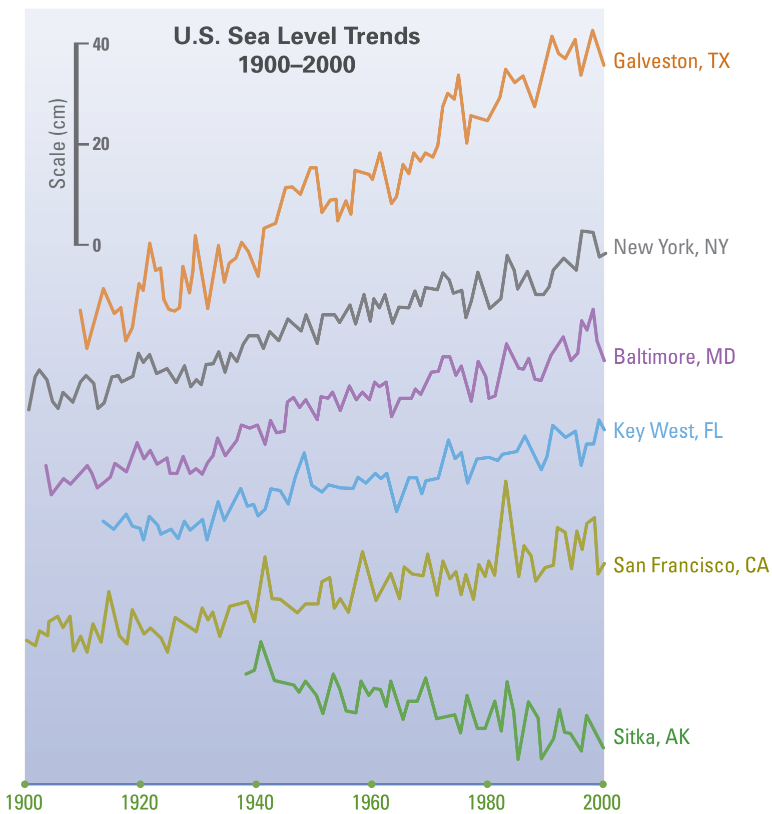


Fig. 3
Locale-specific sea level rise in the United States over the last century. Differences in trends are mainly due to local geophysical trends in land subsidence/uplifting.
Source: United States Environmental Protection Agency 2006

1.2 Rising Sea Level

1.2.1 Causes and extent of sea level rise in the United States

Scientists have observed a rise in sea levels on a global scale. This has been established using a variety of methods that all indicate a steady rise in sea level. Sea level has risen a total of about 195 mm from January 1870 to December 2004, and the 20th century rate of sea level rise has been 1.7 ± 0.3 mm yr^{-1}.[12] Currently, the sea is rising more rapidly, at around 2.6–2.7 ± 0.7 mm/yr globally.[13] Until recently, and looking at records from 1950–2000, there was no evidence that the rate of sea level rise was accelerating,[14] but there is now confirmation by climate models and multi-century sea level records that there is a significant acceleration in the rate of sea level rise equaling 0.013 ± 0.006 mm/yr/yr.[15]

Scientific consensus shows that sea level rise is directly attributable to global warming, which raises the temperature of the oceans, causing expansion of their volume. In addition, global warming causes melting of the polar ice-caps, which also contributes, potentially catastrophically, to the sea level rise. Around 0.81 ± 0.43 mm/yr of the sea level rise is currently a result of the glacier and ice-cap melt.[16, 17]

Sea level rise does not have the same impact everywhere – locale-specific geological processes, such as land rise or subsidence (the sinking of land to lower levels), affect the relative change in water level. Subsidence in south Louisiana, for example, is expected to bring 15,000 square miles of land to or below sea levels within 70 years' time, as has already happened with some areas, notably parts of New Orleans.[18]

Locally, sea level rise in the U.S. has especially affected cities on the East Coast, due to land subsidence. Predictably, the most vulnerable places are those that are already low-lying, as small changes in sea level can lead to inundation and vulnerabilities of larger areas.

The link between sea level rise and impacts of storms. Sea level rise is an especially dangerous threat for society and for insurers in combination with storm surges. A storm surge is the most hazardous aspect of hurricanes, as it generates powerful waves that cause floods and can create strong, dangerous currents. Storm surges are exacerbated by high water levels, such as high tides. El Niño, in combination with increased water levels, is responsible for severe coastal flooding.[19, 20] Furthermore, sea level rise contributes to coastal erosion, and coastal erosion diminishes the protective capacity of the coast from storm surges. Strong storm surges also tend to lead to inland flooding, as water in streams is backlogged due to the pressure from the water forced by the surge. Strong hurricanes in combination with high sea level can cause great damage.

1.2.2 Projected effects

Assuming the rate of sea level rise remains at 0.013 ± 0.006 mm/yr/yr, Church and White (2006) predict that by 2100 we will experience a rise ranging from 280–340 mm above 1990 levels.[21] Douglas and Peltier (2002) have considered the behavior of Earth's crust over the past 20,000 years, and argue that the true rate of annual global sea level rise is around 2 mm.[22] Other projections include approximately 0.5 m sea level rise by the end of the century.[23, 24]

As is seen by Figure 4, in the United States sea level rise is expected to be greater in some areas than others. The East Coast is predicted to generally bear greater than the average global estimates.[26]

Furthermore, it is possible that polar melting will raise sea level sooner than expected. Glaciologists have been surprised by recent disintegration of the polar ice,[27] with both the Greenland Ice Sheet and parts of the Antarctic Ice Sheet being at risk for rapid melting.

Overpeck *et al.* (2006) estimate that polar warming by the end of the 21st century may be similar to that which occurred 130,000–127,000 ago, during which sea level was several meter higher than present. These processes could result in a sea level rise of at least 6 m as early as the year 2600, in addition to having other far-reaching effects.[28] If sea level rose 4 m, nearly every coastal city worldwide would be inundated.[29] Thus the estimates for sea level rise in the 21st century are expected to be a minimum global average of 0.28 m, baring any major unexpected developments, and sea level rise up to 6 m could occur in the next 500 years in the event of catastrophic polar ice meltdown.

Future sea level rise is expected to cause inundation of coastal areas, and put the coasts of the Atlantic and Gulf of Mexico at increased risk from storm surges. Those at most risk in the United States are the Southeastern and mid-Atlantic coasts (see Figure 4), low-lying areas, developed areas and those at risk from hurricanes. The Northeast is vulnerable due to the extent of development as well as low-lying coast. On the other hand, the West Coast is less vulnerable because of its rocky coastline, the exceptions being its low-lying coastal areas, such as the San Francisco Bay and Southern California.[30]

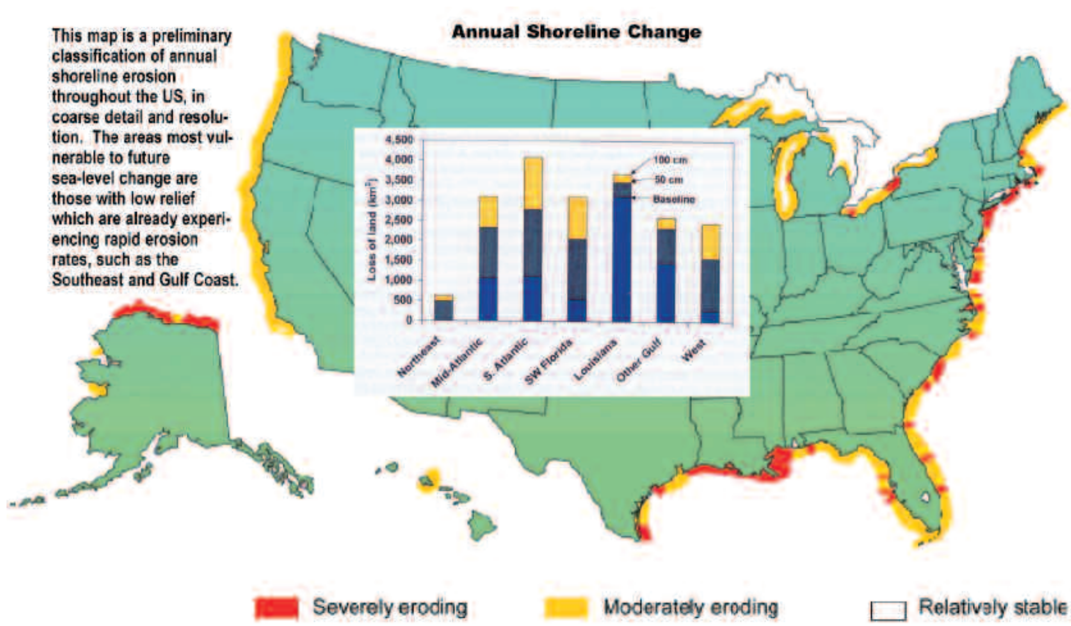


Fig. 4
Preliminary classification of annual shoreline erosion [25]
Source: MacCracken 2006

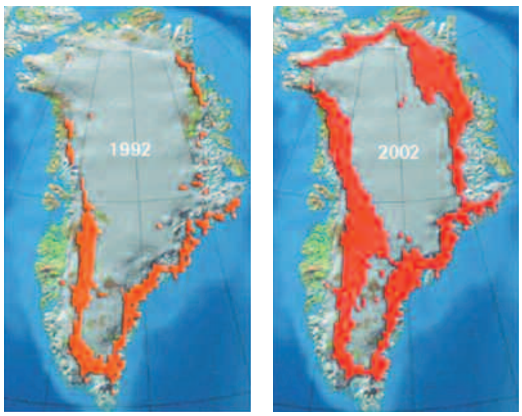


Fig. 5
Extent of summer icemelt in Greenland (left:1992; right: 2002). Greenland is losing ice at an accelerated rate, and surface meltwater is seeping to the base of the ice, where it induces slippage and further disintegration.
Images: Clifford Grabhorn/ACIA 2005
Source: Epstein and Mills, eds. 2005[31]

1.2.3 Economic impacts

In the last few decades, costs from flooding due to storm surges, waves, and wind have risen considerably.[32] This is primarily due to the increase in development in coastal areas. For instance, in the United States, AIR Worldwide (2002) estimates the value of insured residential and commercial property located in coastal counties at $7.2 trillion. The concentration of property in coastal areas is considerable – 79 percent of property in Florida is in coastal areas, as is 63 percent in New York, and 61 percent in Connecticut.[33]

Fig. 6
Maps projecting sea level rise in Florida
Source: Weiss & Overpeck 2005

The value of property located in coastal areas is expected to increase, as the demand for waterfront real-estate is rising.[34, 35] It is expected that, in the United States, coastal populations will grow by 25 million within the next thirty years.[36] This is, at least in part, due to the coastal residents' low level of awareness of the future risks involved with living near the coast.[37] For a sea level rise of 0.5 m, Neumann *et al.* (2000) estimate adaptation would cost around $20–138 billion, including the cost of building defenses to protect high-value areas and abandoning low-value areas,[38] and not considering the "hidden costs" of such an intervention (e.g., ecological damage).

CASE STUDY

The barrier islands of the U.S. Atlantic and Gulf coasts are tourist attractions that draw millions of people on a typical weekend, not in small part because of the beaches, ocean, and many recreational opportunities available. Properties near the ocean are at a premium, but these often expensive homes and tourist facilities are at risk from storms and erosion. As global warming and sea level rise increase, these areas will be increasingly at risk. Not only would a sea level rise of a few centimeters inundate the barrier islands, but global warming is likely to change climate patterns, and possibly lead to increased damage from storms, storm surges, waves, and winds. A few measures are under consideration, including armoring the shorelines, which, however, would lead to the loss of the beaches. Other options include raising the islands and landward migration. The estimated costs of these options are as the following table shows.

Property owners, federal and state agencies, and insurers have a role to play in better management of this problem.[39]

Relative Sea Level Above 1986 (ft)	Year[1]	Years It Will Take Sea to Rise 6 Inches	Cost (millions)		Cost ($/yr/house)	
			Retreat	Raise Island	Retreat	Raise Island
0.5	2013	18	20	57	77	219
1.0	2031	14	34	85	168	420
1.5	2045	12	34	95	196	548
2.0	2057	11	34	110	214	692
2.5	2068	10	34	127	235	876
3.0	2078	9	34	132	261	1015
3.5	2087	9	34	132	261	1015
4.0	2096	8	34	132	294	1142
5.0	2112	7	30	132	296	1305
0.6	2126	6.5	30	132	319	1406
7.0	2139	6	30	132	346	1523

[1] Assuming global sea level rises one meter by the year 2100
Note: All costs assume that until the particular year, the community has responded to sea level rise by raising the island in place.

Table 1
Evolution over time of the relative costs of retreat island raising
Source: Titus 1990

1.3 Forest Fires in the American West

1.3.1 Link between climate change and increasing incidence of fires

Wildfires are determined by the weather and availability of fire-prone fuel,[40] as well as ignition, and the last couple of decades of the 20th century have seen a dramatic increase in wildfires. Since 1980, the average area burned in a year has doubled compared to the annual average for years 1920–1980. The forest area burned in the period 1987–2003 is nearly seven times greater than that burned in the period 1970–1986.[41] Prominent increases in the frequency of large wildfires, duration of wildfires, and length of wildfire seasons began occurring in the mid-1980s, particularly in the "middle elevations" (1,680–2,690 m).[42]

These increases can be attributed to a number of factors. Droughts in many fire-prone areas of the American West and Southwest have been increasing in the last few decades of the 20th century[43] (see Figure 9), and local climatic changes leading to warmer, drier weather have, in turn, lead to drier fuel, easier ignition, and faster growth of fires.[44] Earlier snowmelt has been linked to longer growing seasons, as well as greater soil dryness, increasing the amount and dryness of the fuel available. Higher summer temperatures increase this effect.[45] In Northern Rockies forests, wildfire increases are strongly associated with increases in spring and summer heat along with an earlier spring snowmelt.[46]

Fires in the southwestern U.S. are responsible for increased flooding, erosion and sedimentation.[47]

Because a small percentage of all fires cause a disproportionately large amount of the damage, some advocate for a policy of dangerous fuel

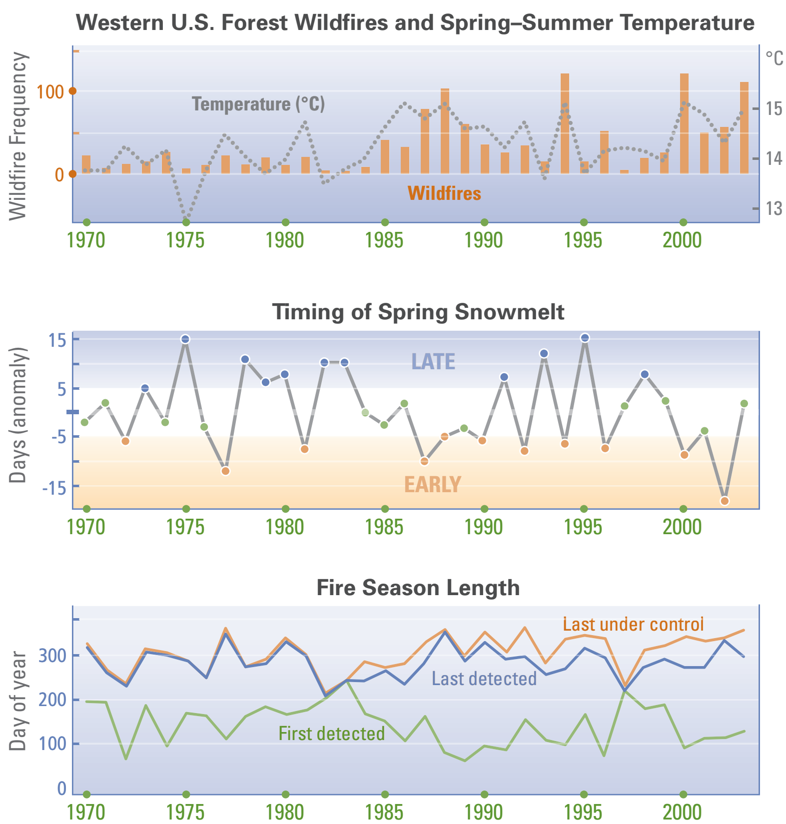


Fig. 7
Correlation between wildfire frequency and spring and summer temperatures (top), increase in early spring snowmelt timing events (middle), and the length between first fire detected, last fire detected, and last fire brought under control per season (bottom).[48]
Source: Westerling 2006.

loads removal,[49] such as through prescribed burning, or mechanical removal of dead biomass, while in Alaska, fires are routinely allowed to burn out naturally, as long as they do not pose a threat.[50] This makes sense under certain conditions – especially in areas where fire suppression has been successful over the last few decades. Areas that would naturally experience some wildfires, but where fire suppression has interfered with their occurrence, can end up accumulating fuel loads that pose a high risk for an uncontrolled, potentially devastating fire.

1.3.2 Projected effects of climate change on incidence of fires

Current climate projections show that year-round temperatures will be above the natural variability range by 2010–2039.[51] Some models indicate that global warming is associated with an increase in frequency of El-Niño-like warm conditions,[52] leading to conditions favorable to wildfires (while other models show the opposite).

Summer heat increase strongly correlates with fire increase. Models predict increases in nearly all areas of the U.S. within this century, with up to 8–14 degrees Celsius (14.4–25.2 degrees F) in the most severely affected areas[53] (see Figure 7).

Forests in areas where the weather is turning warmer and drier are more likely to burn, such is the case in western coastal and inland mountainous areas[54] as well as Alaska.[55, 56] Compounding the issue, climate change may affect the rates of both the spread and intensity of fires, factors that make containment difficult.[57]

Modeling of future fire risk at the U.S. Forest Service's Pacific Northwest (PNW) Research Station in Portland, Oregon, using a climate change scenario was conducted for three multi-county analysis units with differing vegetation types in northern California, which concluded that the area burned and number of fires would rise in all three cases, and that in one scenario, the number of escaped fires would rise by 143 percent. Fire spread rate and intensity showed increases, leading to outcomes much greater than expected. Modest increases in the spread rate distribution led to large increases in escaped fires. At current level, fire-fighting resources available probably do not have the capacity to address such a scenario.[58]

1.3.3 Economic impacts

In the United States, insured losses from catastrophic wildfires amounted to $6.5 billion between 1970 and 2004. This is the equivalent of $400 million in average insured loss per fire, while the extent of area damaged has approximately doubled in recent years from an average of about 40 acres per fire in the 1970s. Wildfires can lead to costly losses, and wildland/urban interface losses have occurred in nearly every state, according to the U.S. Department of Agriculture.[59] In 2003, two fires in California caused total insured losses of $2.1 billion, and such losses affect property owners, federal/state/municipal government, and insurers.[60] Wild-fire home destruction has tripled in 1985–1994, compared to previous three decades. The reasons for this increase are many.

Climate change promotes fire-favorable temperature conditions, as well as positively influencing the availability of flammable vegetation.[61] Compounding these conditions, there has been a dramatic increase in development in fire-prone areas, such as the urban-forest interface, which has led to an increase in human-caused fires.

An analysis that relied only on the effects of climate change on temperature and wind predicts that the damage inflicted by wildfires could increase by four times, even taking into account fire suppression. PNW modeling showed that the greatest increase in fire size and fire escape frequency will occur in low-population density zones, areas with lower fire suppression.[62] It is unclear if there can be a generalization made about damage such a scenario leads to, compared to a fire in a high-population density zone whose potential to cause great damage is offset by higher likelihood of suppression and containment.

Despite this growing risk, anticipated wildfire damages linked to rising temperatures is currently not factored into risk modeling by the insurance industry.

CASE STUDY

The Oakland/Berkeley Hills Fire of 1991 was the third costliest fire in history, and resulted in the destructions of 3,400 buildings, including 2,449 homes, 437 apartment dwellings and condominium units,[63] and 2000 cars, amounting to a total of around $2 billion in damages, in addition to 25 human lives lost and 150 people injured.[64] The fire started due to unknown causes in a developed area, and spread rapidly due to the presence of warm, dry conditions, including dry fuel load, favorable topography, and winds. The fire developed into a firestorm within 15 minutes of ignition, a state when a fire pulls in air, thus feeding itself.

California ranks highest in the United States in economic losses due to wildfires. Of the 38 most expensive wildfires in the U.S., 22 were in California.[65] A combination of development in fire-prone areas and climate change can explain the greater risk of fires and economic loss. In case of Oakland/Berkeley Hills Fire, the fact that the fire was started in and destroyed a developed area led to greater damage than if it had occurred in an undeveloped area. Fire suppression is also more common in developed areas, but in this case, previous fire suppression ensured that there was much dry fuel available, which under normal conditions would periodically be burnt in natural wildfires. Finally, warmer climate exacerbates conditions favorable to wildfires.

July Heat Index Change

The projected changes in the heat index for the Southeast are the most dramatic in the nation with the Hadley model suggesting increases of 8 to 15° F for the southernmost states, while the Canadian model projects above 25° F for much of the region.

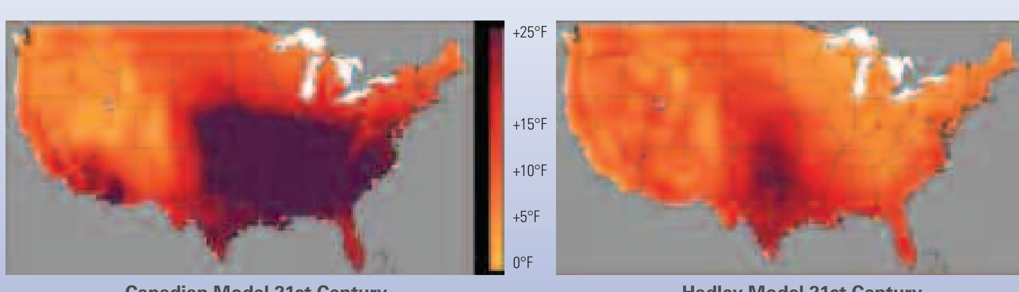


Fig. 8
July heat index change projected over the 21st century. The Canadian model (left) projects increases exceeding 14 degrees Celsius, whereas Hadley model (right) projects 4.5–8 degrees Celsius increase for the south.
Source: National Assessment Synthesis Team 2000

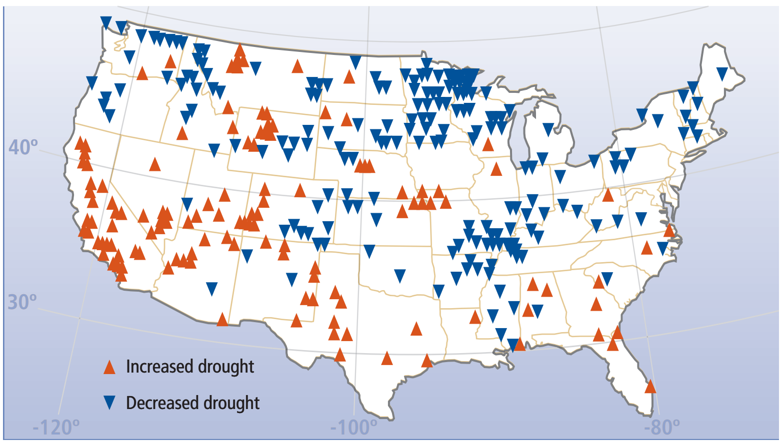


Fig. 9
Trends in drought severity in the 20th century. Red triangle signify increased drought, whereas blue triangle represent decreases.
Source: Andreadis and Lettenmaier 2006

In addition to property, insurers sometimes underwrite the costs of fire-fighting or lost timber. There are also expensive devastation of urban infrastructure such as roads, communications, and other, often uninsured, but exacerbating insured losses as well. Furthermore, some of the effects associated with wildfires, such as landslides, flooding, and water quality loss, can lead to further loss for the insurance industry. As noted by Swiss Re in their "Fire of the Future" report (1992), climate change may influence the frequency and intensity of wildfires in the future.[66] Climatologists and insurers recognize that fires are closely linked with a warm, dry climate, and that a changing climate can lead to more intense, uncontrollable fires in the future.[67]

1.4 Flooding in the United States

1.4.1 Link between climate change and flooding

This section is concerned with flooding that is not a consequence of storm surge or tectonic activity (tsunamis), as per the definition of National Weather Service (NWS) which excludes damages from those two types of ocean floods.[68] Flooding due to levee failure is considered in the next section.

Moisture surplus increased in the last few decades of the 20th century.[69] Stream flow has increased by 25% in eastern U.S.[70] Stream flow has increased in the coterminous U.S. in the period 1941–1999, particularly in the eastern United States since 1970.[71] In western North America, the stream flow decreased by about 2% per decade in 20th century.[72] In the Western United States, snow water equivalent has decreased 15–30 percent due to warming temperatures,[73,74] whereas Regonda and Rajagopalan (2004) have found that the significant changes in the hydrology are associated with increased precipitation in form of rain rather than snow, earlier stream flow peaks, and small changes in temperature in the Pacific Northwest.[75] Stream flow has been diminishing in the Colorado and Columbia basins since 1950.[76] Hamlet *et al.* (2005) contend that the changes in snow quantity, earlier onset of melting and earlier stream flow peak are influenced by year-to-year and decade-to-decade climate variability, as well as longer-term temperature changes that are overall consistent with the global warming observed in the 20th century. Accelerated flooding after wildfires is a problem in fire-prone ecosystems of the American Southwest.[77]

1.4.2 Projected effects

Global warming is not likely to result in observable, significant change in precipitation that fall out of natural variation until the latter half of 21st century.[78] Extreme precipitation appears to have increased in the United States over the 20th Century, with extreme events leading to a significant portion of the increase in total precipitation. There has been a rise in the number of days per year that have more than 50.8 mm (2 inches) and 101.6 mm (4 inches) of precipitation since 1910, and short periods of time (up to a week) that have high total precipitation have increased in frequency since 1930, especially in the southern Mississippi River valley, Southwest, Midwest, and Great Lakes regions.[79]

Importantly, flood-producing events have been increasing significantly in the United States according to a global study that looked at the precipitation in the second half of the 20th Century. The same study also found that the contribution of high-precipitation events to total precipitation has seen a pronounced rise for the United States, whereas all the precipitation indicators used in the study showed significant increases for Eastern United States.[80] Heavy and extreme daily precipitation events are on the rise over much of the United States; yet there is no significant trend in the median precipitation overall for the United States, suggesting that the change in the precipitation regimes is not uniform.[81] Kunkel et al. (2003)[82] have found that for some types of precipitation events, the frequency for the beginning and the end of 20th Century are similar, which suggests that the increasing trend towards the end of the century may be due to natural variability.

Groisman et al. (2005)[83] analyzed changes in intense precipitation using climate modeling that included past and projected GHG increases (assuming a doubling of GHG concentrations in the latter part of 21st Century) and found a likelihood of high precipitation events with higher GHG concentrations. Trenberth et al. refer to a number of climate models (NCAR Climate System Model, Hadley Centre Models, ECHAM4/OPYC3 model) that predict a rise in extreme precipitation given an increase in GHG.[84] Future temperature increases are expected to lead to more intense precipitation, as warming sea surface temperatures and increases in water vapor will make a greater amount of water available for a precipitation event, with the effect particularly pronounced in the tropical areas, whereas in northwestern and northeastern North America it is changes due to sea-level pressure that will cause most of the precipitation intensity.[85]

While the Eastern United States may be experiencing more high precipitation events, in Western North America, it is possible that earlier snow melting and spring stream flow peaks will result in greater flooding.[86]

Various models predict different regional effects, but overall, global warming eventually leads to a decrease of runoff, earlier stream peak flow, and reservoir replenishment.[87] However, earlier snowmelt, another consequence of global

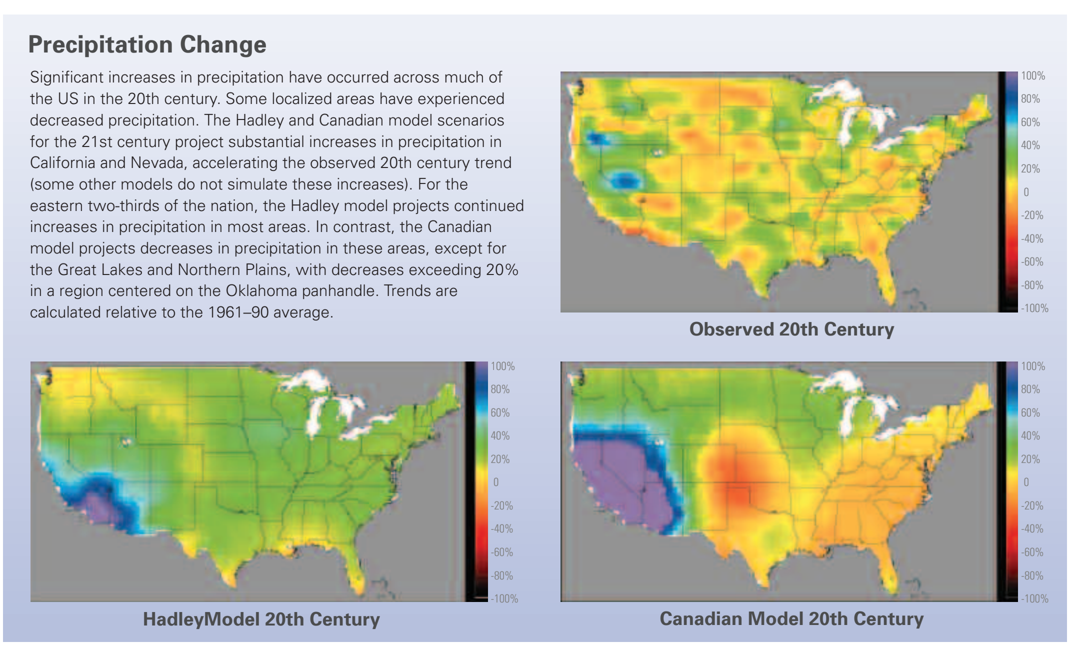


Fig. 10
Precipitation change for U.S. in 21st century.
Source: National Assessment Synthesis Team 2000

warming, coupled with winter precipitation in the form of rain rather than snow, may lead to greater winter flooding. For instance, a model based on CO_2 doubling shows a shift in seasonal snow accumulation and meltdown, with a resulting shift to more winter runoff rather than spring runoff.[88] Under a range of climate models, significant increases in winter flow are predicted for the Pacific Northwest, where increases in temperature and precipitation are foreseen.[89] Under "business as usual" climate change scenarios that included an average warming of about 1–2 degrees Celsius (1.8–3.6 degrees F) and both decrease and increase in precipitation over the western United States indicated a significant decrease in spring snow water equivalent (–30%), annual runoff (–17%) by 2100.[90] More frequent rain-on-snow events, a decrease in snow water equivalent and changes in the onset of melting, and an increased likelihood of resulting winter flooding are predicted by Leung *et al.* (2004)[91] and Wood *et al.* (2004)[92] for the Pacific Northwest region.

1.4.3 Economic impacts (property loss, etc.)

In the 1990s, flooding caused around $50 billion of damages in the United States.[94] Flood losses have increased from 1929 to an annual average of around $7 billion in 2004, a consequence of interplay of climate change and growing vulnerability of society to flood damage, due to population growth and concentration of wealth in risk-prone areas.[95] Flood damages have steadily increased over the course of the 20th century;[96] the main cause of this increase was population growth and development in high-risk areas[97] in flood-prone areas, federal policies,[98] and climate changes.[99] The U.S. National Flood Insurance Program (NFIP; see side bar on page 18) has helped spur this growth to high-risk areas. The program was created by Congress in 1968, whereby the government assumed the role of underwriter of flood insurance. NFIP rates remain artificially low, thus sending the wrong signals to homeowners and businesses about increasing flood risk.

Most of the increases in flood damages are due to population growth and development in at-risk areas, with minor contributions coming from climate change and greater precipitation.[100] Flooding, including that related to hurricanes and wildfires, can inflict more damage in areas that are densely populated and contain valuable commercial and residential property. From 1955 to 1999, Pennsylvania and California had the highest amount of flood damages, at $12 billion and $11 billion respectively.

It is unclear exactly the extent of future economic damage; however, it is expected to increase.[101] Since precipitation modeling predicts visible increases attributable to global warming over mid- to long-term timeframe, it is conceivable, though not conclusive, that further increases in precipitation will be responsible for increases in flooding. Winter flooding losses, as opposed to that occurring in spring, are likely to increase, especially under conditions of increased rain-to-snow precipitation change, and where large snowmelt takes place, such as in the Pacific Northwest. Where climate change leads to a diminished river discharge, damages from floods may be correspondingly tempered. However, in areas susceptible to flooding, it is likely that poor planning will continue to place people and property of value in harm's way.

CASE STUDY

New England experienced the worst flooding in seven decades in May 2006, with Massachusetts, New Hampshire and Maine being affected most severely. Storm rainfall totals for some cities reached up to 35.5 cm in four days of the storm, according to NWS reports. Flood damages are being tentatively estimated in the tens of millions of dollars in Massachusetts alone. Reimbursement from flood insurance is expected to be relatively low, because these states have relatively low levels of participation in the federal flood insurance program and homeowner's insurance policies generally do not include flood coverage.

While flood insurance is more common in the coastal flood plains that are at greater risk from flooding and storms, overall, Massachusetts had only 44,731 policies in February, compared to its population of 6.4 million. Part of the problem may lie in the fact that flood insurance is provided by the National Flood Insurance Program, which does not charge adequate, risk-based premiums (as evidenced by the program's fiscal deficits). Because flood insurance is subsidized by the government, its low cost may send the signal that it is altogether unnecessary, especially where homeowners have low levels of awareness concerning flood risks.[102] Indeed, many of the most severely affected areas of Massachusetts during May 2006 were not coastal, and the flooding was unexpected by the residents of such areas.

Flooding constituted part of the damage in all five of the federally declared major disasters in Massachusetts since 1996. Flood insurance has been increasing due to, at least in part, this recurrence of flooding.[103, 104]

Table 2
State by state average annual flood damages for top 15 states, 1955–1999
Source: Pielke and Klein 2001

State	Rank	Av/Yr (millions 1999 U.S.$)
U.S. Flood Damage		5,942
Pennsylvania	1	682.3
California	2	521.8
Louisiana	3	320.5
Iowa	4	312.9
Texas	5	276.9
Missouri	6	272.2
Connecticut	7	219.4
Illinois	8	218.7
New York	9	218.2
Colorado	10	198.9
Oregon	11	197.8
North Dakota	12	156.8
New Jersey	13	146.9
Mississippi	14	146.1
Minnesota	15	144.9

1.5 Hurricanes

1.5.1 Climate change and hurricanes

Out of the ten strongest hurricanes ever recorded in the North Atlantic, three occurred in 2005.[105] Hurricanes have become more frequent and long-lasting,[106] but some debate remains in the recent body of research regarding whether the frequency is linked to global warming. Previously, natural variation, namely Atlantic Multidecadal Oscillation (AMO), was considered the predominant contributing factor for North Atlantic cyclone activity.[107] (This is a natural oscillation with a 50–70 year cycle). Emanuel (2005)[108] and Webster *et al.* (2005)[109] contend that there is a link between the hurricane intensity and climate change. Most recent findings[110] link hurricanes to sea surface temperature as a significant contributing factor, rather than natural oscillation, thus arguing that global warming may be responsible in part for the recent increase in hurricane frequency and intensity. According to Barnett et. al, global sea temperature has increased due to anthropogenic global warming,[111] but in the tropical Atlantic the change was affected by another factor, previously thought to be AMO, but which Mann and Emanuel (2006)[112] argue is actually the cooling effect of lower-atmosphere aerosols that reflect sunlight and thus lower the sea surface temperatures. However, this effect has been diminishing since the 1980s due to better pollution control in source countries, and this, they argue, may explain the increased intensity and frequency of North Atlantic hurricanes. In another recent study, Trenberth and Shea (2006) concur that global warming is behind the upturn in the hurricane activity since 1995, and that AMO is playing a minor role in this change, attributing to human-made causes nearly half of the temperature increase that lent force to 2005 season's hurricanes.[113]

Because sea surface temperature and moisture content are factors that build hurricane intensity,[114] hurricanes should become stronger and more destructive with global warming. It has been argued that global warming may also usher climatic conditions similar to those associated with El Niño, which tends to be a factor in lower frequency of hurricanes in the North Atlantic, although the intensity of hurricanes under such conditions may be increased.[115]

Table 3
Value of insured coastal properties vulnerable to hurricanes by state, 2004* ($ billions)
Source: AIR Worldwide (from Insurance Information Institute) 2006

State	Coastal $	Total exposure** $	Coastal as a percent of total
Florida	1,937.4	2,443.5	79
New York	1,901.6	3,123.6	61
Texas	740.0	2,895.3	26
Massachusetts	662.4	1,223.0	54
New Jersey	505.8	1,504.8	34
Connecticut	404.9	641.3	63
Louisiana	209.3	551.7	38
South Carolina	148.8	581.2	26
Virginia	129.7	1,140.2	11
Maine	117.2	202.4	58
North Carolina	105.3	1,189.3	9
Alabama	75.9	631.3	12
Georgia	73.0	1,235.7	6
Delaware	46.4	140.1	33
New Hampshire	45.6	196.0	23
Mississippi	44.7	331.4	13
Rhode Island	43.8	156.6	28
Maryland	12.1	853.6	1
Coastal states	6,863.0	19,041.1	36

* Includes residential and commercial properties. Ranked by value of insured coastal property.

** Total exposure is an estimate of the actual total value of all property in the state that is insured or can be insured, including the full replacement value of structures and their contents and the time value of business interruption coverage.

1.5.2 Economic impacts

The material damage caused by hurricanes is actually a combined result of extreme weather events and poor planning.[116] Ceres (2005) estimates present-day losses to be somewhere in the range of $60–85 billion, whereas Munich Re (2006) estimated 2005 year losses to amount to $165 billion. This is a notable change from around $24 billion in overall losses experienced 1999–2003, and $63 billion in 2004. It may be insightful to compare figures. Average yearly hurricane losses are estimated to be at $1.6 billion 1950–1989, $2.2 billion 1950–1995, and $6.2 billion 1989–1995,[117] all adjusted for inflation.

Future losses from catastrophic U.S. hurricanes could rise 70–75 percent above current losses.[118] Models by RMS predict yearly insurance losses from U.S. hurricanes to increase by 40% across the Gulf Coast, Florida and the Southeast in the next five years because of the increase in frequency and severity of hurricanes in the Atlantic and Gulf of Mexico (RMS's model does not include climate change predictions, but is based on increased recent hurricane activity since 1995, and current rising sea temperatures, as opposed to commonly used long-term historical record average hurricane frequencies).[119] Again, societal vulnerability to hurricanes is growing, due to population growth and development in coastal areas vulnerable to hurricanes.[120] The extent of future hurricane damage depends in large part on avoiding catastrophic, cascading effects, such as those seen during hurricane Katrina where levee failure and difficulties with evacuation compounded the losses.

CASE STUDY

Hurricane Katrina began on August 23, 2005 and lasted for only 9 days, but its effects were far-reaching and continue to be felt a year later. After crossing Florida, it made a second landfall in Louisiana as a category 3 storm and hit the Gulf coast with a wind speed of around 125 mph, the 8th strongest hurricane ever recorded in the U.S., and with pressure of 920 hPa, some of the lowest ever recorded for a hurricane to affect the U.S. Katrina swept through 250 miles of coastline of three states, eventually moving on as a strong storm through central U.S. It generated up to 10 m of storm surge in some places, and it would have been the most destructive hurricane recorded even had the levees in New Orleans not breached and caused widespread flooding.

Katrina caused extensive damage, both directly, through wind and storm, and indirectly through cascading effects, and led to the deaths of over 1,200 people. The storm surge overtopped the levees, some of which failed, and led to the flooding of most of New Orleans. It took up to two days for certain areas to fill up with water, and subsequently floodwaters drained away over a week-long period. As this was occurring, the populace experienced hazardous, often life-threatening conditions, and a breakdown in the civil order ensued. These conditions lead to further damage to public infrastructure, residential and commercial property.

It appears that, in light of Katrina, the risk of storm surge may have been underestimated, a point of particular relevance for oil refineries, some of which were planned and established at their locations in times of diminished hurricane activity. In addition, zoning maps of the National Flood Insurance Program (NFIP) indicate that a "too-low estimate" of risk may have been used in the past, as intense inundation occurred in areas significantly inland from zones that were considered low-risk. The Insurance Information Institute (III) estimates insured losses for property due to Katrina to be around 40.6 billion dollars,[121] around twice as much as for the previous record-breaking hurricane, Andrew in 1992, for 700,000 claims. III expects homeowners' insurers to pay out around $16.4 billion to approximately 1 million homeowners in Louisiana and Mississippi. According to III, Katrina along with Rita, Wilma, and Dennis, made 2005 a record-breaking damage season, at around $57.3 billion and 3 million claims expected, more than double the losses incurred during the previous season when there were four hurricane events in Florida.

Katrina was one of the most destructive extreme weather events and the costliest hurricane in U.S. history. However, rather than covering its claims with surplus funds, the insurance industry essentially covered its expenses with premiums earned in the year, leading to one of the lowest ratios of claims and expenses to premiums in a decade. This is attributed in part to disaster reinsurance, purchased largely from overseas firms – and some of them have since increased the rates by as much as 100%. Another factor is that flooding caused much of the damage due to Katrina, and this damage is covered by the National Flood Insurance Program, and not covered by private insurers. Finally, the industry had previously taken steps to protect itself through measures involving risk spreading to the public and policy holders, a consequence, in part, of the devastating effects of the Hurricane Andrew in 1992 and Oakland/Berkeley Hills fire of 1991. Some companies have sought to further minimize the risk by planning to halt offering homeowners insurance in areas of the Gulf and East Coast, and some major insurers have begun canceling existing policies in some coastal citing storm risk.[122,123,124,125,126,127]

2
U.S. Insurance and Climate Change

2.1 Insurance

The U.S. Department of Commerce estimates that one-third of American economy is at risk due to weather,[128] and in the 200-year history of the U.S. insurance industry (and the 400-year history of the European industry), there have always been natural evolutions in climate and weather events. In fact, U.S. insurers have become expert in probabilistic catastrophic risk modeling, which has become an integrated risk management tool throughout the U.S. insurance marketplace. This has helped many U.S. companies to digest the recent unprecedented hurricane losses without significant defaults, unlike after Hurricane Andrew in 1992, which served as a catalytic event to boost cat model usage.

This has led to the fact that U.S. insurance companies are somewhat more sophisticated in understanding, analyzing, and managing their *current* risks due to natural catastrophes than many of their European counterparts.

However, whereas European companies need to improve in this discipline of risk management, many seem to have begun trying to proactively assess and manage *future* risks and trends and incorporate them into risk management strategies (more on this topic in section 2.1.2).

For U.S. insurers, past events continue to form the basis for catastrophic risk modeling and weather-event planning, despite the fact that the science indicates that the future for many years to come is going to be significantly different from the past as a result of anthropogenic climate change. It is for this reason, that the first half of this report focused on clarifying the certainties and uncertainties of current science about how climate change will impact weather-related events.

As many European insurance firms are beginning to note, depending on historical weather patterns is no longer sufficient for future planning, and U.S. companies that wait for more certainty before acting to protect their business interests are at risk.

As SwissRe so astutely puts it:

> "*Those who systematically endeavour to gain more than they lose must consciously examine the risks and opportunities (of climate change). They must identify possible weather-related losses and gains, and consider how the impact of weather conditions can be favourably influenced.*"[129]

While the physical impacts of climate change have implications for all branches of insurance, this report primarily focuses on property and casualty due to their unique exposure to increased intensity of hurricanes (and resulting storm surges), flooding, and fires. Life and health insurance are also exposed, through overall changes in heat and cooling patterns.

2.1.1 Physical impacts' effect on insurers

Insurance and reinsurance companies, as well as the U.S. National Flood Insurance Program (NFIP) and state-backed insurance programs, are likely to feel the physical impacts of climate change sooner than other financial services firms. Even before considering the unforeseen weather-related events resulting from climate change, catastrophe losses have been doubling every ten years as a result of the surge in building along coastlines and other high-risk areas (housing in Florida has grown by over 30% in the last ten years alone),[130] and the fastest growing suburban areas in the west are often cities and suburbs at high risk to wildfires.[131] This trend is expected to continue in Florida and other coastal and high-risk locales.

There are many examples of how extreme, unpredicted weather events in the U.S. can impact insurance companies, the sector, and government backstops. A few illustrations follow:

- Increases in serious weather events have resulted in over 13 times more insured losses, costing U.S. insurers $9.2 billion per year in the 1990s[132]
- 15 insurers became insolvent after 1992's Hurricane Andrew[133]
- 2004's four major hurricanes had combined insurance loss of $23 billion, much of which was absorbed by Florida's state-backed plans
- After Katrina (which caused somewhere between $40 and $60 billion in insured losses[134]) and Rita, the U.S. National Flood Insurance Program (NFIP) has requested a $23 billion loan to cover flood claims of homeowners
- $7.25 billion has been paid by the taxpayer funded NFIP on 120,000 properties for *multiple* floods
- The Oakland/Berkeley Hills fire resulted in $2 billion in damages

While there are other examples of how the insurance industry is affected (see sections 1.2.3, 1.3.3, 1.4.3 and 1.5.3), because the insurance sector has a more flexible product (the annual contract) than banks (who often make 10–30 year corporate loans, project financing, and mortgages), in many ways, the insurance sector is better positioned to adapt to changing weather patterns and events, and in fact, the industry as a whole was still enormously profitable in 2005.

Because the private insurance industry and companies can alter underwriting, change rates, or exit markets, the overall industry is fairly robust, even in the face of climate change. For example, in Texas, State Farm Lloyds has boosted premiums an average of 39 percent in Harris County and 36 percent in Galveston County to cover increasing reinsurance costs.[135]

However, raising rates in the mass market can be difficult because of regulatory limitations and/or public and political pressures, so this is not always an appropriate risk preparatory response. Additionally, companies that have a more diverse portfolio of offerings and locales will be better prepared than companies that operate in high-risk areas or who are not thoroughly diversified.

Importantly, as the risks of floods, storm surge, hurricanes, and fires rise, if private insurance companies are unable to raise rates (due to political or regulatory pressures), they may begin to exit key coastal markets where population rates are growing rapidly, thus causing the risk burden to shift to government run insurance programs, banks and other lenders, investors and equity owners of corporate real estate, and individual home- and business-owners themselves.

2.1.2 What U.S. insurance companies are doing to address climate change risks and opportunities

This section will give a brief overview of activities of U.S. insurers and industry associations and a summary of barriers to the U.S. industry taking action. A recent report released in August 2006 by Ceres[136] provides a detailed analysis of the actions of over 100 insurers globally, and concludes that although there are a number of vanguard programs, "the enormous potential and opportunity from these forward thinking initiatives remains largely untapped. Most U.S. insurers have yet to even experiment with these novel ideas, presumably because many companies have not looked closely at the underlying question of climate change."

Overall, compared to their European counterparts, American insurance companies, and the industry as a whole, have done less to examine and manage the implications of climate change. The industry is stuck between a rock and a hard place in that it is clearly in their best interest to examine this risk, and at the same time the industry is often bombarded by popular media for being "self serving" if they put too much energy or effort into studies that may cause rates to rise. Thus, examining any impacts that may raise rates or change underwriting becomes challenging. On the other hand, AIG received wide positive press coverage upon releasing their new climate change strategies.

Examples of action of the U.S. insurance industry and companies include:

- *Studying the problem.* The American Insurance Association (AIA) produced a white paper in 1999 titled *Property-Casualty Insurance and the Climate Change Debate: A Risk Assessment*, which is currently being updated to incorporate new scientific findings. In July 2006, the Insurance Information Institute (III) released a similar paper titled *Global Climate Change and Extreme Weather: An Exploration of Scientific Uncertainty and the Economics of Insurance* that examines the scientific uncertainty of climate change and its regional impacts on the economics of insurance.

"In insurance we tend to look at the past instead of the future, and when you have a dynamic change taking place, looking at the past does't work so well."

Tim Wagner, Director Nebraska Department of Insurance, co-chair of NAIC's Climate Change Task Force

These industry papers, while bowing to the general scientific consensus that climate change is occurring at the global level, emphasize the uncertainties of measuring regional impacts as well as focus on the industry's ability to adapt by changing pricing or exiting markets.

In the Spring of 2006, after Hurricane Katrina forced the National Association of Insurance Commissioners (NAIC) to postpone their New Orleans-based 2005 annual meeting, the NAIC created a task force to study climate change's impacts on their industry. The task force will examine how global warming will impact the availability and affordability of insurance, and how climate change may affect the financial health of insurance companies. The task force will also consider actions necessary to enable state regulators and insurers to mitigate and otherwise respond to these problems. In addition to the brutal 2004 and 2005 hurricane seasons, the NAIC created the task force in response to "all kinds of extreme weather in the Great Plains states, including drought, tornadoes, brushfires and severe hailstorms."[137]

- *Modeling the potential impacts.* As previously mentioned, U.S. property-casualty insurance companies have become extraordinarily sophisticated in understanding, analyzing, and managing their *current* risks due to natural catastrophes, utilizing cat risk models primarily offered by a handful of firms, such as AIR Worldwide, EQE, and RMS. These models are used to set contract prices and inform planning cycles (typically a few years), and are based on *current* and *historical* data to predict catastrophic risk. RMS models were recently updated to include recent increases in hurricane frequency and rising sea temperature (while remaining agnostic to the causes discussed in section 1.5). The models do not yet incorporate predicted changes in weather events due to climate change, nor the predictions of climate scientists about impacts associated with global warming.

  As was seen in the first section of this report, scenario analyses offered by the scientific community on the impacts of climate change provide a range of predictions about the impacts of sea level rise, changing wind and rainfall patterns, drought and aridity, snow melt, sea temperatures, etc. As an example of the variability produced by models, prominent

The United States'
U.S. National Flood Insurance Program

SENDING THE WRONG MESSAGE TO HOMEOWNERS AND HINDERING THE MARKET

The National Flood Insurance Program (NFIP) was created by Congress in 1968 whereby the government assumed the role of underwriter for flood insurance. The program, while well-intentioned to provide coverage for American families, has largely resulted in the insurance of homes and businesses in high-risk flood zones to whom a private insurer either would not provide insurance or would charge markedly more than NFIP currently charges.

The NFIP charges artificially deflated premiums, which currently cover only 60% of the program's expenditures and payouts. The program also makes payments to consumers who have failed to pay premiums, and to homeowners who continue to build, over and over again in high risk areas. Some 120,000 properties have received multiple payments from NFIP, costing U.S. taxpayers about $7.25 billion. 26,000 of these have received four or more payments.

More than 25 percent of insured properties receive subsidies under the program, which last year paid claims that exceeded by $7 billion total payouts made in the program's 38-year history. Thus, the NFIP is currently $21 billion in debt, and consumers are not only receiving flood insurance prices that do not accurately reflect flood risk along increasingly exposed coastlines, they are also subsidized over and over again while continuing to build in dangerous areas. In this way, the NFIP is distorting market signals (increased insurance rates or unavailability of coverage) that would normally make clear the extent of risk associated with a specific site.

Recently, the National Flood Insurance Program faced insolvency following Rita and Katrina hurricanes, and has asked Congress to provide a $23 billion loan to pay for flood claims stemming from the hurricanes.

Congress is currently examining ways to fix NFIP's distortions. The "Flood Insurance Reform and Modernization Act of 2006" would phase in actuarially correct rates for second homes and businesses but not for repetitive-loss properties.

Unlike the Senate bill, which the Banking, Housing and Urban Affairs Committee approved last month, the House bill does not forgive the program's $24 billion debt, but it raises the debt ceiling from $20.8 billion to $25 billion. The Senate measure also would phase out subsidies faster than the House-passed legislation.

The House bill directs FEMA to review 100- and 500-year flood plain maps that officials say are out-of-date, often inaccurate and encourage construction in high-risk areas. An amendment to the bill stipulates that FEMA utilize "emerging weather forecasting technologies" when updating its flood maps.

Lawmakers rejected three amendments that would have immediately ended subsidies on nonresidential properties and vacation and second houses.

As the insurance industry seeks to protect itself by insulating the risk through non-market based solutions, losses due to other types of events as well may increase further. Alternatively, premiums set at the market price reflecting the risk could play a role in guiding development away from high-risk areas.

Box 1
Sources: Muir-Woods 2006, NFIP, and the Wall Street Journal 2006

hurricane scientist – and climate change skeptic – William Gray forecasted in May that 2006 will produce nine hurricanes, five of which would be major storms with winds over 110 miles per hour;[138] by August, Gray's team had altered their predictions to seven hurricanes, three of which would be major storms.[139] In an effort to better understand how predicted changes in weather events might impact insurance in the U.K., the Association of British

Insurers (ABI) has begun to commission "what if" scenario analyses utilizing the insurance industry models offered by AIR Worldwide[140] and RMS, and inputting the scenarios offered by scientists (see Box 2).

- *Acknowledging and disclosing risk.* When looking at Securities and Exchange Commission (SEC) filings of U.S. insurance companies, only 15% of the largest 27 property-casualty insurers report any climate change risk in their annual filings. To put this in perspective, 96% of U.S. electric utilities provide some kind of climate risk disclosure in their annual securities filings.[141] Rating agencies and shareholder service firms are increasingly scrutinizing how risks are managed across an organization's portfolio of activities. Only four of the eleven U.S. insurers responded when asked to answer the Carbon Disclosure Project questionnaire.
- *Adapting to the problem.* The U.S. insurance industry has primarily taken an adaptive approach to the impacts of increasing wind damage from hurricanes, more dangerous wildfires and other property-casualty impacts. Similar to promoting increased auto safety mechanisms, such as seat belts and airbags, the AIA

Box 2

Examples of European Insurance Research, Publications, and Action On Climate Change

EUROPEAN INSURERS AND INDUSTRY

2006 Lloyd's of London. *Climate Change: Adapt or Bust*

2005 Allianz and WWF. *Climate Change and the Financial Sector: An Agenda for Action*

2005 Association of British Insurers. *Financial Risks of Climate Change*

2005 Association of British Insurers. *Making Communities Sustainable: Managing Flood Risk in the Government's Growth Areas*

2004 Association of British Insurers. *Climate Change: Moving Forward*

2004 Association of British Insurers. *Climate Change and Water Security*

2003 Association of British Insurers. *The Vulnerability of UK Property to Windstorm Damage*

EUROPEAN REINSURERS

2006 Munich Re. *Climate Change, Solvency II and Occupational Disability*

2006 Swiss Re. *The Effects of Climate Change: Storm Damage in Europe on the Rise*

2006 Munich Re. *Climate Change & Tropical Cyclones in the North Atlantic, Caribbean and Gulf of Mexico*

2005 Swiss Re (with Harvard Medical School). *Climate Change Futures: Health, Ecological and Economic Dimensions*

2005 Munich Re. Creation of the *Munich Climate Insurance Initiative (MCII)*

2005 Munich Re. *Weather Catastrophes and Climate Change: Is There Still Hope for Us?*

2005 Munich Re. *Annual Review: Natural Catastrophes 2004*

2004 Swiss Re. *Tackling Climate Change*

2002 Swiss Re. *Opportunities and Risks of Climate Change* and the Institute for Business and Home Safety have begun to lobby for improved building codes as technology and mitigation products come on the market (such as better hurricane shutters, wind resistant glass, and fire resistant tile, metal or slate roof tiles[142]). In some instances individual insurance companies have actually required individuals to build with these materials in order to qualify for coverage. Also a form of adaptation, some insurers are withdrawing from high-risk coastal locations in Florida, or the state as a whole,[143] in part because regulators are preventing them from raising rates to reflect the increasing risk, thus hampering the market's ability to send price signals to consumers that would begin to educate the public on the perils of building along exposed coastlines or fire-prone areas. In addition to Florida, American International Group (AIG) is no longer writing new property policies in some parts of the Gulf Coast, and Allstate is limiting policies in areas as far north as New York.[144] Neither Allstate nor Nationwide Mutual are writing new policies for the eastern half of Long Island, and MetLife has stated that it will require extra inspections and storm shutters for new customers living within five miles of the ocean before it will issue coverage.[145]

While this form of adaptation may protect insurance companies, it causes a problematic shift in risk burden away from insurance companies and onto property owners (individuals, companies, equity investors, and banks), as well as local, state, and the federal governments.

The following section describes some of the barriers that may prevent American companies from engaging on this issue as proactively as European insurance companies (such as Allianz, Lloyd's of London, and others), reinsurance companies (SwissRe, MunichRe, and others), and the industry as a whole (such as the Association of British Insurers) have.

The 2005 hurricane season may have been a tipping point for insurers to examine climate change more closely, and until recently, many barriers led to inaction by U.S. insurers, including:

- *Public and political pressure to keep rates low.* It is important to note that insurance companies only exit markets as a last resort. This action is only taken when the company believes payouts will outstrip premiums. Most insurers seek to build long-term relationships with customers and to provide products that protect their customers' health, safety and assets over the long-term. In general, insurance companies only leave markets or remove products when the risk factors become too high or when regulators or public/political pressure prevent them from accurately pricing products.

  U.S. insurance companies are regulated at the state level, and in some cases suffer from extraordinary rate suppression in States' efforts to keep insurance affordable. While affordable insurance is a laudable goal, keeping rates artificially low may be convincing consumers that building in high-risk areas is sustainable, when in fact, the cost of insurance should indicate the level of risk. For example, Florida wages a constant battle to keep home and commercial property insurance affordable, even in the wake of six strong hurricanes in the last two years, and a shaky property insurance market. Rate increases that can be actuarially justified by past experience and catastrophe modeling are often denied or cut to a fraction of the requested rate. Recently, Florida took a very small step toward competitive rating to send a better risk message to the public. Florida now prohibits homes with a value of more than $1 million to be placed in the state-run residual market (Citizens Property Insurance Company) and such homes have to seek coverage on the open market. Much more needs to be done, however. Florida is also taking steps to create a residual market for commercial property insurance market as well, and insurers are similarly concerned about artificial rate suppression for that mechanism. Numerous other examples of rate suppression exist in Louisiana, Mississippi, North Carolina, California, Massachusetts and other states.

U.S. insurers are facing ever-increasing rates from reinsurance companies, who (as is shown in Box 2) are studying the problem of climate change in greater detail, and are increasing reinsurance rates to ensure solvency. All too often, U.S. regulators and the media put pressure on insurance companies to keep rates artificially low, or to continue coverage in high-risk areas.

- *Political and cultural uncertainty about climate change.* In Europe, reinsurers and insurers operate in a political and cultural environment that has largely adopted the belief that anthropogenic climate change is not merely a reality, but one with effects that are observable and measurable already. Tony Blair placed climate change as one of the top two problems that governments need to handle during the 2005 G8 meetings in Gleneagles. Furthermore, this belief system was bolstered by Europe's extreme wind storms in 1999, summer floods of 2002, and heat wave of 2003.

In addition to the social and political differences between Europe and the United States, the differing physical manifestations of climate change between the E.U. and U.S. partially explain the different response to this issue. In Europe, where floods pose – and are expected to continue posing – a growing risk due to climate change, precise flood records exist for hundreds of years. Hurricanes, currently considered the most urgent threat with a link to climate change in the United States, are much more difficult to measure, and for this and other reasons, their record is considerably shorter. In addition, in contrast to European counterparts, U.S. insurers operate with a federal government that has continually questioned climate science, and has remained deeply divided – though not always along party lines – on the issue. Likewise, the American public has remained confused by mixed messages in the media and from their government about the validity of global warming science and how it may impact them personally. This environment is rapidly changing as the mainstream media, including Time Magazine, Vogue Magazine, the New York Times, Business Week, the Economist, and many others, have acknowledged the science and warned Americans to pay attention. Additionally, Hurricane Katrina left Americans in shock at the region's inadequate levee system, poor preparation, and the 2005 hurricanes have resulted in a flurry of research and activity by insurance companies.[146]

"(Insurers') improving risk management skills could make them increasingly disengaged, seen to be shirking their share of society's burden of catastrophic loss costs."

Dr. Robert Muir-Woods, Chief Research Officer, RMS

- *General philosophy that even if climate change is happening, how it will play out is too complicated to predict meaningfully.* As previously stated, the U.S. insurance industry has emphasized, through its industry associations, that scientists disagree about the regional implications of climate change. Unfortunately, because current cat models used by insurance companies do not include scenarios to examine even the highly certain events (such as continued and accelerating future sea level rise, and continued future polar ice melting), U.S. insurance companies' ability to predict future risk is very slim.

The U.S. insurance industry, either through its associations or as individual companies, could build on its already solid cat risk modeling expertise by building "what if" scenarios offered by leading climate scientists into existing risk models to gain a better understanding of the changing future. The Association of British Insurers has already commissioned such studies from both AIR Worldwide and RMS. According to AIR Worldwide, when considering the impacts of climate change on major catastrophic events, "it's not a question of *if*, it's a question of *when* and *how big*?"[147]

- *Belief that the industries' financial solvency is not at risk.* The reports by AIA and III indicated that the U.S. industry believes that through diversification of products and geographies, and through adaptation such as price increases and market-exiting, the industry as a whole bears substantially small risk. And because most industry contracts are relatively short-term, compared to bank loans or personal home investments, insurers do not need to prepare as readily. In fact, U.S. insurers have the capability to provide more accurate risk signals to governments and individuals by not exiting markets and instead producing new products that reflect the rising risk. In some quarters of the industry, there is concern that the frequency and force of the hurricanes are expected to rise, and although in recent years the insurance industry has coped well, a similar scenario in the future could lead to financial depletion of the industry.[148] Some even predicted that the 2006 hurricane season could wipe out twenty to forty insurers.[149]
- *Overall hesitancy to push government or society.* A significant finding of this report relates the regulatory environment for U.S. flood insurance. If flood insurance was managed on the free market (and not by state governments) in the United States, as risks of floods associated with hurricanes rise, the cost of flood, homeowners, and business insurance would rise to coincide with rising risk. This would send a price signal to consumers and businesses about increasing flood risk. By commissioning risk studies, exiting markets, raising rates, and lobbying local and federal governments for action, insurance companies have the opportunity to help slow the rapid development of high-risk areas and communicate the increasing risks to society.

2.1.3 U.S. examples of specific insurance solutions to tackle climate change risks

- *American International Group* (AIG) unveiled a new climate change strategy on May 15, 2006. AIG is the first U.S. insurer to publicly state a belief that there are risks and opportunities as a result of climate change, and their new program includes: improved sophistication of catastrophe exposure modeling; allocation of additional private equity investments to projects, technologies, and other assets that contribute to GHG emission mitigation; generation of tradable carbon credits; development of risk management/derivative products to support the carbon market; continued offering of environmental remediation and environmental liability insurance; among many other things.
- *Fireman's Fund Insurance Company* is in the final stages of developing several new "green" products that seek to minimize environmental and climate impact, while also garnering bottom-line benefits for FFIC and its customers. The first product is a new property insurance policy for LEED or Green Globes Certified buildings. This new coverage will specifically apply to the unique attributes of green buildings not covered by conventional property policies, such as solar panels, green roofs, and recycled water supply systems. Because green buildings are proven to be less prone to water damage, electrical fires, or full loss due to fire, FFIC will offer a rate *credit* of 5% to these building owners. While there are only about 500 LEED-certified buildings at the moment,

there are over 5,000 buildings currently undergoing certification. Another new FFIC green product will be a "Green Upgrade Form", which will apply to customers with "normal" buildings and responds to FFIC's customers' growing concern about the costs of energy and the availability of water. For customers who purchase this product, at a 1–2% premium, Fireman's Fund would replace damaged systems not with like kind and quality, but with upgraded green products designed to save money on energy and water. For example, a damaged roof would be upgraded to an energy star compliant roof, providing the customer with better energy efficiency. The same is true for all the building attributes that need replacement after a loss including lighting systems, plumbing, office equipment, carpeting, etc. If the customer suffers a total loss, FFIC would rebuild to LEED or Green Globes certified standards. Fireman's Fund sees these products as a way to differentiate themselves from their competitors.

> *"A lot of building owners are concerned about climate change but don't know what to do. Here's one thing building owners can do that addresses more than their bottom line."*
>
> Steve Bushnell, Director of Product Development, FFIC

- *Marsh*, a prominent U.S. insurance broker and consultancy has also written a substantial report on the topic of climate change. The report provides insights into the business risks from climate change including: the threat of increasingly volatile weather conditions; the impacts on insurance markets, business resources, personnel, and corporate preparedness; and the increasing legal and regulatory pressures and mounting public and shareholder activism.
  The report finds that uncertainty regarding frequency, intensity, and or spatial distribution of weather-related losses will increase vulnerability, and likely cause the following reactions: increasing premiums for coverage applicable to weather-related events and catastrophes; increasing the use of exclusions applicable to losses associated with climate change; and increasing deductibles for weather-related losses.
  Examples of risk-mitigation activities offered by Marsh include: working to change building codes to make construction more likely to withstand damage; encouraging insureds to maintain strong loss-control policies – such as emergency-preparedness and business-continuity plans; and developing new insurance products that will allow for risk transfer.
- *Traveler's Auto Insurance* announced in February, 2006 that it would offer a 10% discount on auto insurance to drivers of hybrid-electric vehicles. The company also developed an online community for hybrid drivers called www.hybridtravelers.com. The firm sees this move as an opportunity to gain market share with the LOHAS (Lifestyles of Health and Sustainability) market, a $227 billion market segment.

2.1.4 Recommendations

There are many activities that insurance companies or industry associations can take to improve their understanding of climate change's impacts, help governments and society better understand and prepare for the risks of development in coastal or fire-prone regions, and create products that protect their clients from climate change induced damages. Various solutions will fit different companies depending on their portfolio of products, corporate culture, and relationship with local, state and federal regulators. Examples of activities that insurers or industry associations could take to reduce the physical impacts of climate change, to adapt to the changes produced by climate change, and to capitalize on potential opportunities include:

1 IMPROVE UNDERSTANDING OF THE PROBLEM

- *Commission scenario risk analysis studies* that incorporate the predictions of leading climate scientists into existing cat risk models offered by a number of risk modeling agencies. Most climate scientists agree that weather events in the future are likely to be quite different than weather events in the past, thus it would be prudent for insurers to better understand what the future could look like if scientists' predictions come to pass. This is probably the most important of the following recommendations because of the highly complex interaction of climatic and weather variables that will affect extreme weather events and catastrophes. Scenario analysis studies could build on the U.S. industry's already solid cat risk modeling expertise by inputting "what if" peril situations based on scientists predictions. Such studies would provide increased knowledge and predictive capacity and would allow insurance companies to find hidden markets and new product opportunities, as well as manage risk and educate consumers.

- *Work with scientists to increase the economic relevance and accuracy of climate change modeling.* There are many climate change processes of direct interest to the financial services industry that readily lend themselves to scientific inquiry but are rarely being studied due to lack of industry support to the scientific community. The insurance industry can take a lead in strengthening the relationship between itself and the research community.
- *Partner with environmental NGO's or other stakeholders to utilize varying expertise.* More and more, corporations and NGOs are partnering to capitalize on each others' core competencies.

2 SEND STRONGER SIGNALS OF RISK TO THE PUBLIC

- *Work with governments and regulators to (where appropriate) allow for adjustment of homeowner insurance rates and flood insurances rates,* and to develop actuarially sound risk-based pricing that sends appropriate risk signals to consumers and businesses moving into high risk areas. This is an admittedly difficult recommendation as regulators generally seek to keep prices as low as possible. However, both governments and insurance companies have an important role to play in correcting market distortions, and both groups have a vested interest in communicating accurate risk levels to homeowners, businesses, and consumers. Regulators need to consider carefully the risk signals being sent to consumers when governments keep insurance rates artificially low. Additionally, some states do not allow insurers to utilize cat risk modeling as a means of setting underwriting rates. Again, by suppressing use of data to examine risk, regulators could be doing more harm to the public than the protection they are trying to give.
- *Acknowledge and disclose the risks of climate change in annual securities filings and through other corporate communications.* More and more investors are requesting improved disclosure of climate risk from companies, and each year more shareholder resolutions are filed on this topic, not only from "Socially Responsible Investors", but also from main stream pension funds that manage hundreds of billions of dollars of retirees' money, including city and state pension funds many of which are leading the way on these efforts. In 2005, the Investor Network on Climate Risk, which collectively manages over $3 trillion, sent a letter to the nation's top 30 insurance companies seeking better climate risk disclosure. Likewise in 2005/2006, thousands of individual investors urged their mutual funds to support shareholder resolutions seeking increased climate change disclosure. AIG's recent climate change strategy is an important first example of climate risk acknowledgement, which is a key component of educating shareholders and consumers about the changing physical environment, particularly along coastlines and drought-prone areas, due to climate change. Similarly, Millea Holding, a Japanese insurer, is the first and only insurer to examine the link between climate change and the increased frequency and severity of natural disasters in their SEC filing 20-F

(for foreign corporations), and to consider the effect such changes will have on the firm. The firm discloses that if it cannot predict the severity of natural disasters and therefore cannot adequately reinsure such occurrences, this could significantly affect its financial position. Millea's SEC disclosure can be used as a model for U.S. insurance firms.

- *Take a proactive approach to influencing land use development and planning*, in part because much of the anticipated increases in losses stemming from catastrophic events could be avoided by better spatial planning. It is expected that development and investment will continue to grow in areas at risk. This is the low-hanging fruit for avoiding increasing losses. There are many measures that can be taken that: a) keep valuable property out of risk areas, and b) confer both environmental and economic benefits. Example of the latter include better forest management that simultaneously decreases risks from wildfires, mudslides, and floods, while sequestering carbon, or conservation of mangroves, which also sequester carbon while providing a natural buffer from storms, surges, and waves.
- *Incentivize the reduction of GHG emissions that exacerbate climate change.* In many cases, the companies, communities and sectors that are high emitters of CO_2 may not be the most impacted by climate change. The insurance industry uniquely links up the two ends of climate change (causes and impacts) by bearing the costs of the impacts and by insuring gasoline-burning automobiles, energy-consuming homes, and pollution-emitting airplanes that are some of the primary cause of human-induced CO_2 emissions[150] (electricity generation plants and oil companies are often self-insured). Thus, the industry is uniquely positioned to drive change and to build education among those most impacted. In some cases, high emitters are in fact also vulnerable to climate change impacts. For example, Florida's CO_2 emissions have increased 350 percent between 1960 and 2001,[151] and Florida is likely to be one of the first areas in the U.S. to experience catastrophic sea level rise and increased hurricane damage through wind and storm surge. Insurers could offer reduced rates for owners of fuel economical cars (such as Traveler's Insurance is already doing) or could offer incentives to homeowners who invest in energy efficiency or renewable power. Insurers can also encourage the use of public transportation.

3 PREPARE FOR AND ADAPT TO CHANGING CLIMATE

- *Continue to adapt to the impacts of climate change through promotion of and lobbying for appropriate building materials and improved building codes*, emphasizing the win-win scenarios of highly energy efficient buildings that also incorporate state of the art protection against wind damage, fire, and water influx. This is an area that U.S. insurance companies and associations already have experience, both through their past efforts on issues such as seat belt and air bag requirements, and through existing work to improve building material requirements in hurricane or fire-prone areas. These activities not only reduce insured losses, but also protect consumers' assets and safety.
- *Examine how the physical impacts of climate change may provide business opportunities* through environmental remediation or new climate change-oriented products. Examples may include developing new or customized insurance initiatives such as customization, "bundling" and/or targeted marketing of existing insurance products for developers of renewable energy (e.g. wind, biomass, solar), other mitigation technologies and projects that generate carbon credits within the E.U. and other emissions trading systems. Globally, many of the areas that are expected to be worst impacted by climate change are currently un- or under-insured, and the same is true in the United States where millions of people may be underinsured according to a recent poll by MSNBC.[152] In the United States, new products such as those described on page 25 could be a

lucrative new market for insurers. And globally, new insurance products could be offered to/ through development or aid organizations such as the World Bank, not only building new profit lines for insurers, but also meeting a substantial unmet need in some of the world's most vulnerable populations. For example, Swiss Re recently provided the first-of-its-kind insurance product to RNK Capital for managing Kyoto Protocol-related risk in carbon credit transactions.[153]

- *Commit to make internal operations climate neutral* through usage of alternative energy, funding of sequestration projects, efficiency improvements and "green" purchasing, and carbon offset purchases. For example, two insurance companies, St. Paul Travelers and the Hartford, have joined the U.S. Environmental Protection Agency's Climate Leaders program. Climate Leaders is an "industry-government partnership that works with companies to develop long-term comprehensive climate change strategies. Partners set a corporate-wide greenhouse gas (GHG) reduction goal and inventory their emissions to measure progress."

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