Moody's

Adapting to Hurricane Risk

Quantifying Benefits Now & in the Future for Insurers and Real Asset Investors

A Florida Case Study

Profitable Coastal Markets Continue to Grow Despite Increasing Hurricane Risks

More than half of the world's population live in cities, and by 2050 that will include an additional 2.5 billion people, according to United Nations estimates. Some of the fastest-growing urban centers in the United States are the most exposed to physical climate hazards and are at risk for rising perils in a warming climate.

Given the increasingly costly and severe nature of physical climate risks in urban centers, adaptation measures that help lower the built environment's susceptibility to hazard-based damages are crucial. Areas such as South Florida, which includes the Miami metropolitan area and the Florida Keys, continue to see population growth and development expansion despite the high risks associated with rising sea levels and hurricanes.

Addressing Hurricane Hazards with Adaptation Investments

Hazards from hurricanes and sea-level rise are predicted to become more severe with climate change. Hurricane hazards include high wind velocities, storm surge and associated flooding, and extreme precipitation.

Cities and governments have the option to protect populated areas along the coastline from hurricane-induced flooding and damage by investing in robust coastal defense infrastructure, such as seawalls, levees, and storm surge barriers. While construction and maintenance costs may be substantial, in the long run, the economic losses that can be avoided from property damage and business interruption make these adaptation measures economically viable.

Additionally, implementing stricter building codes and standards for hurricane-prone regions will enhance the structural integrity of buildings and reduce the risk of great destruction during severe storms. Although compliance costs may initially be higher, the overall economic benefit – in terms of reduced reconstruction expenses and human casualties – is significant.

Measuring the cost-benefits of adaptation investments is crucial to making strategic upgrades and property construction decisions. Allocating capital and building resilience into properties are both essential to maintaining viable insurance markets in at-risk regions.

Climate Hazards

Translating Physical Climate Risk into Business Impacts and Damage

The monetary impact of investments and prospective adaptation measures is quantifiable and can be translated to business strategies in financial terms. Moody's physical climate risk models assess potential financial impacts using a framework that combines hazard, exposure, vulnerability and financial modeling. Moody's has developed robust, science-based and comprehensive property-level integrated risk models that provide high resolution, ground-up hurricane risk-cost information with downstream impacts to the built environment and businesses. These models go deep into hazard risks and financial impact drivers to measure on-the-ground adaptation cost-benefit analyses at location levels.

To quantify hazard, the models combine bottom-up weather simulations using climate model output and the latest scientific consensus on climate change. They calculate the expected frequency and severity of weather and climate events both now and in the future, along with the details of hazard associated with such events, such as flood depths, windspeeds, and expected wildfire burn areas.

Vulnerability curves translate hazard into damage and disruption and are developed from engineering studies, regional building codes, and information on millions of losses from real events, including property level repair and business interruption costs. This helps to reflect the local and regional variations that affect how real assets respond to extreme weather events.

To measure financial impacts, Moody's uses average annual damage (AAD) metrics, which are the expected damage in dollars (or other currency) per year, on average, over time. The financial impact depends on the value of the assets as well as the hazard and vulnerability.

Adaptations to Hurricane Risk

Real World Spotlight: Extreme Wind and Storm Surge in South Florida

Let's delve into a few residential properties in South Florida and their relative exposure to the hurricane perils of extreme wind and storm surge, as explored through present and future AAD values. As shown with these examples, construction building codes clearly influence predicted hurricane damages and how these damages are expected to change over time in a warming climate.

Extreme Wind

By comparing standard, two-story, single-family homes near the south Florida Coast – one constructed in the early 1990s and the other constructed in 2022 – clear differences emerge in expected extreme wind damages between the two homes. Notably, building codes between the 1990s and present day have progressed to include advanced construction techniques and materials to enhance wind resistance.

More recently, Florida building codes have placed greater emphasis on the use of impact-resistant windows, reinforced doors, enhanced roof coverings, and stronger connections between structural elements, such as hurricane straps or clips. These new construction adaptations lower expected hurricane damage costs associated with intense winds and are effective at reducing AAD, as shown in the table below.

Present Day Wind Derived Average Annual Damage

Building Code Era

1990s	2022
$28,448	$4,603

1990s Building Code Era

2022 Building Code Era

Extreme Wind Impacts in the Future

Looking ahead to 2050 under Representative Concentration Pathway (RCP) 4.5 (an intermediate emissions scenario with moderate additional effort to constrain emissions), extreme wind impacts from hurricanes are predicted to become increasingly more severe.

The impact of Florida building code upgrades is even more apparent from a growing gap in expected average annual damages. These simple upgrades in building requirements result in significantly reduced damage and costs year-on-year over the long term, paying 'dividends' within the term of a 30-year mortgage taken out today.

2050 Wind Derived Average Annual Damage

Building Code Era

1990s	2022
$34,129	$5,584

Storm Surge

A comparison of South Florida homes that are identical in distance to the coast and ground elevation show that building code requirements and building height are both important factors for lowering expected financial impacts from storm surge. Similar to extreme wind, the effect of storm surge on these residences illustrates the influence of building construction on the financial impacts of physical climate risks.

Building code advances in the last decade are based on building elevation specifications that incorporate the concept of base flood elevation (BFE), the level to which water will likely reach during a flood with a 1% probably of occurring per year. To sustain insurance, new build structures in designated flood zones must be constructed above the BFE to mitigate the risk of storm surge damage. In addition, the building code has further defined areas where coastal construction needs to be regulated to protect against erosion of dunes during a storm surge.

The emerging predictor of lower storm surge risk is the height of the ground floor of the building as shown below.

Present Day Base Flood Elevation (BFE)

Present Day Storm Surge Derived Average Annual Damage

Below Code	At Code	Above Code
$56,120	$30,101	$5,619

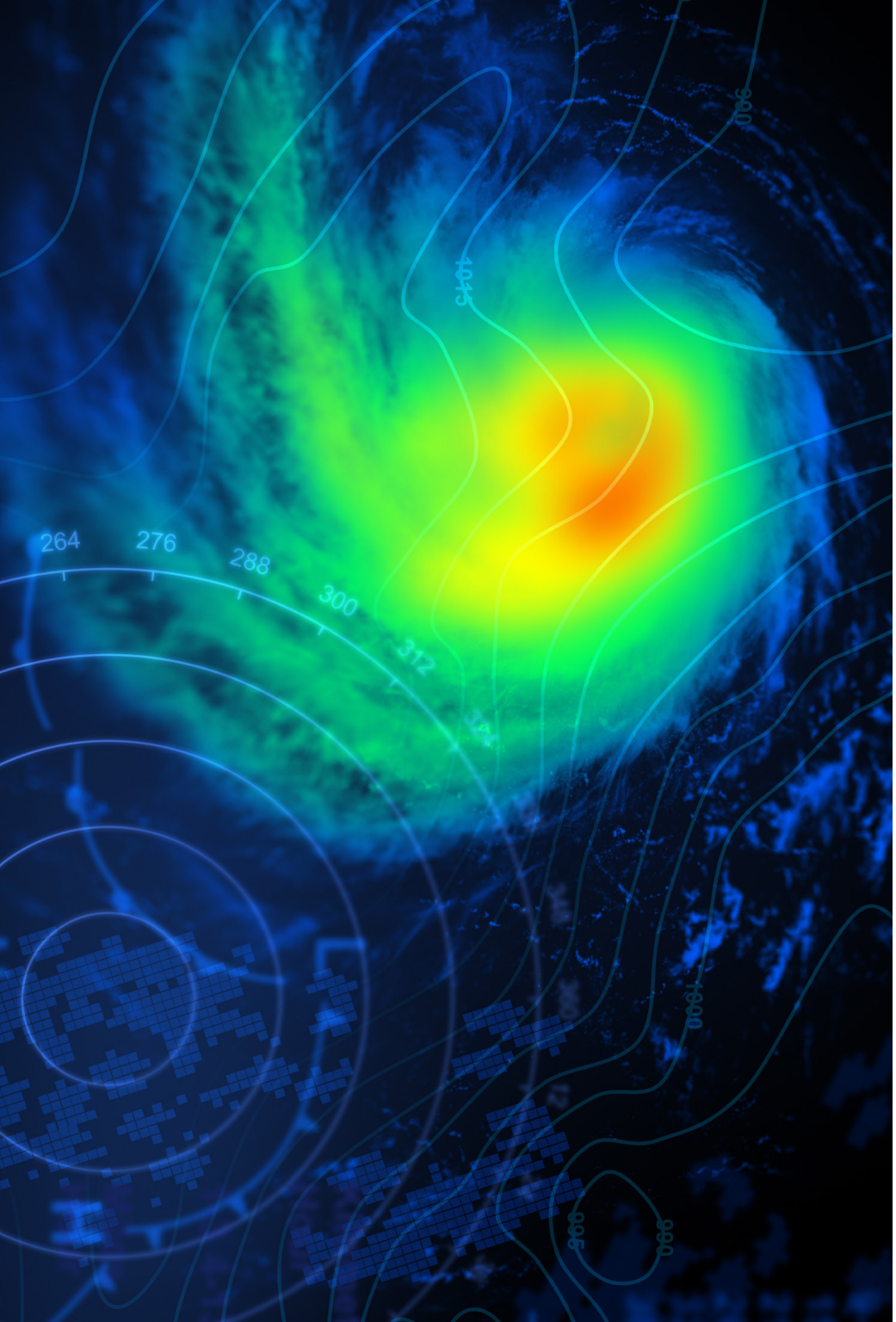
Storm Surge Impacts in the Future

Looking ahead to 2050 under RCP 4.5, the structures which have been elevated the most are predicted to have significantly lower expected AAD. They will avoid the most catastrophic impacts from all but the most extreme hurricane storm surge, as shown below.

This study clearly shows that even present-day building codes reduce future AAD. Additionally, there may be opportunities for new builds to consider enhanced adaptation measures that account for increasing storm surge risks. In this case, superseding present-day building BFE requirements results in a significant reduction in storm surge AAD by the mid-century to just 20% of a property built to the current BFE elevation. This type of analysis enables homeowners and planners to directly weigh the value of advanced adaptation measures in terms of the reductions in expected future damage estimates that could be incurred towards the end of a 30-year mortgage term.

2050 Storm Surge Derived Average Annual Damage

Below Code	At Code	Above Code
$88,886	$46,264	$9,650



Importance of Asset-Level Risk Mitigation Measures

This brief study highlights the importance of considering asset-level risk mitigation measures when developing or investing in high-risk locations, including South Florida and the many fast-growing urban centers around the world. Decision-makers can now directly weigh incremental adaptation investment costs against the value of future risk reduction in dollar-to-dollar terms. Most recently, Moody's RMS published a study on preliminary observations from August 2023's Hurricane Idalia (which made landfall in North Florida) showing that newer buildings generally fared better, highlighting the significance of advanced building codes. Additionally, elevated homes were only lightly touched compared to some of their lower neighbors, which were badly damaged by flooding. This real-world example demonstrates the very real reduction in damage that results from the adaptation investments discussed in this study.

Moody's

Moody's on Climate

Climate Risk is Business Risk

The foundation of Moody's value is market insight defining our approach to financial quantification of risk and the capabilities to deliver consistent and complete perspective on the interconnected risks impacting your business.

Moody's on Climate encompasses market-tested analytical tools designed for identifying and quantifying the impact of climate risk on global debt markets, credit performance, and financial outcomes.

Our solutions enable understanding of physical climate risks by leveraging decades of real-world data on damages and costs from climate events to inform transparent and robust solutions for modeling risk to real assets and translating it to company and entry-level impacts. We cover transition risk with comprehensive and continuously improving datasets, analytics, and assessments of policy, macroeconomic trends, and company-specific profiles to analyze the impacts of potential future climate scenarios.

Our solutions are developed to seamlessly integrate into the workflows your teams manage across the organization, in which climate data, analytics, and insights should inform strategy and decision-making to future-proof your competitive position in the market.

Learn more at **https://climate.moodys.com/**

Our physical risk capabilities are developed on the foundation of Moody's RMS climate science and modeling expertise. For more than 20 years, Moody's RMS has worked with partners and stakeholders to understand the complexity of modeling physical risks and financial impacts on P&C insurance portfolios and assets. We have extended our understanding of the interconnected and complex dimensions of current risk with globally recognized, forward-looking climate change models and best-available climate science to develop consistent frameworks for assessing future scenarios of risk applicable to enterprise risk management across sectors.

Learn more at **https://www.rms.com/climate-change**

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