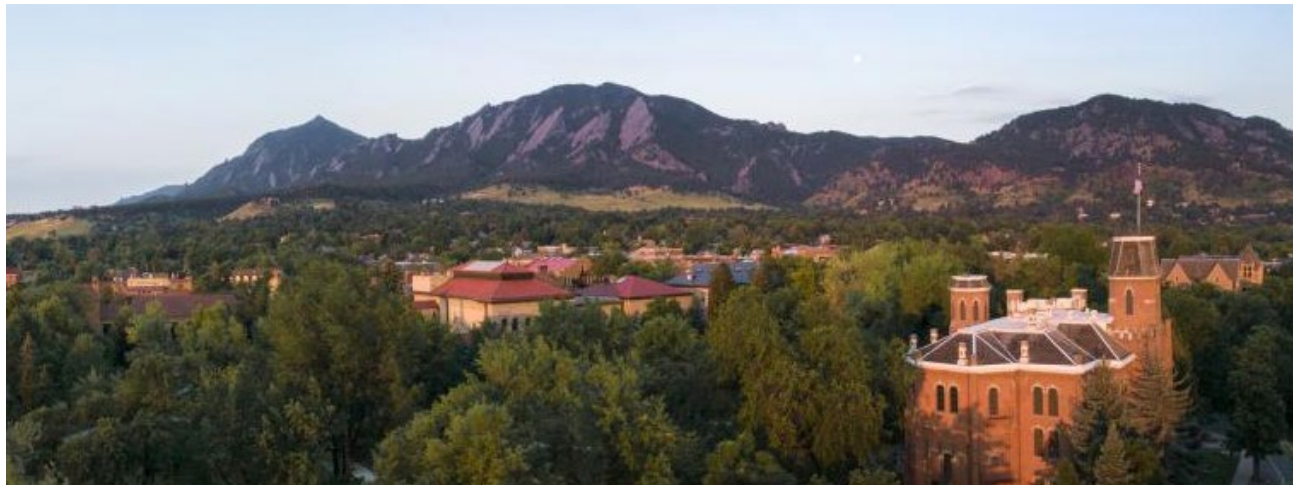
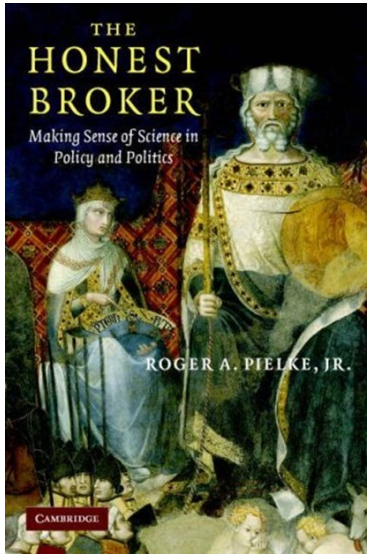
What Climate Science Actually Says About Extreme Weather

Climate Impact Seminar
Cornell Atkinson Seminar Series
Cornell University

Roger Pielke Jr.
12 November 2025



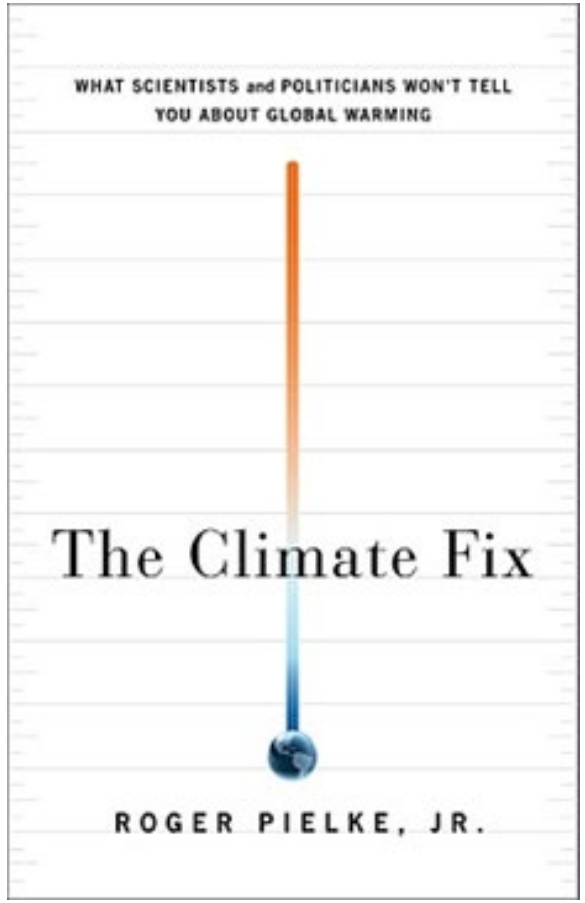
University of Colorado **Boulder**



Background

- I am a Senior Fellow at the American Enterprise Institute (2025-), emeritus professor at the University of Colorado Boulder (2001-) & before that I was a staff scientist at the US National Center for Atmospheric Research (1993-2001)
- I study and write on topics involving contested science, often in highly politicized contexts
- My PhD dissertation (1994) was on how to structure climate science to best support climate policy
- My work was cited in all 3 Working Groups of the recent Intergovernmental Panel on Climate Change AR6 report
- I have published widely on tropical cyclones, floods, wildfire, and other extreme events
- I have testified before the US Congress many times (most recently in September)
- I do my work in public and invite discussion and debate on important issues
- Scientific integrity is always paramount

Before diving in … let's make this clear



Climate change is

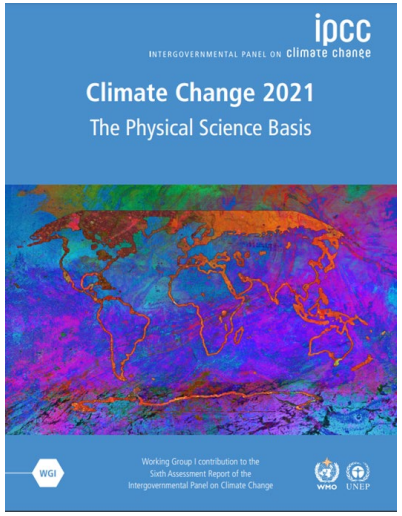
- **Real**
- **Serious**
- **And deserving of serious attention to both mitigation and adaptation policies**

My views

For a deeper dive see the IPCC Working Group I

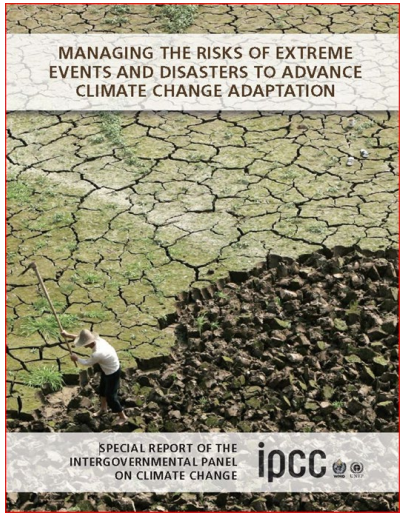
A note on references

- IPCC = Intergovernmental Panel on Climate Change
- IPCC AR5 = 5th assessment report in 2013/14
- IPCC AR6 = 6th assessment report in 2021
- IPCC SREX = Special Report on Extreme Events in 2012
- US NCA = US National Climate Assessment 2017



IPCC AR6

IPCC AR5



IPCC SREX

US NCA

“You are in the Wikileaks release today” – October 2016

Roger Pielke Jr. @RogerPielkeJr · Oct 27

#scicomm

Do peer-reviewed research that is well-ctied, communicated & with impact, we are told.

OK, I did

Then this:

WikiLeaks Exposes Podesta-Steyer Climate McCar...

John Podesta's henchmen orchestrated a hate campaign against a scientist bold enough to tell the truth about climate change.

nationalreview.com

46 30

A well-funded campaign

"I think it's fair say that, without Climate Progress, Pielke would still be writing on climate change for 538"

Email from Center for American Progress editor to billionaire donor Tom Steyer and John Podesta, after getting me fired from Nate Silver's FiveThirtyEight

Daily Camera

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WikiLeaks exposes liberal group's efforts to thwart climate writings of CU's Roger Pielke Jr.

Email from 2014 is part of leak of John Podesta emails

By Sarah Kuta
Staff Writer

POSTED: 10/26/2016 06:19:33 PM MDT | UPDATED: 3 MONTHS AGO

A University of Colorado professor who's been criticized for his writings about climate change has been caught up in WikiLeaks' dump of emails involving John Podesta, campaign chairman for Hillary Clinton.

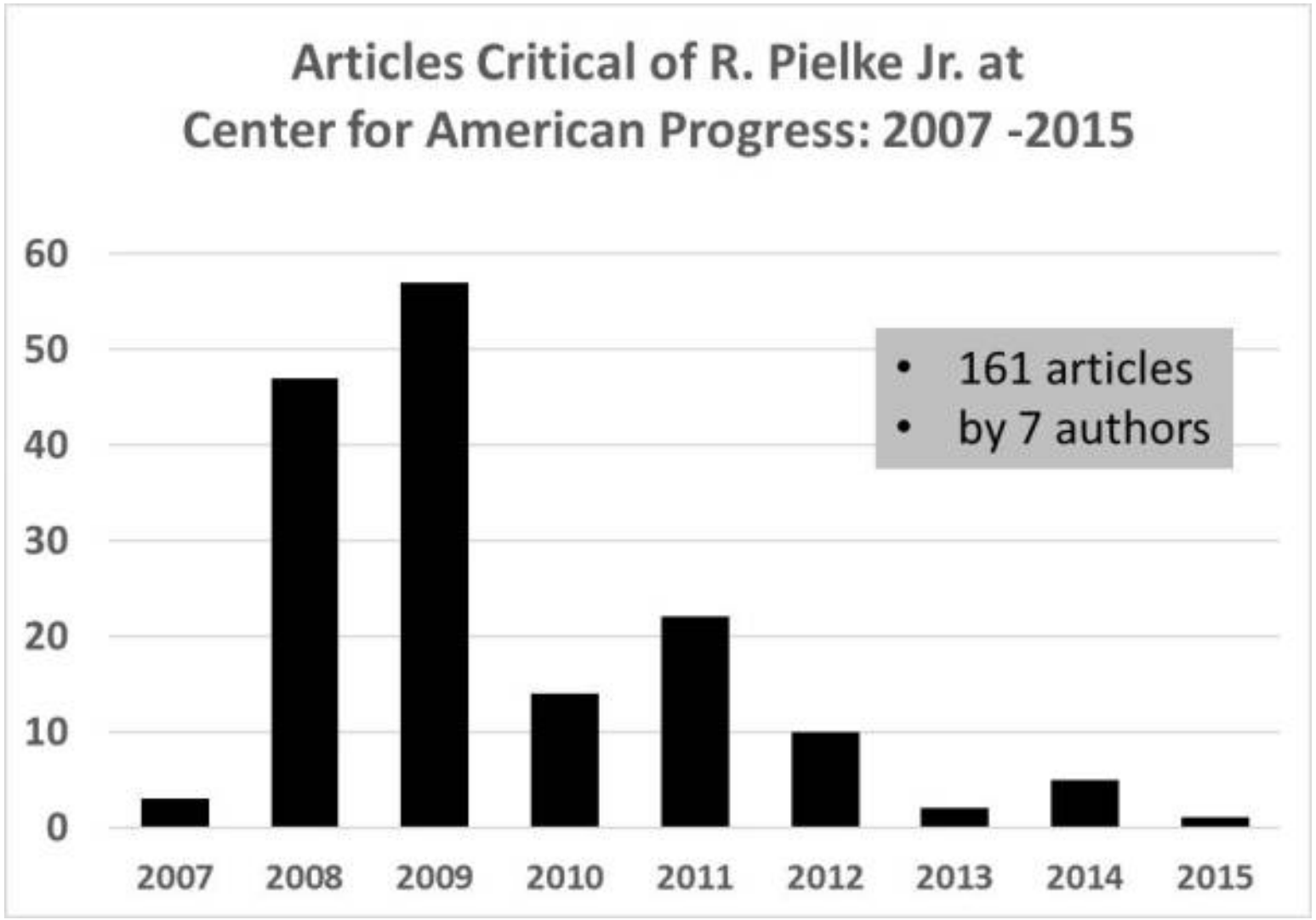
Roger Pielke Jr., who has been a faculty member on the Boulder campus since 2001, was the subject of a July 2014 email about an essay he wrote on climate change for the website FiveThirtyEight.

Pielke writes a regular column about sports governance for the Daily Camera.

The email was sent by Judd Legum, the editor of ThinkProgress, a site that's part of the Center for American Progress Action Fund, the advocacy arm of the liberal think tank Center for American

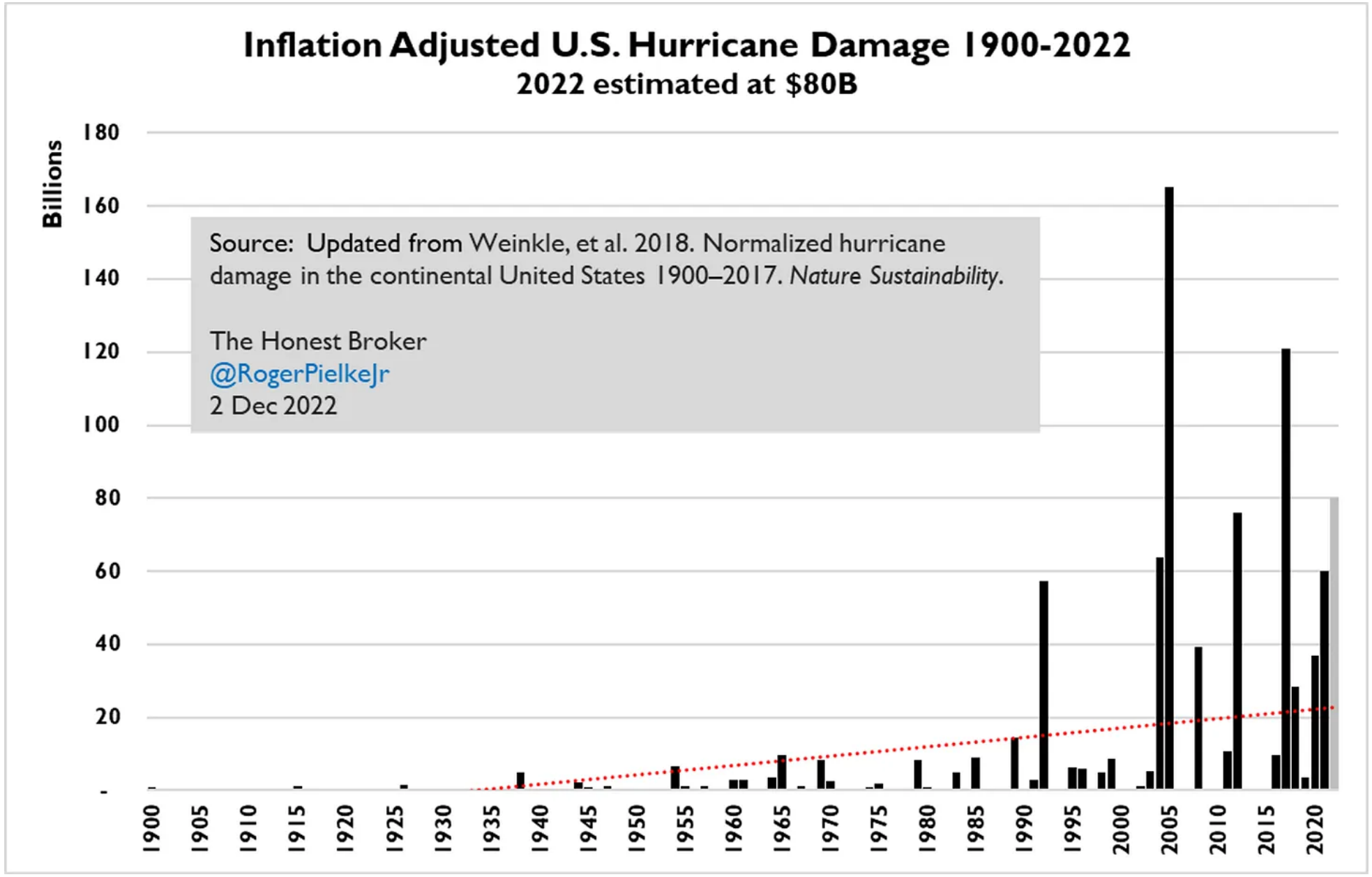
Roger Pielke Jr. (*Courtesy photo*)

Wikileaks revealed the inner workings of a campaign against me and my work that I was already aware of . . .



Let's Go Back to the Start … ~1995

Chris Landsea, left, on board a NOAA Hurricane Hunter in the early 2000s. Roger Pielke Jr. at the National Center for Atmospheric Research in the mid-1990s.
(Courtesy of Chris Landsea and Roger Pielke)


Inflation Adjusted U.S. Hurricane Damage 1900-2022
2022 estimated at $80B
Billions
180
160
140
120
100
80
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40
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-
Source: Updated from Weinkle, et al. 2018. Normalized hurricane damage in the continental United States 1900–2017. Nature Sustainability.
The Honest Broker
@RogerPielkeJr
2 Dec 2022
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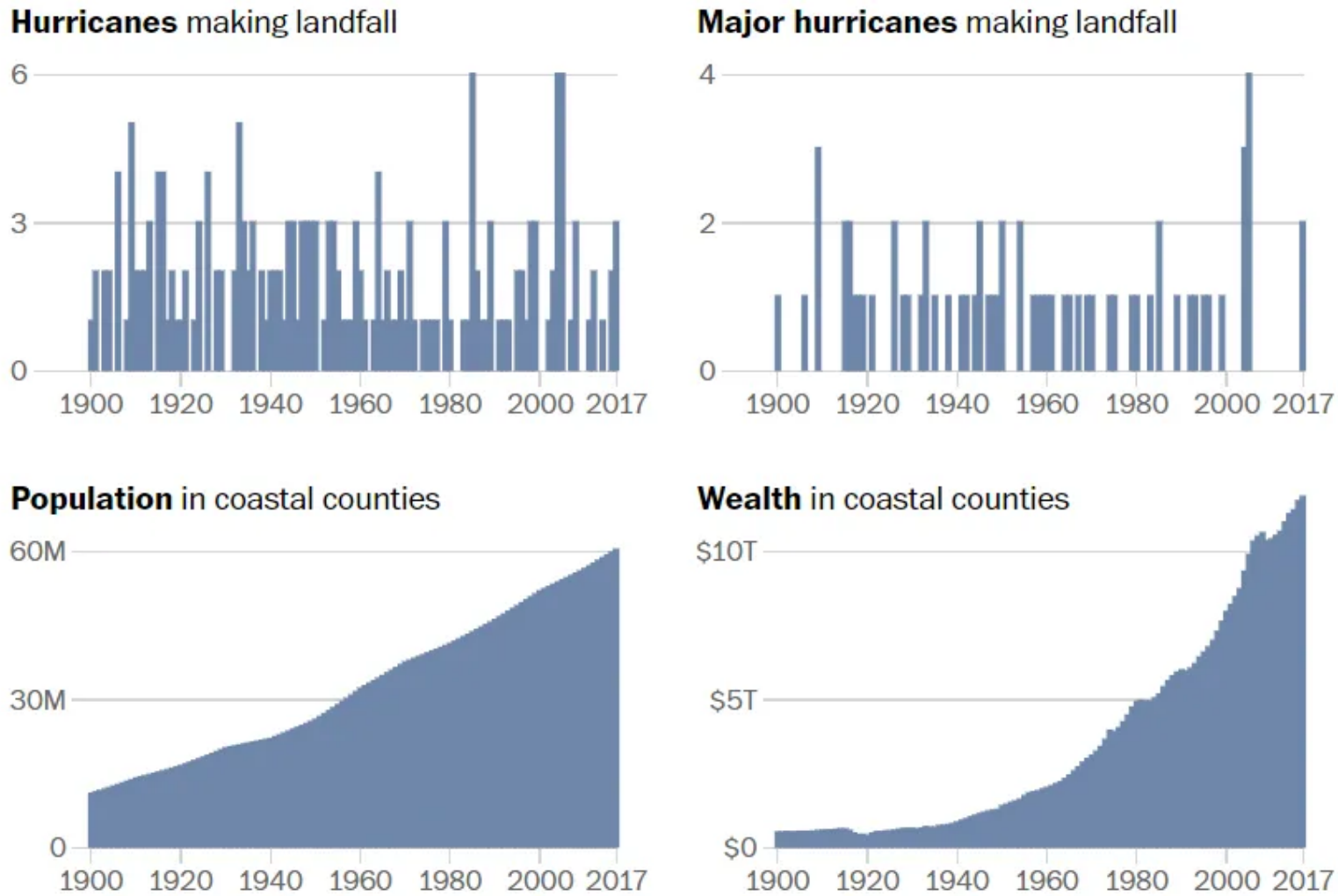
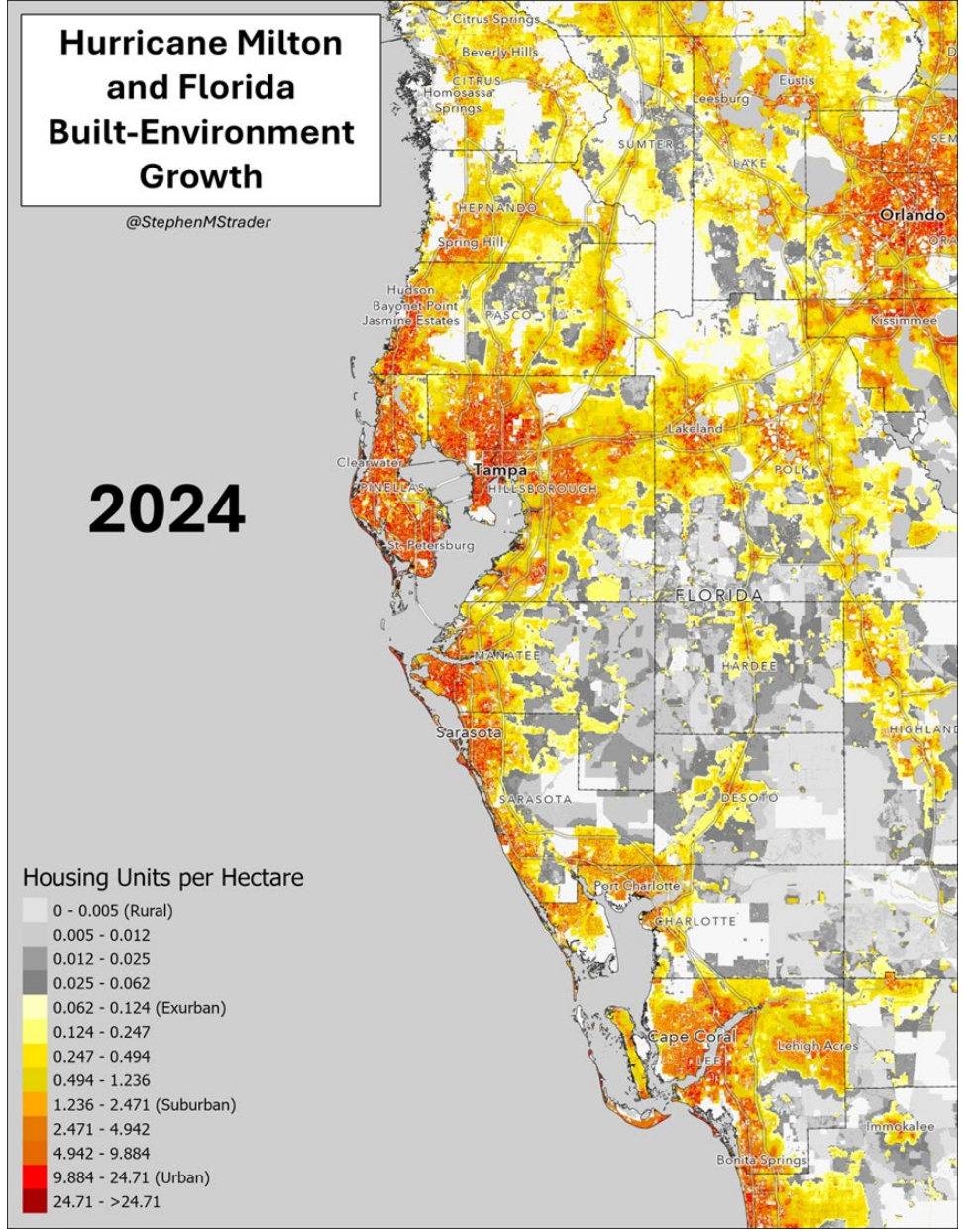
Factors influencing U.S. hurricane damage, 1900-2017



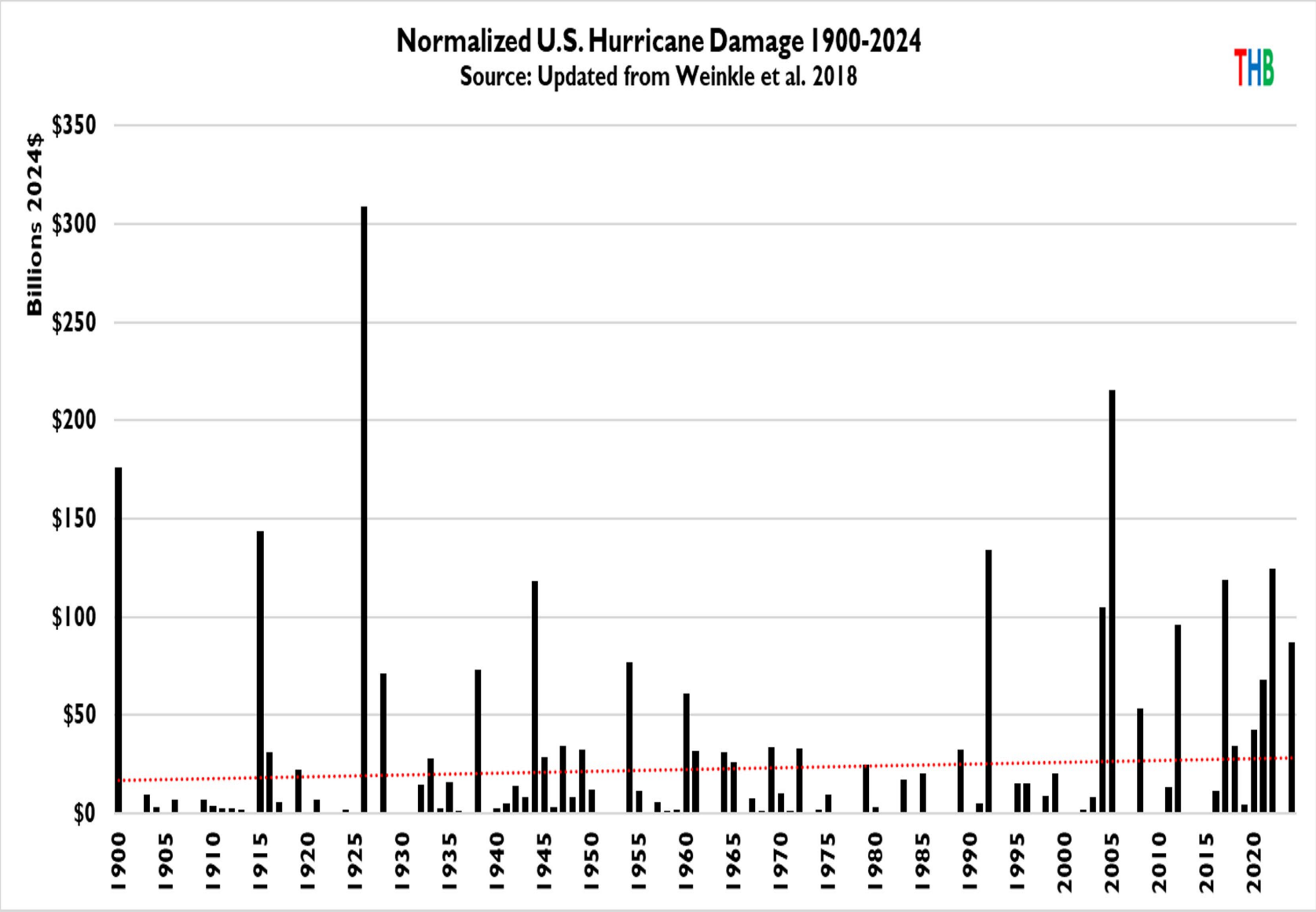
Source: Weinkle et. al. 2018, U.S. Census Bureau, Andrew J. Van Leuven and NOAA. Major hurricanes are defined as Category 3 or higher. Wealth is in 2018 dollars.



Images via Prof. Stephen M. Strader
Villanova University
https://x.com/StephenMStrader/status/1843282282037358628

@StephenStrader


1926
2022
Miami Beach
Wendler Collection
Wikipedia



nature sustainability
ANALYSIS
https://doi.org/10.1038/s41893-018-0165-2

Normalized hurricane damage in the continental United States 1900–2017

Jessica Weinkle[1], Chris Landsea[2], Douglas Collins[3], Rade Musulin[4], Ryan P. Crompton[5], Philip J. Klotzbach[6] and Roger Pielke Jr[7]*

Direct economic losses result when a hurricane encounters an exposed, vulnerable society. A normalization estimates direct economic losses from a historical extreme event if that same event was to occur under contemporary societal conditions. Under the global indicator framework of United Nations Sustainable Development Goals, the reduction of direct economic losses as a proportion of total economic activity is identified as a key indicator of progress in the mitigation of disaster impacts. Understanding loss trends in the context of development can therefore aid in assessing sustainable development. This analysis provides a major update to the leading dataset on normalized US hurricane losses in the continental United States from 1900 to 2017. Over this period, 197 hurricanes resulted in 206 landfalls with about US$2 trillion in normalized (2018) damage, or just under US$17 billion annually. Consistent with observed trends in the frequency and intensity of hurricane landfalls along the continental United States since 1900, the updated normalized loss estimates also show no trend. A more detailed comparison of trends in hurricanes and normalized losses over various periods in the twentieth century to 2017 demonstrates a very high degree of consistency.

Landfalling hurricanes in the continental United States (CONUS) are responsible for more than two-thirds of total global catastrophe losses since 1980, according to data from Munich Re, a global reinsurance company, which are consistent with the academic literature on disaster loss trends and the assessments of the Intergovernmental Panel on Climate Change (IPCC)[1]. The management of economic risks associated with hurricanes largely relies on 'catastrophe models', which estimate losses from modelled storms in the context of contemporary data on exposure and vulnerability[2,3]. As a complement to such model-based approaches, an empirical approach to hurricane loss estimation called normalization was first published in 1998, and then updated and extended in 2008[4,5]. A normalization estimates direct economic losses (damage) from an historical extreme event were it to occur under contemporary societal conditions. Normalization methodologies are widely employed for tropical cyclones, floods, tornadoes, fires, earthquakes and other phenomena in locations around the world[3].

The United Nations global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development have identified direct economic losses from disasters in the context of economic growth as a key indicator[6]. With respect to weather disasters, according to the IPCC, disentangling the relative roles of variability and changes in climate from changes in vulnerability and exposure could contribute information useful to sustainable development[1]. Future changes in the climatology of tropical cyclones (called hurricanes in the North Atlantic) are highly uncertain[7]. However, research is robust in concluding that, for many decades into the future, the primary driver behind increasing economic losses related to hurricanes is expected to be societal growth[8,9].

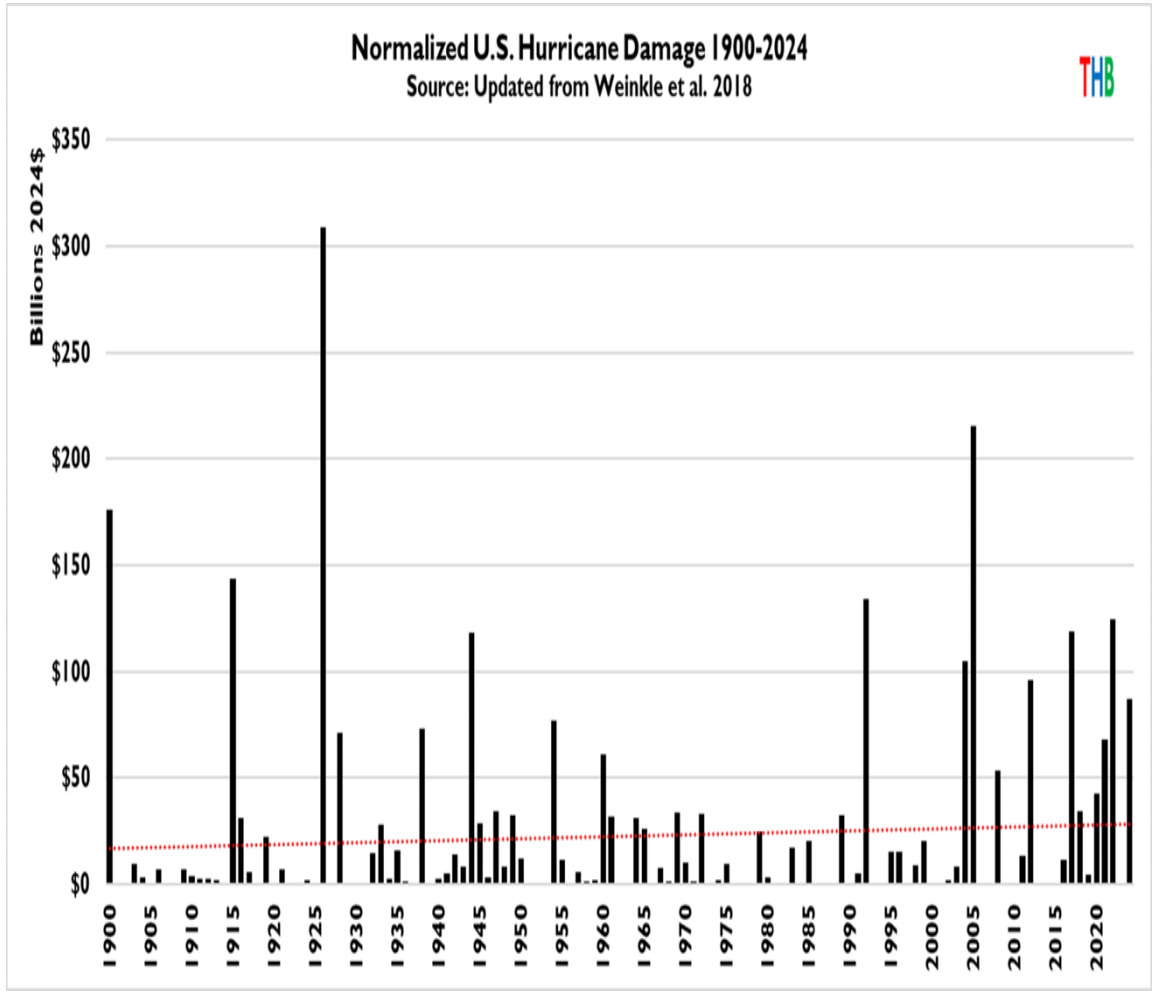
In this analysis we provide a comprehensive update of the leading dataset on normalized CONUS hurricane losses for the period 1900–2017. Earlier versions of this dataset (1925–1995[4] and 1900–2005[5]) have been widely used in insurance and reinsurance industry analyses[10], as well as in subsequent research and in policy settings. Our analysis provides a substantial advance on this earlier work. Specifically, we (1) extend the dataset by 12 years, through the 2017 Atlantic hurricane season, (2) introduce loss estimates for dozens of historical storms of the early twentieth century that previously lacked damage estimates (and thus did not appear in earlier datasets), (3) address methodological discontinuities newly introduced in US government hurricane loss records and (4) perform updated consistency checks of normalization results with independent data on the long-term climatology of landfalling CONUS hurricanes.

Results

Figure 1 shows normalized hurricane damage in the period 1900–2017 for the Pielke Landsea 2018 (PL18) and Collins Lowe 2018 (CL18) methodologies. Total normalized losses over the 118-year study period are about US$2 trillion under either method or an average of US$16.7 billion per year. The figure also shows a trailing 11-year average, indicating that losses on a decadal scale were larger in the earlier part of the twentieth century, lower in the 1970s and 1980s, and then higher again in the first decades of the twenty-first century. Over the entire dataset there is no significant trend in normalized losses, CONUS hurricane landfalls or CONUS intense hurricane landfalls (discussed in greater detail in the Supplementary Information).

The greatest annual normalized damage occurred in 1926 (US$244 billion, PL18), exceeding the next greatest loss year (2005) by about US$74 billion. Most of the 1926 estimate comes from the Great Miami Hurricane of 1926, estimated to have caused damage of US$105 million in 1926 US dollars (US$76 million in Florida and US$29 million on its second landfall in Mississippi). The hurricane devastated Miami, bringing the 1920s Florida land boom to a close and initiating an early onset of the Great Depression in this region[11].

[1]University of North Carolina Wilmington, Wilmington, NC, USA. [2]National Oceanic and Atmospheric Administration, Miami, FL, USA. [3]Climate Index Working Group Chair, Casualty Actuarial Society, Harpswell, ME, USA. [4]FB Alliance Insurance, Schaumburg, IL, USA. [5]Risk Frontiers, St Leonards, NSW, Australia. [6]Colorado State University, Fort Collins, CO, USA. [7]University of Colorado Boulder, Boulder, CO, USA. *e-mail: pielke@colorado.edu


Normalized U.S. Hurricane Damage 1900-2024
Source: Updated from Weinkle et al. 2018
THB
Billions 2024$
$350
$300
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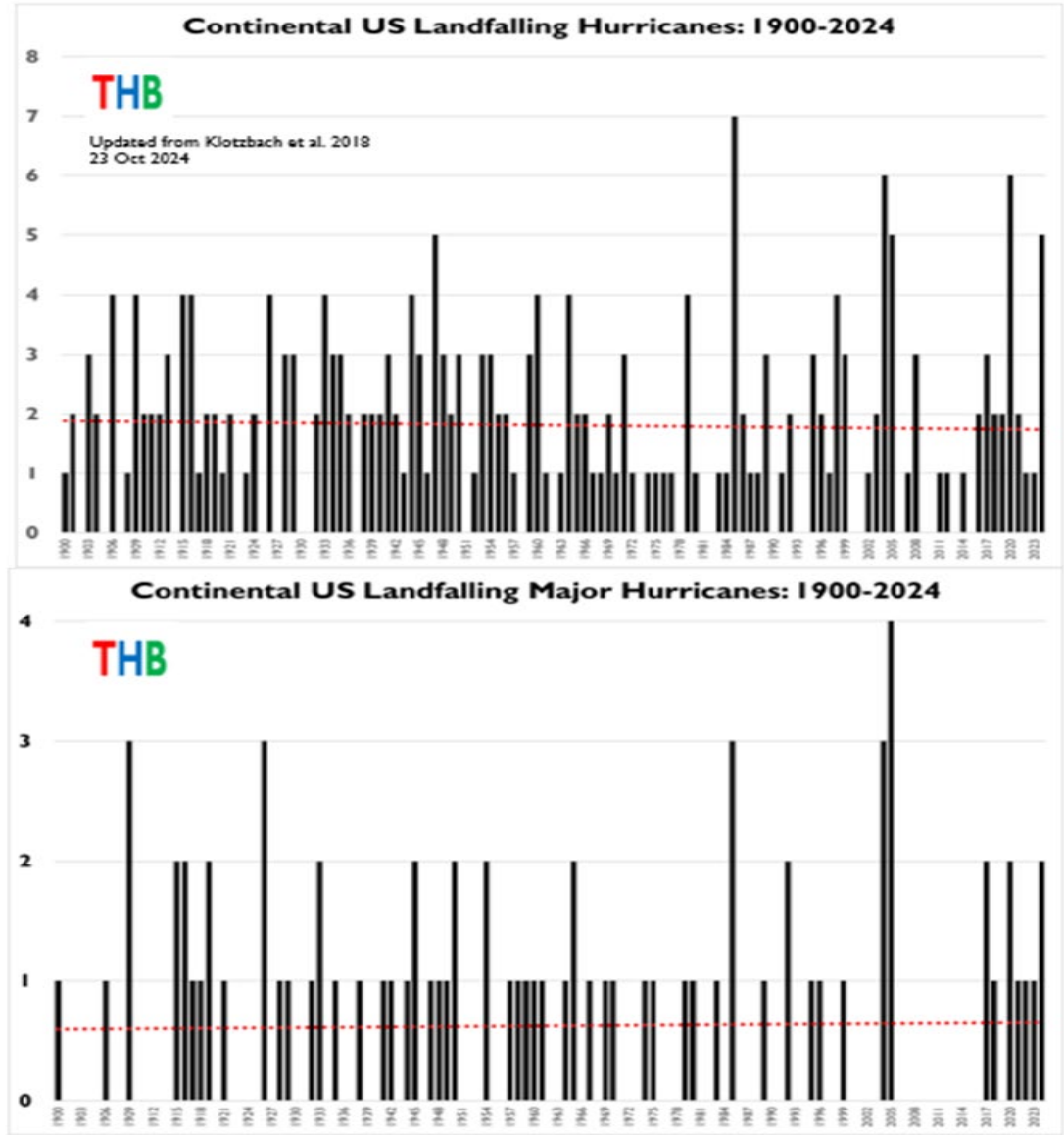
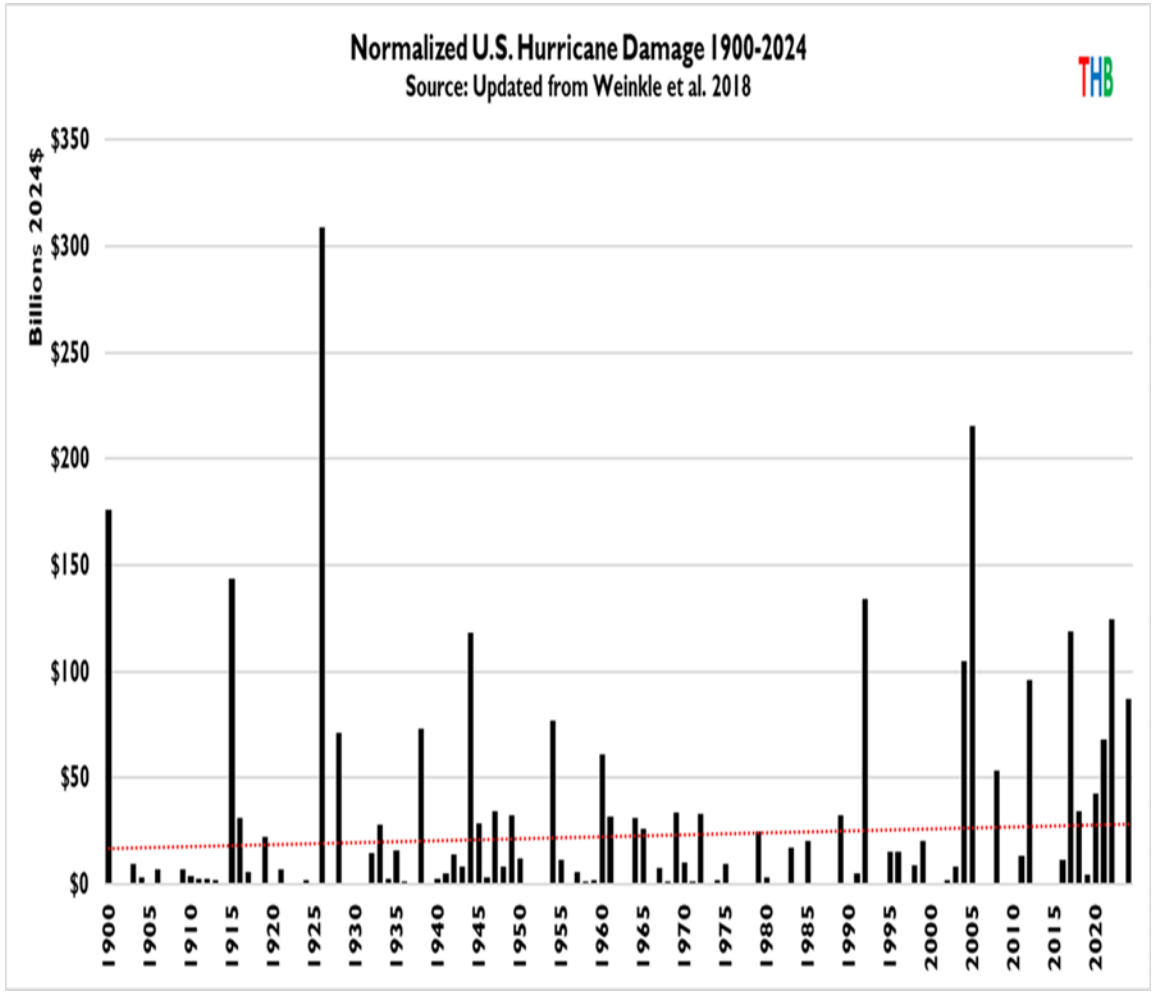
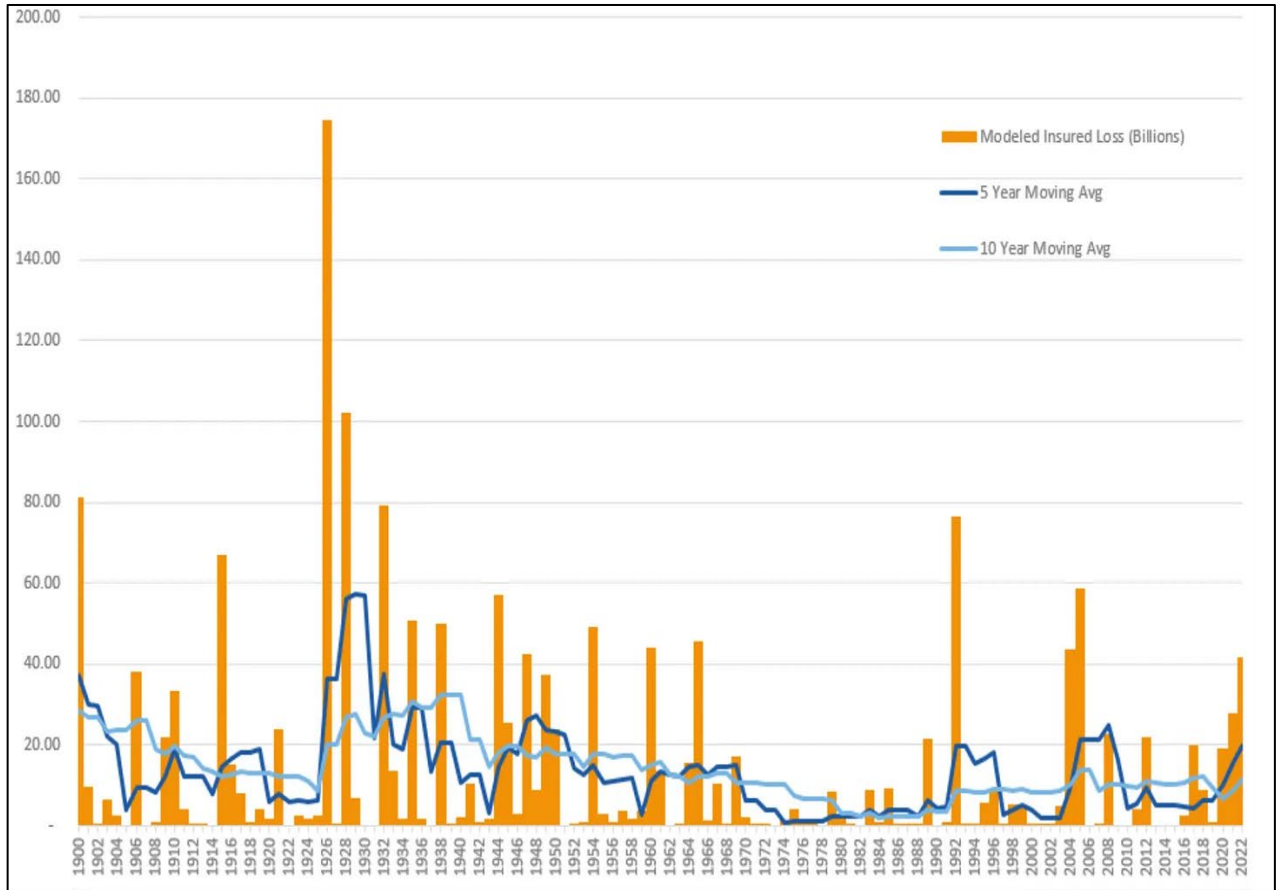

Continental US Landfalling Hurricanes: 1900-2024
THB
Updated from Klotzbach et al. 2018
23 Oct 2024
Continental US Landfalling Major Hurricanes: 1900-2024
THB





The plot above is a catastrophe-modeled loss of historical storms since 1900. This represents what the losses would be today. As one can see, 2022 with 40B dollar loss on part with several 40B+ dollar losses between the 1920s - 1960' of which many of the storms were Northeast impacting storms. The 5 years and 10-year moving averages have also been plotted, and it should be noted the Average Annual Loss is around 17B dollars.

https://www.bmsgroup.com/news/bmstropicalupdate12012022

The Apex of my Career – March 15, 2006

The National Academies of
SCIENCES • ENGINEERING • MEDICINE

ROGER REVELLE LECTURE SERIES
PRESENTED BY THE OCEAN STUDIES BOARD

2006–Roger Pielke, Jr.

Roger Pielke, Jr. is a professor in the Environmental Studies Program and a fellow of the Cooperative Institute for Research in the Environmental Sciences (CIRES) at the University of Colorado. At CIRES, Dr. Pielke directed the Center for Science and Technology Policy Research from 2001-2007. From 1993-2001 he was a scientist at the Environmental and Societal Impacts Group at the National Center for Atmospheric Research in Boulder, Colorado, where he studied societal responses to extreme weather events, policy responses to climate change, and U.S. science policy. Dr. Pielke's research focuses on the relation of scientific information and public and private sector decision-making. His current areas of interest include the politicization of science, decision making under uncertainty, and policy education for scientists. Dr. Pielke chaired the American Meteorological Society's Committee on Societal Impacts 1999-2002, and has served on the Science Steering Committee of the World Meteorological Organization's World Weather Research Programme and the Board on Atmospheric Sciences and Climate of the National Research Council, among other advisory committees. Dr. Pielke received his B.A. in mathematics, M.A. in public policy and Ph.D. in political science from the University of Colorado.

Disasters, Death and Destruction: Accounting for Recent Calamities

The recent devastation caused by Hurricane Katrina, the Indian Ocean tsunami, and South Asian earthquake has kept natural disasters at the focus of our attention. The past decades have seen a spectacular series of catastrophes around the world with ever increasing economic losses and horrific loss of life. The recent spate of disasters has created two common perceptions among decision makers and the general public. First, there is a sense that the economic impacts associated with extreme events have increased in recent years. Second, given that a human influence on the climate system has been well established, a perception exists that the recent increase in weather-related disasters like floods and hurricanes is in some way related to changes in climate. These perceptions beg two questions:

- Have loss of life and damages associated with extreme weather events actually increased in recent years?
- What factors account for observed trends in the impacts of weather on society?

WELCOME

In 1999, the Ocean Studies Board (OSB) launched the Roger Revelle Commemorative Lecture to highlight the important links between ocean science and public policy. The series was named in honor of the late Roger Revelle, a leader in the field of oceanography for over 50 years who spearheaded efforts to investigate the mechanisms and consequences of climate change. In recognition of the critical importance of education in linking science and public policy, the OSB has partnered with the National Science Resources Center and the Smithsonian's National Museum of Natural History to bring the Revelle Lecture to a broader audience. The lecture is held annually in conjunction with the OSB meeting in Washington, DC.

About Roger Revelle

SPONSORS

- National Science Foundation (NSF)
- The Office of Naval Research (ONR)
- The U.S. Geological Survey (USGS)
- The National Aeronautics and Space Administration (NASA)
- The National Oceanic and Atmospheric Administration (NOAA)
- The Smithsonian Science Education Center
- The Smithsonian Institution
- The Gordon and Betty Moore Foundation

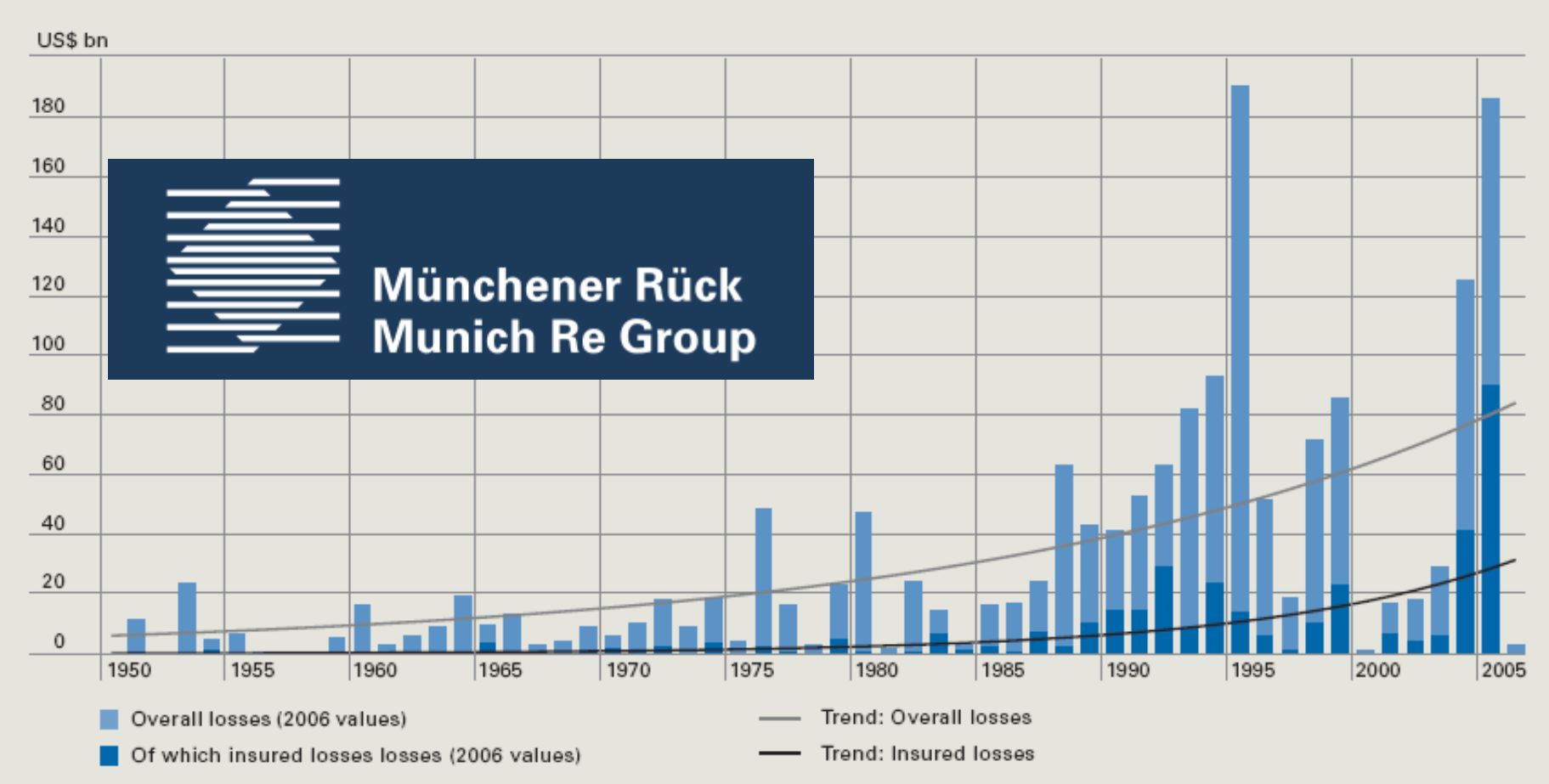
CONTACT INFORMATION

Two months later, May 2006 …

Hohenkammer workshop in May 2006

Münchener Rück
Munich Re Group

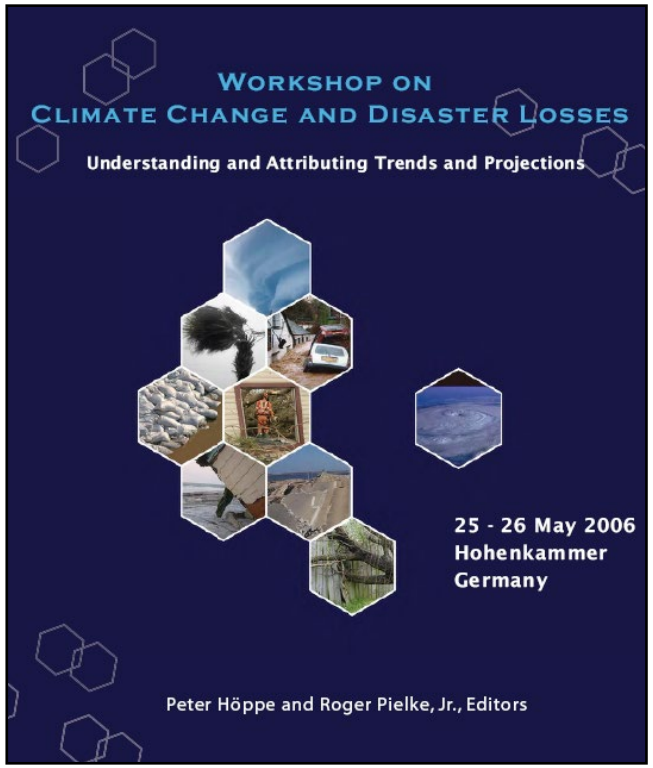
Increasing global losses . . . Why?



Source: Munich Re 2007

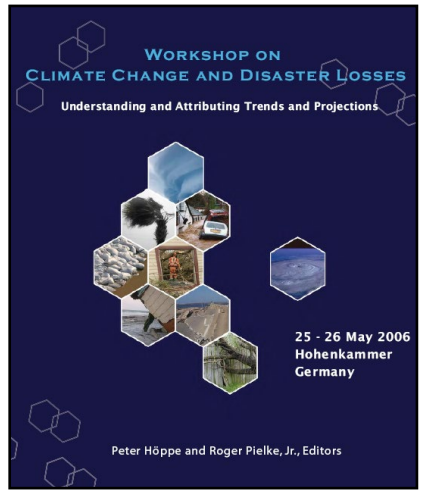
Hohenkammer Workshop May 2006

- Co-sponsors: US NSF, Munich Re, GKSS Institute for Coastal Research, Tyndall Centre for Climate Change Research
- 32 participants from 16 countries
- 24 background "white papers"
- Summary consensus report
- Consistent with IPCC WGI



Münchener Rück
Munich Re Group

Hohenkammer Workshop May 2006



•Analyses of long-term records of disaster losses indicate that societal change and economic development are the principal factors responsible for the documented increasing losses to date.

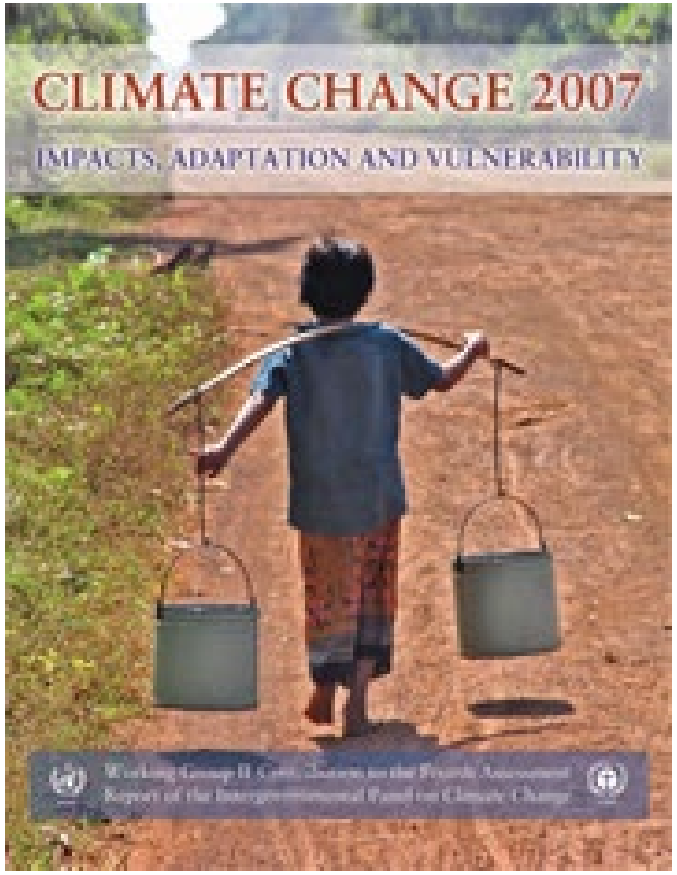
•Because of issues related to data quality, the stochastic nature of extreme event impacts, length of time series, and various societal factors present in the disaster loss record, **it is still not possible to determine the portion of the increase in damages that might be attributed to climate change due to GHG emissions**

•In the near future the quantitative link (attribution) of trends in storm and flood losses to climate changes related to GHG emissions is unlikely to be answered unequivocally.

IPCC 2007: Reliance on "one study"

1.3.8.5 Summary of disasters and hazards

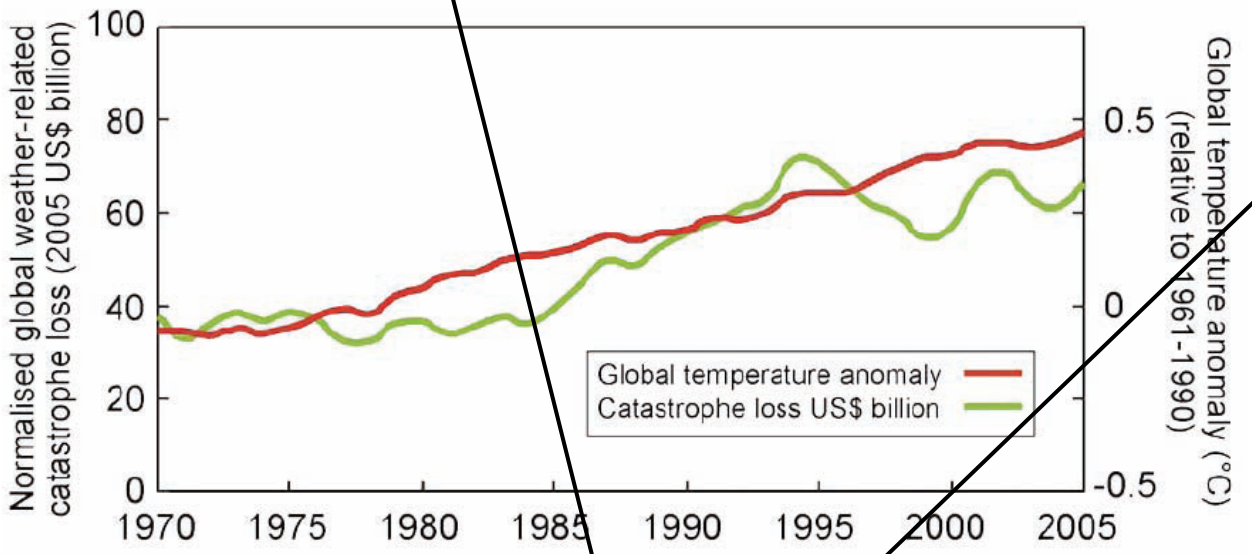
Global losses reveal rapidly rising costs due to extreme weather-related events since the 1970s. One study has found that while the dominant signal remains that of the significant increases in the values of exposure at risk, once losses are normalised for exposure, there still remains an underlying rising trend.



Relies on “one study” -- What is that ”one study”?

(Muir Wood et al., 2006).

1.3.8 Disasters and hazards



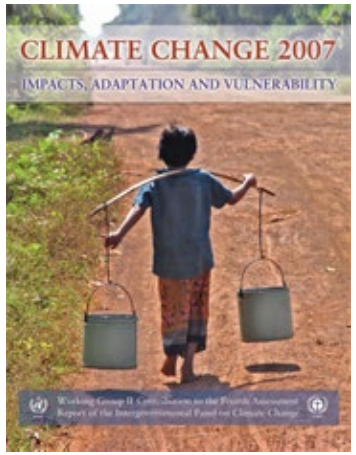


Figure SM-1.1. *An example from the literature of one study analysing rising costs of normalised weather-related catastrophes compared with global temperatures. Data smoothed over ±4 years = 9 years until 2001 (Muir Wood et al., 2006).*

The "one study" was a 2006 workshop paper

Systems in the Hindu Kush-Himalayan Region. ICIMOD, Bhutan, Kathmandu, 227 pp.

Moonen, A.C., L. Ercoli, M. Mariotti and A. Masoni, 2002: Climate change in Italy indicated by agrometeorological indices over 122 years. *Agr. Forest Meteorol.*, **111**, 13-27.

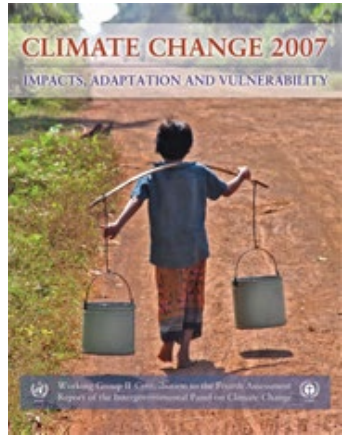
Mueller, D.R., W.F. Vincent and M.O. Jeffries, 2003: Break-up of the largest Arctic ice shelf and associated loss of an epishelf lake. *Geophys. Res. Lett.*, **30**, 2031, doi:10.1029/2003GL017931.

Muir Wood, R., S. Miller and A. Boissonnade, 2006: The search for trends in a global catalogue of normalized weather-related catastrophe losses. *Workshop on Climate Change and Disaster Losses: Understanding and Attributing Trends and Projections*. Hohenkammer, Munich, 188-194.

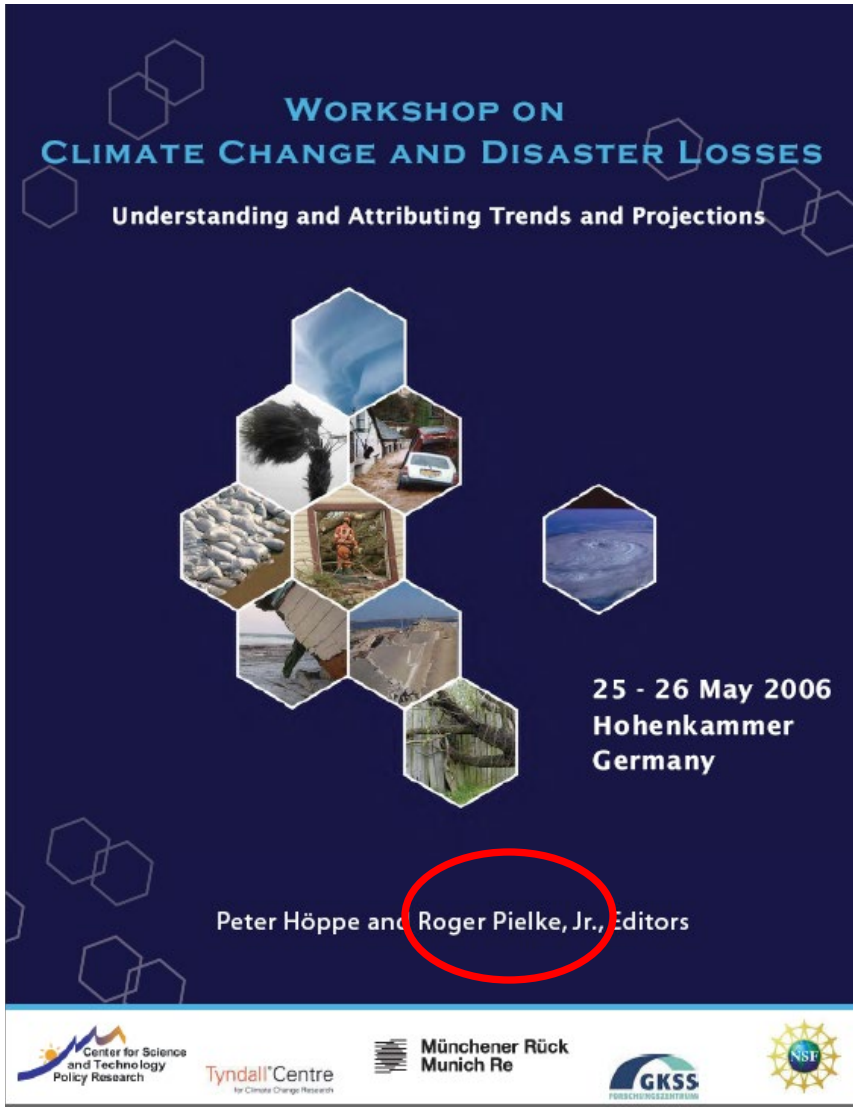
Munich Re Group, 2005: Annual Review: *Natural Catastrophes 2004*. WKD Offsetdruck GmbH, Munich, 60 pp.

Myneni, R.B., C.D. Keeling, C.J. Tucker, G. Asrar and R.R. Nemani, 1997: Increased plant growth in the northern high latitudes from 1981 to 1991. *Nature*, **386**, 698-702.

Nabuurs, G.J., A. Pussinen, T. Karjalainen, M. Erhard and K. Kramer, 2002: Stemwood volume increment changes in European forests due to climate change: a



Hey look! I co-organized that workshop!



Guess what?

•The graph from the IPCC does not appear in Muir-Wood et al. 2006, nor does the underlying data!

•In February 2010 during a public debate at the Royal Institution in London, Robert Muir-Wood revealed that he had created the graph, included it in the IPCC and then ***intentionally miscited it*** in order to circumvent the IPCC deadline for inclusion of published material.

•IPCC Lead Author Muir-Wood (and RMS) said that the graph should never have been included in the report

•In 2006 Risk Management Solutions (the company that employs RM-W) predicted that the risk of US hurricane damages had increased by 40%, necessitating much higher insurance and reinsurance premiums ($82 billion according to Sarasota Herald Tribune)

Post-script: What the mis-cited source for the IPCC graph actually said when finally published in 2008 . . .

"We find insufficient evidence to claim a statistical relationship between global temperature increase and normalized catastrophe losses."

Miller et al. 2008
(RM-W was a co-author)

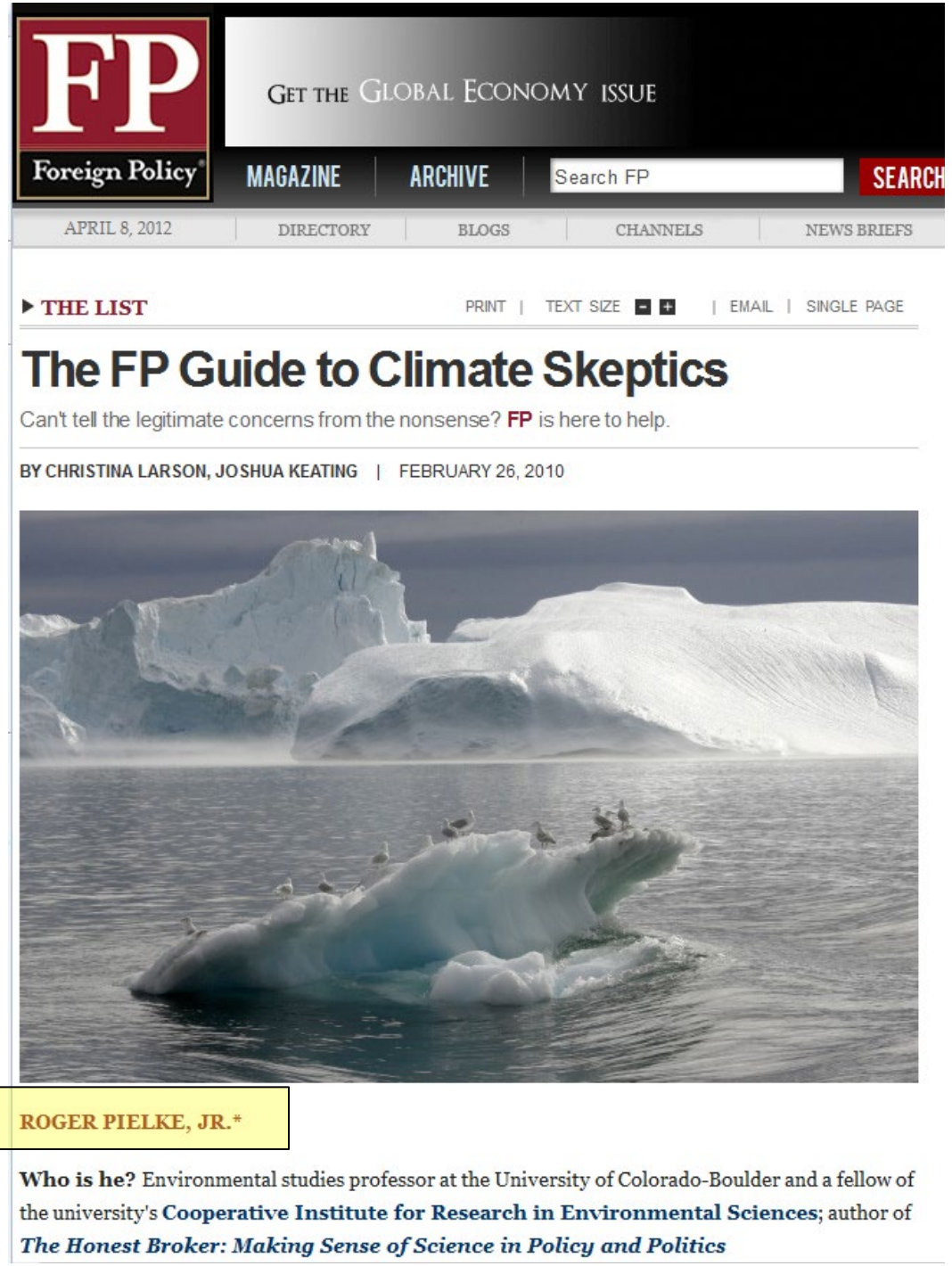
26 February 2010

FROM THE ARTICLE:

"Chief beef: Hurricanes and the bottom line

Telling quote: "We cannot make a causal link between increase in greenhouse gases and the costs of damage associated with hurricanes, floods, and extreme weather phenomena." —interview with FP

. . . For his work questioning certain graphs presented in IPCC reports, Pielke has been accused by some of being a climate change "denier.""



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The FP Guide to Climate Skeptics

Can't tell the legitimate concerns from the nonsense? FP is here to help.

BY CHRISTINA LARSON, JOSHUA KEATING | FEBRUARY 26, 2010

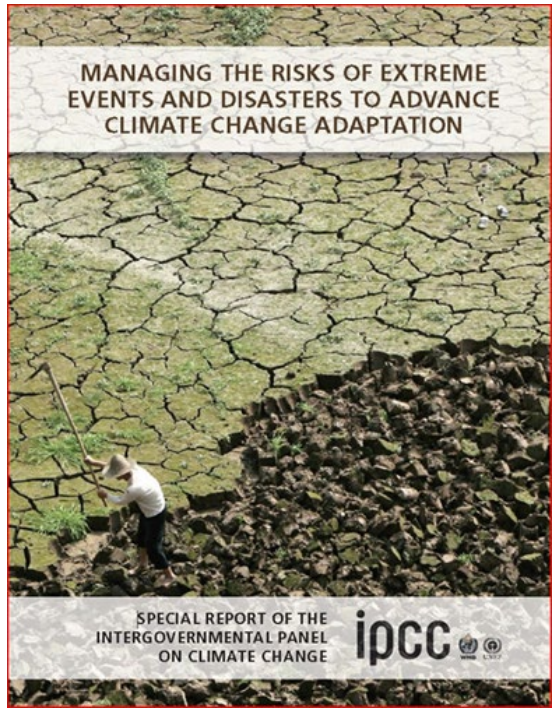
ROGER PIELKE, JR.*

Who is he? Environmental studies professor at the University of Colorado-Boulder and a fellow of the university's **Cooperative Institute for Research in Environmental Sciences**; author of ***The Honest Broker: Making Sense of Science in Policy and Politics***

IPCC 2012 SREX on disaster losses

"Long-term trends in economic disaster losses adjusted for wealth and population increases have not been attributed to climate change, but a role for climate change has not been excluded (medium evidence, high agreement)."

IPCC SREX 2012



My 2013 Senate EPW testimony

YouTube

pielke jr senate testimony

423K views 12 years ago

Story: http://wp.me/p2FjTj-2CU ...more

Feb 2014 John Holdren , President Obama's science advisor Testifies Before the Same Committee

Not long after, I was under investigation by Congress

The New York Times

SCIENCE

Lawmakers Seek Information on Funding for Climate Change Critics

By JOHN SCHWARTZ FEB. 25, 2015

Democratic lawmakers in Washington are demanding information about funding for scientists who publicly dispute widely held views on the causes and risks of climate change.

Prominent members of the United States House of Representatives and the Senate have sent letters to universities, companies and trade groups asking for information about funding to the scientists.

The letters came after evidence emerged over the weekend that Wei-Hock Soon, known as Willie, a scientist at the Harvard-Smithsonian Center for Astrophysics, had failed to disclose the industry funding for his academic work. The documents also included correspondence between Dr. Soon and the companies who funded his work in which he referred to his papers and testimony as "deliverables."

In letters sent to seven universities on Tuesday, Representative Raúl M. Grijalva, an Arizona Democrat who is the ranking member of the House committee on natural resources, sent detailed requests to the academic

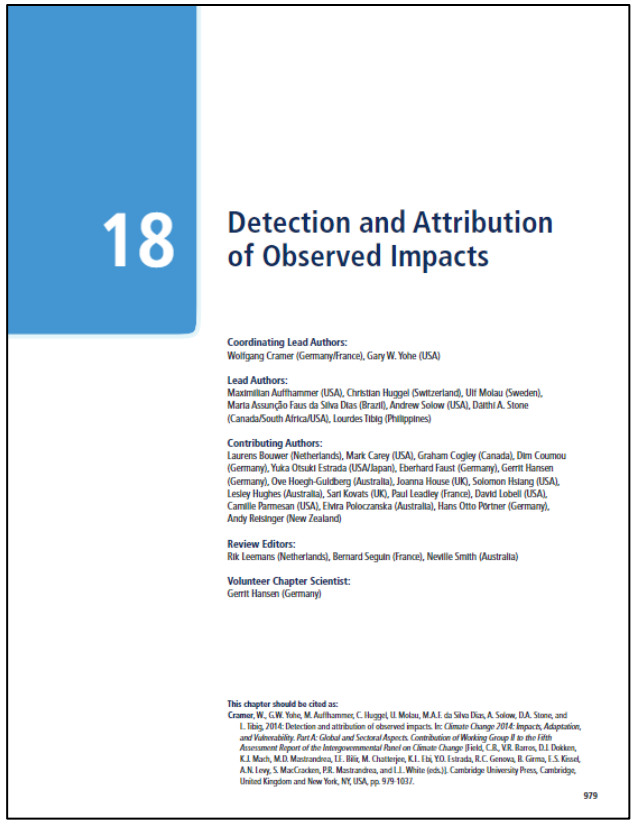
Of course, both parties play politics with the weather

My initial motivation for writing the short book: Listening to Pres Obama's June 29, 2013 Radio Address

"[W]hile we know no single weather event is caused solely by climate change, we also know that in a world that's getting warmer than it used to be, all weather events are affected by it – more extreme droughts, floods, wildfires, and hurricanes. . .

And Americans across the country are already paying the price of inaction in higher food costs, insurance premiums, and the tab for rebuilding."

Extremes:
The Perspective from 2025



18

Detection and Attribution of Observed Impacts

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ipcc
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

"**Detection** of change is defined as the process of demonstrating that climate or a system affected by climate has changed in some defined statistical sense, without providing a reason for that change. An identified change is detected in observations if its likelihood of occurrence by chance due to internal variability alone is determined to be small, for example, <10%."

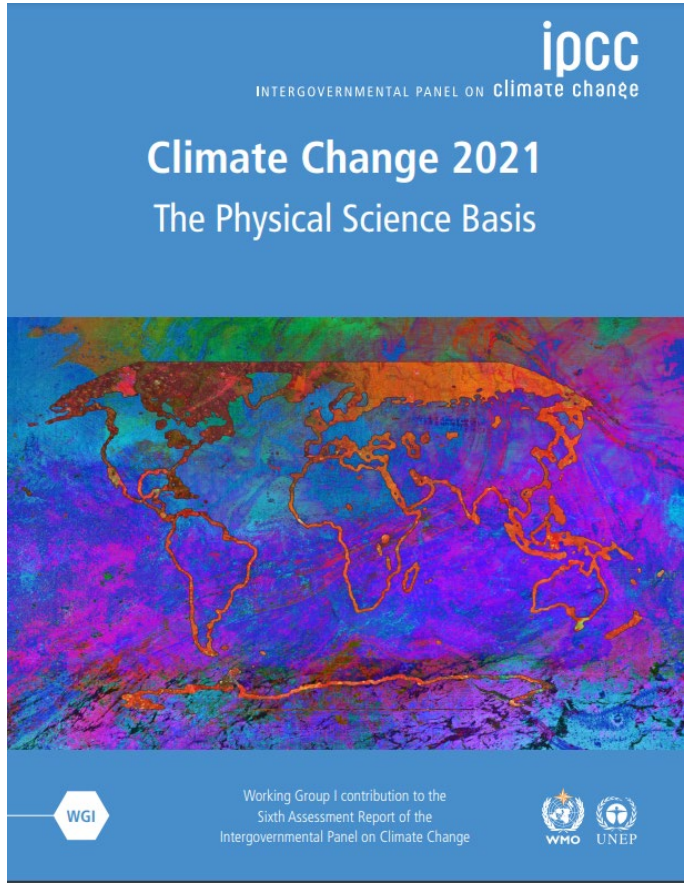
"**Attribution** is defined as the process of evaluating the relative contributions of multiple causal factors to a change or event with an assessment of confidence."

Source: IPCC Glossary

Disaster: "A 'serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts' (UNGA, 2016)."

Climate extreme (extreme weather or climate event) "The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classified as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., high temperature, drought, or heavy rainfall over a season). For simplicity, both extreme weather events and extreme climate events are referred to collectively as climate extremes."

Summary of IPCC 2021 AR6 WG1 on Extremes



	Detection	Attribution
heat waves	yes	yes
heavy precipitation	yes	yes
flooding	no	no
meteorological drought	no	no
hydrological drought	no	no
ecological drought	yes	yes
agricultural drought	yes	yes
tropical cyclones	no	no
winter storms	no	no
thunderstorms	no	no
tornadoes	no	no
hail	no	no
lightning	no	no
extreme winds	no	no
fire weather	yes	yes

Heat Waves

- Heat Waves: "It is virtually certain that there has been increases in the intensity and duration of heat waves and in the number of heat wave days at the global scale"

In summary, it is *virtually certain* that there has been an increase in the number of warm days and nights and a decrease in the number of cold days and nights on the global scale since 1950. Both the coldest extremes and hottest extremes display increasing temperatures. It is *very likely* that these changes have also occurred at the regional scale in Europe, Australasia, Asia, and North America. It is *virtually certain* that there has been increases in the intensity and duration of heat waves and in the number of heat wave days at the global scale. These trends *likely* occur in Europe, Asia, and Australia. There is *medium confidence* in similar changes in temperature extremes in Africa and *high confidence* in South America; the lower confidence is due to reduced data availability and fewer studies. Annual minimum temperatures on land have increased about three times more than global surface temperature since the 1960s, with particularly strong warming in the Arctic (*high confidence*).

Screenshots from IPCC AR6 WG1 unless otherwise noted

Heavy Precipitation

- Heavy precipitation: “the frequency and intensity of heavy precipitation have likely increased at the global scale over a majority of land regions with good observational coverage”

In summary, the frequency and intensity of heavy precipitation have *likely* increased at the global scale over a majority of land regions with good observational coverage. Since 1950, the annual maximum amount of precipitation falling in a day or over five consecutive days has *likely* increased over land regions with sufficient observational coverage for assessment, with increases in more regions than there are decreases. Heavy precipitation has *likely* increased on the continental scale over three continents, including North America, Europe, and Asia where observational data are more abundant. There is *very low confidence* about

Heavy Precipitation does not always lead to greater flooding

- The IPCC (in its accompanying FAQ) recognizes that "heavier rainfall does not always lead to greater flooding." This is something that we first argued more than two decades ago (here and here), and it is great to see it explicitly acknowledged in the IPCC report. To make claims about trends in flooding, one should look at trends in flooding and not precipitation. The conflation of the two is a common error.

expected to be greater in the future, contributing to more severe flooding.

However, heavier rainfall does not always lead to greater flooding. This is because flooding also depends upon the type of river basin, the surface landscape, the extent and duration of the rainfall, and how wet the ground is before the rainfall event (FAQ 8.2, Figure 1) Some regions will experience a drying in the soil as the climate warms, particularly in sub-tropical climates, which could make floods from a rainfall event less probable because the ground can potentially soak up more of the rain. On the other hand, less frequent but more intense downpours can lead to dry, hard ground that is less able to soak up heavy rainfall when it does occur, resulting in more runoff into lakes, rivers and hollows. Earlier spring snowmelt combined with more precipitation falling as rain rather than snow can trigger flood events in cold regions. Reduced winter snow cover can, in contrast, decrease the chance of flooding arising from the combination of rainfall and rapid snowmelt. Rapid melting of glaciers and snow in a warming climate is already increasing river flow in some regions, but as the volumes of ice diminish, flows will peak and then decline in the future. Flooding is also affected by changes in the management of the land and river systems. For example, clearing forests for agriculture or building cities can make rain water flow more rapidly into rivers or low lying areas. On the other hand, increased extraction of water from rivers can reduce water levels and the likelihood of flooding.

Flooding

- Flooding (detection): “Confidence about peak flow trends over past decades on the global scale is low, but there are regions experiencing increases, including parts of Asia, southern South America, the northeast USA, northwestern Europe, and the Amazon, and regions experiencing decreases, including parts of the Mediterranean, Australia, Africa, and the southwestern USA.”

> In summary, the seasonality of floods has changed in cold regions where snowmelt dominates the flow regime in response to warming (*high confidence*). *Confidence* about peak flow trends over past decades on the global scale is *low*, but there are regions experiencing increases, including parts of Asia, southern South America, the northeast USA, northwestern Europe, and the Amazon, and regions experiencing decreases, including parts of the Mediterranean, Australia, Africa, and the southwestern USA.

- Flooding (attribution): “there is low confidence in the human influence on the changes in high river flows on the global scale”

> In summary there is *low confidence* in the human influence on the changes in high river flows on the global scale. *Confidence* is in general *low* in attributing changes in the probability or magnitude of flood events to human influence because of a limited number of studies and differences in the results of these studies, and large modelling uncertainties.

Drought

Box 3-3 | The Definition of Drought

IPCC SREX

Though a commonly used term, drought is defined in various ways, and these definitional issues make the analysis of changes in drought characteristics difficult. This explains why assessments of (past or projected) changes in drought can substantially differ between published studies or chosen indices (see Section 3.5.1). Some of these difficulties and their causes are highlighted in this box.

What is Drought or Dryness?

The Glossary defines drought as follows: "A period of abnormally dry weather long enough to cause a serious hydrological imbalance. Drought is a relative term, therefore any discussion in terms of precipitation deficit must refer to the particular precipitation-related activity that is under discussion. For example, shortage of precipitation during the growing season impinges on crop production or ecosystem function in general (due to soil moisture drought, also termed agricultural drought), and during the runoff and percolation season primarily affects water supplies (hydrological drought). Storage changes in soil moisture and groundwater are also affected by increases in actual evapotranspiration in addition to reductions in precipitation. A period with an abnormal precipitation deficit is defined as a meteorological drought. A megadrought is a very lengthy and pervasive drought, lasting much longer than normal, usually a decade or more."

As highlighted in the above definition, drought can be defined from different perspectives, depending on the stakeholders involved. The scientific literature commonly distinguishes *meteorological drought*, which refers to a deficit of precipitation, *soil moisture drought* (often called *agricultural drought*), which refers to a deficit of (mostly root zone) soil moisture, and *hydrological drought*, which refers to negative anomalies in streamflow, lake, and/or groundwater levels (e.g., Heim Jr., 2002). We use here the term 'soil moisture drought' instead of 'agricultural drought,' despite the widespread use of the latter term (e.g., Heim Jr., 2002; Wang, 2005), because soil moisture deficits have several additional effects beside those on agroecosystems, most importantly on other natural or managed ecosystems (including both forests and pastures), on building infrastructure through soil mechanical processes (e.g., Corti et al., 2009), and health through impacts on heat waves (Section 3.1.4). Water scarcity (linked to *socioeconomic drought*), which may be caused fully or in part by use from human activities, does not lie within the scope of this chapter (see Section 4.2.2); however, it should be noted that changing pressure on water resources by human uses may itself influence climate and possibly the drought conditions, for example, via declining groundwater levels, or enhanced local evapotranspiration and associated land-atmosphere feedbacks. Drought should not be confused with aridity, which describes the general characteristic of an arid climate (e.g., desert). Indeed, drought is considered a recurring feature of climate occurring in any region and is defined with respect to the average climate of the given region (e.g., Heim Jr., 2002; Dai, 2011). Nonetheless, the effects of droughts are not linear, given the existence of, for example, discrete soil moisture thresholds affecting vegetation and surface fluxes (e.g., Koster et al., 2004b; Seneviratne et al., 2010), which means that the same precipitation deficit or radiation excess relative to normal will not affect different regions equally (e.g., short-term lack of precipitation in a very humid region may not be critical for agriculture because of the ample soil moisture supply). In this chapter we often use the term 'dryness' instead of 'drought' as a more general term.

Continued next page ...

- Drought. The IPCC has distinguished four types of drought: hydrological, meteorological, ecological and agricultural. That means that simply saying "drought" in the context of the IPCC report is incomplete, and potentially confusing. Here is what the report says about each:
  - Hydrological drought: "There is still limited evidence and thus low confidence in assessing these trends at the scale of single regions, with few exceptions"
  - Meteorological drought: "The regional evidence on attribution for single AR6 regions generally shows low confidence for a human contribution to observed trends in meteorological droughts at regional scale, with few exceptions"
  - Ecological and agricultural drought: "There is medium confidence that human influence has contributed to changes in agricultural and ecological droughts and has led to an increase in the overall affected land area"

[15] Agricultural and ecological drought (depending on the affected biome): a period with abnormal soil moisture deficit, which results from combined shortage of precipitation and excess evapotranspiration, and during the growing season impinges on crop production or ecosystem function in general. Observed changes in meteorological droughts (precipitation deficits) and hydrological droughts (streamflow deficits) are distinct from those in agricultural and ecological droughts and addressed in the underlying AR6 material (Chapter 11).

IPCC AR6 WG1

Tropical Cyclones

- Tropical cyclones: "There is low confidence in most reported long-term (multidecadal to centennial) trends in TC frequency- or intensity-based metrics"

Identifying past trends in TC metrics remains a challenge due to the heterogeneous character of the historical instrumental data, which are known as "best-track" data (Schreck et al., 2014). There is *low confidence* in most reported long-term (multidecadal to centennial) trends in TC frequency- or intensity-based metrics due to changes in the technology used to collect the best-track data. This should not be interpreted as implying that no physical (real) trends exist, but rather as indicating that either the quality or the temporal length of the data is not adequate to provide robust trend detection statements, particularly in the presence of multidecadal variability.

IPCC Glossary

Winter Storms

- Winter storms: "There is low confidence in observed recent changes in the total number of extratropical cyclones over both hemispheres. There is also low confidence in past-century trends in the number and intensity of the strongest extratropical cyclones over the Northern Hemisphere…"

11.7.2.1 Observed trends

Chapter 2 (Section 2.3.1.4.3) concluded that there is overall *low confidence* in recent changes in the total number of ETCs over both hemispheres and that there is *medium confidence* in a poleward shift of the storm tracks over both hemispheres since the 1980s. Overall, there is also *low confidence* in past-century trends in the number and intensity of the strongest ETCs due to the large interannual and decadal variability (Feser et al., 2015; Reboita et al., 2015; Wang et al., 2016; Varino et al., 2018) and due to temporal and spatial heterogeneities in the number and type of assimilated data in reanalyses, particularly before the satellite era (Krueger et al., 2013; Tilinina et al., 2013; Befort et al., 2016; Chang and Yau, 2016; Wang et al., 2016).

Thunderstorms, tornadoes, hail, lightning

- Thunderstorms, tornadoes, hail, lightning: “observational trends in tornadoes, hail, and lightning associated with severe convective storms are not robustly detected due to insufficient coverage of the long-term observations”

In summary, because the definition of severe convective storms varies depending on the literature and the region, it is not straightforward to make a synthesizing view of observed trends in severe convective storms in different regions. In particular, observational trends in tornadoes, hail, and lightning associated with severe convective storms are not robustly detected due to insufficient coverage of the long-term observations. There is *medium confidence* that the mean annual number of tornadoes in the United States has remained relatively constant, but their variability of occurrence has increased since the 1970s, particularly over the 2000s, with a decrease in the number of days per year and an increase in the number of tornadoes on these days (*high confidence*). Detected tornadoes have also increased in Europe, but the trend depends on the density of observations.

Extreme winds (between 60S and 60N)

- Extreme winds (between 60S and 60N): "the observed intensity of extreme winds is becoming less severe in the lower to mid-latitudes, while becoming more severe in higher latitudes poleward of 60 degrees (low confidence)"

In summary, the observed intensity of extreme winds is becoming less severe in the lower to mid-latitudes, while becoming more severe in higher latitudes poleward of 60 degrees (*low confidence*). Projected changes in the frequency and intensity of extreme winds are associated with projected changes in the frequency and intensity of TCs and ETCs (*medium confidence*).

Fire Weather

- Fire weather: "There is medium confidence that weather conditions that promote wildfires (fire weather) have become more probable in southern Europe, northern Eurasia, the US, and Australia over the last century"

In summary, there is *high confidence* that concurrent heat waves and droughts have increased in frequency over the last century at the global scale due to human influence. There is *medium confidence* that weather conditions that promote wildfires (fire weather) have become more probable in southern Europe, northern Eurasia, the US, and Australia over the last century. There is *high confidence* that compound hot and dry conditions become more probable in nearly all land regions as global mean temperature increases. There is *high confidence* that fire weather conditions will become more frequent at higher levels of global warming in some regions.

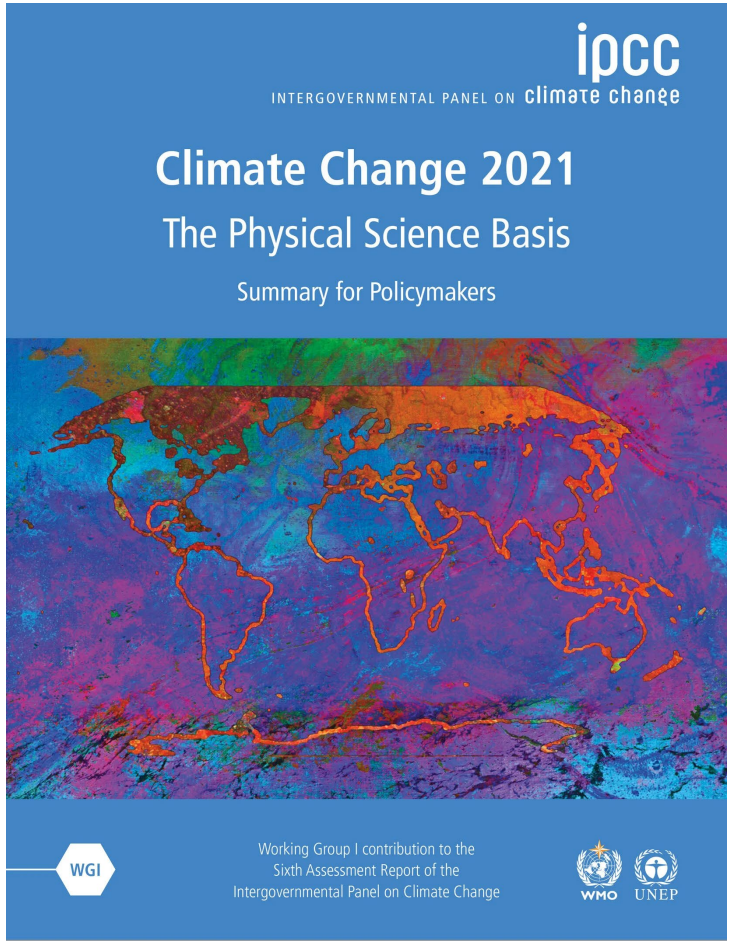


Table 12.12 | Emergence of CIDs in different time periods, as assessed in this section. The colour corresponds to the confidence of the region with the highest confidence: white cells indicate where evidence is lacking or the signal is not present, leading to overall *low confidence* of an emerging signal.

Climatic Impact-driver Type	Climatic Impact-driver Category	Already Emerged in Historical Period	Emerging by 2050 at Least for RCP8.5/SSP5-8.5	Emerging Between 2050 and 2100 for at Least RC8.5/SSP5-8.5
Heat and Cold	Mean air temperature	1		
	Extreme heat	2	3	
	Cold spell	4	5	
	Frost			
Wet and Dry	Mean precipitation		6 / 7	
	River flood			
	Heavy precipitation and pluvial flood			8
	Landslide			
	Aridity			
	Hydrological drought			
	Agricultural and ecological drought			
	Fire weather			
Wind	Mean wind speed			
	Severe wind storm			
	Tropical cyclone			
	Sand and dust storm			
Snow and Ice	Snow, glacier and ice sheet		9	10
	Permafrost			
	Lake, river and sea ice	11		
	Heavy snowfall and ice storm			
	Hail			
	Snow avalanche			
Coastal	Relative sea level		12	
	Coastal flood			
	Coastal erosion			
Open Ocean	Mean ocean temperature			
	Marine heatwave			
	Ocean acidity			
	Ocean salinity	13		
	Dissolved oxygen	14		
Other	Air pollution weather			
	Atmospheric CO_2 at surface			
	Radiation at surface			

1. *High confidence* except over a few regions (CNA and NWS) where there is *low agreement* across observation datasets.
2. *High confidence* in tropical regions where observations allow trend estimation and in most regions in the mid-latitudes, *medium confidence* elsewhere.
3. *High confidence* in all land regions.
4. Emergence in Australia, Africa and most of Northern South America where observations allow trend estimation.
5. Emergence in other regions.
6. Increase in most northern mid-latitudes, Siberia, Arctic regions by mid-century, others later in the century.
7. Decrease in the Mediterranean area, Southern Africa, South-west Australia.
8. Northern Europe, Northern Asia and East Asia under RCP8.5 and not in low-end scenarios.
9. Europe, Eastern and Western North America (snow).
10. Arctic (snow).
11. Arctic sea ice only.
12. Everywhere except WAN under RCP8.5.
13. With varying area fraction depending on basin.
14. Pacific and Southern oceans then many other regions by 2050.

High confidence of decrease | Medium confidence of decrease | Low confidence in direction of change | Medium confidence of increase | High confidence of increase

Signal has already emerged	Signal has **NOT** already emerged	Signal Would Emerge by 2050 under RCP8.5	Signal Would Emerge by 2100 under RCP8.5
mean air temperature	frost		
extreme heat	mean precipitation	mean precipitation	mean precipitation
cold spell	river flood		
permafrost	heavy precipitation and pluvial flood		heavy precipitation and pluvial flood
lake, river, sea ice	landslide aridity		
mean ocean temperature	hydrological drought		
ocean salinity	agricultural and ecological drought		
dissolved oxygen	fire weather		
atmospheric CO2 at surface	mean wind speed		
	sever wind storm		
	tropical cyclone		
	sand and dust storm		
	snow, glacier, and ice sheet	snow, glacier, and ice sheet	snow, glacier, and ice sheet
	heavy snow and ice storm		
	hail		
	snow avalanche		
	relative sea level	relative sea level	relative sea level
	coastal flood		
	coastal erosion		
	marine heatwave		
	ocean acidity	ocean acidity	ocean acidity
	Air pollution weather		
	radiation at surface		

Quality Control in IPCC AR6?

since 1900 is considered to be reliable, and shows no trend in the frequency of U.S. landfall events (Knutson et al., 2019). However, in this period since 1900, an increasing trend in normalized U.S. hurricane damage, which accounts for temporal changes in exposed wealth (Grinsted et al., 2019), and a decreasing trend in TC translation speed over the U.S. (Kossin, 2019) have been identified. A similarly reliable subset of the data

I was of course very happy to see the reference to "normalized" damages in the IPCC, as this methodology and terminology we introduced to the literature in 1998 (Pielke and Landsea 1998) … But …

ENVIRONMENTAL HAZARDS
https://doi.org/10.1080/17477891.2020.1800440

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Economic 'normalisation' of disaster losses 1998–2020: a literature review and assessment

Roger Pielke

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ABSTRACT

Nowadays, following every weather disaster quickly follow estimates of economic loss. Quick blame for those losses, or some part, often is placed on claims of more frequent or intense weather events. However, understanding what role changes in climate may have played in increasing weather-related disaster losses is challenging because, in addition to changes in climate, society also undergoes dramatic change. Increasing development and wealth influence exposure and vulnerability to loss – typically increasing exposure while reducing vulnerability. In recent decades a scientific literature has emerged that seeks to adjust historical economic damage from extreme weather to remove the influences of societal change from economic loss time series to estimate what losses past extreme events would cause under present-day societal conditions. In regions with broad exposure to loss, an unbiased economic normalisation will exhibit trends consistent with corresponding climatological trends in related extreme events, providing an independent check on normalisation results. This paper reviews 54 normalisation studies published 1998–2020 and finds little evidence to support claims that any part of the overall increase in global economic losses documented on climate time scales is attributable to human-caused changes in climate, reinforcing conclusions of recent assessments of the Intergovernmental Panel on Climate Change.

ARTICLE HISTORY
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KEYWORDS
Disasters; normalisation; economics; climate change

Introduction

Disaster normalisation research has been conducted for more than 20 years (Pielke & Landsea, 1998). Such research seeks to adjust historical economic losses from extreme events to a common base year to estimate losses today if extreme events of the past were to occur with contemporary societal exposure and vulnerability. Normalisation is a goal of research achieved by employing a wide range of methodologies. There is no single approach to normalisation. Fifty-four such normalisation studies, employing far more than 54 different methodological approaches, have been identified in the literature from 1998 to 2020 (through June) that have sought to adjust economic losses from past disasters to contemporary values in countries, regions and globally and for tropical cyclones, floods, tornadoes, fires, earthquakes and other phenomena.

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Pielke, R. (2021). Economic 'normalisation' of disaster losses 1998–2020: A literature review and assessment. *Environmental Hazards*, *20*(2), 93-111.

Table 1. Studies focused on specific phenomena and studies focused on particular regions.

Study (ordered by date of publication)	Phenomenon (region)	Detection claimed to be achieved?	Trend direction	Attribution claimed to be achieved?	Period (*italics* =<30 years)
Studies focused on specific phenomena					
	Tropical cyclones				
Martinez (2020)	United States	No	n/a	No	1900–2018
Grinsted et al. (2019)	United States	Yes	Increase	Yes	1900–2018
Chen et al. (2018)	China	No	n/a	No	1983–2015
Ye and Fang (2018)	China	Yes	Decrease	No	*1985–2010*
Weinkle et al. (2018)	United States	No	n/a	No	1900–2017
Klotzbach et al. (2018)	United States	No	n/a	No	1900–2016
Fischer et al. (2015)	China	No	n/a	No	*1984–2013*
Estrada et al. (2015)	United States	Yes	Increase	No	1900–2005
Bouwer and Wouter Botzen (2011)	United States	No	n/a	No	1900–2005
Nordhaus (2010)	United States	Yes	Increase	No	1900–2005
Zhang et al. (2009)	China	No	n/a	No	*1983–2006*
Schmidt et al. (2009)	United States	No	n/a	No	1950–2005
Pielke et al. (2008)	United States	No	n/a	No	1900–2005
Pielke et al. (2003)	Latin America and Caribbean	No	n/a	No	1944–1999
Raghavan and Rajesh (2003)	India	No	n/a	No	*1977–1998*
Collins and Lowe (2001)	United States	No	n/a	No	1900–1999
Pielke and Landsea (1998)	United States	No	n/a	No	1926–1995
	Floods				
Du et al. (2019)	China	Yes	Decrease	No	1990–2017
Paprotny et al. (2018)	Europe	No	n/a	No	1870–2016
Wei et al. (2018)	China	Yes	Decrease	No	*2000–2015*
Fang et al. (2018)	China (Yangtze River)	Yes	Decrease	No	*1998–2014*
Perez-Morales et al. (2018)	Spain	No	n/a	No	1975–2013
Stevens et al. (2016)	United Kingdom	No	n/a	No	1884–2013
Barredo et al. (2012)	Spain	No	n/a	No	1971–2008
Hilker et al. (2009)	Switzerland	No	n/a	No	1972–2007
Chang et al. (2009)	Korea	No	Increase	No	1971–2005
Barredo (2009)	Europe	No	n/a	No	1970–2006
Downton et al. (2005)	United States	Yes	Decrease	No	1926–2000
Fengqing et al. (2005)	China	No	n/a	No	1950–2001
Pielke and Downton (2000)	United States	No	n/a	No	1932–1997
	Extratropical storms				
Andres and Badoux (2019)	Switzerland	No	n/a	No	1972–2016
Stucki et al. (2014)	Switzerland	No	n/a	No	1859–2011
Barredo (2010)	Europe	No	n/a	No	1970–2008
	Tornadoes				
Simmons et al. (2013)	United States	No	n/a	No	1950–2011
Brooks and Doswell (2001)	United States	No	n/a	No	1890–1999
Boruff et al. (2003)	United States	No	n/a	No	1900–2000
	Convective storms				
Sander et al. (2013)	United States	Yes	Increase	No	1970–2009
	Wildfire				
Crompton et al. (2010)	Australia	No	n/a	No	1925–2009
Studies focused on particular regions					
Study	Region (location & phenomena)	Detection claimed to be achieved?	Trend direction	Attribution claimed to be achieved	Period
	Region				
Choi et al. (2019)	Korea (weather)	Yes	Decrease	No	1965–2015

(*Continued*)

Table 1. Continued.

Study (ordered by date of publication)	Phenomenon (region)	Detection claimed to be achieved?	Trend direction	Attribution claimed to be achieved?	Period (*italics* =<30 years)
Reyes and Elias (2019)	United States (crop loss)	Yes	Mixed	No	*2001–2016*
McAneney et al. (2019)	Australia (weather)	No	n/a	No	1966–2017
Paul and Sharif (2018)	Texas (hydro-meteorological)	No	n/a	No	1960–2016
Bahinipati and Venktachalam (2016)	India (weather)	No	n/a	No	1972–2009
Zhou et al. (2013)	China (natural disasters)	No	n/a	No	*1990–2011*
Crompton and McAneney (2008)	Australia (weather)	No	n/a	No	1967–2006
Choi and Fisher (2003)	United States (weather)	No	n/a	No	1951–1997
	World				
Pielke (2019)	All disasters & weather only	Yes	Decrease	No	*1990–2017*
Watts et al. (2019)	All disasters	No	n/a	No	*1990–2016*
Daniell et al. (2018)	Multi-hazard	Yes	Decrease	No	1950–2015
Mohleji and Pielke (2014)	All-weather related	No	n/a	No	*1980–2008*
Neumayer and Barthel (2011)	All-weather related	No	n/a	No	*1980–2008*
Visser et al. (2014)	All-weather related	No	n/a	No	1980–2010
Miller et al. (2008)	All-weather related	No	n/a	No	1950–2005

From Pielke 2021

By the time that the IPCC AR6 was written, there were more than 60 normalization studies in the peer reviewed literature, reviewed in Pielke 2021

Only one claimed to have attributed disaster losses to human-caused climate change — Grinsted et al. 2019

The IPCC AR6 ignored this significant literature and featured one normalization study — Grinsted et al. 2019

rainfall, wind damage, storm surge, and coastal flooding; notably, after accounting for changes in the value of property and other assets placed in harm's way, hurricane damage in the United States has generally increased since 1900.[158]

158. Grinsted, A., P. Ditlevsen, and J.H. Christensen, 2019: Normalized US hurricane damage estimates using area of total destruction, 1900–2018. *Proceedings of the National Academy of Sciences of the United States of America*, **116** (48), 23942–23946. https://doi.org/10.1073/pnas.1912277116

Bouwer, L. M., & Wouter Botzen, W. J. (2011). How sensitive are US hurri **46** nages to climate? Comment on a paper by WD Nordhaus. Climate Change Econo 1), 1–7.

Collins, D., & Lowe, S. P. (2001). A macro validation dataset for US hurrica **38** els. Casualty Actuarial Society.

Grinsted, A., Ditlevsen, P., & Christensen, J. H. (2019). Normalized US hurricane damage estimates using area of total destructio **122** 018. *Proceedings of the National Academy of Sciences, 116*(48), 23942-23946.

Klotzbach, P. J., Bowen, S. G., Pielke, R., & Bell, M. (2018). Continental U **299** landfall frequency and associated damage: Observations and future risks. Bulle merican Meteorological Society, 99(7), 1359–1376.

Martinez, A. (2020). Improving normalized hurricane damages. Nature Su **20** lity, 3, 517–518.

Pielke, R. A., Gratz, J., Landsea, C. W., Collins, D., Saunders, M. A., & Mu **1472** 8). Normalized hurricane damage in the United States: 1900–2005. Natur view, 9(1), 29–42.

Pielke, R. A., & Landsea, C. W. (1998). Normalized hurricane damages in **799** States: 1925–95. Weather and Forecasting, 13(3), 621–631.

Schmidt, S., Kemfert, C., & Höppe, P. (2009). Tropical cyclone losses in th **97** d the impact of climate change – a trend analysis based on data from a new ap to adjusting storm losses. Environmental Impact Assessment Review, 29(6), 359–369.

Weinkle, J., Landsea, C., Collins, D., Musulin, R., Crompton, R. P., Klotzba **270** Pielke, R. (2018). Normalized hurricane damage in the continental United States Nature Sustainability, 1(12), 808

To make matters worse, it turns out that the one study cited by the IPCC AR6 on normalized losses – Grinsted et al. 2019 used (presumably unknowingly) a fake dataset

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Do Not Use the ICAT Hurricane Loss "Dataset": An Opportunity for Course Correction in Climate Science

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(Manuscript received 19 November 2024, in final form 20 December 2024, accepted 31 January 2025)

ABSTRACT: A fatally flawed time series of U.S. hurricane losses assembled by an insurance company almost a decade ago has found its way into analyses published in the peer-reviewed literature. The flawed time series is based on undocumented modifications to a research-quality dataset that I and my colleagues published almost two decades ago. The uncritical use of the time series has led to erroneous conclusions published in the peer-reviewed literature which then were repeated in important climate science assessments. This paper explains the origin of the flawed dataset and demonstrates its many biases. The errors are so obvious and consequential that papers published in the peer-reviewed literature that rely on the flawed dataset should be retracted. While mistakes happen in science, what matters more is what we in the community do when mistakes are discovered.

KEYWORDS: Hurricanes/typhoons; Data quality control; Databases; Time series

1. Introduction

Mistakes and errors happen in scientific research. As astronomer Carl Sagan explained almost a half century ago:

Pielke et al. 2008; Schmidt et al. 2009; Nordhaus 2010; Bouwer and Wouter Botzen 2011; Estrada et al. 2015; Klotzbach et al. 2018; Weinkle et al. 2018; Grinsted et al. 2019; Martinez 2020; Willoughby et al. 2024). All normalization methodologies

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Perspective

https://doi.org/10.1038/s44304-024-00011-0

Scientific integrity and U.S. "Billion Dollar Disasters"

Check for updates

Roger Pielke Jr[1,2]

For more than two decades, the U.S. National Oceanic and Atmospheric Administration (NOAA) has published a count of weather-related disasters in the United States that it estimates have exceeded one billion dollars (inflation adjusted) in each calendar year starting in 1980. The dataset is widely cited and applied in research, assessment and invoked to justify policy in federal agencies, Congress and by the U.S. President. This paper performs an evaluation of the dataset under criteria of procedure and substance defined under NOAA's Information Quality and Scientific Integrity policies. The evaluation finds that the "billion dollar disaster" dataset falls short of meeting these criteria. Thus, public claims promoted by NOAA associated with the dataset and its significance are flawed and at times misleading. Specifically, NOAA incorrectly claims that for some types of extreme weather, the dataset demonstrates detection and attribution of changes on climate timescales. Similarly flawed are NOAA's claims that increasing annual counts of billion dollar disasters are in part a consequence of human caused climate change. NOAA's claims to have achieved detection and attribution are not supported by any scientific analysis that it has performed. Given the importance and influence of the dataset in science and policy, NOAA should act quickly to address this scientific integrity shortfall.

In the late 1990s, the U.S. National Oceanic and Atmospheric Administration (NOAA) began publishing a tally of weather and climate disasters that each resulted in more than $1 billion in damage, noting that the time series had become "one of our more popular web pages"[1]. Originally, the data was reported in current-year U.S. dollars. In 2011, following criticism that the dataset was misleading, NOAA modified its methods to adjusted historical losses to constant-year dollars by accounting for inflation (https://www.washingtonpost.com/blogs/capital-weather-gang/post/2011-billion-dollar-weather-disaster-record-legit-or-bad-economics/2012/01/12/gIQADoc2tP_blog.html).

By 2023, the billion dollar disaster time series had become a fixture in NOAA's public outreach, was highlighted by the U.S. government's U.S. Global Change Research Program (USGCRP) as a "climate change indicator" (https://storymaps.arcgis.com/collections/ad628a4d3e7e4460b089d96fe96b2475d?item=1), was a cited as evidence in support of a "key message" of the Fifth U.S. National Climate Assessment showing that "extreme events are becoming more frequent and severe" (https://nca2023.globalchange.gov/chapter/2/). The time series is often cited in policy settings as evidence of the effects of human-caused climate change to increase the frequency and intensity of extreme weather events and associated economic damage, including in federal agencies, Congress and by the U.S. President (https://www.congress.gov/bill/118th-congress/house-bill/598/text; https://www.whitehouse.gov/briefing-room/statements-releases/2023/11/14/fact-sheet-biden-harris-administration-releases-fifth-national-climate-assessment-and-announces-more-than-6-billion-to-strengthen-climate-resilience-across-the-country). In addition to being widely cited in justifications of policy, as of March, 2024, NOAA's billion dollar dataset has been cited in almost 1000 articles according to Google Scholar (https://scholar.google.com/scholar?hl=en&as_sdt=0%2C6&q=%22billion+dollar+disasters%22&btnG=).

This paper evaluates the billion dollar disaster time series by applying criteria of NOAA's Information Quality and Scientific Integrity policies. The evaluation finds that billion dollar disaster time series fails to meet NOAA's criteria for "information quality," specifically, NOAA's criteria of traceability, transparency, presentation, and substance.

Thus, the billion dollar disaster dataset is not simply an insufficient basis for claims of the detection and attribution of changes in climate variables (or a consequence of such changes), but the dataset is inappropriate for use in such research. Throughout, I use the terms "detection" and "attribution" as defined by the Intergovernmental panel on Climate Change (IPCC)[2]. Climate data should be the basis for claims of detection and attribution of changes in climate variables, not economic loss data. Because of the shortfalls in scientific integrity documented in this evaluation,

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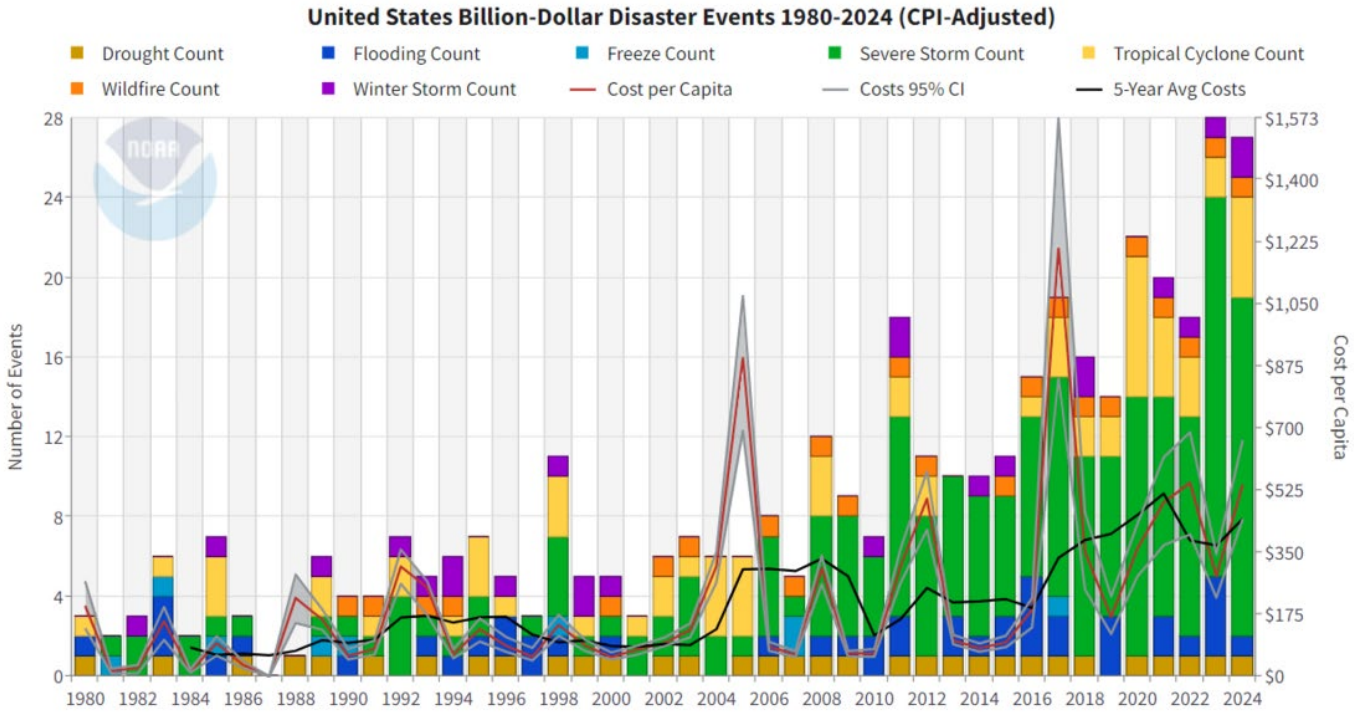

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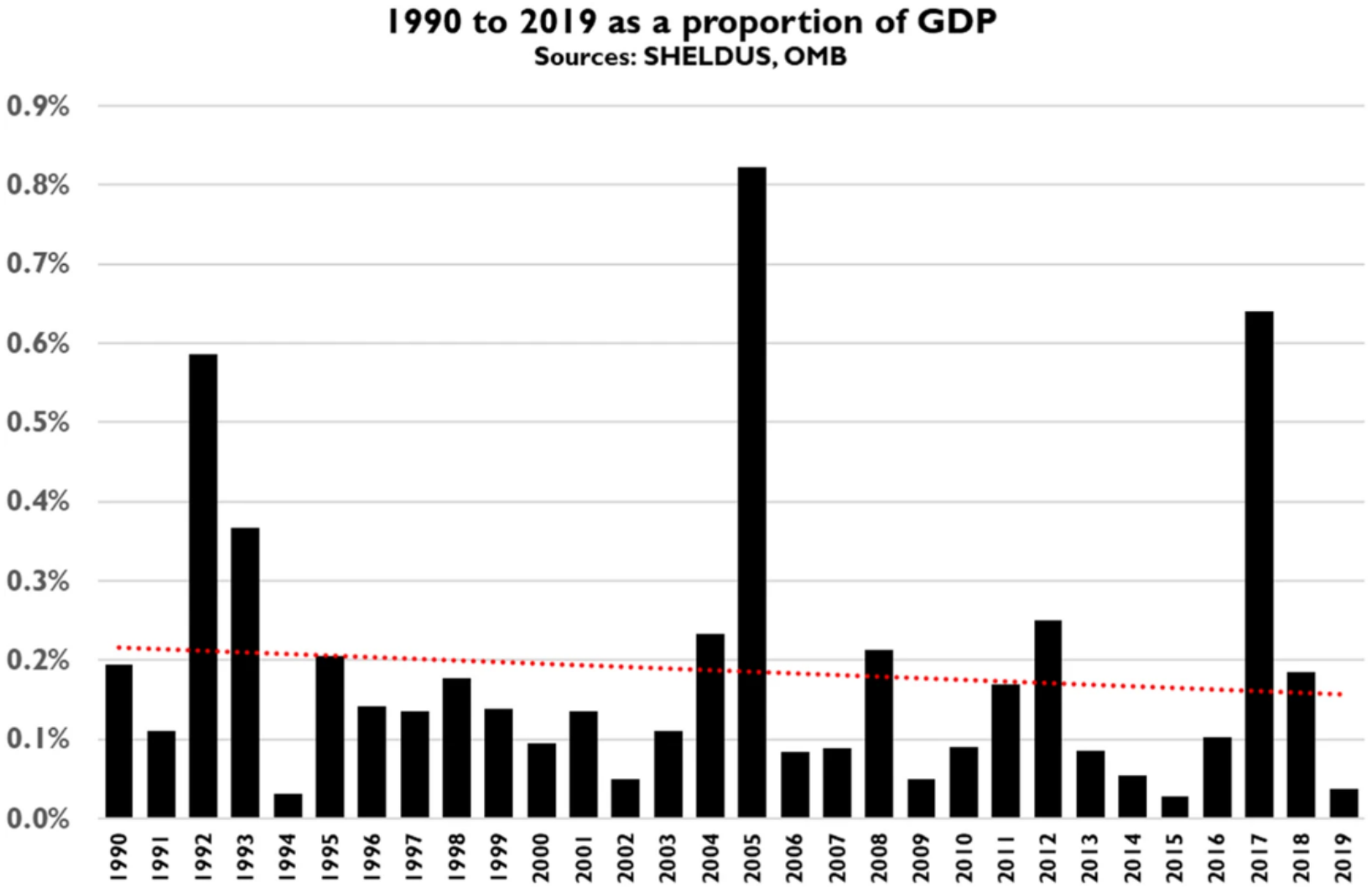
NOAA will stop updating database tracking costliest weather disasters

The billion-dollar disaster tracker is on a growing list of datasets NOAA says that either scientists will no longer update or the administration will decommission entirely.

Updated May 8, 2025

4 min 339



Sources: Spatial Hazard Events and Losses Database for the United States (SHELDUS) at Arizona State University, which has made public aggregate losses from 1990 to 2019. Data on GDP from the U.S. Office of Management and Budget.

Concluding thoughts

- **The IPCC is important, if it did not exist, we'd have to invent it**
- **According to the IPCC most types of extreme weather have not achieved detection or attribution of a change in their statistics over climate time scales (e.g., tropical cyclones, flooding, meteorological or hydrological drought …)**
- **The important exceptions are heat waves and (in some places) extreme precipitation**
- **There is a concerted effort to deny the IPCC's findings in the media, by activists, and by some scientists**
- **Extreme events are not the best way to market climate change or climate policy**
- **Some areas of climate science face challenges with respect to scientific integrity**

Thank You!

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