Swiss Re Institute

15 years after Katrina: **Would we be prepared today?**

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Overview

Fifteen years ago, Hurricane Katrina struck the US, inflicting significant loss of life and devastating damage. Hurricane Katrina remains a watershed event for re/insurance as the most expensive natural catastrophe for the global insurance industry to date. Though New Orleans' hurricane exposure and vulnerability have changed since Katrina, hurricane wind and storm surge continue to present a key risk to the Gulf Coast region, despite extensive mitigation efforts. Reviews of historical natural hazards, such as this one, are crucial for understanding today's risk and for validating probabilistic catastrophe loss modelling and related assessments.

Event Recap: Meteorological and damage summary

Hurricane Katrina's first landfall in the US occurred on August 25, 2005 in South Florida.[1] As a weak Saffir-Simpson Category 1 hurricane, Katrina brought strong winds and heavy rain to Miami-Dade County and throughout the Everglades region. After crossing South Florida, Katrina emerged into the Gulf of Mexico, where the storm underwent rapid intensification and its wind field significantly expanded. By August 28, Hurricane Katrina reached Category 5 intensity, with peak winds reaching 175 mph, and was an unusually large storm, with tropical storm-force winds extending 200 nautical miles from its center. This massive and powerful system in the Gulf of Mexico allowed storm surge to take shape. Just prior to landfall in Louisiana, the storm system deteriorated rapidly, likely due to internal structural changes such as the weakening of the inner eyewall. On August 29, 2005, Katrina made landfall as a strong Category 3 hurricane with maximum sustained winds of 125 mph near Buras, Louisiana. After landfall in Louisiana, Katrina weakened as it moved through Mississippi, Tennessee and Kentucky.

Hurricane Katrina's powerful winds and storm surge-induced flooding resulted in rampant damage throughout both Louisiana and Mississippi. According to studies by the National Hurricane Center and the Federal Emergency Management Agency, surge in Louisiana crested at 27.8 feet, with a swath of about 20 miles wide experiencing surge of 24 to 28 feet.[2] In New Orleans, surge of 10 to 19 feet stressed the city's levee and floodwall systems, resulting in widespread inundation with approximately 80% of the City of New Orleans flooded. Katrina and its aftermath resulted in 1,833 deaths in the US, along with the destruction of thousands of residential and commercial properties throughout Louisiana, Mississippi, Alabama, Florida and Georgia[3].

Katrina's impact on re/insurance industries

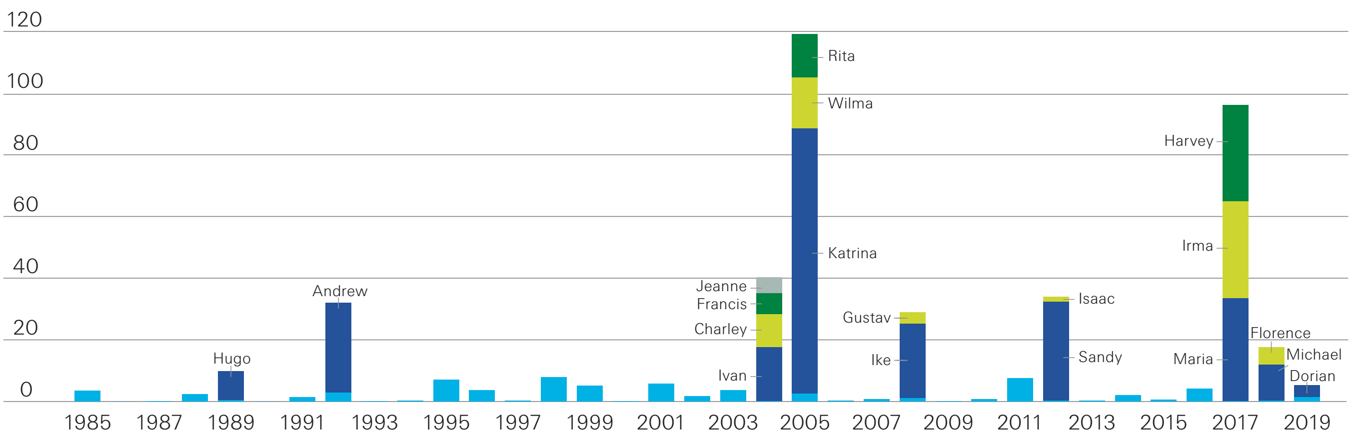
Hurricane Katrina had a remarkable impact on the reinsurance and insurance industries. The total economic damage from Katrina is estimated to be upward of USD 160bn (2020 USD).[4] Private insurance companies paid USD (2005) 41bn on 1.7 million claims for residential, commercial and automotive damage in the US. On top of this, insurers paid another USD 8bn for damages to offshore energy facilities in the Gulf of Mexico. These losses, together with USD 16.3bn in publicly-insured losses to the Federal Emergency Management Agency's National Flood Insurance Program (FEMA NFIP), brought Katrina's total insured loss to more than 65bn (2005 USD). Accounting for inflation, this would be equivalent to nearly USD 86bn (2020 USD). The difference between Katrina's total economic damage and insured loss illustrates the natural catastrophe protection gap that stems from uninsured and underinsured losses; for Hurricane Katrina, the protection gap was strongly driven by uninsured and underinsured flood losses.

While the figure below illustrates that Katrina is the costliest insured North Atlantic hurricane on record, its impact is even more profound: Hurricane Katrina is the most expensive natural catastrophe for the global insurance industry (across all perils and regions) to date. Moreover, when considering a hurricane's loss (excluding losses to the NFIP) as a percentage of the US' property & casualty industry capital, Katrina's is the highest at 11.3%. FEMA paid out USD 16.3bn in flood-related claims for Hurricane Katrina, the highest NFIP payout for a single event to date.[5]

[1–3] https://www.nhc.noaa.gov/data/tcr/AL122005_Katrina.pdf
[4] https://coast.noaa.gov/states/fast-facts/hurricane-costs.html
[5] https://www.iii.org/fact-statistic/facts-statistics-flood-insurance

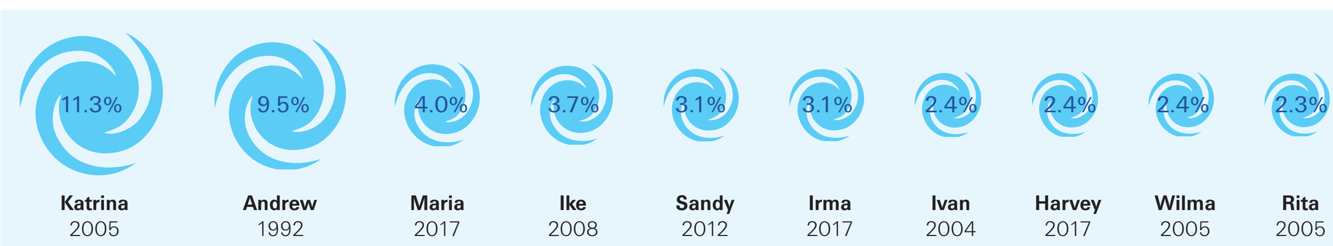
In addition, Katrina occurred during the 2005 North Atlantic hurricane season, where storms combined to have an unprecedented impact on the re/insurance industry. Katrina, Rita and Wilma collectively caused insured losses of roughly USD 119bn (2020 USD), more than 20% higher than the combined losses of 2017 events of Harvey, Irma and Maria.

Insured losses from North America tropical cyclones, 1985–2019 (in USD 2020 billions)



Source: Swiss Re Institute

Top 10 insured losses from tropical cyclones (excluding NFIP), as percentage of US P&C Capital

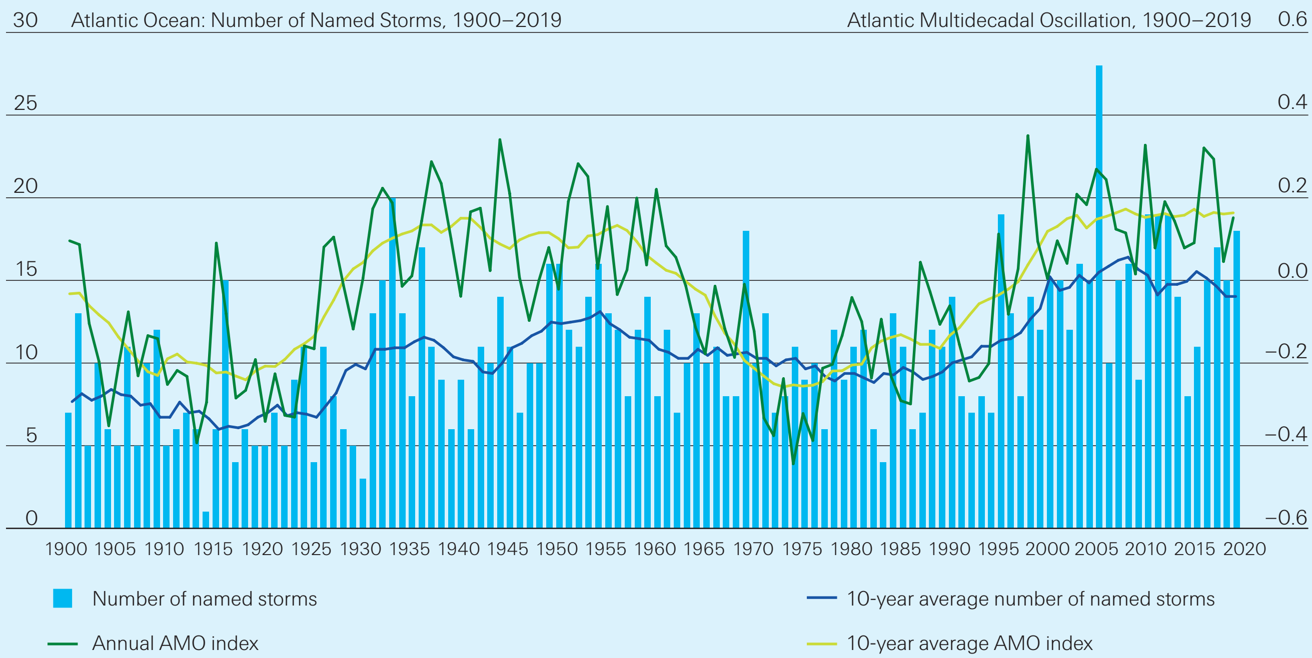


Source: Swiss Re Institute

When discussing Katrina's impact on the insurance industry, it is impossible not to mention the extensive litigation on wind versus flood claims. Katrina was a sobering reminder that water can be a main driver of hurricane damage. In the US, standard residential insurance policies (for both homeowners and renters) exclude coverage for flood damage resulting from surface water, including storm surge caused by hurricanes; separate flood insurance policies have been available through FEMA's NFIP. Litigation regarding Katrina claims focused on attribution of the damage to wind and/or water, an especially difficult distinction when sometimes only a property's foundation remained. Such litigation forced the insurance industry to adopt better practices in policy wording, while also encouraging policyholders to better understand the scope of their coverage.

The development of near-term hurricane risk views

The 2004 and 2005 Atlantic hurricane seasons produced a total of 24 hurricanes. This two-year period of elevated hurricane activity sparked the development of hurricane catastrophe models with a near-term view of risk, rather than the established approach that relied on long-term historical data. Near-term risk views often consider annual-to-decadal patterns of natural climate variability that influence sea surface temperatures in the Atlantic, such as the Atlantic Multidecadal Oscillation (AMO) and the El-Nino Southern Oscillation (ENSO).



Above we present the Atlantic Multidecadal Oscillation Index from 1900–2019, which is a measure of sea surface temperature anomalies in the North Atlantic; when the index is positive, surface waters are warmer than usual, and atmospheric/oceanic conditions tend to be more conducive to hurricane formation, growth and intensification.

The AMO index has remained positive since the mid-1990s which corresponds to high-activity at the basin-wide scale, despite few landfalls from 2006–2016. While Katrina, Rita and Wilma came in the second half of two active US hurricane seasons, they did not mark an end to the climatic conditions favoring such occurrences in the Atlantic basin and, in consequence, elsewhere along the coast. Recent events of 2017–2019 illustrate this high propensity of occurrence and serve as a reminder that short-term climate patterns continue to have a profound impact on year-to-year hurricane risk levels.

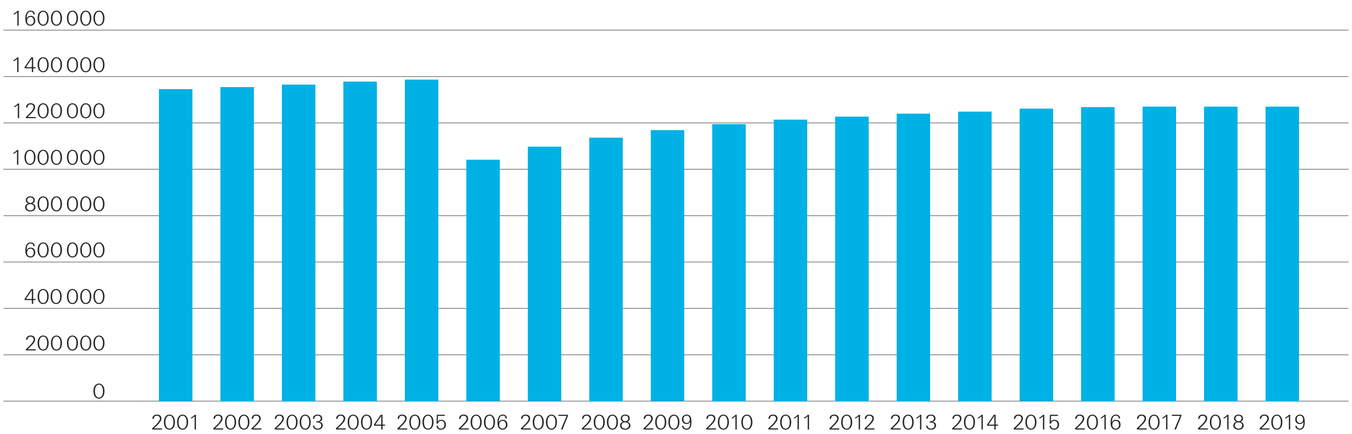
Changes since Katrina in New Orleans and beyond

To evaluate how New Orleans might fare in future hurricanes similar to Katrina, we must consider post-Katrina changes to factors that influence the city's hurricane risk: population/exposure, vulnerability and hazard.

Population

New Orleans' population has not fully returned to pre-Katrina levels. The city's population decreased from 484,674 in April 2000 to an estimated 230,172 in July 2006, a decrease of over 52%.[6] The US Census Bureau estimates that New Orleans' population in 2019 increased to 390,144, which is approximately 80% of what is was in 2000. On a wider scale, the New Orleans-Metairie Metropolitan Statistical Area had a population of 1,386,429 in 2005, while the 2019 population estimate for this region was 1,270,530, about 10% below the pre-Katrina population.

New Orleans-Metairie Metropolitan Statistical Area Population, 2001–2019



However, it is important to note New Orleans' population since 2005 shows an opposite trend compared to other coastal regions along the Eastern Seaboard and Gulf Coast of the US, where residential growth in coastal counties has far outpaced the national average. From 2010 to 2019, significant population growth has been observed in hurricane-exposed coastal regions throughout Florida and Texas, as seen in Table 1. This population growth is at the forefront of increasing hurricane exposure in the US.

[6] https://www.datacenterresearch.org/data-resources/katrina/facts-for-impact/

Flood-protection efforts and building codes

In the years following Katrina, New Orleans' flood protection system, the Hurricane Storm Damage Risk Reduction System (HSDRRS), was the beneficiary of a multi-billion dollar upgrade. The New Orleans HSDRRS was a USD 14.6bn project, completed in 2011 and designed to protect against storm surge with a minimum return period of 100 years — the baseline standard the federal government agreed to provide for the levee system so properties behind the levees can be eligible for NFIP policies. The HSDRRS includes a series of surge barrier walls, flood walls, canal flood walls, pump stations and lakefront levees that combine to form a perimeter around the greater New Orleans area. To account for subsidence and sea-level rise, the HSDRRS must be recertified in 2023. Regardless of the outcome of such recertification, the completion of the HSDRRS in New Orleans stands out as a national success story in increasing local resilience via protection measures following natural-hazard events.

Furthermore, in the wake of Katrina, Louisiana adopted its initial statewide building code, the Louisiana State Uniform Construction Code, to reduce the vulnerability of buildings, and the likelihood of wind damage from subsequent hurricanes. This building code was based on the 2006 version of the International Building Code (IBC) and the International Residential Code (IRC), and has been periodically updated since its first adoption. In neighboring Mississippi, it is worth noting only five coastal counties were required to adopt stricter building codes (2003 IBC and IRC) following Katrina, while a statewide building code was adopted only in 2014; counties and municipalities could also opt out of the statewide code. The contemplation of local/state-level changes in vulnerability and adherence to building codes is vital in exercises to assess the Gulf Region's present risk.

Improved flood risk-assessment tools

Hurricane Katrina demonstrated the devastating impact of flooding as well as the profound protection gap in the US. Factors influencing the protection gap include low risk awareness, lack of understanding of typical coverage under standard homeowners policies, and affordability. Historically, private insurers avoided the flood insurance market because sharp gradients in flood hazard on small spatial scales gave this peril a reputation as being poorly understood and therefore too risky.

However, since Katrina, flood risk-assessment capabilities have improved greatly due to more powerful computing resources, better understanding of the physics/dynamics behind flooding, and a greater availability of high-resolution and high-quality data. These improvements have resulted in a more comprehensive flood-risk view that can delineate flood risk at a much higher spatial resolution than before, accounting for more than storm surge and river flooding. This has paved the way for a growing private-insurance market for residential flood.

Unfortunately, the US flood protection gap remains wide, despite these improvements and lessons from recent events like Hurricanes Harvey and Florence. In the US, five out of six homes do not have flood insurance, resulting in a protection gap of USD 10bn in average annual flood losses that aren't covered.[7] Flood insurance take-up rates in areas within the 100-year floodplain are substantially higher for residences in coastal counties along the Gulf and East Coasts. Nonetheless, the flood insurance gap remains wide in other coastal areas, with a 2017 McKinsey analysis finding that the residential flood insurance take-up rate was less than 20% in areas affected by Hurricane Harvey.[8] As flooding remains the most common and most expensive natural hazard in the US, our hope is that advancements in flood risk assessment tools will help in narrowing this protection gap.

7 https://www.swissre.com/risk-knowledge/mitigating-climate-risk/tackling-americas-flood-risk-problem.html
8 https://www.mckinsey.com/industries/financial-services/our-insights/insuring-hurricanes-perspectives-gaps-and-opportunities-after-2017

Climate change

In addition to examining evolving changes among exposure, vulnerability and risk-assessment tools, we must also consider the changes to hurricane hazard that result from climate change. The Swiss Re Institute has recently engaged with researchers at Columbia University on the topic of climate-change impacts to hurricanes; such impacts were thoroughly detailed in a recent Swiss Re *sigma* report[9]. We include here a summary of key findings:

- Sea-level rise is expected to exacerbate coastal flooding associated with tropical cyclone storm surge.
- Tropical cyclone rainfall rates are projected to increase in the future due to warming and the increase in atmospheric moisture content.
- Globally, tropical cyclone intensities are expected to increase, leading to an associated increase in the proportion of tropical cyclones reaching higher intensities.
- The impact of climate change on tropical cyclone frequency in the Atlantic remains uncertain.
- Several recent studies show that the forward speed of storms has been decreasing and suggest that this is a consequence of climate change. All else being equal, slower-moving storms produce greater storm surge.

Katrina, with already tremendous storm surge, intense winds and heavy rainfall (exceeding 12 inches in parts of Louisiana and Mississippi[10]), is characteristic of an event more sensitive to the expected effects of climate change. We note that at Grand Isle, Louisiana, a small barrier island south of New Orleans, the sea level has risen by a total of 24 inches since 1950 and is now rising by over one inch every two years, with subsidence (land sinkage) of the Mississippi Delta being one of the main contributors.[11] With one of the fastest local rates of sea-level rise[12], climate change is projected to result in more frequent and higher coastal flooding.

[9] https://www.swissre.com/institute/research/sigma-research/sigma-2020-02.html
[10] https://www.weather.gov/mob/katrina#Rainfall
[11] https://sealevelrise.org/states/louisiana/
[12] https://www.pnas.org/content/pnas/early/2016/11/02/1605312113.full.pdf

Katrina: 2005 vs. 2020

While Katrina remains the costliest natural catastrophe for the global insurance industry to date, there is unfortunately room for other plausible scenarios to produce even larger losses.

Hurricane Katrina caused USD 41bn in insured losses (USD 2005) in the US (excluding offshore and NFIP losses), which equates to roughly 54bn (USD 2020) now. Estimating present-day losses based solely on inflation still does not consider many of the other boundary conditions that influence what a Katrina might look like in 2020, including changes in coastal population/vulnerability and climate change.

To evaluate what Hurricane Katrina might look like in 2020 in terms of insured and economic losses, we ran Katrina's 2005 wind and surge footprint on our US market portfolio using Swiss Re's probabilistic tropical-cyclone loss model. The market portfolio is a representation of all insured properties (residential, commercial, industrial and automotive) in the US as well as an assumption regarding insured values and coverages.

If Hurricane Katrina were to hit the US in 2020 with the same wind and storm surge as 2005, but with current exposure information and updated flood protection and vulnerability assumptions, the privately insured losses in the US alone could rise to 60bn (excluding offshore losses in the Gulf of Mexico or losses to the NFIP). This is true, despite the city currently only having 80% of the population it did in 2005. The total economic toll from such an event could likely exceed USD 175bn. These figures illustrate that despite New Orleans' lower population and strengthened flood protection system, economic losses from natural hazards like Katrina are expected to continue to increase.

The expected impacts of climate change on tropical cyclones could also materialize in a pronounced way for a hurricane where most damage stems from flood (storm surge and/or rainfall), like Hurricane Katrina. Using our in-house probabilistic tropical-cyclone loss model, we can examine the financial impact of hypothetical and yet physically possible versions of Katrina that might develop in a future, warmer climate. Sample climate-change scenarios like increasing the sea level by six inches or increasing Katrina's windspeeds by 5 mph (which in turn would generate greater storm surge), would lead to an insured loss of up to USD 65bn (excluding offshore losses in the Gulf of Mexico or losses to the NFIP). The total economic loss associated with such an event could easily reach USD 200bn. Considering that sea level in the barrier islands near New Orleans is now rising by over one inch every two years, a six-inch increase in sea level — and an event like this could happen in just over a decade.[13] In these scenarios, the majority of the insured loss would be caused by wind due to the large flood protection gap in the US. While climate change is a real factor at work that could significantly impact total insured and economic losses, the impact of a changed climate in 2020 compared to 2005 for an event like Katrina is, with high likelihood, still secondary to potential changes in population, exposure, vulnerability and flood protection.

13 https://sealevelrise.org/states/louisiana/

Broadening the lens: From Katrina to US hurricane risk

This detailed examination of changes in New Orleans since Katrina illustrated the complex interplay between several risk trends, many of which point to a steadily increasing hurricane risk. Unfortunately, trends in hurricane exposure, vulnerability and hazard are not limited to only the New Orleans region; elsewhere, the trends take on different magnitudes and directions. In Florida, for example, hurricane risk has only increased since Katrina, largely due to population and exposure growth in coastal counties that far outpace the national average. Moreover, sea level rise affects regions all along the US Eastern Seaboard and Gulf Coasts; however, some cities have implemented far fewer flood protection measures than New Orleans.

Table 1: Population in select US counties and nationwide, 2010–2019

County/State	2010 Population	Estimated Population (2019)	Change (2010 to 2019)
Miami-Dade, FL[7]	2,496,435	2,716,940	8.8%
Broward, FL[8]	1,748,066	1,952,778	11.7%
Palm Beach, FL[9]	1,320,134	1,496,770	13.4%
Hillsborough County, FL[10]	1,229,226	1,471,968	19.7%
Harris County, TX[11]	4,092,459	4,713,325	15.2%
United States[12]	308,745,538	328,239,523	6.3%

A reoccurrence of the 2004–2005 seasons is likely to impact much more exposure, at often aggravated boundary conditions: population increase, coastal concentration, sea level rise and insufficient flood protection. While catastrophe models provide a reasonable framework to manage the industry's key natural hazard risks, there is always a fear of falling short by failing to consider key risk trends or factors. To best promote sustainable risk transfer, a forward-looking perspective on both occurrence probabilities and severity needs has to become an industry norm.

[14] https://www.census.gov/quickfacts/fact/table/miamidadecountyflorida/POP060210
[15] https://www.census.gov/quickfacts/fact/table/browardcountyflorida/POP060210
[16] https://www.census.gov/quickfacts/fact/table/palmbeachcountyflorida/POP060210
[17] https://www.census.gov/quickfacts/fact/table/hillsboroughcountyflorida/POP060210
[18] https://www.census.gov/quickfacts/fact/table/harriscountytexas/POP060210
[19] https://www.census.gov/quickfacts/fact/table/US/POP060210

Summary

The sample scenarios here illustrate how the risk landscape has changed in the last 15 years due to changing hazard, exposure and protection factors. It is crucial to consider such factors when evaluating the current risk landscape or in any modeling exercise at the local level. Additionally, the scenarios here demonstrate the effectiveness of natural-hazard mitigation efforts and flood defenses, as well as the role of re/insurance in enabling resilience.

While Katrina and variations thereof reveal the absolute loss potential posed by tropical cyclones under current and future climate scenarios, it is still important to note that this potential is dwarfed by a similar event impacting a more populated region with greater residential and commercial assets, like Miami-Dade County, Florida or Houston, Texas. Moving forward, a dynamic tracking of the risk landscape is paramount for any tropical-cyclone risk assessment, as several percentage points of change per year in factors like hazard, exposure and vulnerability quickly accumulate to create immense increases in natural catastrophe risk.

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Title:
15 years after Katrina:
The tale of a changing risk landscape

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Graphic design and production:
Corporate Real Estate & Services

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08/20, en