BANKING & INSURANCE SPECIAL REPORT

A Deluge of Risk...and a Looming Crisis

Insurers and lenders have failed to adequately price the exposure of likely events, such as climate-change-driven chronic flooding, into their portfolios.

A Jupiter Intelligence study shows that even moderate flooding can have a massive economic impact and cause systemic failure. The study focuses on Miami-Dade County, Florida, but has implications for all communities vulnerable to sea-level rise and prolonged rain events, as well as severe storms.

"Ignoring, or underestimating, the actual economic risk posed by moderate flooding is common to other geographies in the U.S. and around the world," warns Rich Sorkin, co-founder and CEO of Jupiter. "Almost none of this risk is reflected in prices. Most of this dynamic is not yet understood, nor is it implemented into the decision-making of financial institutions."

The Jupiter study reveals that:

- **By 2050, 61 percent more properties in Miami-Dade County will be at risk for chronic flooding than are at risk today**, diminishing or destroying home valuations, drastically increasing the needs for resiliency spending by local communities, and causing a rise in building and business interruption claims to insurers.
- **Within the next ten years, 86% of properties within one Miami-Dade oceanfront community will be at risk from moderate flooding damage, compared to 5% today**, a significant underestimation of risk by insurers and financial institutions that poses a potential economic calamity in the short term.
- **By 2050, annual flooding damage county-wide in Miami-Dade is expected to roughly double**, leading to shortages in affordable insurance coverage and real estate market instability.

"The urgency and the uncertainty are very real for everyone—homeowners, lenders, risk managers, underwriters, and public officials," Sorkin says. "While our projections look ahead 30 years, the impact from even moderate flooding in the short term may cause risk exposure crises next year, or the year after, before lenders and insurers have an opportunity to adjust portfolios or pricing. What's more, the vulnerability of individual properties to these events varies from house to house, block to block and town to town."

Moderate Flooding Poses Hidden and Near-Term Dangers

Because of sea-level rise, longer-duration rain events, land subsidence, and the erosion of natural barriers, "nuisance flooding" from climate change is poised to become more than just a nuisance. Although it's often overshadowed by more dramatic extreme weather events like hurricanes and typhoons, chronic flooding may also contribute to systemic risk from a mortgage crisis, and create a significant and far-reaching economic problem.

A Jupiter Intelligence study of probable flood risk in Miami-Dade County, Florida, revealed that even moderate flooding (up to one foot/0.3m in depth, as defined by FEMA) with a 50% annual probability of occurring will affect 61% more properties across the county as a whole by 2050.

Over the same period, a similar "moderate" scale event will damage almost nine times the number of properties in an oceanfront city in 2050 as in 2019; it will double the number of damaged properties in a city facing Biscayne Bay; and it will drive an increase of almost 75% in damaged property in a Miami-Dade community that's located well inland from the bay and ocean.

Jupiter projects that the percentage of vulnerable oceanfront properties affected by extreme flooding will rise from 5% in 2019 to 98% by 2050. Miami-Dade County, as a whole, will see a two-fold increase in the number of properties at risk from extreme flood events.

Jupiter used parcel level data to calculate average expected losses as a percentage of residential mortgage value. Lenders, investors and regulators can use their own data to calculate similar metrics for their own portfolios as part of stress testing. Across Miami-Dade County, these expected losses as a percentage of mortgage value will rise from 1.24% in 2019 to 1.67% in 2040 and 1.97% in 2050, a nearly 60% increase. Across the county, as of 2019, the average expected loss is about 50% higher for higher risk communities than the least exposed. However, as these risks increase, the spread between high and low risk communities increases substantially.

> *Almost none of this is reflected in prices anywhere in the world. Most of this dynamic is not yet understood nor is it implemented into the decision-making of financial institutions.*
>
> *—Rich Sorkin, Jupiter co-founder & CEO*

Significant Rise in Short-Term Risk

While many people typically focus on dramatic, 20- to 30-year impacts, the economic consequences of short-term risk are also significant.

Within the next ten years, impact from moderate flooding in an oceanfront city will increase from 13% of total properties to 48%, while properties at risk from extreme flooding will jump from 5% to 86% of the total. Miami-Dade County as a whole will see a 26% increase in properties affected by moderate flooding from now through 2030, and a 59% rise in properties damaged by extreme floods over the same ten-year period.

The increase in expected damage from flooding comes primarily from routine moderate flooding of up to one foot, driven primarily by sea-level rise. Most of the expected damage from these types of floods will come from a combination of extended or heavy precipitation and "sunny day" flooding in events likely to occur every other year. Severe storms and extreme impacts will cause ever greater damage, but not the majority of the economic impacts.

> *Over 50% of the expected damage will come from a combination of extended or heavy precipitation and "sunny day" flooding from events likely to occur every other year. Severe storms and extreme impacts will cause ever greater damage, but not the majority of the economic impacts.*

Expected Losses to Mortgage Values Will Vary by Community

While increases in risk will put pressure on mortgage approvals and loan rates for the entire county, the impact will be quite different across communities.

Expected losses as a percent of mortgage value in the City of Miami itself will increase from 1.3% to 1.48% in 2040 to 1.63% in 2050, a 25% increase in the metric over 30 years.

However, other Miami-Dade communities will see severe pressure on loan approvals and mortgage rates over the next three decades. In one bayfront city, the expected losses as a percent of mortgage value outstanding increase almost three-fold, from 1.4% to 3.9%. An oceanfront city will experience a seven-fold jump in expected losses, from 1.3% to 9.2%.

In addition, there will be significant pressure on municipal finances. County-wide, residential damage is expected to rise roughly 2% per year. However, in the oceanfront city, damages over 30 years increase by a factor of seven, and grow from the equivalent of 5% of the current municipal budget to over 30% (in terms of constant dollars). In the bayfront community, expected residential damages increase from the equivalent of 143% to over 400% of the annual municipal budget.

Far-Reaching and Potentially Catastrophic Implications

"Here is the crucial question," asks a newsletter published by The Financial Times after reviewing the Jupiter data in September 2019. "Do homeowners understand this looming shock? Does the mortgage industry? Or insurance world? Or the Federal Emergency Management Agency?"

The twin probabilities that high-frequency flooding will also affect inland communities in Miami-Dade while impacting more properties and more people, and that storm-driven severe flooding events will strike more frequently on the immediate coast, pose significant financial risks to property owners, insurers, lenders, and the economy as a whole.

- For **homeowners**, they will lead to more claims, spikes in insurance premiums, and, if the tepid rebound experienced after 2012's Superstorm Sandy as studied by CUNY/Queens College is any indication, long-lasting depressed property values.
- For **insurers**, these projections necessitate making ongoing adjustments within their risk portfolios, revising underwriting guidelines and adjusting short- to medium-term pricing strategies.
- For **lenders**, the prospect of greater-than-foreseen flood damage or storm occurrence within 30-year mortgage windows could cause risk of systemic failure from a wave of defaults and foreclosures; Hans Helbekkmo, a partner in McKinsey's Risk Practice, told The Financial Times that the flooding projections could drive loss rates from mortgage defaults similar to the 2007 subprime crisis within the next two decades. Furthermore, the ongoing pressure for risk exposure transparency emanating from organizations like TCFD demand that financial services companies reckon with latent time-bombs in their portfolios.
- For **policy-makers**, not only in South Florida but also along the vulnerable Gulf and Atlantic coastlines from Texas to New England, projections of ongoing climate-change-caused flooding, and more severe and frequent events, could have devastating consequences for people, their property, businesses, infrastructure, and even national security.

"Homes, livelihoods, and the viability of financial institutions and the economy as a whole may find themselves under a Sword of Damocles, unaware of the extent of risk they bear, and without time to prepare," Jupiter's Sorkin says. "Granular, property-level probabilistic projections based on the non-stationary nature of the climate—physical asset risk intelligence—is an essential tool as all stakeholders prepare for the effects of climate change."

Do homeowners understand this looming shock? Does the mortgage industry? Or the insurance world, or FEMA?

—The Financial Times

The Miami-Dade Study: Based on Forward-Looking Risk Models

Jupiter Intelligence is the global leader in data and analytics services to help make informed decisions that safeguard critical at-risk infrastructure from extreme weather, sea-level rise, storm intensification, and rising temperatures caused by short, medium and long-term climate change. In this study, Jupiter Intelligence modeled probable flood scenarios based on FEMA thresholds for both moderate and severe events for every land parcel in Miami-Dade County. The results are based on the current "business as usual" approach to climate-change mitigation.

Jupiter's FloodScore™ service, which probabilistically predicts long-term flood hazard from six months to 50-plus-years in advance for different climate scenarios, rendered the analysis of flood depths and vulnerability curves.

Jupiter's climate risk models are based on current, dynamic climate data (not historical information) and the principle of non-stationarity, which applies to systems—like the climate—that are constantly changing and not stationary. The application of non-stationary climate risk modeling of expected loss yields a dramatically more concerning result (see solid lines in Figure 1) than old methods (see the dotted line in Figure 1).

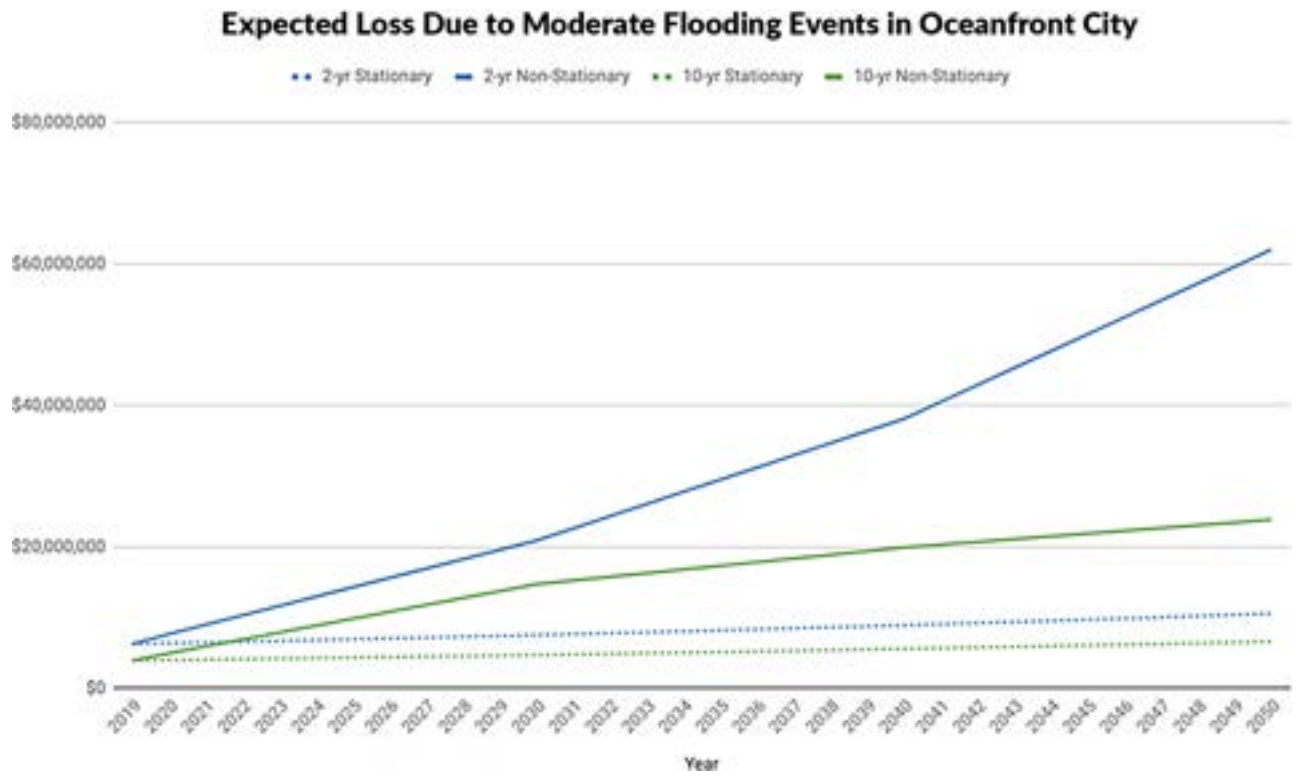

Figure 1 Non-stationary vs. stationary projections of expected loss from moderate flooding events in an oceanfront community in Miami-Dade County. Solid blue line represents non-stationary modeling of a 50 percent annual probability weather event; the solid green line represents non-stationary modeling of a 10 percent annual probability weather event. The dotted lines are based on traditional, stationary modeling.

"Moderate" Flooding: Affecting More Homes and More People

In the moderate flooding example, the change in the number of affected properties is greatest at higher probability periods; this means that more frequent flooding events will cause damage and loss to a larger number of people.

The cities in red are expected to see the largest percentage impacts at these intervals.

Region	Annual Probability %			
	50%	10%	1%	0.1%
Miami-Dade County	61%	56%	20%	7%
Miami (City)	17%	24%	16%	4%
Inland City	73%	27%	14%	14%
Bayfront City 1	220%	141%	35%	0%
Bayfront City 2	13%	28%	91%	0%
Oceanfront City	874%	498%	5%	0%

Figure 2 Moderate (1 foot) Flooding: Percentage change in affected properties from 2019-2050

Region	50% Annual Probability of Flooding				10% Annual Probability of Flooding			
	2019	2030	2040	2050	2019	2030	2040	2050
Miami-Dade County	5%	6%	7%	9%	13%	16%	18%	20%
Miami (City)	6%	6%	6%	7%	13%	14%	15%	16%
Inland City	4%	5%	6%	7%	11%	12%	13%	14%
Bayfront City 1	5%	8%	11%	15%	15%	27%	31%	35%
Bayfront City 2	6%	6%	6%	7%	16%	17%	18%	20%
Oceanfront City	4%	14%	25%	41%	13%	48%	65%	78%

Figure 3 Moderate (1 foot) Flooding: Percentage increase in total properties affected from 2019-2050

"Extreme" Flooding: Plaguing Coastal Properties More Often

The scenario is more startling in considering the impact of extreme floods (depths of up to three feet/0.91m, per FEMA definition) for events with a one percent annual probability of occurring, the benchmark used by insurance and financial services companies to manage risk. The oceanfront city studied will see the largest impact at the 100-year level, going from five percent of properties affected by three-foot flooding to 98% by 2050.

Region	Annual Probability %			
	50%	10%	1%	0.1%
Miami-Dade County	133%	120%	111%	8%
Miami (City)	86%	36%	66%	9%
Inland City	154%	152%	93%	13%
Bayfront City 1	514%	1344%	96%	3%
Bayfront City 2	89%	110%	175%	15%
Oceanfront City	600%	1162%	1788%	0%

Figure 4 Extreme (3 foot) Flooding: Percentage change in affected properties from 2019-2050

Region	1% Annual Probability of Flooding				0.1% Annual Probability of Flooding			
	2019	2030	2040	2050	2019	2030	2040	2050
Miami-Dade County	7%	11%	12%	15%	32%	33%	34%	35%
Miami (City)	6%	7%	8%	9%	30%	30%	31%	32%
Inland City	3%	3%	4%	5%	20%	20%	21%	22%
Bayfront City 1	25%	33%	39%	50%	94%	97%	97%	97%
Bayfront City 2	6%	8%	10%	16%	81%	85%	89%	92%
Oceanfront City	5%	86%	90%	98%	99%	100%	100%	100%

Figure 5 Extreme (3 foot) Flooding: Percentage increase in total properties affected from 2019-2050

Insurers and Lenders Need Tools to Understand Risk and Develop Mitigation Strategies

The tools to confront this massive challenge and improve resilience begin with dynamic, high-resolution physical risk intelligence.

The Jupiter FloodScore service is built upon the ClimateScore™ Intelligence Platform, which provides scientifically rigorous, continually updated, hyper-local risk analysis for weather in a changing climate. In addition to FloodScore, Jupiter HeatScore,™ Jupiter WindScore,™ and Jupiter FireScore™ services are currently in use for climate-related risk assessment and management in every region of the planet.

Jupiter's customers use its services for applications such as capital planning, risk management, site selection, design requirements, supply chain management, investor valuations, and shareholder disclosures. This type of analysis has been provided to large banks, insurance companies, and municipal governments. For details, contact info@jupiterintel.com.

APPENDIX

Details On Analysis

Climate Change Scenario

Sea Level Rise

The sea level rise scenario used in this analysis is the NOAA High 2017 regional sea level rise estimate, which is a higher-end scenario that results in 2.0 meters of sea level rise by the year 2100. Jupiter uses the NOAA 2017 sea level rise scenarios because they present the most up-to-date, peer-reviewed standard for the United States and are used to inform the recently released Fourth National Climate Assessment. This scenario is broadly consistent with RCP 8.5, which is likely to result in global temperature increases of 2.6 to 4.8 degrees Celsius relative to current global temperature by the end of the century. Pathways ranging between RCP 6.0 and RCP 8.5 are expected if global emission growth continues to persist and there are no additional efforts to reduce emissions beyond those already in place. The high scenario assumes a higher end estimate of ocean warming and more rapid melting of glaciers and polar ice sheets in response to this level of global emissions, thus resulting in greater changes in sea level.

The Southeast Florida Regional Climate Change Compact ("*Compact*") currently recommends using the NOAA High 2014 regional sea level rise estimate, which is about 4 inches lower than the NOAA High 2017 estimate. The NOAA 2017 projections are higher than those used by the Southeast Florida Regional Compact because they are based on more recent climate projections that take into account newer evidence of rapidly melting ice sheets in Greenland and West Antarctica. According to Compact guidance, which was released in 2015, the High estimate should be used as an upper bound for high risk projects with planned constructed after 2060, projects which are not easily replaceable or removable, projects that have a design life greater than 50 years, or projects that are critically interdependent with other infrastructure or services.[1] The Compact is in the process of updating its guidance and is expected to release updated recommendations shortly.[2]

Figure A–1 and Figure A–2 on p. A2 show the specific sea level rise estimates for the Miami metro area.

1 See Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (*Compact*). October 2015. Unified Sea Level Rise Projection for Southeast Florida. A document prepared for the Southeast Florida Regional Climate Change Compact Steering Committee. pp. 21-25.

2 See https://southeastfloridaclimatecompact.org/resources/unified-sea-level-rise-projections/.

Other sources of change

Flooding in South Florida is caused by coastal storm surge resulting from tropical cyclones, extreme rainfall, and seasonal ("king tide") floods. While sea level rise is one factor that causes flooding, Jupiter also accounts for changing weather patterns that impact precipitation frequency and intensity. For the Miami area, Jupiter uses the RCP 8.5 scenario. The rainfall increases are consistent with scientific consensus, with an emphasis on increasing intensity for the most intense storms (10-20% by end of century).

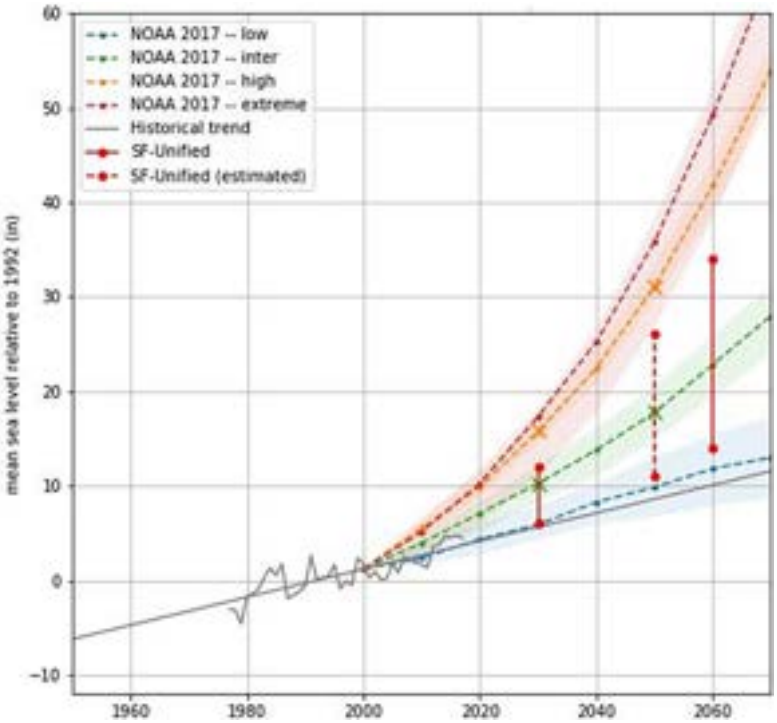

Figure A–1 NOAA 2017 sea level rise projections for the Miami metro area compared with the Southeast Florida Regional Climate Change Compact Unified Sea Level Rise Projections.

Timeframe	IPCC AR5 RCP8.5	USACE High	NOAA 2014 High	NOAA 2017 High
2030	6 in	10 in	12 in	16 in
2050 (estimated)	11 in	20 in	27 in	31 in

Figure A–2 Southeast Florida Regional Compact Unified Sea Level Rise Projections and NOAA 2017 High Sea Level Rise Projections used in Jupiter's Analysis.

Modeling Specifics

- **Property data source:** Parcel data from Miami-Dade County https://gis-mdc.opendata.arcgis.com/datasets/parcel
- **Vulnerability functions:** USACE curves from HAAZUS v4.2
- **Ocean model:** Jupiter Ocean Model
- **Weather model:** WRF v4.0.0
- **Hydraulic model:** HEC-RAS 5.06