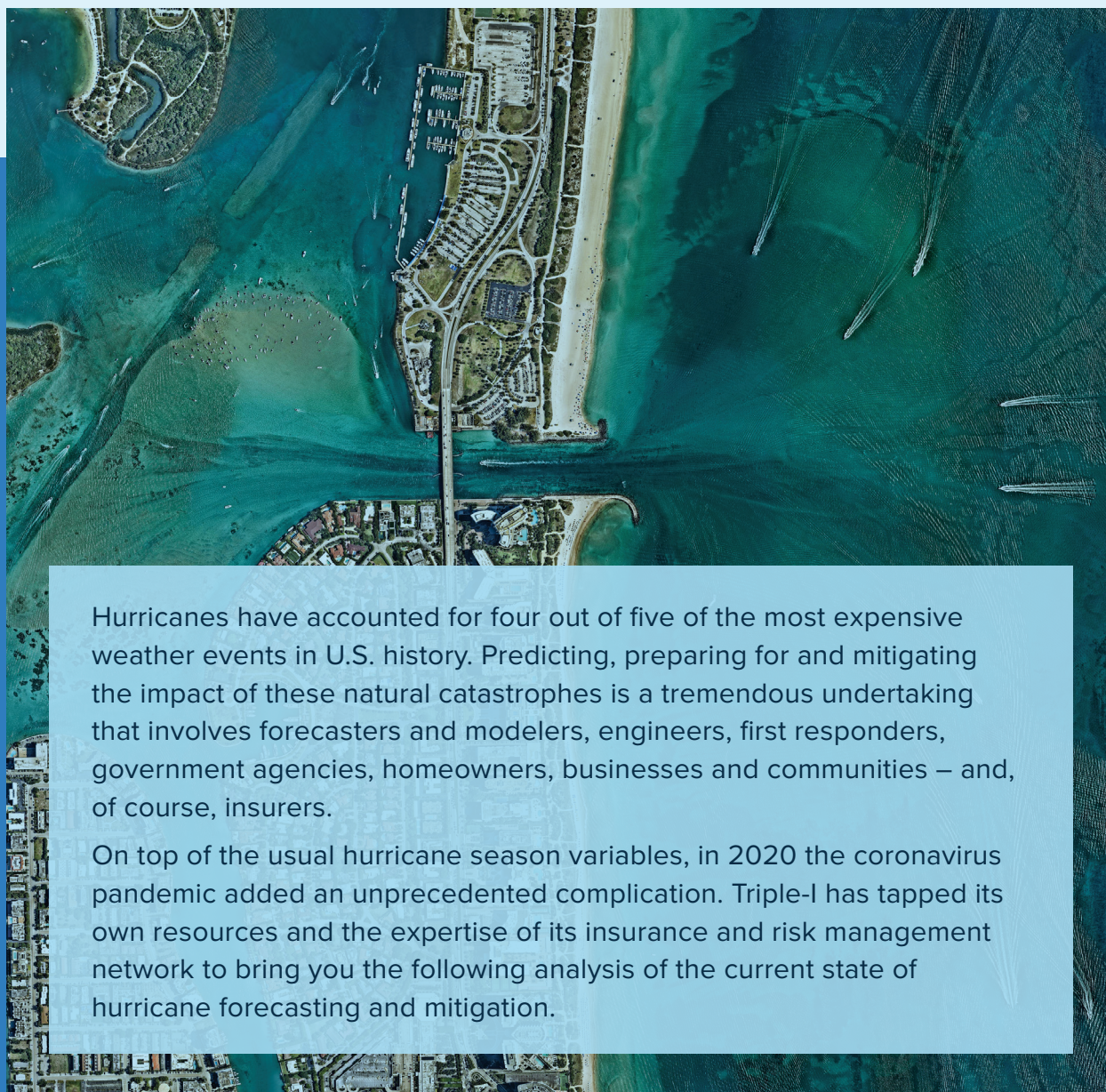


HURRICANE SEASON

More Than Just Wind and Water

August 2020



Hurricanes have accounted for four out of five of the most expensive weather events in U.S. history. Predicting, preparing for and mitigating the impact of these natural catastrophes is a tremendous undertaking that involves forecasters and modelers, engineers, first responders, government agencies, homeowners, businesses and communities – and, of course, insurers.

On top of the usual hurricane season variables, in 2020 the coronavirus pandemic added an unprecedented complication. Triple-I has tapped its own resources and the expertise of its insurance and risk management network to bring you the following analysis of the current state of hurricane forecasting and mitigation.



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Introduction

Under the best of circumstances, the Atlantic hurricane season is a challenging time. Despite improved forecasting; more data and more-advanced analytical tools; greater public awareness and pre-storm communication; and improved materials and engineering, hurricane-related losses continue to climb. Nine of the 10 costliest hurricanes in U.S. history have occurred since 2004, and 2017, 2018, and 2019 represent the largest back-to-back-to-back insured property loss years in U.S. history.

And the 2020 season did not come during the best of circumstances.

It arrived on the heels of a global pandemic that has not ebbed and continues to complicate this year's [convective storm](#) season. It also has been accompanied by protracted civil unrest in the United States and elsewhere that could draw attention and resources away from storm preparation in some communities.

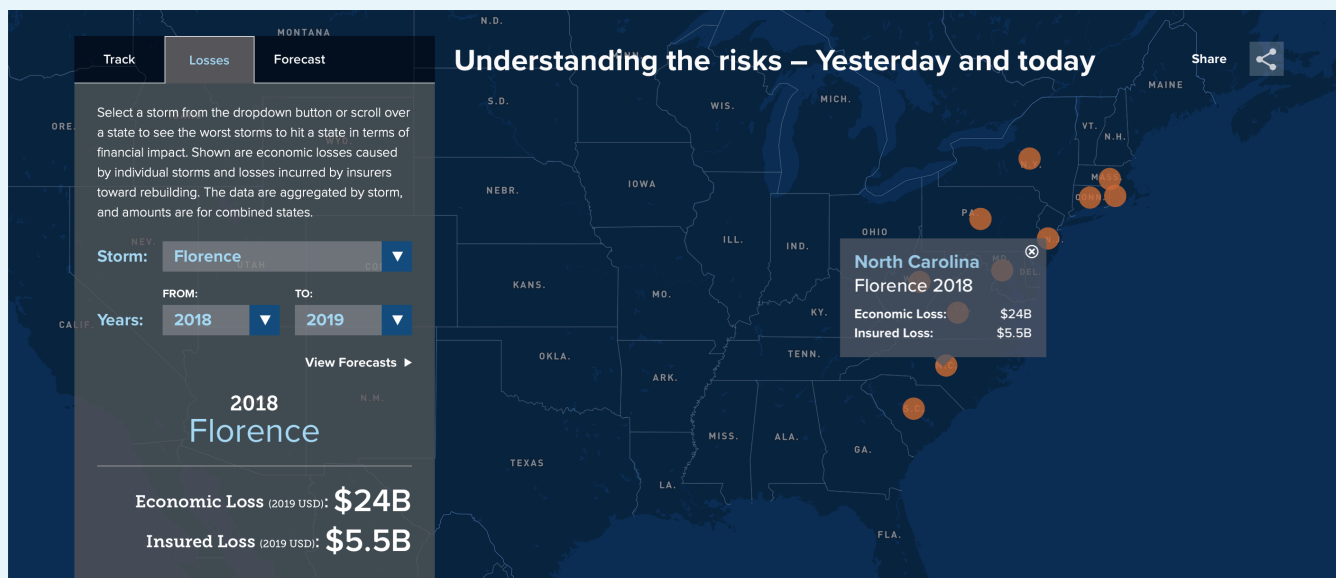
And, as if those complications were not enough, the season is forecast to be extremely active in terms of the number of named storms and “major” hurricanes.

This paper examines

- How climate and socio-economic factors affect hurricane loss trends
- The evolution of hurricane preparation and response
- The role advances in modeling and forecasting play in insurance and in helping communities and businesses plan for resilience
- The importance of flood insurance in general and as a component of hurricane resilience

It looks at these issues and trends through multiple lenses, including weather and climate research, insurance and reinsurance expertise, and public policy. It also addresses how the COVID-19 pandemic may affect preparation for and the cost associated with this year's storms.





Resilience meets innovation

Triple-I's [Resilience Accelerator](#) is an initiative launched last year to build awareness and adoption of insurance as a frontline defense against the impact of extreme weather events — including hurricanes — on households, businesses and communities.

“Hurricanes have accounted for four out of five of the most expensive weather events in U.S. history,” says Triple-I Senior Economist and Vice President Dr. Michel Léonard, CBE, in a [video](#) where he explains the project’s mission of “demonstrating the power of insurance as a force for resilience.”

“Specifically,” Léonard says, “we’re looking at the impact insurance coverage has on quickening the pace of economic recovery after disasters... to empower stakeholders to make data-driven decisions about the cost and benefits of pre-emptive risk mitigation.”

The Accelerator will fast-track the use of data-driven tools to drive risk mitigation, transfer and retention. Its goal is to create a “resilience movement” that gives households, businesses owners and community leaders a stake in positive outcomes by helping all to better understand protection gaps and how they inhibit recovery from extreme weather catastrophes.

As part of the initiative, the [Gulf Coast & Southwest Resilience Innovation Hub](#) was launched on June 18, 2020, by Triple-I, [ResilientH2O Partners](#),

and [the Cannon](#). The Hub resides in downtown Houston’s Cannon Tower and will act as a space for private and public sector entities — from academic partners and tech companies to investors and government agencies — to work together on pre-disaster mitigation innovations. This brick-and-mortar hub, a companion to the Accelerator’s hub website, provides a physical presence for the Accelerator’s and Triple-I’s activities in a key part of the country.

The Hub’s creation was announced at a [virtual town hall](#) titled “Technology, Innovation and Investment” and co-hosted by Triple-I and ResilientH2O Partners. The town hall focused on private-public partnerships.

More recently, Triple-I and ResilientH2O Partners held their first [Lightning Round](#) — virtual events in which pre-vetted technology companies, equipment suppliers, integrated solution providers and large-scale project development teams present their value propositions and receive feedback from insurers and potential investors.

Through events like these, along with the creation and sharing of valuable content, the Resilience Accelerator aims to build an action-oriented coalition to help people and businesses understand the risks they face and prepare not only to mitigate their impact but to meet and bounce back from catastrophes.

What is driving hurricane losses?

Natural catastrophe losses are on the rise globally, and hurricanes account for a significant proportion of them.

Tropical cyclones — called “hurricanes” when they occur in the Atlantic Ocean and the eastern North Pacific — have a long history of driving losses. During the 2017-18 season, Atlantic hurricanes combined to cause more than \$355 billion in direct economic damage, according to [an Aon report](#).¹

Total damage and economic loss caused by named storms in 2019 was \$7 billion, mostly from Hurricane Imelda (\$5 billion) in the United States, Aon reported. In addition, the Bahamas incurred \$8 billion in damage due to Dorian.

According to the [latest forecast](#) from Colorado State University, the 2020 Atlantic season is expected to produce 24 named storms (up from 20 in the previous forecast), 12 hurricanes (up from nine), and five major — Category 3 or higher on the Saffir-Simpson Hurricane Wind Scale — hurricanes (up from four). Last year’s season was “[slightly above average](#),” yielding 18 named storms, six of which became hurricanes, including three major ones.

As this paper goes to press, we are awaiting the possible formations of storms Nana and Omar, following [Hurricane Laura’s damaging passage](#) across Louisiana after making landfall near Cameron, La., on August 27. Laura inflicted considerable wind damage in the city of Lake Charles, La., but the city avoided much of the feared storm surge. [Click here](#) for information about post-disaster safety and insurance coverage, including resources specific to those in Texas and Louisiana affected by Laura.

Hurricane season typically peaks around September 10, when waters in the Atlantic are warm and vertical wind

Fig. 1

10 Costliest U.S. Catastrophes*			
Rank	Event	Date	Insured losses (2019 dollars)**
1	Hurricane Katrina	Aug. 2005	\$52,828
2	Sept. 11, 2001, terrorist attacks	Sept. 2001	26,431
3	Hurricane Maria***	Sep. 2017	26,100-31,300
4	Hurricane Irma***	Sep. 2017	26,100-31,300
5	Hurricane Andrew	Aug. 1992	25,867
6	Hurricane Sandy	Oct. 2012	21,065
7	Northridge, Calif. Earthquake	Jan. 1994	19,952
8	Hurricane Harvey***	Aug. 2017	18,800-20,800
9	Hurricane Ike	Sep. 2008	14,898
10	Hurricane Michael***	Oct. 2018	9,200-12,200

*Property losses only. Excludes flood damage covered by the federally administered National Flood Insurance Program (NFIP). As of April 17, 2020. **Adjusted for inflation through 2019 by the Insurance Information Institute using the GDP implicit price deflator. ***Insurance Information Institute estimate based on data from catastrophe risk modelers, reinsurance companies, the Property Claims Services unit of Verisk Analytics, the Federal Emergency Management Agency of the U.S. Department of Homeland Security, and the Florida Office of Insurance Regulation. These estimates are preliminary because the organizations involved periodically resurvey the events, and the severity of losses and other factors create a high level of uncertainty surrounding the ultimate loss figures. Source: Insurance Information Institute, catastrophe risk modelers, reinsurance companies, U.S. Department of Homeland Security, the Florida Office of Insurance Regulation, the Property Claim Services® (PCS®) unit of ISO®, a Verisk Analytics® company, and the U.S. Bureau of Economic Analysis.

1. Aon, *Weather, Climate & Catastrophe Insight: 2019 Annual Report*.

shear is low. To have had so many named storms this early in the calendar year is unprecedented.

Preliminary insured loss estimates from Isaias range from over \$1 billion (Aon) to as much as \$5 billion (RMS). Damage is still being tallied, and these estimates are likely to change.

Losses growing faster than inflation

According to data compiled by Aon, global insured weather-related property losses have outpaced the annual rate of inflation by about 7 percent since 1950 (Figure 2).

“Of the \$1.7 trillion of global insured property loss reported since 1990,” Aon Director and Meteorologist Dan Hartung recently said at a meeting of the [Casualty Actuarial Society](#) (CAS), “a third is from tropical cyclones.”

Nine of the 10 costliest hurricanes in U.S. history, as defined by private-sector insured losses paid to auto, home, and business insurance policyholders and Federal Emergency Management Agency (FEMA) [National Flood Insurance Program](#) (NFIP) payouts, have occurred since 2004. And 2017, 2018 and 2019 represent the largest back-to-back-to-back insured property loss years in U.S. history, Hartung said.

“Let that sink in: Approximately 10 percent of all insured weather loss globally since 1990 has occurred from tropical cyclones within the past three years,” he said.

Is climate change to blame?

Many would instinctively chalk up such numbers to climate change. In fact, when attendees at the CAS meeting were asked if they believed increasing catastrophe losses are due to climate change, 83 percent said they did.

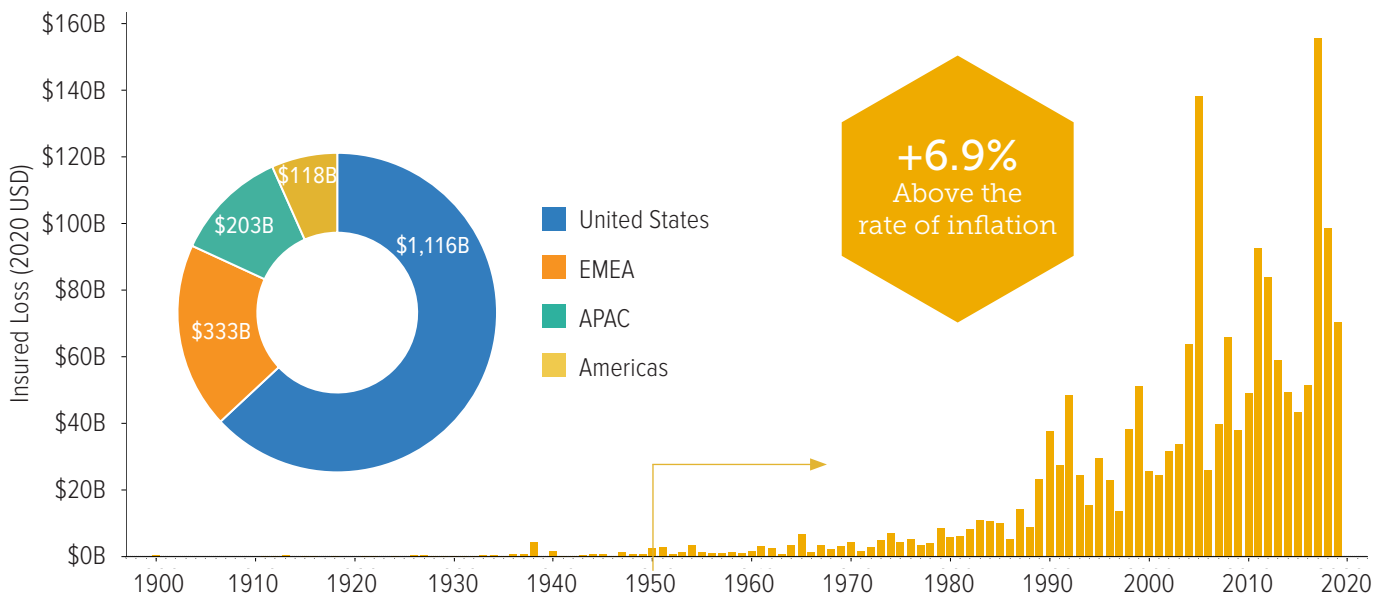
But a careful look at the data reveals a picture in which climate change, while playing a role, is not necessarily the predominant driver of hurricane-related financial losses.

As shown in **Figure 3**, the number of hurricane and major hurricane landfalls along the U.S. mainland since 1851 shows little to no trend. During the same period, mean global temperatures have risen substantially. Such trends, when combined with the notable growth in incurred damaged in the past several decades, suggest stronger storms affecting more highly exposed areas are leading to greater risk and costs.

Fig. 2

Insured weather losses on the rise

Global insured losses, 1900-2019

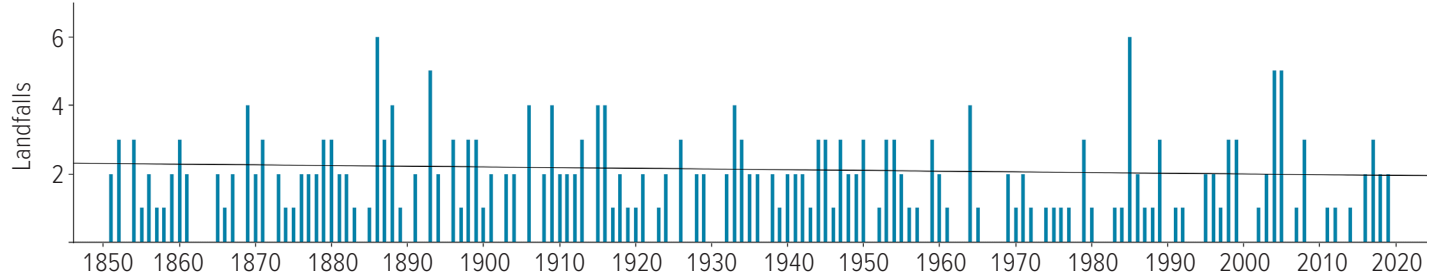


Data and graphic: Aon (Cat Insight). Compiled by Aon, used with permission. All losses CPI-Adjusted to 2020 USD.

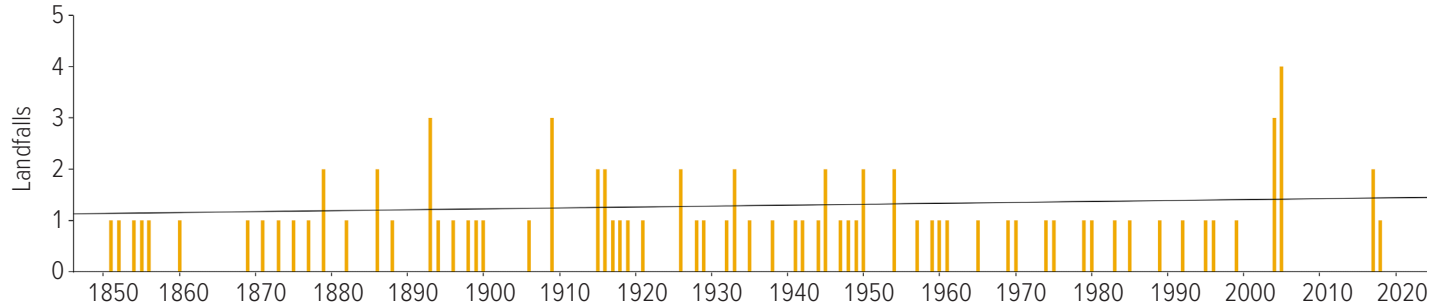
Fig. 3

U.S. mainland hurricane landfalls

Hurricane (Category 1+)



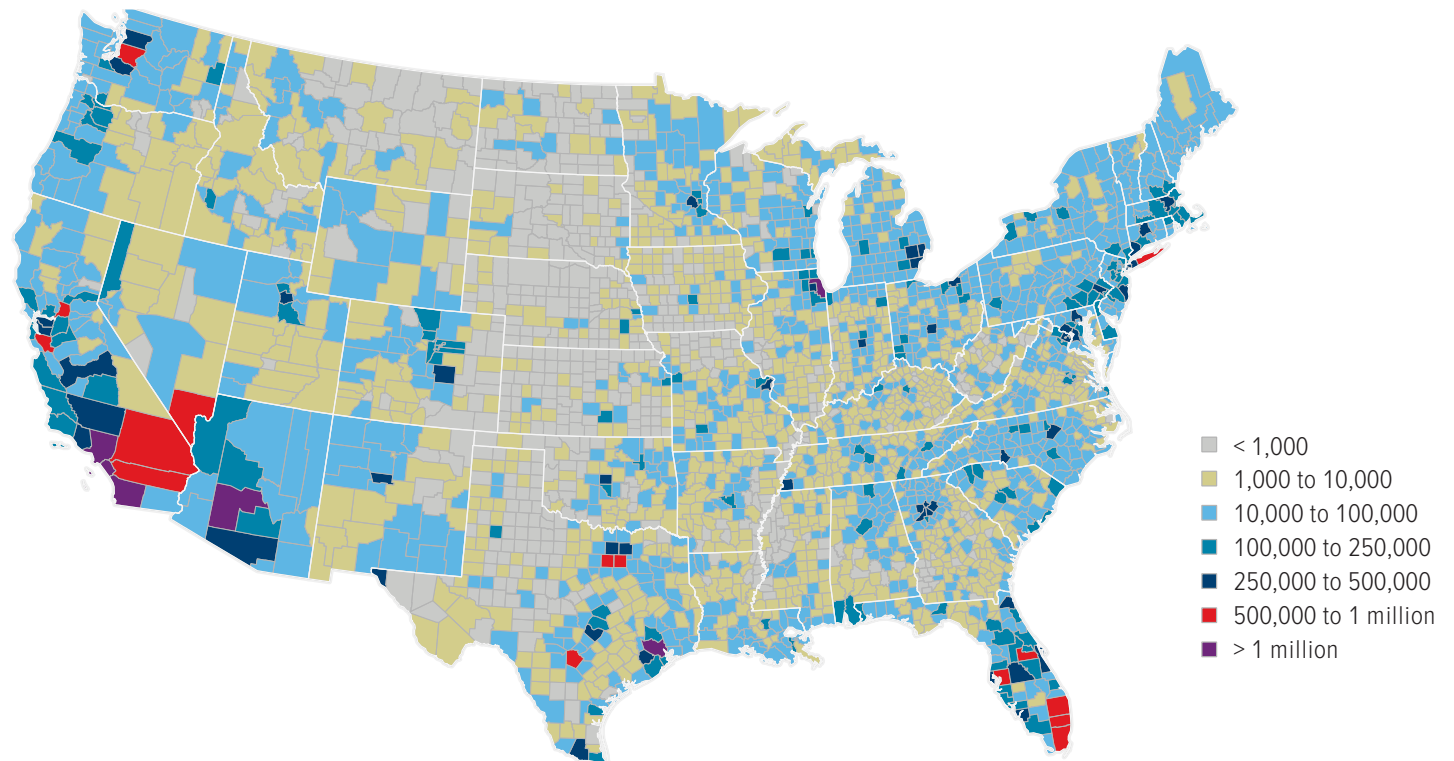
Major hurricane (Category 3+)



Data: National Oceanic and Atmospheric Administration (NOAA). Graphic: Aon (Cat Insight).

Fig. 4

More people moving into danger zones



Data: U.S. Census Bureau. Graphic: Aon (Cat Insight).

Demographics a major driver

As the map above (**Figure 4**) — based on U.S. Census Bureau data — indicates, the number of housing units in the United States has increased most dramatically since 1940 in many areas that are most vulnerable to weather- and climate-related damage.

Red and purple represent the greatest increases, and these colors disproportionately cluster around hurricane- and flood-prone areas in Florida and Texas, as well as parts of California, Nevada and Washington that are at an elevated risk of wildfire or drought.

“More people are moving to the coasts,” Hartung says. “During the 1900 to 2018 period, if we just look at coastal counties, the areas that have seen the greatest growth in home building are the tri-county area of South Florida, the Houston metro area, and a few places in the Northeast.”

Census Bureau data also show that the homes being built are bigger and more expensive than they were in past decades (**Figure 5**).

Bigger homes filled with more valuables; more vehicles; all the infrastructure that goes with increasing populations — the data suggest that demographic changes play a greater role in natural catastrophe-related claims and losses than weather and climate do. With respect to hurricanes specifically, even a modest rise in the number of landfalls — or no rise at all — could yield the sorts of increased losses the industry has been seeing over the past few decades.

And while there is no strong trend in terms of hurricane frequency or number of landfalls, Hartung points out that there has been some increase in intensity, as well as a more pronounced trend in the rate at which hurricanes intensify and organize.

“Many records have been set in recent years for the time frame within which hurricanes are intensifying,” he said. “Over warmer oceans, tropical cyclones are intensifying at a faster rate than they ever have before.”



Inland flooding has caused more deaths in the United States in the past 30 years than any other hurricane-related threat.

He cited Hurricanes Matthew, Irma, Michael and Dorian as storms that have “set numerous records for quickly going from Category 1 and 2 to Category 5 strength.”

When it rains...

Hurricanes may not be more frequent or significantly more intense, but they do appear to be getting wetter.

Inland flooding has caused more deaths in the United States in the past 30 years than any other hurricane-

related threat, according to [CNN meteorologist Brandon Miller](#), reporting on Tropical Storm Cristobal in June. “Though wind speeds and storm surge are important, and get a lot of the headlines, flash flooding from intense rainfall associated with the storm’s rainbands impact

far more people and stretch over a much larger area.”²

Cristobal made landfall along the coast of southeastern Louisiana between the mouth of the Mississippi River and Grand Isle on June 7, 2020. It was the second-earliest landfalling named storm on record in Louisiana, according to [Dr. Phil Klotzbach](#), an atmospheric scientist at Colorado State University and a [Triple-I non-resident scholar](#).

“Rainfall rates of 3 to 6 inches per hour on June 7 triggered significant flash flooding in parts of downtown Jacksonville, Fla., trapping cars,” [Weather.com reported](#). “Farther west, a weather station in Suwannee Springs, Fla., reported 13.03 inches of rain between midnight and 8 p.m. EDT on June 7.”³

As Cristobal headed north, its associated downpours triggered inland flash flooding from parts of Arkansas and northern Mississippi to northwest Wisconsin.

“As the atmosphere continues to warm, storms can hold more moisture and consequently bring more rainfall,” Klotzbach said. He cited [research by Kerry Emanuel at MIT](#)⁴ that “looked at climate model simulations of future hurricanes in Texas and found that a current one in 100-year rainfall event would be a one in 5.5-year event by 2100.”

2. CNN, “Tropical Depression Cristobal moves inland, but the flooding threat is far from over,” June 8, 2020.

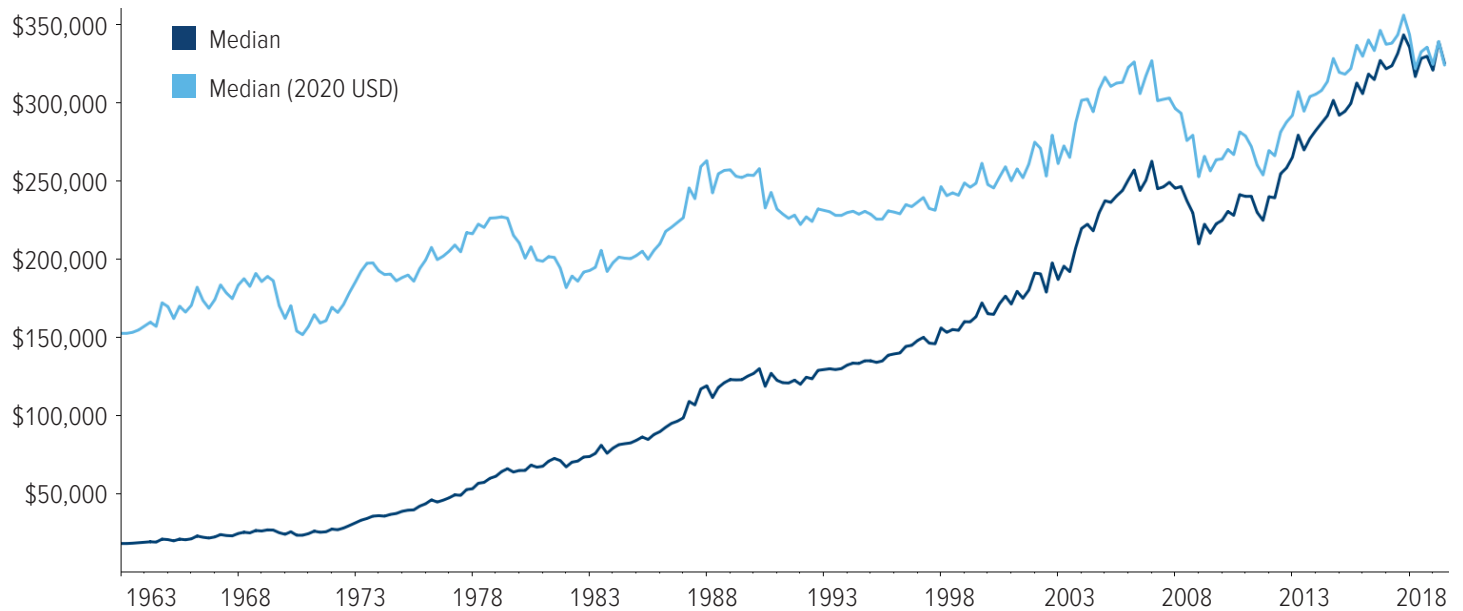
3. Weather.com, “[Tropical Storm Cristobal hammered the Gulf Coast with storm surge, heavy rain, then tracked into the Upper Midwest](#),” June 10, 2020.

4. Kerry Emanuel, “[Assessing the present and future probability of Hurricane Harvey’s rainfall](#),” November 17, 2017.

Fig. 5

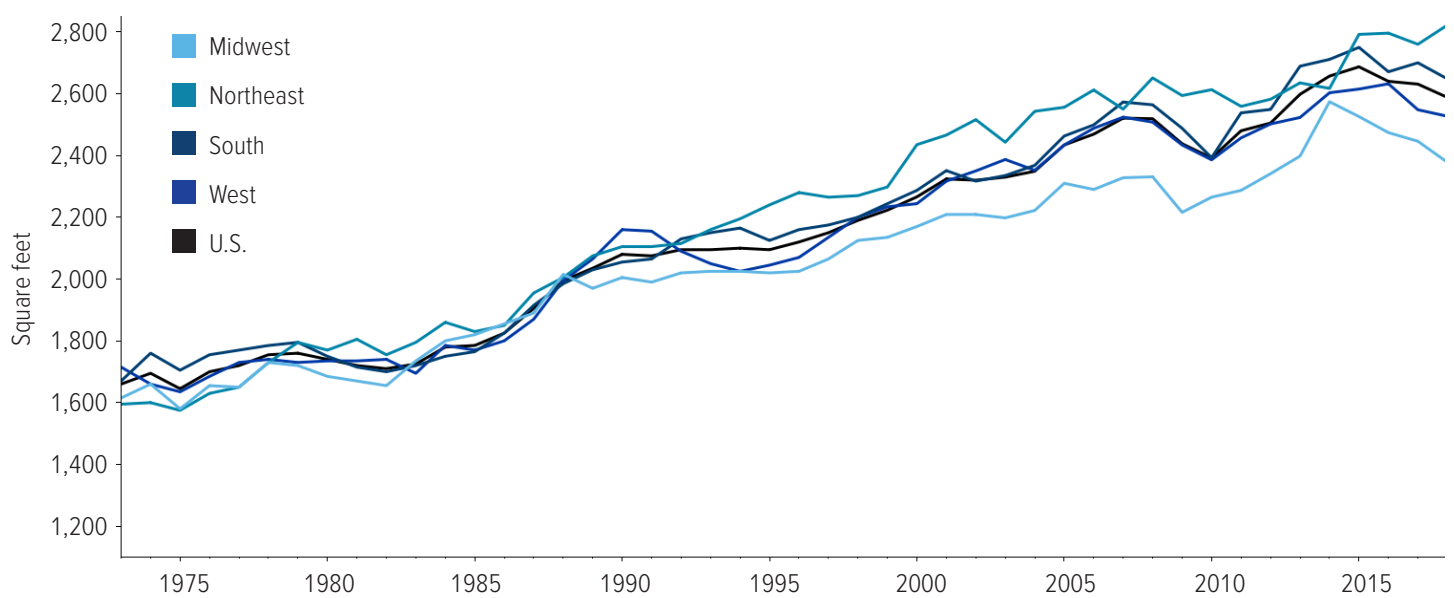
Bigger, more expensive homes — greater potential losses

U.S. median housing value, new home sales, 1963-2019



Data: U.S. Census Bureau. Graphic: Aon (Cat Insight).

U.S. average housing size, completed single-family new home construction, 1973-2018



Data: U.S. Census Bureau. Graphic: Aon (Cat Insight).

While that research was based on fairly pessimistic assumptions about greenhouse gas emissions, Klotzbach said, “Even if we do reduce emissions somewhat, it seems extremely likely that we will see heavier rainfall from tropical cyclones in the future, due to the warmer atmosphere.”

This trend could be exacerbated if, as some in the meteorological community suspect, storms begin traveling more slowly, adding to the moisture they would pick up from the ocean and drop over land.

According to a [recent Swiss Re report](#), a storm of the magnitude Hurricane Katrina — which struck the United States in 2005 and caused economic damage exceeding \$160 billion in 2020 dollars — “could easily” cause \$200 billion worth of damage if it hit today.

According to a recent Swiss Re report, a storm the size of Hurricane Katrina — which struck the United States in 2005 and caused economic damage exceeding \$160 billion in 2020 dollars — “could easily” cause more than \$200 billion worth of damage if it hit today.

Expect higher rates

The collision of rising hurricane losses with high claims due to the coronavirus pandemic suggest property insurance rates will rise.

After conducting virtual field research in Florida, analysts at [Keefe, Bruyette & Woods](#) said they expect reinsurance pricing in the state to increase at least 20 percent.⁵

Reinsurers share the burden of large losses like hurricanes in return for part of the premium. Insurers typically pass at least part of the reinsurance rates they pay onto policyholders.

[Lloyd’s of London](#) said it expected underwriting losses to the insurance sector to be as much as \$107 billion.⁶

“I don’t actually think we will really know the full cost of COVID-19 maybe for up to two years,” Lloyd’s CEO John Neal told CNBC’s “Street Signs Europe.”

Lloyd’s and large global reinsurers are among the entities with the highest reported estimates of pandemic-related losses to date, which rating agency [Fitch reports](#), reinforces further price hardening in reinsurance and specialty insurance lines: “The underwriting response to the pandemic includes tighter terms and conditions, such as virus and communicable disease exclusions and sub-limits in more coverage areas.”⁷

Analysts at securities and investment banking firm [Jefferies Group](#) said they see the hardening of reinsurance pricing lasting until the end of 2021, and that the broad-based firming is now being seen in almost all lines of business globally.⁸

5. *Reinsurance News*, “Florida renewal rate increases of at least 20%: KBW,” May 20, 2020.

6. CNBC, “Coronavirus will be the largest loss on record for insurers, Lloyd’s of London says,” May 14, 2020.

7. Fitch, “Reinsurance Price Hikes Attract Capital Amid Coronavirus Fallout,” June 26, 2020.

8. Artemis, “Reinsurance hard market to last till end of 2021 (at least): Jefferies,” July 9, 2020.



If it can rain, it can flood

About 90 percent of all natural disasters in the U.S. [involve flooding](#). This is why experts like Dan Kaniewski — managing director for public sector innovation at Marsh & McLennan and former deputy administrator for resilience at the Federal Emergency Management Agency (FEMA) — strenuously urge everyone to buy flood insurance.

“Any home can flood,” Kaniewski said in a recent [Triple-I webinar](#). “Even if you’re well outside a floodplain.... Get flood insurance. Whether you’re a homeowner or a renter or a business — get flood insurance.”

[Dr. Rick Knabb](#) — on-air hurricane expert for the Weather Channel, speaking at Triple-I’s 2019 [Joint Industry Forum](#) — was similarly emphatic.

“If it can rain where you live,” he said, “it can flood where you live.”

Knabb recounted buying a new home, asking his agent about flood insurance, and being told, “You don’t need it.”

“I told him, ‘Get it for me anyway,’” he said.

Flood damage is excluded under standard homeowners and renters insurance policies. However, flood coverage is available as a separate policy from the National Flood Insurance Program (NFIP), administered by FEMA, and from a growing number of private insurers. The NFIP, created in 1968, makes federally backed flood insurance available in communities that agree to adopt and enforce floodplain management ordinances.

Flood was long considered an untouchable risk by private insurers because they did not have a reliable way to measure the risk. However, insurers in recent years have become more comfortable using sophisticated models to underwrite and price flood insurance, and modeling firms are getting better at predicting the risk (see “Modeling and Forecasting Advance Resilience,” page 13).

There were 140 private companies writing flood insurance in 2019, compared with 116 in 2018, according to National Association of Insurance Commissioners (NAIC) data compiled by S&P Global Market Intelligence.

Many people — even inside designated flood zones — don’t have coverage or are unaware that homeowners policies typically exclude coverage for flood damage.

“The private flood insurance market in the United States has really started to gain traction over the past few years, but there’s still a large untapped opportunity out there,” said Marla Schwartz-Pourrabhani, a natural catastrophe specialist with Swiss Re. “Many people — even inside designated flood zones — don’t have coverage or are unaware that homeowners policies typically exclude coverage for flood damage. As modeling continues to improve and insurers become more confident pricing flood coverage based on our models, we’re hopeful more and more people can be protected.”

Increasing insurance capacity made available by the private market helps spread the risk associated with flooding, and growing competition should make the coverage — especially in communities not designated as flood zones — more affordable.

A worrisome protection gap

Nevertheless, even in designated flood zones, the protection gap remains large.

A [McKinsey & Co. analysis](#) of flood insurance purchase rates in areas most affected by three Category 4 hurricanes that recently made landfall in the United States — Harvey, Irma, and Maria — found that as many as 80 percent of homeowners in Texas, 60 percent in Florida, and 99 percent in Puerto Rico lacked flood insurance.⁹

To make matters worse, a [recent analysis](#) by the nonprofit [First Street Foundation](#) found the United States to be woefully underprepared for damaging floods. The report consists of a high-level methodological overview, a national summary, and a state-by-state analysis of the lower 48 states and the District of Columbia, with a focus on providing insight into flood risk, adaptation, and how changing environmental factors impact future flood risk.¹⁰

The foundation identifies “around 1.7 times the number of properties as having substantial risk,” compared with FEMA’s designation.

“This equates to a total of 14.6 million properties across the country at substantial risk, of which 5.9 million property owners are currently unaware of or underestimating the risk they face,” the foundation says.

The foundation’s national property-level data supports a range of efforts, including helping individuals and businesses understand and mitigate the risks associated with their properties and to help governments make better-informed policy decisions. First Street has created the [First Street Foundation Flood Lab](#) — a collection of academic and industry researchers who will drill into the data to better understand flood risk, its consequences and to develop possible solutions.

FEMA Risk Rating 2.0

Recognizing that purchasing flood insurance can be confusing and time-consuming, FEMA is redesigning its risk rating system to improve the policyholder experience. [Risk Rating 2.0](#) “aims to accomplish this by leveraging industry best practices and current technology to deliver rates that are fairer, easier to understand, and better reflect a property’s unique flood risk.”

FEMA’s goal is to make flood insurance significantly easier for agents to price and sell policies and, in turn, help customers better understand their flood risk and the importance of flood insurance. The new rating system is slated to go into effect in October 2021.

9. McKinsey, [Insuring Hurricanes: Perspectives, Gaps, and Opportunities After 2017](#), December 2017.

10. First Street Foundation, [Highlights From “The First National Flood Risk Assessment,”](#) June 29, 2020.

Hurricane prep and response

Hurricane preparation, mitigation and recovery methods have come a long way in recent decades. Just ask Todd Blachier, risk control consultant manager at Church Mutual Insurance, a leading insurer of houses of worship.

With nearly two decades providing risk control advice and deep roots in Louisiana, one of Blachier's earliest memories is evacuating from his parents' home on a flatboat as Hurricane Betsy bore down on New Orleans in 1965.

"Back then, someone said, 'Hurricane's coming!' and you saw very little evacuation," Blachier said. "Many people still don't evacuate the way they should, but states like Louisiana, Florida, Alabama and Mississippi have gotten much better over the years in terms of shutting down inbound roads and creating one-way egress to facilitate evacuation."

He says officials are acting much more quickly and communicating more effectively, thanks in large part to improved information from the National Oceanic and Atmospheric Administration (NOAA) and other resources.

"Houses of worship are more willing to evacuate than they used to be," he said. With improved forecasts and communication giving them more time to prepare, "they want to button everything up and get out of there so they can come back as fast as possible" to provide services and shelter for people who've been displaced by the disaster.

Playing this role will be a challenge during the COVID-19 pandemic.

"We're encouraging houses of worship to strictly follow [CDC guidelines](#)," Blachier said

The biggest problem during hurricane season, Blachier emphasized, is failure to prepare adequately.


Secure property, build in resilience

When managing risks related to wind and water, it is important for homeowners, businesses and other organizations to make sure their property and buildings are well built and maintained and that any objects that might become projectiles in high wind are secured.

Zurich Risk Engineering Services, part of Zurich Insurance, recently replaced its own standard for assessing exposures to customer buildings and new construction with the [FORTIFIED Commercial](#)™ standards and compliance program created by the [Insurance Institute for Business & Home Safety](#) (IBHS). IBHS is a nonprofit research and communications organization supported by property/casualty companies that insure or reinsure risks in the U.S. Its scientists and risk communicators deliver strategies to build safer and stronger homes and businesses — to help insurers and property owners avoid losses.

IBHS research contributes to product and standards improvements aimed at reducing damage and losses due to hail, wildfire, hurricanes, tornadoes and rain. Zurich encourages all its customers to adhere to FORTIFIED Commercial standards, which it says makes new and existing commercial buildings stronger against severe weather, including high wind.

"Most local building codes are designed primarily for human safety—not to preserve buildings," said Adam Hurley, head of Property Risk Engineering Services for Zurich North America. "FORTIFIED Commercial goes further. The benefits of building to the IBHS FORTIFIED Commercial standard have been recognized by modeling programs used by many insurance companies to help develop rates and premium. The financial incentive to apply these standards lies in the potential for fewer damages and the ability to recover more quickly."

 **Because high winds can expose structures to further damage due to water seepage and animal intrusion, it is important to detect damage as early as possible.**

Identify damage quickly

Because high winds can expose structures to further damage due to water seepage or animal intrusion, it is important to detect damage as early as possible. Historically, it has been difficult, time-consuming, and dangerous for insurance adjusters to get up onto every insured building in an area affected by hurricanes to look for damage.

Advances in aerial imagery are helping to address this deficit. Whether using drones, manned aircraft or satellite technology, it is getting easier and less expensive for insurers to assess damage remotely. These technologies become even more important as COVID-19 complicates the process of putting personnel on the ground.

Zurich has developed a [Remote Collaboration](#) app to allow its risk engineers to conduct virtual site visits. The app was launched in 2019, long before anyone thought a pandemic would make physical site inspections an even riskier proposition than they already were.

Better building codes would help

Implementing modern building codes would go a long way toward mitigating losses from hurricanes and other natural disasters and helping communities and businesses bounce back after such events.



Implementing modern building codes would go a long way toward mitigating losses from hurricanes and other natural disasters.

A recent [study](#) by the Federal Emergency Management Agency (FEMA) quantifies the physical and economic losses that have been avoided due to buildings being constructed according to modern, hazard-resistant building codes and standards.

In [California and Florida](#) — two of the most catastrophe-prone U.S. states — the study found that adopting and enforcing modern hazard-resistant building codes over the past 20 years indicate a long-term average future savings of \$1 billion per year for those two states combined.¹¹

“The combined savings from these two states demonstrate the high value of adopting I-Codes for hazard mitigation as a return on investment,” FEMA wrote, referring to model construction codes published by the [International Code Council](#).

“This gives us the foundation to back up the recommendations that we’re making,” FEMA building engineer [Jonathan Westcott said](#) at a recent conference on flood prevention.¹²

The study is part of FEMA’s broader effort to reduce the growing cost of natural disasters by convincing states and municipalities to adopt post-2000 building codes. Two-thirds of the nation’s localities have not adopted recent model codes, Westcott said.

Communities often don’t understand the long-term benefits of adopting stronger codes.

“Instead of just hearing about how expensive it is to add a foot of freeboard,” Westcott said, “they’re going to understand the financial benefits of doing that so they can make a balanced decision on what’s best for their community.”

11. FEMA, [Building Codes Save: A Nationwide Study of Loss Prevention](#), Summer 2020.

12. [E&E News, Tougher Building Codes Would Avert Major Losses, FEMA Study Shows](#), June 13, 2020.

Modeling and forecasting advance resilience

The more accurately experts can predict a hurricane's formation and impact, the better prepared individuals, communities, and businesses can be to soften the blow and bounce back from the damage.

Until the advent of Doppler radar and satellite imagery, those wishing to forecast hurricanes and other weather events were confined to using historical data and ground-based observations and measurements. Doppler and satellites greatly improved forecasting, but insurers still struggled to price hurricane risk appropriately.

"Before Hurricane Andrew in 1992, policyholders' rates were often based largely on historical experience," said Swiss Re Atmospheric Perils Specialist Marla Schwartz-Pourrabani. As accident and ticket history affect the premiums drivers pay for car insurance, homeowners' rates were based, in part, on whether their homes had previously been damaged by a hurricane. "As a result, some communities paid much more than their neighbors, simply because an event that could well happen to them never had before."

Some empirical models mostly based on historical data, Schwartz-Pourrabani said, "may have never seen Andrew coming."

Andrew was a Category 5 storm that hit Florida on August 24, 1992, with wind speeds of 165 mph. The storm caused damage to southern Louisiana and the Bahamas, but the brunt of its impact fell on South Florida, where:

- About 250,000 people were left homeless in Dade County alone,
- Twenty-six people died, and
- 25,524 homes were destroyed and 101,241 others were damaged.

Insured losses totaled \$25.9 billion in 2019 dollars. At least 16 insurers failed in 1992 and 1993 because of Andrew. Limited availability of insurance coverage for the

most vulnerable properties — a problem before 1992 — became a crisis in Andrew's aftermath.

In the decades since, hurricane modeling and forecasting have evolved in both sophistication and insurer acceptance.

More data, better tools

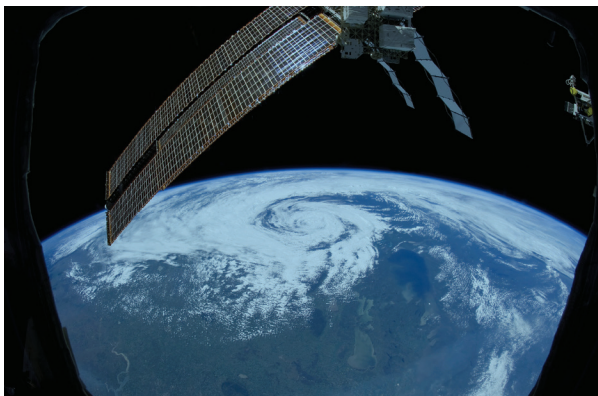
The availability of vastly greater amounts of data — combined with ever-increasing computing power and storage capacity — has enabled modelers to create more elaborate simulations than would have been possible even just a few years ago. Meteorological data from

The availability of vastly greater amounts of data — combined with increasing computing power and storage capacity — has enabled modelers to create more elaborate simulations than would have been possible even just a few years ago.

satellites, ground-based stations and aviation sources have become more abundant and refined. At the same time, modelers today have access to more demographic and economic data and more granular details about the physical characteristics of structures to inform their work.

Tapping expertise from the disciplines of statistics, finance, computer science, engineering and others, risk modelers now can tweak initial conditions of past storms to see how new storms with similar characteristics might play out under various scenarios.

Actuarial models using advanced statistical tools can predict the impact of tens of thousands of potential hurricanes over thousands of years. One meteorology component of a model uses [up to 55,000-year simulations](#) to generate stochastic data — meaning the data is randomly determined but still may be analyzed statistically — based on observed historical hurricane tracks. For every one of these simulated storms, there is an estimated track and a set of modeled wind fields at succeeding time intervals.



Advances in modeling have led to increased confidence in and adoption by insurers, enabling them to underwrite risks they would not have before and making new insurance products possible.

Even ZIP codes are accounted for, providing a finely tuned model that generates data that are both broad in time frame and very specific in direct impacts.¹³

Hurricane climatologists have developed statistical models to predict the level of coastal hurricane activity, with a focus on climate conditions prior to the beginning of the season — sometimes throughout the past 50 years, or for however long data is available. With [this methodology](#), scientists have found that climate conditions prior to a hurricane season can help determine the distribution of probable annual losses.¹⁴

Models like the two mentioned above are not always used in conjunction, as many are privately owned and not synthesized for collaboration. Some researchers have tried to combine data from several public models to create a more holistic picture of how to account for the potential damage caused by hurricane seasons. [One such study](#) outlined a methodology to conduct research that combined meteorological and topographical science with the building codes of affected areas.¹⁵

Not just satellites and software

It can be tempting to think of hurricane forecasting and modeling as being all about high-resolution images, big data and sophisticated algorithms. While these technologies are critical to developing and implementing effective models, they depend heavily on local knowledge and “boots on the ground.”

“After an event, we quickly send engineers to survey structural damage and look for linkages to the storm’s characteristics,” said Jeff Waters, senior product manager for risk modeler RMS. “Information gathered by our people on the ground is incorporated into our reconstruction of

the event to help us identify drivers of the damage and inform our models.”

Waters recounted how, in the wake of Hurricane Maria in 2017, an RMS team arrived in Puerto Rico on October 3 — 13 days after landfall — to validate a modeled loss estimate. During the week the team spent on the island, they found that damage to insured buildings was less than expected for a storm of Maria’s magnitude. They also observed that most insured buildings featured bunker-style reinforced-concrete construction and flat concrete roofs.

“These buildings performed very well,” Waters said. “Reinforced concrete prevents significant structural damage, and, with less drywall and tiled flooring, interior damage from water intrusion is limited. Wood and light-metal structures — which tend to be in older neighborhoods where fewer properties are insured — fared far worse.”

Such ground-level information not only helped validate RMS’s loss estimate — it also contributes to the model’s continuous improvement. You can read [a more detailed account](#) on the RMS blog.

Will COVID-19 foul up our forecasts?

As with many other aspects of hurricane preparedness and response, the coronavirus pandemic could complicate modelers’ ability to get the information they need.

Forecasting models depend heavily on [data collected by aircraft](#). A 2017 [American Meteorological Society study](#) found that using aircraft observations reduced six-hour forecast errors in wind, humidity, and temperature by 15 percent to 30 percent across the United States.

13. Shahid S. Hamid, Florida International University, [Actuarial Model for Estimating Insured Hurricane Losses](#).

14. Thomas H. Jagger, Florida State University, [Forecasting Insured U.S. Hurricane Losses](#), January 2008.

15. Charles C. Watson, Jr., Mark E. Johnson, Martin Simons, [Insurance Rate Filings and Hurricane Loss Estimation Models](#).

Reduced air travel due to the pandemic raises the possibility that the models could become less effective, leading to less timely preparation and bad weather-related decisions. From an insurance perspective, this could result in larger claims and losses.

Colorado State University atmospheric scientist [Dr. Philip J. Klotzbach](#) — a [Triple-I non-resident scholar](#) — does not find this overly concerning.

“The lack of aircraft data has a greater impact on shorter-term forecasts — say, one day or less — than it does on forecasts five to seven days out,” Klotzbach said, adding that some of the data loss can be mitigated by other sources, such as additional launches of weather balloons.

RMS’s Jeff Waters echoed that sentiment in terms of the possibility of COVID-19 restricting his company’s ability to put personnel on the ground quickly after a hurricane.

“Timely local information is important,” he said, “but we have numerous other data resources as well.”

Growing confidence among insurers

Advances in modeling have led to increased confidence in and adoption by insurers, enabling them to underwrite risks they would not have before and making new insurance products possible. Parametric insurance is one that could not have been feasible without sophisticated models.

Parametric policies promote post-disaster resilience by covering risks without the complications of sending adjusters to assess damage. Instead of indemnifying for the actual loss incurred, parametric insurance policies pay a fixed amount to policyholders if an event that meets agreed-upon criteria (wind of a certain speed, for example, or an earthquake of a specific magnitude) triggers the terms of the policy, regardless of whether the policyholder’s property experiences any damage.

A policy might be structured to pay out 50 percent, 75 percent, or 100 percent of a predefined limit for a Category 3, 4, or 5 hurricane within a 30-mile radius around the client’s property.

Speed of payment and reduced policy administration costs can ease the burden on both insurers and policyholders.

“As climate-related weather risks become increasingly complex and unpredictable, the requests for such innovative parametric insurance structures have been increasing,” [according to Marsh and McLennan](#). “Improved data and models enable parametric cover as an increasingly efficient, affordable and viable option in the market.”

According to Schwartz-Pourrabbani, parametric policies are not intended to replace traditional insurance but to complement it and speed up recovery. [SwissRe’s STORM](#), for example, is a parametric product designed to complement traditional insurance to cover a range of losses related to a named storm. It uses [RMS HWind](#) data to calculate wind speed closest to policyholders’ properties. For insureds with multiple locations, coverage limits can be allocated based on their needs.

Still evolving

Despite these advances, disagreement remains as to which models are best suited to predict hurricane development and the damage they can cause. The [proprietary nature](#) of these models can make it difficult for regulators who are charged with determining whether the filed rates based on models are extreme, insufficient or unfairly discriminatory. It also can discourage collaboration and cooperation among the companies that develop and market them.

Triple-I Research Writer Max Dorfman contributed to this article.

Waffle House: Casual dining, an informal risk metric

By Maria Sassian

The Waffle House's unassuming and reliable food has earned the 24/7 diner chain a devoted clientele. Anthony Bourdain once [described it](#) as "A place of safety and nourishment. It never closes, it is always, always faithful, always there for you."

There are more than 2,000 Waffle House restaurants across 25 states, mostly in the southern U.S. areas that also happen to be frequently hit by hurricanes. And since the diners often manage to stay open during natural disasters, they are even used as an informal measure of how severely a catastrophe has affected an area.

The "Waffle House Index," was first coined by former Federal Emergency Management Agency (FEMA) Director W. Craig Fugate. The idea occurred to him while surveying tornado damage in 2011: "If you get there and the Waffle House is closed? That's really bad. That's where you go to work," [he said](#).

The simple but ingenious idea works like this:

- If a Waffle House is open and serving its full menu: **Green**. That means the diner probably has power or is running on a generator.
- If a Waffle House is open but serving a limited menu: **Yellow**. The diner may not have electricity or running water but can still cook on a gas stove.
- If a Waffle House is closed: **Red**.

Waffle House's risk-management procedures and disaster preparedness are good for the communities it serves.

"Businesses in communities are often some of the biggest drivers of recovery," wrote FEMA's Jessica Stapf in a blog post. "If stores can open, people can go back to work. If people can go back to work, they can return to at least one piece of a normal

life — and that little piece of normalcy can make a big difference."

[Panos Kouvelis](#), an Olin Business School professor at Washington University in St. Louis and an expert in supply chain management, cited Waffle House as one of several "world-class examples in their disaster management and humanitarian response planning

approaches." His paper, "The 'Waffle House Emergency Level Index,'" detailed how businesses, including Wal-Mart, Lowe's, and Home Depot, provide key services to recovering communities.

Kouvelis said predicting customer demand after a disaster, establishing appropriate and ethical prices, and maintaining adequate workforce levels after a disaster event "are

all part of an ironclad recovery plan."

Waffle Houses are also disaster-ready with backup generators and fuel, and "jump teams" from several states away in case local staff have evacuated or have to take care of family. They also have construction teams and mobile communication RVs ready to assist from the corporate headquarters in Norcross, Ga.

If Waffle Houses have proved particularly resilient to storms, they have been vulnerable to the economic impact of the COVID-19 pandemic. In March, the index [went to Red](#) — the first time ever for a non-weather-related disaster. Like most businesses, Waffle House is grappling with keeping employees and customers safe. In April 2020, at least 700 locations were reported to be closed due to the coronavirus pandemic.

Chairman Joe Rogers Jr. spoke to [Forbes](#) in late April about the worst-case scenario for the chain. He said that if the recession turns into a full-blown depression, "Then, in a lasting way, we can only operate probably half the restaurants."

In the meantime, Waffle House has been finding ways to adapt, including selling bags of its waffle mix to make at home and partnering with an online service to make home deliveries.





A better tool to predict hurricane damage?

A recent paper in the *Bulletin of the American Meteorological Society* suggests an underutilized tool may be better at predicting hurricane damage than the traditionally used “maximum sustained wind speed.”

The commonly used Saffir-Simpson Hurricane Wind Scale measures only the hurricane wind threat — not the totality of impacts, including storm surge and rainfall. According to the report, several scales have been proposed to replace Saffir-Simpson, but most are not easily calculated in real time, nor can they be reliably calculated historically.

Minimum sea level pressure (MSLP), the paper finds, is a better predictor of the scope of a storm’s damage and can be more accurately measured in real time, “making it an ideal quantity for evaluating a hurricane’s potential damage.”

MSLP is the lowest pressure recorded in a hurricane. It occurs at the center of the storm and is part of the large-scale structure of a hurricane’s vortex. Because winds are generated by differences in barometric

pressure between the hurricane’s eye and its perimeter, lower pressure is typically associated with stronger winds. Also, if two hurricanes have the same wind speed, the one with the lower pressure typically will cover a greater area, potentially posing greater storm surge risk.

“With aircraft reconnaissance, MSLP can be reliably calculated,” the paper says. It’s also much easier to measure at landfall than is maximum sustained wind speed. “Barometers are among the simplest meteorological instruments and will usually operate in a wide range of conditions,” the report says. Anemometers, which measure wind speed, “are prone to mechanical failure...precisely when they matter most.”

The paper was authored by [Dr. Philip J. Klotzbach](#) — a Colorado State University atmospheric scientist [Triple-I non-resident scholar](#) — along with scientists from the National Oceanic and Atmospheric Administration (NOAA), North Carolina State University, the University Corporation for Atmospheric Research, and insurance broker Aon.

Additional Reading: From [The Triple-I Blog](#)

[If the Power Goes Out, Can You Get Reimbursed for Spoiled Food?](#) (August 27, 2020)

[Ordered to Evacuate Due to Hurricane Laura? You Might Have Insurance Coverage for Additional Living Expenses](#) (August 27, 2020)

[Hurricane Laura Update: 8/27/2020](#) (August 27, 2020)

[Hurricane Watch: 8/25/2020](#) (August 25, 2020)

[Laura and Marco Set Sights on Northern Gulf Coast](#) (August 24, 2020)

[Hurricane Isaias Follow-Up: 8/11/2020](#) (August 12, 2020)

[2020 Hurricane Forecast Updated: “Extremely Active” Season Expected](#) (August 5, 2020)

[Isaias Meets COVID-19: South Floridians Advised to Consider Evacuation](#) (July 30, 2020)

[Close Call for Hawaii as Hurricane Douglas Passes](#) (July 27, 2020)

[Hurricane Hanna Leaves Wind Damage and Flooding in Its Wake](#) (July 27, 2020)

[Lightning Rounds: Investing in Disaster and Risk Management Technology](#) (July 17, 2020)

[Hurricane Modeling: High-Tech Meets Local Insight](#) (July 13, 2020)

[Mangroves and Reefs: Insurance Can Help Protect Our Protectors](#) (July 10, 2020)

[Colorado State University Issues Updated Forecast for 2020 Hurricane Activity](#) (July 7, 2020)

[Understanding FEMA and Other Flood Maps](#) (July 1, 2020)

[Triple-I, ResilientH2O Partners Launch Resilience Innovation Hub](#) (June 18, 2020)

[Modern Building Codes Would Prevent Billions in Catastrophe Losses](#) (June 16, 2020)

[Get Your Business Ready for Severe Weather — How to Prepare, Respond & Recover](#) (June 11, 2020)

[World’s Insurance Markets Hit Hard by COVID-19: Triple-I](#) (June 11, 2020)

[Hurricanes Don’t Just Affect Coasts; Experts Say: “Get Flood Insurance”](#) (June 9, 2020)

[COVID-19 Wrap-Up: Pandemic Complicates Hurricane Preparation](#) (May 26, 2020)

[Webinar: Building Resilient Businesses and Communities in the Time Of COVID-19](#) (May 14, 2020)

[Triple-I Paper Looks at Convective Storms, Mitigation, and Resilience](#) (May 7, 2020)

[National Hurricane Preparedness Week 2020](#) (May 1, 2020)

[Will COVID-19 Foul Up Our Weather Forecasts?](#) (March 27, 2020)

[Mississippi Flood Insurance Purchases Low, Despite Wetter Rainy Seasons — And They’re Not Alone](#) (February 25, 2020)

[A Better Tool to Predict Impact of Hurricanes?](#) (February 14, 2020)



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