White Paper Prepared for Workshop on Climate Change and Disaster Losses: Understanding and Attribution Trends and Projections

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Summary

- Climate change is real, and has a significant human component related to greenhouse gases, as summarized by the IPCC's Working Group I. Nothing in this white paper contradicts this work.
- Global disaster losses have increased.
- The increase in disaster losses is primarily due to floods and storms.
- Scientists have not yet attributed changes in floods and storms to human causes. However, there is evidence for the detection of trends in some phenomena, especially tropical cyclones.
- Some long-term disaster loss records are of suitable quality for research purposes.
- Long-term records of disaster losses indicate that the overwhelming factors responsible for increasing disaster losses are a result of societal change and development.
- Looking to the future, societal change will continue to be the dominant factor in increasing disaster losses. This conclusion is robust to a wide range of climate change scenarios. Identifying the signal of human-caused climate change in disaster loss trends will remain difficult for decades to come.

Global disaster losses have increased.

A wide range of datasets from around the world paint a consistent picture: Disaster losses have been increases rapidly in recent decades. Figure 1 below was produced by Munich Re and is illustrative of the more general conclusions (Munich Re, 2005).

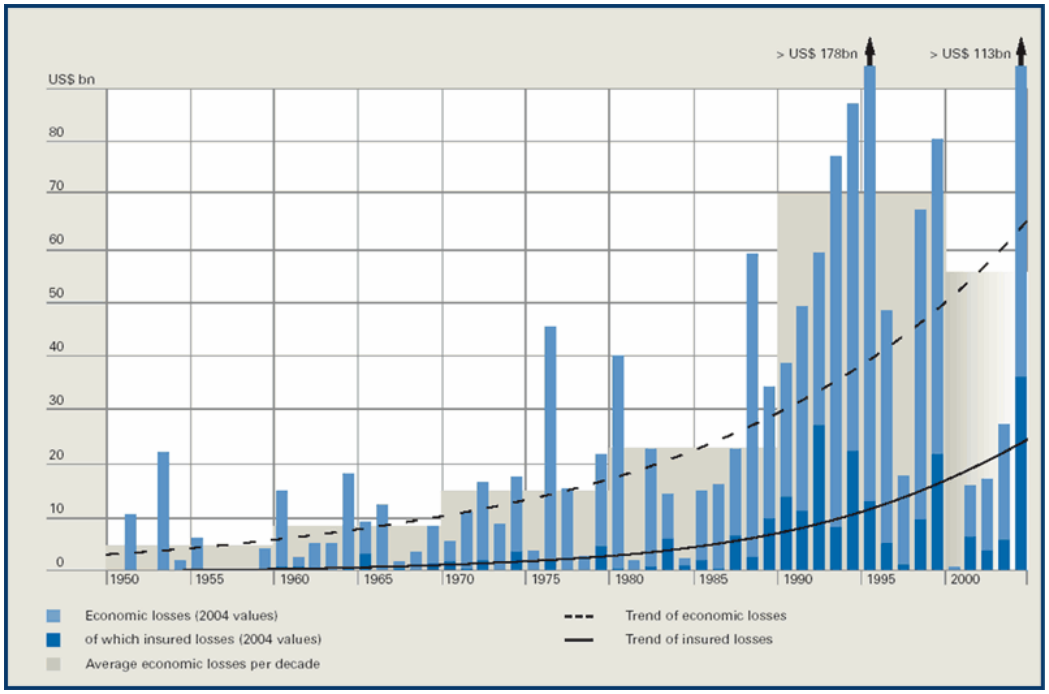


Figure 1. Global trend in disaster losses.

It is important to recognize that disaster losses do not increase in every region at a constant rate. Some regions may see decreasing trends. Disaster losses typically come in discrete, large values and the trend record is driven by the increase in the costs of the largest disasters, such as hurricanes in the United States.

The increase in disaster losses is primarily due to floods and storms.

The trend of increasing disaster losses has been driven largely by damage associated with floods and storms. Figure 2 (right) indicates that the vast majority of insured losses are the result of floods and storms (Association of British Insurers, 2005).

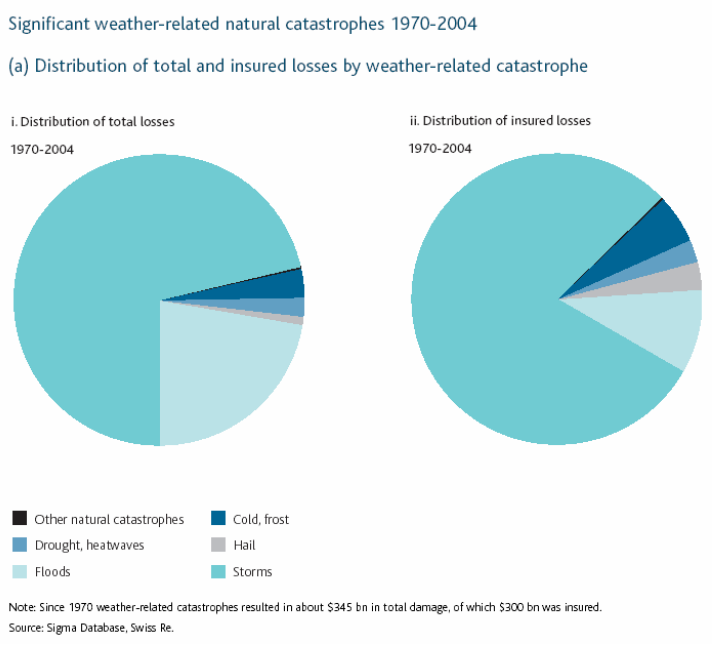


Figure 2. Distribution of insured losses 1970-2004, ABI, 2005.

The three figures below (3a, b, 3c) show for the decades of the 1990s the distribution of disasters by phenomena in terms of the number of disasters, total damage, an loss of life.[1] A consistent picture emerges from this data for atmospheric-related disasters – floods and wind storms are the primary phenomena responsible for disasters around the world according to each of these metrics.

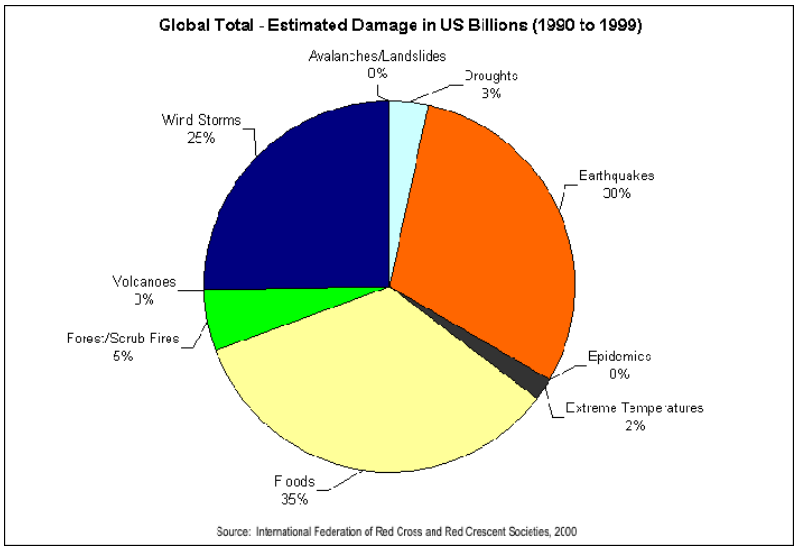
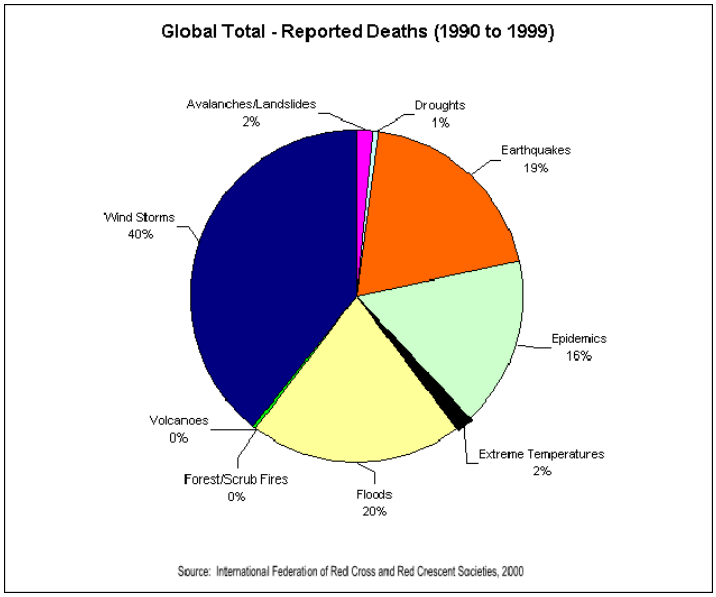
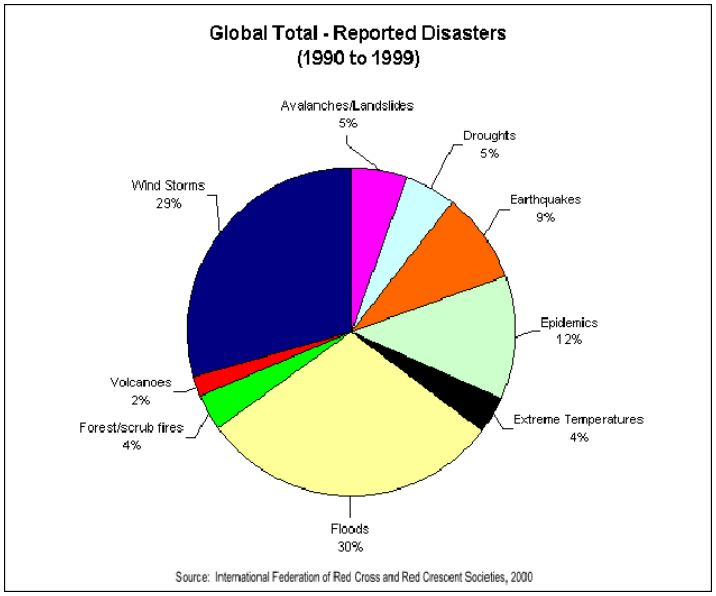


Figure 3a. IFRC, 2000. Total disaster losses in the 1990s by cause.

[1] Data from the Red Cross World Disasters Report (International Federation of Red Cross and Red Crescent Societies, 2000).





Figures 3b and 3c. Total deaths and number of disasters by cause during the 1990s. IFRC, 2000.

Scientists have not yet attributed changes in floods and storms to human causes. However, there is evidence for the detection of trends in some phenomena, especially tropical cyclones.

The most recent IPCC report took a close look at research on extreme weather events and found little evidence for changes over time (IPCC, 2001). Consider that over recent decades, the IPCC found no long-term global trends in extra-tropical cyclones (i.e., winter storms), in "droughts or wet spells," or in "tornados, hail, and other severe weather." No research (that I am aware of) has been published that would overturn these conclusions. In the absence of global trends in these weather events, they cannot be identified as being responsible for any part of the growing global economic toll. Regional trends may paint a different picture, however, in this context as well detection of trends and attribution to human causes remains incomplete.

Tropical Cyclones

Research on tropical cyclones has advanced rapidly since the last IPCC. In 2005 Massachusetts Institute of Technology's Kerry Emanuel published a study in the journal Nature that described an increase in the intensity of

hurricanes in the North Atlantic and North Pacific (Emanuel, 2005). Another prominent study by Webster et al. has found an increase in the proportion of the strongest storms since 1970 (Webster et al., 2005). These two papers, published in the midst of a record Atlantic hurricane season in terms of both activity and damages have prompted much discussion about trends in tropical cyclone behavior.

However, it is important to recognize that neither of these papers focused on attribution. Emanuel (2005) expressed some uncertainty as to the factors responsible for the trends presented in that paper, stating "*Whatever the cause*, the near doubling of power dissipation over the period of record should be a matter of some concern" (emphasis added). Webster et al. (2005) even go so far as to observe that "attribution of the 30-year trends to global warming would require a longer global data record and, especially, a deeper understanding of the role of hurricanes in the general circulation of the atmosphere and ocean, even in the present climate state." And both the Emanuel and Webster et al. papers have prompted a vigorous discussion with responses to each subsequently published by Landsea (2005) and Chan (2006), respectively.

A vigorous debate continues within the community about the trends themselves. These studies are complemented by a new paper forthcoming in *Geophysical Research Letters* in May, 2006 which find no trends in global tropical cyclone intensity from 1986-2005, with the exception of a dramatic increase in intense storms in the Atlantic Basin (Klotzbach, 2006a). Its author concludes,

> These findings indicate that there has been very little trend in global tropical cyclone activity over the past twenty years, and therefore, that a large portion of the dramatic increasing trend found by Webster et al. [2005] and Emanuel [2005] is likely due to the diminished quality of the datasets before the middle 1980s. One would expect that if the results of Webster et al. and Emanuel were accurate reflections of what is going on in the climate system, than a similar trend would be found over the past twenty years, especially since SSTs have warmed considerably (about 0.2°C – 0.4°C) during this time period (Klotzbach, 2006b).

Given these various results, a position paper by the World Meteorological Organization's Commission on Atmospheric Sciences, its Tropical Meteorology Research Program Panel (whose authorship included Emanuel, Holland, Knutson, Landsea, among other prominent scientists) concluded:

> The research issues discussed here are in a fluid state and are the subject of much current investigation. Given time the problem of causes and attribution of the events of 2004-2005 will be discussed and argued in the refereed scientific literature. Prior to this happening it is not possible to make any authoritative comment (WMO/CAS, 2006).

Disaster losses related to tropical cyclones are discussed in some detail below. However, it seems reasonable to conclude that, at the present time, while detection of trends in tropical cyclone behavior may yet achieve a scientific consensus, attribution of such trends to human causes remains to be settled in the scientific literature. This area of science is undergoing rapid change as new research results are published, so it may be that detection and attribution will soon be unambiguously achieved. But until that occurs claims of definitive detection and attribution are premature, and thus so too would be any definitive link between trends in damage and human effects on tropical cyclones. In any case, this issue is largely moot as will be shown below, there are no long term trends in damages related to tropical cyclones – in the U.S., Caribbean, or India.

Floods

The IPCC did find "a widespread increase in heavy and extreme precipitation events in regions where total precipitation has increased, e.g., the mid- and high latitudes of the Northern Hemisphere". (IPCC, 2001) But, at the same time, the IPCC warned that "an increase (or decrease) in heavy precipitation events may not necessarily translate into annual peak

(or low) river levels". Indeed, while the IPCC found some changes in streamflow, it did not identify changes in streamflow extremes (i.e., floods), and concluded on a regional basis that, "Even if a trend is identified, it may be difficult to attribute it to global warming because of other changes that are continuing in a catchment."

Since the IPCC was published it does not appear that uncertainties have been resolved one way or another. For example, a recent (2005) study by the International Ad Hoc Detection and Attribution Group, published in the Journal of Climate, was unable to detect a greenhouse gas signal in global precipitation (International Ad Hoc Detection and Attribution Group, 2005). And research on trends in precipitation appears to have mixed results, e.g., with one recent study finding no global trends: "Increased precipitation in some regions is balanced by decreased precipitation in other regions, and the global average change is near zero; " (Smith et al., 2006) Yet another recent study reaches a different conclusion, "Data are often incomplete in spatial and temporal domains and regional analyses are variable and sometimes contradictory; however, the weight of evidence indicates an ongoing intensification of the water cycle." (Huntington, 2006)

But in this case, like that in the case of tropical cyclones, a close look at the damage data does not indicate that climate trends play anything more than a very minor role (if any) in the global increase is disaster losses related to floods.

Some long-term disaster loss records are of suitable quality for research purposes.

We have intensively studied disaster loss data in the United States (Downton et al., 2005; Downton and Pielke, 2005). In particular we have reconstructed the record of flood losses kept by the U.S. National Weather Service and compared the updated loss figures with those collected independently by states. We found very large disagreements on loss totals for small events, but much lower disagreement for losses which totaled more than $500 million. We also found no reason to believe that errors in these estimates of disaster losses contain systematic biases over time. Thus, it is appropriate to conclude:

- Disaster loss data collected by the U.S. NWS is appropriate for seeking to identify climate trends.
- Estimates for large events may contain errors of, on average, 40% when compared to independently collected estimates for the same event.
- However, these errors tend to even out over time and space. There is no reason to believe that a longitudinal bias exists in the errors.
- Extreme caution should be applied when aggregating loss datasets collected in different places for different purposes.
- If loss datasets are combined for purposes of discerning climate trends, we recommend that it is absolutely essential to at the same time study each loss database independently for purposes of quality control and bias, and to conduct analyses of the role of climate trends in the region where the losses occurred.

Long-term records of disaster losses indicate that the overwhelming factors responsible for increasing disaster losses are a result of societal change and development.

<u>Floods</u>

Using the dataset described in the previous section, Figure 4a from our research shows how flood damage has increased dramatically in the United States, but Figure 4b shows that it has stayed almost constant when growing national wealth is considered.

This analysis indicates that the entire trend in losses is removed once one accounts for the growth in wealth. However, there are some indications that increasing precipitation is related to increasing damages. In a 2000 study, using an earlier version of the NWS flood loss dataset, we found a relationship between precipitation trends and damages (Pielke and Downton, 2000). The relationships were strongest when we focused at the regional scale and identified metrics of

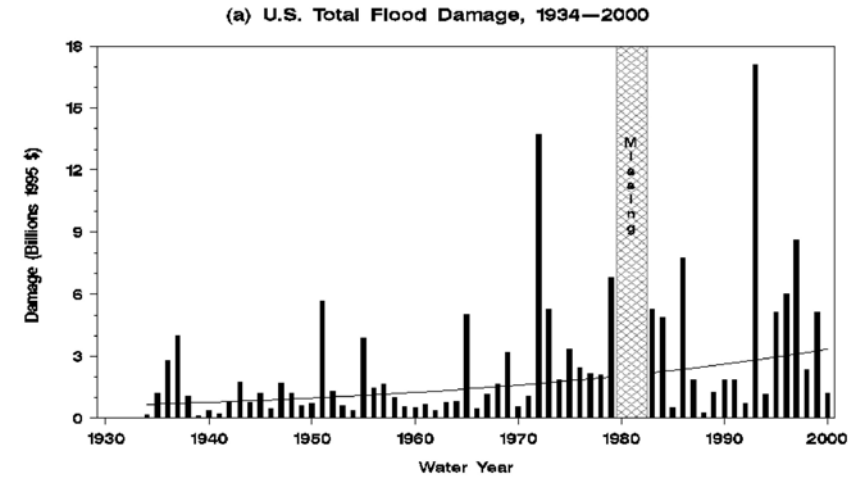


Figure 4a. Trends in U.S. flood damage, 1934-2000, adjusted for inflation. http://www.flooddamagedata.org.

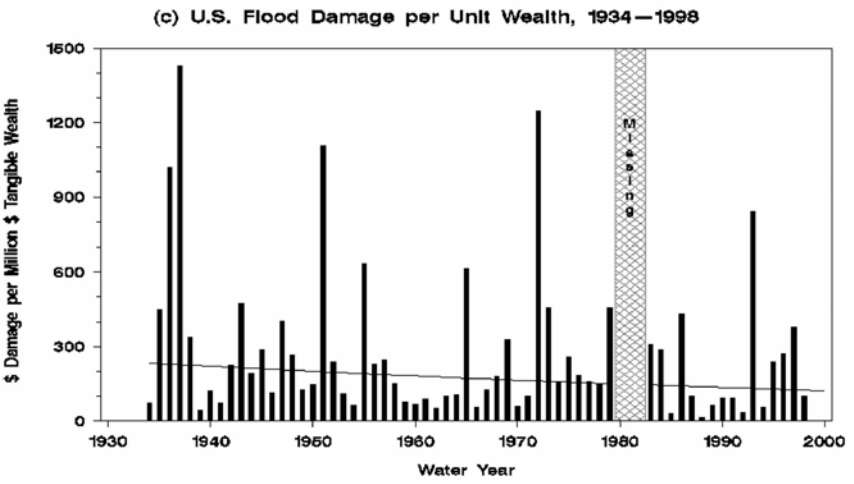


Figure 4b. Trends in U.S. flood damage per unit of wealth, 1934-1998. http://www.flooddamagedata.org.

precipitation most closely related to the regional hydrologic and societal characteristics associated with flood damage. As the scale increases from the regional to the national, the relationship between various metrics of precipitation and damage becomes weaker. I would hypothesize that this relationship would change similarly when one goes from the national to global scale. In any case, the relationship of precipitation trends to damage is dwarfed by the overwhelming influence of societal changes as drivers of increasing flood losses.[2]

Tropical Cyclones

The case of hurricane impacts in the United States is similarly instructive. Consider economic damage (adjusted for inflation) related to hurricane landfalls in the United States, 1900–2005, as shown in Figure 5. Although damage is growing in both frequency and intensity, this trend does not reflect increased frequency or strength of hurricanes. In fact, while hurricane frequencies have varied a great deal over the past 100 + years, they have not increased in recent decades in parallel with increasing damages. To the contrary, although damage increased during the 1970s and 1980s, hurricane activity was considerably lower than in previous decades.

[2] The UK Foresight project on flooding came to similar conclusions, http://www.foresight.gov.uk/Previous_Projects/Flood_and_Coastal_Defence/index.html

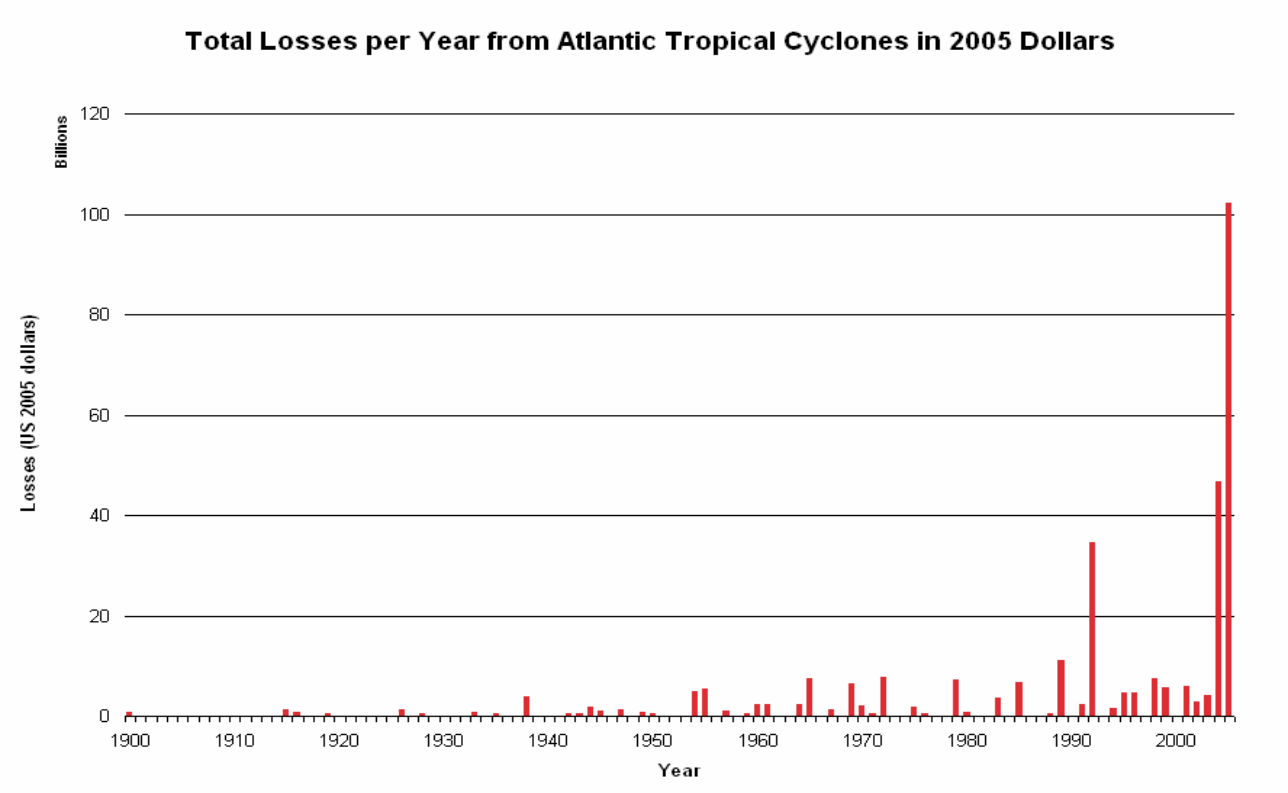


Figure 5. Trend in U.S. hurricane damage, 1900-2005. Source: NOAA/NHC

To explain the increase in damage, it is therefore necessary to consider factors other than variability or change in climate. Society has changed enormously during the past century and coastal development has taken pace at an incredible pace.

Given the significance of societal change in trends of hurricane damage, one way to present a more accurate perspective on such trends is to consider how past storms would affect present society. We developed a methodology for ''normalizing'' past hurricane damage to present day values (using wealth, population, and inflation). (Pielke and Landsea, 1998) Figure 6 shows the historical losses of Figure 5 normalized to 2005 values. The normalized record shows that the impacts of Hurricane Andrew, at close to $53 billion (2005 values) (unpublished analysis by author, updated from Pielke and Landsea, 1998), would have been far surpassed by the Great Miami Hurricane of 1926, which would have caused an estimated $137 billion damage had it occurred in 2005, exceeding similarly accounted costs of Katrina. We can have some confidence that the normalized loss record accounts for societal changes because, unlike the unadjusted data, the adjusted damage data accurately reflect well-understood patterns of climate variability, such as the signal of El Niño and La Niña in hurricane frequencies (Katz, 2002).

Figure 6 shows no longitudinal trend in losses related to tropical cyclones, even with the extreme losses of 2004 and 2005. Kerry Emanuel, who has documented an increase in hurricane intensities in the Atlantic Basin accepts this conclusion. He writes on his website, "There is a huge upward trend in hurricane damage in the U.S., but all or almost all of this is due to increasing coastal population and building in hurricane-prone areas. When this increase in population and wealth is accounted for, there is no discernible trend left in the hurricane damage data." (Emanuel, 2006) A comment that I wrote in response to Emanuel's paper (2005), also published in Nature, provided evidence that indicated that once U.S. hurricane damage was adjusted to reflect societal changes, there was no trend of increasing damages over the twentieth century or an increase in damages per storm (Pielke, 2005).

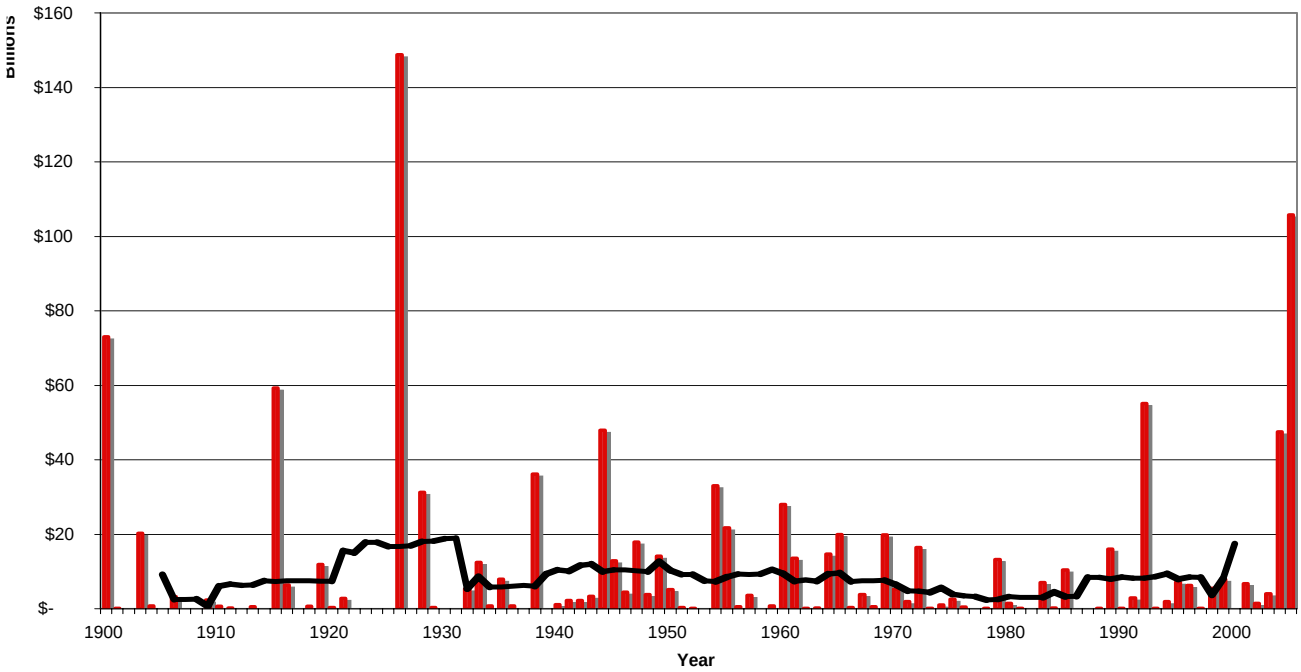


Figure 6. Estimated hurricane damages 1900-2005 if storms of the past made landfall with coastal development of 2005. Source: Roger A. Pielke, Jr., work in progress

Similar conclusions have been reached in studies that looked at Latin America and the Caribbean (Pielke et al., 2003), and well as in an India case study (Raghavan and Rajesh, 2003).

Of course, the case studies discussed above focus only on the United States and do not provide a global perspective. However, a very large portion of the trend in global losses is from the United States, and in particular from hurricane losses. A focus on death or other human impacts would necessarily result in a different focus, perhaps with different conclusions. As an operating hypothesis, the results from the case studies discussed above provide suggest that research in Europe and Asia, in particular, might focus on identifying disaster datasets of suitable quality for such research and efforts to quantitatively disaggregate the role of population growth and wealth in regional trends in disaster losses.

What About the Conclusion of the IPCC 2001 WG II?

One important reason for some confusion among scientists stems from a claim made by the IPCC Working Group II attributing some part of the trend of increasing disaster losses to changes in climate. (IPCC, 2001) However, upon closer look, the claim seems unfounded. The IPCC relied on a report published in 2000 by Munich Re that found that global disasters resulted in $636 billion in losses in the 1990s compared with $315 billion in the 1970s, after adjusting for changes in population and wealth. (Munich Re, 2000) The Munich Re report concludes that disaster costs have increased by a factor of two (i.e., 636/315), independent of societal changes, and the IPCC suggests that climate change is responsible for the difference.

Methodologically, the calculation is suspect for a number of reasons. First, Munich Re provides neither their methods nor data. Second, Munich Re admits that data on changes in wealth are not available around the world and changes in GDP are not always a good proxy for data on wealth. Third, Munich Re's data apparently includes weather and non-weather events (e.g., it appears to also include earthquake damages).

But assuming that all of the issues raised above can be overcome, and in the end there remains a 2-to-1 ratio. The fact is that the large decadal variability in disaster losses makes it quite dodgy to assert a trend by comparing two different ten-year periods over a period of 30 years. This can be illustrated with an example from our database of hurricane losses. If

we adjust the hurricane loss data, accounting for trends in population, wealth, and inflation, to 2005 values and then compare decades (data can be seen in Figure 6), we see some interesting things.

First, the ratio of the 1990s to the 1970s is quite similar to the Munich Re analysis, 2.1 ($87B/$41B). But if we look at other decadal comparisons, the picture looks quite different, the 1990s to the 1940s = 0.8 ($87B/$110B) compared to the 1990s to the 1920s = 0.5 ($87B/$184B). The bottom line is that the 2000 Munich Re analysis, which provided some valuable insights on disasters to be sure, tells us nothing about the attribution of the causes for increasing disasters, yet its results were used by the IPCC to suggest otherwise.

Looking to the future, societal change will continue to be the dominant factor in increasing disaster losses. This conclusion is robust to a wide range of climate change scenarios.

It goes beyond the scope of the present workshop to focus on the future. However, it should be simply noted that societal change will continue, of course, with dramatic implications for continued increases in disaster losses. In this context, identifying the signal of human-caused climate change will require that two conditions be met:

1. Scientific evidence of both the detection and attribution of trends in extreme events (i.e., storms and floods) to human-caused climate change.
2. A signal of such changes evident in the disaster loss record that is significant in the context of societal change, and importantly, in the context of the inherently noisy data of disaster losses.

Until that time occurs, it is premature to suggest that the observed large increase in disaster losses is related to anything other than increasing population at risk possessing ever-greater amounts of wealth at risk of loss. The bottom line is that identifying the signal of human-caused climate change in disaster loss trends will remain difficult for decades to come.

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