Climate Risk as a Tool for Municipal Bond Stakeholders

Insights Insurers Have Used for Decades are Now Tailored for the Municipal Market

Current and future climate risk is an existential threat to the municipal debt ecosystem. The majority of economic climate losses are now absorbed in some form by the public sector. Figure 1, originally produced by CatPerils and SwissRe, shows not only the increasing trend in total global catastrophic losses, but also the so-called protection or insurance gap—those economic losses that have been absorbed by the public. Much of these recent uninsured losses are a result of flooding in the U.S.[1]

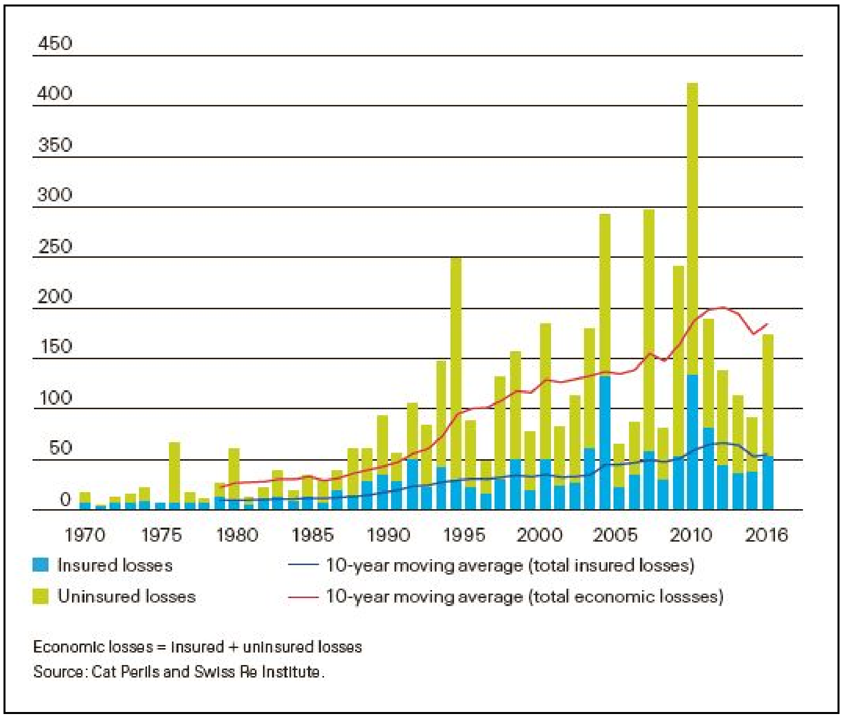

Figure 1: *The protection/ insurance gap shows insured versus uninsured losses, 1970-2018, in 2016 USD. Source, Cat Perils and SwissRe.*

FEMA typically serves as the ultimate backstop. The agency's National Flood Insurance Program (NFIP) continues to be in a tenuous position—it currently owes $20.525 billion to the U.S. Treasury, leaving $9.9 billion in borrowing authority from a $30.425 billion legal limit. For context, in September 2017, the NFIP had borrowed $5.825 billion to cover claims from Hurricanes Harvey, Irma and Maria, effectively reaching that same borrowing limit. The next month, and for the first time ever, Congress canceled $16 billion of the NFIP's debt so that it could cover those losses. The NFIP itself also now transfers some of its risk to private reinsurers—a new tactic.[2]

[1] Protection gap is not just an emerging market issue: Swiss Re, March 30, 2017

[2] Introduction to the National Flood Insurance Program (NFIP), Updated December 23, 2019

Despite clear evidence that the economics of the NFIP are structured ineffectively, given pushback from lawmakers in coastal states, FEMA pushed its timeline to rehaul the program's risk rating system and corresponding premiums—which were originally supposed to be updated in October 2019—back to 2021.[3]

While flood is the predominant driver of financial losses in the U.S., in the last several years wildfire losses have spiked dramatically. Drought conditions and strong winds that are conducive to large wildfires continue to linger in California, prompting Pacific Gas & Electric (PG&E) to preemptively shut power off for millions of residents to avoid sparking wildfires.[4] Insurers have increasingly been dropping policies for at risk properties, prompting the state of California to impose a one-year ban on the practice in high-risk zip codes. Perhaps in contradiction, California (like many other states) has banned insurers from setting rates based on future expected losses—even though climate change is widely assumed to be a partial driver of increasing risk.[5]

All signs point to increasing risk to a large portion of the U.S.'s municipal debt. risQ's mission is to help all stakeholders in the market understand both current and future climate risk in a way that is operationally and strategically relevant. risQ's partnership with ICE marries best-in-class climate risk analytics, translated to municipal market-relevant financial metrics.

There are 4 fundamental components of risQ's underlying climate risk modeling platform, illustrated conceptually in Figure 2:

- **Hazard**: risQ's hazard coverage on product launch will include wildfire, flood (inland and non-hurricane induced coastal flooding, the latter modulated by sea level rise), and hurricane (wind speed, storm surge, and precipitation-based flooding). Each hazard is a combination of probabilities and intensities, which are in turn modulated by climate change scenarios. As an exemplary hazard, risQ's hurricane wind speed model is highlighted in Figure 3.
- **Climate Conditioning**: risQ's climate conditioning explicitly incorporates projected changes in the climate variables that modulate the intensity and/or probability of the above hazards. For example, projected changes in Sea Surface Temperature (SST)—estimated by leveraging a collection of International Panel on Climate Change (IPCC) Global Climate Models (GCMs)—are tied to the probability of witnessing the most catastrophic hurricanes (e.g., Category 3-5) making landfall. risQ blends projected SSTs from multiple GCMs into input to its hurricane landfall probability model. Figure 4 illustrates these changing probabilities for spatially averaged change in Category 3 hurricane probability.

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[3] FEMA Pushes Back Its Overhaul of Flood Insurance Rates, Last Updated November 7, 2019
[4] More than 2 million people expected to lose power in PG&E blackout as California wildfires rage, October 26, 2019
[5] California Bans Insurers From Dropping Policies Made Riskier by Climate Change, December 5, 2019

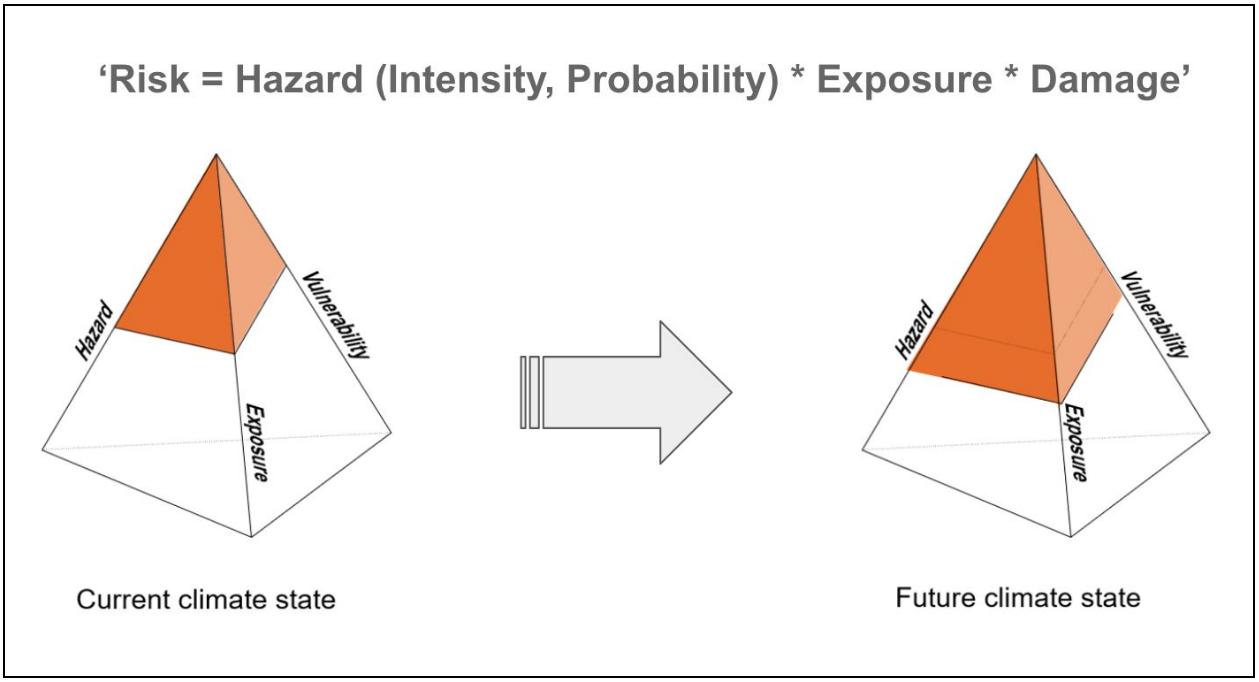

Figure 2: *A conceptual illustration of the 4 components of climate risk—exposure, vulnerability, hazard, and climate conditioning.*

- **Economic Exposure:** risQ analyzes risk to fundamental economic exposures, or slices of an obligor's tax generating assets, all on a universal 100-meter grid that covers the contiguous U.S.. Specifically, for each hazard risQ quantifies risk to *property value*, as measured by expected equivalent replacement cost, and *GDP impairment*, as measured via commercial and industrial business interruption. Exposure is modeled using a combination of sources, including satellite imagery, census data products, transit data and FEMA's HAZUS data repository. Figure 5 overlays multiple spatial layers for El Tejon School District in California as an example.
- **Damage Functions**: Each of those probabilistic hazards are intersected with exposure through data-driven damage functions—developed over decades within the field of structural engineering—that translate probabilistic intensities (flood depth, wind speeds, fire flame heights) to both (a) expected replacement cost and (b) business interruption as measured by commercial and industrial property downtime.

All of these 4 components are modeled on risQ's 100-meter grid. This flexible underlying spatial architecture allows for aggregation of comparable, levelized financial climate risk metrics over *any* spatial (obligor's) boundary—e.g., states, cities, counties, school districts, development districts and utility districts, and customizable commute-based service areas.[6]

[6] risQ's Partnership with Intercontinental Exchange: What it Means for the Municipal Bond Ecosystem

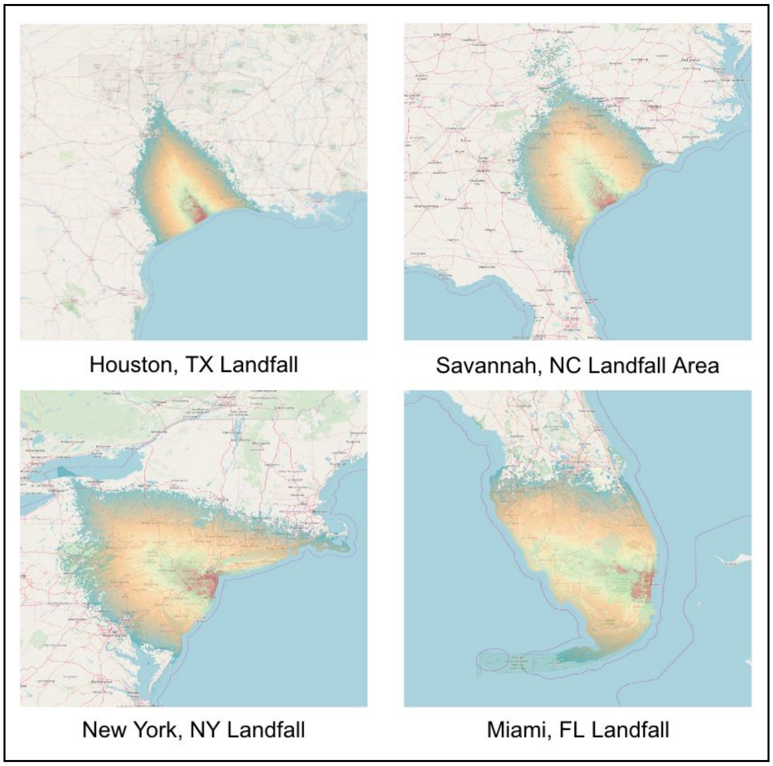

Figure 3*: risQ's hurricane hazard model takes historical observed hurricanes as "fingerprints" and slides them along the entire eastern seaboard to estimate their what-if impact in locations other than where they actually made landfall. Here, Hurricane Katrina's wind speed fingerprint is modeled over four other cities. Local land cover is used to estimate differential in expected impact among the locations. After property value and GDP impairment risks are calculated for all locations, they are scaled by their actual local probability (see Figure 7).*

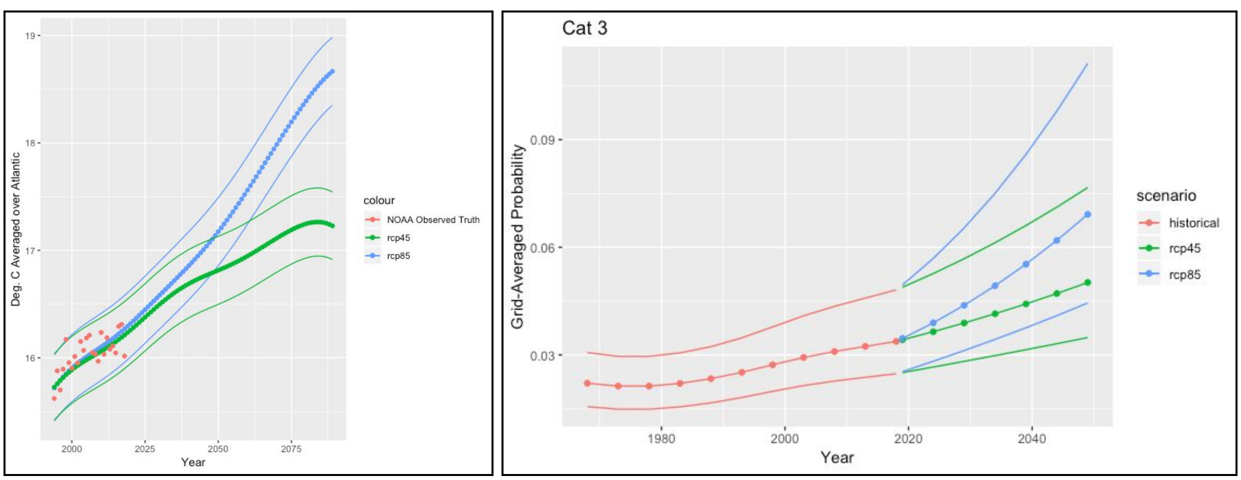

Figure 4: *(Left) Projected changes in Atlantic Ocean SSTs under the two most oft-used state of the art IPCC climate change scenarios, RCP4.5 (assumes some climate mitigation) and RCP8.5 (business as usual). Projections are shown with 95% confidence intervals and contextualized with recent observed SSTs that risQ's model predicted accurately out of sample. Physical theory and statistical evidence support a link between warmer SSTs and the ocean's energy potential to generate the most intense hurricanes. (Right) Near term risQ projections for spatially averaged annual Category 3 hurricane probabilities with 95% confidence bounds over time, "conditioned" by projected SSTs from the left graph.*

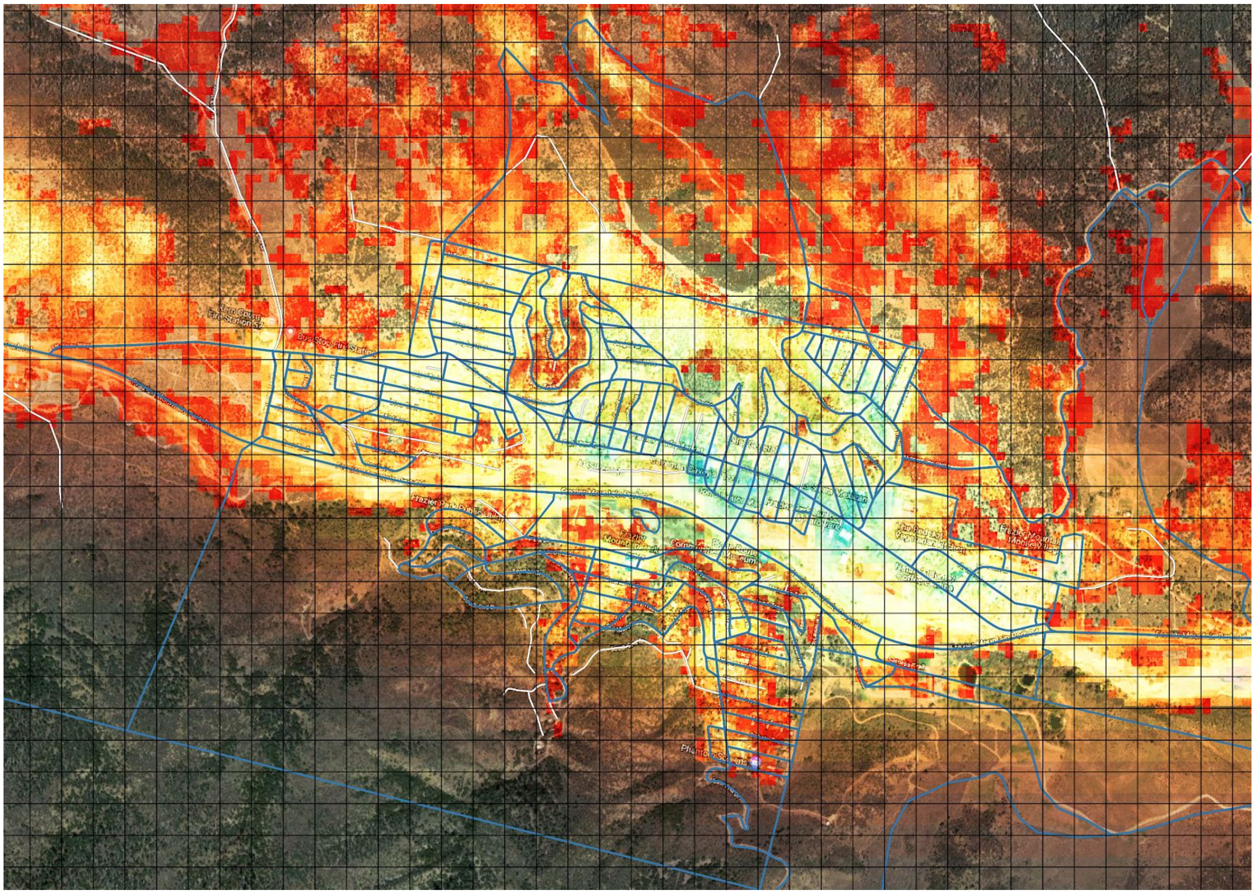

Figure 5: *Selected spatial data ingredients used in modeling exposure on risQ's 100-meter grid, shown for El Tejon School District in California. Black squares represent the 100-meter grid, white lines represent roads, blue lines represent census boundaries, and the red-to-blue gradient represents lower-to-higher built structure density. All of these features are used to disaggregate property values and GDP data to the 100-meter grid. This same data and grid structure is utilized over the entire contiguous U.S.*

HOW THE MUNICIPAL BOND ECOSYSTEM CAN ENGAGE

The range of climate hazards,exposures, geographical variance, obligors and securities to navigate is vast, but the data and analytics to rapidly assess a specific case, conduct head-to-head comparisons, and assess entire portfolios are now available. Importantly, the tools risQ and ICE Data Services are making available are grounded in science, back-tested across climate, exposure and damage function components, and deliver insights that are interpretable and based on consistent metrics.

For those interested in specific examples of use cases, please see the "risQ's Partnership with Intercontinental Exchange: What it Means for the Municipal Bond Ecosystem" on the risQ website, or contact chris.hartshorn@risq.io with additional questions or for further information.