Coastal Flood Resilience Project

WHITE PAPER

Recommended Federal Actions to Strengthen the Assessment of Current and Future Flood Risk from Tropical Storms and Hurricanes
7.12.2024

The ***Coastal Flood Resilience Project*** is a coalition of organizations working for stronger programs to prepare for coastal storm flooding and rising sea level in the United States. This *White Paper* recommends that the federal government take steps to strengthen assessments of the current and future flood risks from tropical storms and hurricanes at places along the Atlantic and Gulf of Mexico coasts of the United States.

I. Introduction

Tropical storms and hurricanes cause extensive loss of life and property damage, especially along the Atlantic and Gulf of Mexico coasts of the United States. Storm surge flooding is a primary cause of these losses. A warming climate is projected to increase the frequency of the most intense storms with the highest water surges (i.e., hurricane categories 4 and 5), increase rainfall during storms, and drive rising sea levels that will push storm flooding further inland. The population in communities along the Atlantic and Gulf coasts that is right along the shore (i.e., at or below 33 feet of elevation) is projected to double by 2060, putting many more people and much more property at risk of storm flooding.

Unfortunately, preparing for future storms in the near- and long-term can be challenging for the public and policymakers. The National Weather Service provides warnings a week or two prior to a storm and publishes estimates of the number and strength of major storms on an annual basis. Although federal agencies have information describing how a changing climate will make coastal storms more severe over the coming decades, this information is not easily available to policymakers and the public. In addition, new research is needed to improve public understanding of changing storm characteristics.

Access to reliable, user-friendly tools to assess current and future coastal storm flood risks based on climate change science would be a valuable tool to better inform decision-makers and the general public. For example, better storm flood risk information can improve investment and management decisions concerning existing homes, infrastructure, new development, and land conservation to manage development in risky areas. These more informed decisions will likely result in better preparedness, reduced costs of storm damage, dramatically reduced federal spending for disaster relief, less precarious insurance and mortgage markets, and reduced loss of life. Disadvantaged people and communities suffer disproportionately as coastal flood risk grows and would benefit from improved coastal storm flood risk information and management.

The Coastal Flood Resilience Project (CFRP) recommends that the federal government develop user-friendly, publicly available, climate-informed assessments of future flood and storm surge risk from tropical storms and hurricanes along the Atlantic and Gulf of Mexico coasts of the United States.

Specifically, the federal government should:

1. **Establish Institutional Capacity to Assess Coastal Storm Flood Risk:** The federal government should formally assign responsibility to strengthen assessment of current and future flood risk from storms and hurricanes to an interagency task force (e.g., the existing Sea Level Rise and Coastal Flood Hazard and Tools Interagency Task Force).

2. **Create an Online Coastal Storm Flood Risk Assessment Tool:** The federal government should direct agencies to work together to create an online tool to support decision-makers and the public in assessing current and long-term flood risk from tropical storms and hurricanes along the Atlantic and Gulf coasts. Initial iterations of such a tool should be designed with data limitations in mind (e.g., not offer projections for fine-scale geographic areas) while future iterations should be improved to reflect research findings (see recommendation #4 below).

3. **Apply Coastal Storm Flood Risk Assessment Products to Inform Decisions:** The federal government should work with state, tribal, and local governments, the

Defining Coastal Storms

NOAA uses these definitions of coastal storms:

Tropical Storm: A tropical cyclone with maximum sustained winds of 39 to 73 mph (34 to 63 knots).
Hurricane: A tropical cyclone with maximum sustained winds of 74 mph (64 knots) or higher.
Major Hurricane: A tropical cyclone with maximum sustained winds of 111 mph (96 knots) or higher, corresponding to a Category 3, 4 or 5 on the Saffir-Simpson Hurricane Wind Scale.

private sector, and the public to apply coastal storm flood risk assessment tools to a range of decisions and policies (e.g., flood risk disclosure at time of property sale, federal guarantee of a mortgage, federal flood insurance rate setting, and coastal planning and zoning). Improvements to the storm flood risk management tool over time will allow application of storm risk information to a wider range of decisions.

4. **Establish Coastal Storm Flood Risk Assessment Research Agenda:** The federal government should establish and implement an agenda for research needed to improve the accuracy of the assessment of current and future coastal storm risk (e.g., improve models related to storm frequency and intensity, geographic scale of information, and intensity and expand the assessment to include Pacific Ocean storm risks)**.**

II. The Case for Improved Assessment of Coastal Storm Flood Risk

The case for a major new effort by the federal government to strengthen assessment of coastal storm risk and improve decision-making for coastal investments and management is based on the following arguments:

1. **Current Coastal Storm Risk is Significant:** Coastal storms have a proven record of causing extensive loss of life and property damage and are the highest cost disasters among all other types of disasters contributing to billion-dollar impact events. Storm surge is a leading cause of storm damage and deaths.

2. **Coastal Storm Risk is Growing:** The National Oceanic and Atmospheric Administration (NOAA) projects that coastal storms will be more intense and damaging in the decades ahead.

3. **Coastal Population Growth is Increasing Putting More People and Property at Risk:** Current trends of significant growth in coastal population are expected to continue and to double the population right along the coast (i.e., at or below 33 feet of elevation) by 2060, putting many more people and much more property at risk of flooding.

4. **Existing Coastal Storm Flood Risk Information is Difficult to Access:** Information about current and future storm flood risk is not readily available to decision-makers in the public and private sectors in a user friendly, publicly available format.

5. **Deployment of Climate Informed Coastal Storm Flood Risk Information Will Increase Preparedness:** The sustained development and application of improved coastal storm flood risk assessment information and tools would support improved decisions related to coastal investments and management in both the public and private sector.

6. **Reduced Storm Flood Damage Costs Have Macroeconomic Benefits:** Policies and plans that draw on better information about coastal storm flood risk will reduce total damage costs, reduce federal spending for disaster assistance, and help stabilize property insurance and home mortgage markets.

7. **Reduced Flood Damages Have Social Justice Benefits:** Disadvantaged communities and people have disproportionately fewer resources to prepare for storms and recover from storms. Reducing storm flood damage improves social justice.

8. **Improved Coastal Storm Flood Risk Assessment Supports Better Recognition of Sea Level Rise Risks:** A key part of future storm flood risk is the expansion of storm impact areas because of increasing sea level. Better understanding of the connection between coastal storm flooding and rising seas will help overcome hesitancy to adapt to the existential risks that rising seas pose to many coastal communities.

Each of these arguments is discussed in greater detail below.

Current Coastal Storm Risk is Significant: Coastal storms are a major risk to life and property. In its most recent assessment of all types of disasters with damages of over one billion dollars between 1980 and 2022, NOAA found that hurricanes (i.e., tropical cyclones) accounted for 51.8 percent of the total costs and almost half the deaths (i.e., 6,897). NOAA explains:

> "The distribution of damage from U.S. billion-dollar disaster events from 1980 to 2023 is dominated by tropical cyclone losses. Tropical cyclones have caused the most damage ($1,379.3 billion) and have the highest average event cost ($22.2 billion per event). Severe storms ($455.2 billion), drought ($352.9 billion), and inland flooding ($196.6 billion) have also caused considerable damage based on the list of billion-dollar events."

Billion-dollar events to affect the United States from 1980 to 2023 (CPI-Adjusted)

Disaster Type	Events	Events/ Year	Percent Frequency	Total Costs	Percent of Total Costs	Cost/ Event	Cost/ Year	Deaths	Deaths/ Year
Drought	31	0.7	8.2%	$352.9B CI	13.3%	$11.4B	$8.0B	4,522†	103†
Flooding	44	1.0	11.7%	$196.6B CI	7.4%	$4.5B	$4.5B	738	17
Freeze	9	0.2	2.4%	$36.4B CI	1.4%	$4.0B	$0.8B	162	4
Severe Storm	186	4.2	49.5%	$455.2B CI	17.1%	$2.4B	$10.3B	2,094	48
Tropical Cyclone	62	1.4	16.5%	$1,379.3B CI	51.8%	$22.2B	$31.3B	6,897	157
Wildfire	22	0.5	5.9%	$142.4B CI	5.4%	$6.5B	$3.2B	535	12
Winter Storm	22	0.5	5.9%	$98.3B CI	3.7%	$4.5B	$2.2B	1,402	32
All Disasters	**376**	**8.5**	**100.0%**	**$2,661.1B CI**	**100.0%**	**$7.1B**	**$60.5B**	**16,350**	**372**

†Deaths associated with drought are the result of heat waves. (Not all droughts are accompanied by extreme heat waves.)
Flooding events (river basin or urban flooding from excessive rainfall) are separate from inland flood damage caused by tropical cyclone events.

Major coastal storms can deliver storm surges that, combined with storm tides, can reach up to twenty feet or more (e.g., Hurricane Katrina's storm surge was 28 feet in places). Storm surge is sensitive to storm intensity, angle of approach to the coast, the shape and characteristics of coastal features such as bays and estuaries, and other factors.

NOAA points out that the high waters from a storm surge are the major cause of loss of life during a storm.

> "Along the coast, storm surge is often the greatest threat to life and property from a hurricane. In the past, large death tolls have resulted from the rise of the ocean associated with many of the major hurricanes that have made landfall. Hurricane Katrina (2005) is a prime example of the damage and devastation that can be caused by surge. At least 1500 persons lost their lives during Katrina and many of those deaths occurred directly, or indirectly, as a result of storm surge."

Coastal Storm Risk is Growing: The question of future changes to characteristics of storms in the North Atlantic Basin is well studied. After years of sometimes conflicting research, there is growing agreement on worsening storm conditions. After a review of research on possible changes to storm characteristics over time, NOAA published in May of 2023 the following general conclusions:

> "Based on a survey of existing studies, with regards to future North Atlantic, Caribbean Sea, and Gulf of Mexico tropical storm and hurricane activity, a 2˚C (4˚F) global warming scenario would be expected to lead to the following:
>
> - Storm inundation levels during hurricane surge events will increase due to sea level rise, anticipated to rise by about 2 to 3 ft (0.4 to 0.8 meters) by 2100. [NOTE: Sea level rise is projected to be greater in some places, e.g., 4.3 feet by 2100 under the intermediate scenario at Hampton Roads, Va.] This sea level rise will contribute toward significantly more coastal destruction and increased economic damage.
> - Rainfall rates within tropical storms and hurricanes are projected to increase by about 15%.
> - Numbers of Atlantic hurricanes reaching Category 4 or 5 intensity are projected to increase about 10% but with large uncertainty and with some studies projecting a decrease.
> - Total numbers of Atlantic tropical storms and hurricanes combined are projected to decrease by 15%, but with large uncertainty; a minority of studies project an increase.
> - Strongest winds of tropical storms and hurricanes are projected to increase about 3%.

- Other aspects of hurricanes – such as named storm formation location, tracks, and size – may also change, but there is little consensus in available projections."

More information supporting this assessment of changing storm characteristics, including discussion of uncertainties and issues of projections at smaller scales, can be found in this article in the Bulletin of the American Meteorological Society.

It is important to note that these assessments of storm changes are associated with warming of air temperatures of 2 degrees C from pre-industrial levels (i.e., 1 degree C from current levels). These projected changes in storm characteristics are not consistently expressed in the context of future decades (e.g., 2050 or 2100) as is the case in the sea level scenario reports of the federal Sea Level Rise and Coastal Flood Hazard and Tools Interagency Task Force. These projected changes also do not apply to specific places or various climate scenarios, as do the projections in the sea level rise scenario reports.

Compound Events

The Fifth National Climate Assessment points to a possible decrease in the frequency of all Atlantic storms but also includes a chapter describing the risks from compounding of climate related events noting: "Compound events are expected to become more frequent with continued climate change…".

The report describes the compound impacts of Hurricanes Henri and Ida on the Northeast, concluding: "This temporally compounding event was about 30 times more deadly and more damaging than Hurricane Henri alone, straining local governance and emergency management systems."

It is also important to recognize that warming of 2 degrees C is expected to occur around 2043 in a high emissions scenario and 2052 in a lower emissions scenario. Storm characteristics in later decades (e.g., by 2100) may well prove to be more damaging. The United Nations concluded that current emissions of greenhouse gases are likely to result in a global temperature increase of 3 degrees C by 2100. A simple extrapolation of storm characteristic changes projected for an increase from 2 degrees C to 3 degrees C would effectively double impacts (e.g., a 20% increase in Cat 4-5 storms, a 30% increase in rainfall). Work is needed to develop research and assess storm changes spanning longer periods (e.g., to 2100).

The key conclusion that sea level rise is a critical factor in driving the severity and impacts of major coastal storms and "compound" extreme events is supported by other research, including a recent study using new techniques to assess future storms.

> "We find that sea level rise (SLR) alone will increase the TC and ETC compound flooding hazard more significantly than changes in storm climatology as the climate warms. We also project that the probability of destructive Sandy-like compound flooding will increase by up to 5 times by the end of the century."

The chart below illustrates how storm characteristics are expressed by existing information.

Atlantic and Gulf Coast Tropical Storm and Hurricane Information

Storm Characteristics	Past/Historical Storm	Based on 2 Degree C Temperature Increase	For Future Decades (e.g., 2050/ 2100)	Future Change by Coastal Location	By Climate Change Scenario (see interagency sea level rise report)
Frequency All Storms	✓	✓	X	X	X
Intensity (% Cat. 4-5 Storm as % of all Storms)	✓	✓	X	X	X
Rainfall Increase	✓	✓	X	X	X
Increased Surge Height Due to Sea Level Rise	NA	✓	✓	✓	✓

A key benefit that federal agencies can provide to coastal decision-makers is translating existing and future research concerning future storm characteristics into a format that addresses place, time, and climate change scenario and in a manner that is generally consistent with the existing online tool for assessing future sea level rise (i.e., the tool based on the report of the Sea Level Rise and Coastal Flood Hazard and Tools Interagency Task Force).

Coastal Population Growth is Increasingly Putting More People and Property at Risk: The Atlantic and Gulf of Mexico coasts are home to over 70 million Americans (i.e. people living in coastal shoreline counties as defined by NOAA in 2010). Population density in these counties was about 446 people per square mile, whereas for the country as a whole it was only 105 persons per square mile.

NOAA has projected that population in these coastal counties would increase by about 10 percent on average between 2010 and 2020, with higher rates in some states (e.g., South Carolina 23 percent; Georgia 19; Virginia 18; Florida 16; Texas 16). Although NOAA has not issued long-term projections for coastal populations, demographer Mathew Hauer, estimated future population in 258 coastal counties, finding a population of 99.5 million in 2020, increasing to 123 million in 2050 and 153 million in 2100.

Although most of the people in coastal shoreline counties are affected by coastal storms to some degree, the population living right along the coast (i.e., at elevations of 33 feet and lower) is at greatest risk of storm damage due to exposure to storm surges. This population right along the coast was estimated to be about 23 million in 2000 and projected to double by 2060 to about 44 million.

A growing population right along the coast will result in the development of new homes, roads, utilities, services, and commercial businesses in places that are at risk of more severe storms and storm flooding, as well as gradually rising sea levels. So, just as storm characteristics worsen, more people and property will be in jeopardy from these storms. Total damage costs, federal and state disaster relief costs, and loss of life will go up. And, as described in more detail below, financing of this risky, new development, including offering insurance that is required for mortgages, will add to the current instability in insurance and mortgage markets.

Existing Coastal Storm Risk Information is Difficult to Access: Information about current and future storm flood risks is not generally available to decision-makers in the public and private sector. Some key existing risk tools are described below.

- **FEMA: "National Risk Index":** The Federal Emergency Management Agency (FEMA) manages the National Risk Index. This online resource offers a national map that allows a user to identify a county or census track and see an overall risk score between 0 and 100 based on estimated current risk from some eighteen different natural hazards. One of the 18 natural hazards is "Hurricanes," and each county/census track has a hurricane risk score. For example, Broward County, Florida has a "Very High" hurricane risk, a hurricane risk score of 100 percent, and a projected storm frequency of 0.3 events per year.

  Information concerning expected annual losses, social vulnerability, and community resilience is also provided. For example, in the case of expected annual loss, the costs of losses are associated with specific natural hazards (e.g., the expected annual loss due to hurricanes in St. Luci County Florida is $188 million).

  A key issue with the National Risk Index, however, is that it evaluates relative risk from historical data and does not account for future risk from a changing climate or other factors. So, local risk scores do not reflect projected increments of increasing hurricane risk over time due to changing storm characteristics or higher storm surges due to rising sea level.

- **First Street Foundation: "Risk Factor" Tool**: This risk assessment resource addresses flooding, fire, wind, heat, and air quality. The "Flood Factor" element of the system estimates for a specific place or address identified by a user the current and future flood risk, including sea level rise impacts, for a thirty-year period. Flood factor provides a flood risk score from 1-10 and supporting information including flood history, current and future flood maps, damage assessment, and community scale risk.

  Although there is much to recommend in Flood Factor, there are several critical shortcomings:

- **Cost of Access:** Access to Flood Factor risk information is behind a paywall. Flood Factor data is available for individual homes that are for sale from First Street Foundation and using the Redfin real estate sales online system. Each Redfin listed property includes an overall Flood Factor score as a free part of the listing. But additional information is only available to people signing up for a 7-day free trial. A subscription costs $36.99 a month or $443.88 per year. This greatly limits the use of the system for general purpose education of the public and many use cases involving public and private decisionmakers.
- **Short Time Period:** Flood Factor provides a projection of future flood risk, but only for a thirty-year period. Although this time period includes the common term of a home mortgage, many homeowners are interested in changes in home value (often their principal financial asset) over a longer period. The median age of housing is forty years and, in the case of new home construction, investments in roads, power, sewer, and other infrastructure last much longer. Longer time periods also provide a completer and more accurate picture of risk.
- **Lack of Climate Change Scenarios:** As presently configured, Flood Factor does not allow a user to optimize a flood risk assessment by selecting different climate scenarios (e.g., climate scenarios in the sea level rise scenarios report of the Sea Level Rise and Coastal Flood Hazard and Tools Interagency Task Force).
- **Flood Risk vs. Storm Risk:** Flood Factor is designed to address flooding generally and does not speak directly to the risk associated with major coastal storms. Coastal storm risk can be assessed from Flood Factor data, but this requires an experienced user.
- **Lack of Government Endorsement:** Although Flood Factor is the product of experienced analysts in the public and academic sectors, it lacks the endorsement of the federal government. The tool might be discontinued at any time (e.g., due to revenues not matching costs) and might interpret flood data in a way that federal agencies generating the data do not endorse.

- **CoreLogic:** CoreLogic is a private company offering risk assessment services to a wide range of private and public sector decision-makers. In the case of coastal storms, CoreLogic offers a "Hurricane Risk Report" including a "storm surge risk score" based on historical risk information. The company also produces general reports, such as a report on the 2024 hurricane season.

  Unfortunately, like First Street Foundation, CoreLogic charges for place specific risk assessments and the assessments lack an endorsement from the federal government.

- **NOAA National Hurricane Center Storm Surge Risk Maps:** The NOAA National Hurricane Center offers an online "Storm Surge Risk Map" program that allows a user to find a place on a map of the Atlantic and Gulf of Mexico coast and see the geographic

area that would be subject to varying levels of storm surge. This is a helpful tool in that it provides detailed, place specific storm surge risk for hurricanes in Categories 1 – 5 and at 3 foot, 6 foot, and 9 foot storm surges. This data is also available on the NOAA Coastal Flood Exposure Mapper.

Although this information is useful to decision-making, it does not indicate for the selected place the likelihood of a storm (e.g., storm frequency), risk of high intensity storms (e.g., Categories 4-5), or address how storms may change in the future. It also does not factor in future sea level rise increases in storm surges on a time scale.

- **NOAA Storm Frequency Return Rate Maps**: NOAA has developed maps showing the frequency of return of hurricanes with wind speeds below and above 96 knots along the Atlantic and Gulf of Mexico coasts (see Attachment 1).

  Although the maps provide no data on future changes in frequency, they do provide a general sense of where hurricanes of all categories have been most frequent and where the most severe storms (i.e., winds greater than 96 knots) have occurred.

- **FEMA National Flood Insurance: Risk Rating 2.0 and Flood Maps:** The new system for determining premiums under the National Flood Insurance Program (i.e., Risk Rating 2.0) is intended to better reflect site specific risk in premium adjustments. The new system accounts for where a property is (e.g. distance from the coast or other waterbody) as well as how the property is built.

  Unfortunately, neither historical nor projected coastal storm flood risk is directly considered in risk ratings and ratings therefore do not offer a homeowner an assessment of future storm flood risk.

  Although FEMA no longer uses maps of the 100-year flood zones to set premiums, these maps are used to determine whether flood insurance is required for a federally guaranteed mortgage. The maps provide a general sense of flood risk but are based on historical data and do not include future risks.

- **Department of Energy: "CLIM-RR":** The Climate Risk and Resilience Portal is an online, map-based tool to evaluate current and future risk related to temperature, precipitation, fire, and wind. The tool allows for selection of a location and generates projections in risk categories for mid-century under two different climate scenarios.

  Although CLIM-RR does a good job of presenting current and future risks for some hazards, it does not address risks due to flooding, coastal storms, or rising sea levels.

Overall, for most decision-makers trying to form a picture of current and future storm flood risk at a given location along the Atlantic and Gulf of Mexico coasts, the data and tools that are now available are not enough. The information that is publicly available is not integrated into a consistent assessment format, generally lacks information about future conditions, and is not presented in an easy to find, user friendly application. Some private sector tools are useful but only available at a significant cost, have limited data on future storms, and do not have the authority or the continuity that a federal government tool would offer.

Deployment of Improved Coastal Storm Flood Risk Information is Useful: Any investment by the federal government to improve coastal storm flood risk information should be informed by understanding of how the information would be most effectively used. Some examples of use cases for improved coastal storm flood risk information are described below.

- **Existing Home Purchase or Sale**: People considering buying or selling a home need reliable and accurate information about future flood risks due to coastal storms to evaluate future insurance costs, potential costs associated with damages, cost and inconvenience associated with disruption of use of a home or supporting utilities and services, changes in property value, and potential for loss of life. Without clear, easily available, free storm flood risk information, coastal home buyers or sellers are likely to make an uninformed decision and discount future economic costs related to insurance and damage repairs.

  In addition, there is evidence that people consider hurricane risk when they decide where to live and that better access to more user-friendly information on coastal storm flood risks would help reduce the density of people and property in risky coastal areas. A recent study looked at a range of factors that influence the "where to live" decision reporting:

  > "We find that during the 2010s, controlling for environmental and socioeconomic factors, people tended to move away from areas with more frequent heat waves and hurricanes, but toward areas with greater risk of wildfires."

- **New Home Development and Construction**: Growing coastal populations will present demand for new housing and related commercial businesses. Private developers need to decide where to build new homes and businesses and often have options to build on sites that may have relatively more or less coastal storm flood risk.

  Many developers do not plan to be the long-term owner of a new property but have an interest in being able to represent a new property to a buyer as having low flood risk and related liabilities. Reliable, easy to use coastal storm flood risk assessments can

increase the chance that a developer will seek sites that have low flood risk compared to other available sites.

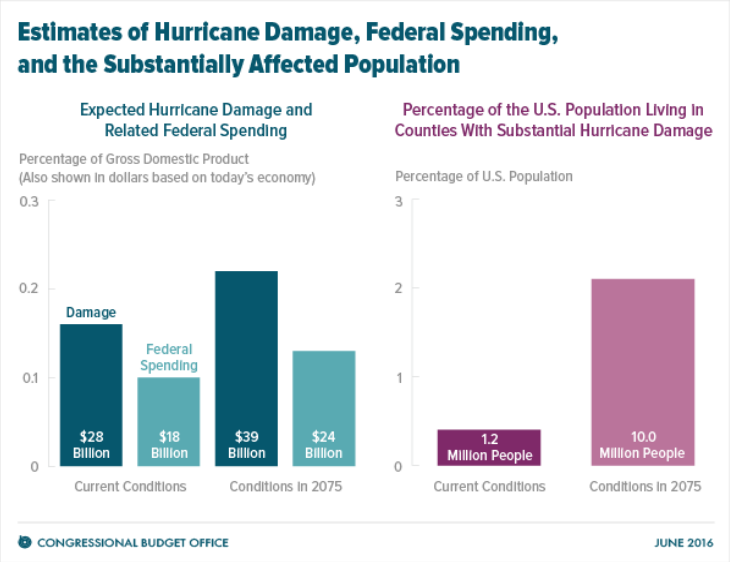
- **Home Mortgage Approval:** A financial institution issuing a mortgage for a home, or guaranteeing a mortgage, has an interest in understanding that significant damage due to coastal storm flooding will increase the risk of a default. Federal home loan guarantee institutions, such as Freddie Mac and Fannie Mae, also need good flood risk information to manage risk across a broad portfolio and to make decisions specific to a given mortgage.

- **Community Planning**: Coastal communities developing plans for reducing storm flood risks to existing property or steering new development away from risky places to sites where flood risk is low need access to storm flood risk data that is both reliable and easy for the public to understand. This data can also inform the planning of future conserved open space areas to eliminate property risk altogether or facilitate the migration of shoreline ecosystems.

- **Infrastructure Planning:** Increasing population in coastal areas will drive demand for public services including utilities (e.g., power, water, sewage, gas), transportation (e.g., roads, transit), police, fire, emergency services, and schools. Institutions delivering these services have an interest in avoiding new service in areas with coastal storm flood risks. Where providing new service is necessary, infrastructure managers need to design systems that are able to function in the event of storm flooding.

Reduced Storm Flood Damage Costs have Macroeconomic Benefits: Policies and plans that draw on better information about coastal storm flood risk will help reduce risk and thus help reduce federal spending for disaster assistance and minimize costs to the broader economy.

The Congressional Budget Office (CBO) has estimated the economic impacts of future hurricane damage made worse by rising sea level on property damages and on the federal budget. CBO found that combined damage costs and federal response costs in 2016 were about $46 billion and are likely to increase to $63 billion in 2075. The population exposed to hurricane risk increases ten-fold to about 10 million.



Finally, CBO estimated that hurricane costs were about .16 percent of Gross Domestic Product in 2016 but would rise to .22 percent by 2075, posing an increasing drain on the economy.

Another benefit of using better risk information to reduce damages from coastal storm flooding is that the financial stability of insurance and mortgage markets will be increased. The *New York Times* recently reported that: "As climate change produces more extreme weather, insurers are losing money, even in states with low hurricane and wildfire danger."
Based on its research, the *Times* found:

> "The insurance turmoil caused by climate change — which had been concentrated in Florida, California and Louisiana — is fast becoming a contagion, spreading to states like Iowa, Arkansas, Ohio, Utah and Washington. Even in the Northeast, where homeowners insurance was still generally profitable last year, the trends are worsening. In 2023, insurers lost money on homeowners coverage in 18 states, more than a third of the country…".

In response to these losses, some insurance companies have increased property insurance rates or declined to offer coverage in some places following major storms. Better storm risk information would allow companies to make better decisions about premiums and coverage and this supports a sustainable property insurance market. It also helps steer new development away from risky places and reduces demand for insurance for properties that result in costly damage payments. A weak insurance market drives companies to raise premiums or decline to issue policies, pushing some people to use "last resort" policies issued by state run programs.

> "It's not hyperbole to say that the United States may very well be on the brink of a homeowners insurance crisis, at least in its coastal areas."
>
> *States May Need to Scramble to Address Possible Homeowners Insurance Crisis*; LexisNexis; July 2023

The National Flood Insurance Program (NFIP) is working to align premiums with risk in its new Risk Rating 2.0 effort. But the NFIP would benefit from better information on coastal storm flood risk to existing property and a reduction in the rate of development of new property in risky areas.

Finally, property and flood insurance are critical elements in providing the assurances that are needed for financial institutions to issue mortgages. Mortgage institutions rely on insurance to help reduce defaults and can use coastal flood risk assessments to identify properties that are most at risk of major damage and default. Federal institutions that guarantee mortgages (e.g., Fannie Mae and Freddie Mac) also have an interest in minimizing defaults associated with storm flood damages. Weeding risky properties out of mortgage portfolios can stabilize mortgage markets generally.

Reduced Flood Damages have Social Justice Benefits: Coastal storms pose special risks to disadvantaged people and communities. Although damaging storms are no more likely to hit disadvantaged areas than other areas, disadvantaged people and communities have comparatively fewer resources to invest in preparing for a storm or to recover from a storm. Flood insurance is a key resource to assist in flood recovery, but research shows that wealthier people are more likely to buy flood insurance when it is not required than those with lower incomes. The lack of flood insurance makes recovery after a flood more difficult.

In addition, several studies have concluded that disadvantaged communities receive less assistance in recovering from a disaster than their better resourced neighbors. A 2018 study concluded: "At any given level of local damage, the more aid an area receives from the Federal Emergency Management Agency, the more this inequality grows." And, a 2019 study found:

> "The federal government spends billions of dollars annually helping communities rebuild and prevent future damage. But an NPR investigation has found that across the country, white Americans and those with more wealth often receive more federal dollars after a disaster than do minorities and those with less wealth. Federal aid isn't necessarily allocated to those who need it most; it's allocated according to cost-benefit calculations meant to minimize taxpayer risk."

> "A point raised repeatedly in the case study workshops and interviews is that while severe storms fall on the rich and poor alike, the capacity to respond to and recover from flooding is much lower in socially vulnerable populations that even in the best of times are struggling to function. This point is supported by research on social vulnerability and flood hazard impacts."
>
> National Academy of Sciences; *Framing the Challenges of Urban Flooding in the United States*; 2019

Resolving social justice challenges related to disasters is a complex problem, but improving storm flood risk assessment of existing properties and discouraging new development in risky places can help reduce inequities over the long-term.

Improved Coastal Storm Flood Risk Assessment Supports Recognition of Sea Level Rise Risks: A final benefit of better coastal storm flood risk assessment is that it opens the door to better understanding of the related risks that lie down the road in the form of inundation by rising sea levels.

Although coastal storms generate devastating flood damage, impacts occur in the path of a storm and floodwaters recede after a storm. Rising sea levels expand the area at risk of storm flooding but also bring permanent inundation to parts of all coastal communities over the long-term. Because storm risks are more dramatic than incremental sea level rise and more immediate (i.e., a storm could happen tomorrow, but the worst impacts of rising seas are

decades away) they tend to get more attention than the existential risk from rising seas. But better understanding of storm flood risks, including the connection between coastal storm flooding and rising seas, will help overcome hesitancy to adapt to the existential risks that rising seas pose to many coastal homeowners and communities.

III. Recommended Steps to Strengthen Coastal Storm Flood Risk Assessment

The federal government can provide leadership to strengthen the assessment of current and future coastal storm flood risk and help support substantial improvements in investment and planning decisions along the Atlantic and Gulf of Mexico coasts, including Puerto Rico and the U.S. Virgin Islands, by public and private parties.

Specific steps that the federal government should take are:

1. Establish institutional capacity to assess climate-informed coastal storm flood risk;
2. Create an online coastal storm flood risk assessment tool;
3. Apply coastal storm flood risk assessment products to inform decisions; and
4. Establish coastal storm flood risk assessment research agenda.

Each of these recommendations is discussed below.

1. **Establish Institutional Capacity to Assess Coastal Storm Flood Risk:** The federal government should assign responsibility for strengthening assessment of current and future storm flood risk from tropical storms and hurricanes to an interagency task force (e.g., the existing Sea Level Rise and Coastal Flood Hazard and Tools Interagency Task Force).

   A key product of the Task Force is a report on future sea level rise under various climate scenarios, including projections of future sea level rise by decade to 2150 and predictions of changes to non-storm "sunny day" flooding. A key factor in future storm flood risk is the degree of sea level rise occurring under a range of climate scenarios. Federal agencies already included in the Task Force are the same agencies that should participate in work to strengthen coastal storm flood risk assessment.

An Integrated Approach to Assess and Manage Hurricane Risk in a Changing Climate

"Major advances in hurricane risk management are urgently needed. Given the inherent uncertainties in hurricane activity, such management should be strongly informed by probabilistic risk assessment. Furthermore, hurricane risk assessment cannot rely solely on historical records: to account for projected future changes, it should integrate physical knowledge and models with observational data." p. 118

National Academies of Sciences, Engineering, and Medicine. 2016. The National Academies Press. https://doi.org/10.17226/21825.

Given the close connection of sea level rise flood assessment and coastal storm flood risk assessment, the federal government should formally assign the work of strengthening storm flood risk assessment to the existing Task Force. It should be directed to integrate assessment of future coastal storm flood risk with its continuing work on sea level rise.

2. **Create Online Coastal Storm Flood Risk Assessment Tool:** The federal government should direct agencies to work together (e.g., through the existing Task Force) to create an online tool to support decision-makers and the public in assessing current and future flood risk from tropical storms and hurricanes along the Atlantic and Gulf coasts.

   Design Principles: Some principles to guide the development and design of a coastal storm risk tool include:

   A. **Federal Interagency Product:** A new coastal storm risk assessment tool should be developed by the federal government as a free to use and widely available resource. To avoid duplication or inconsistencies across federal agencies, the tool should be developed and maintained on an interagency basis.

      The *National Strategy for a Sustainable Ocean Economy*, published by the White House in June 2024, includes a recommendation for expanding tools to inform planning for future ocean conditions:

      "Expand the development and use of climate products and services in planning, such as the Interagency Sea Level Rise Scenario Tool, to inform planning and development resilient to future ocean conditions. Data, information, products, and climate tools should be user-friendly and developed at relevant geographic, temporal, and spatial scales to encourage uptake and use." p. 25

   B. **Address Atlantic and Gulf of Mexico Coasts:** Although coastal storms and hurricanes pose a threat to the entire coastline of the United States, the greatest potential for loss of life and property damage is far greater along the Atlantic and Gulf of Mexico coasts and work to develop a tool to assess the current and future risks that storm flooding poses should initially focus on these areas.

   C. **Begin with Existing Data and Research:** A risk in developing an assessment tool is that the risk information provided will exceed the data and research that is available (e.g., provides place specific projections poorly supported by data).

      Federal agencies should be careful to design a risk tool that starts with current data and information and is improved in subsequent iterations as the products

of new research become available (i.e., work identified in a research agenda as recommended in #4 below). At the same time, federal agencies should avoid putting off development of an initial iteration of a coastal storm flood risk tool (i.e., avoid "making the perfect the enemy of the good").

D. **Align with Existing Sea Level Rise Analysis and Tool:** The existing Task Force has published reports assessing coastal flood risks associated with rising sea levels and developed an online tool to assist decision-makers and the public in applying the data supporting the assessment. A new tool addressing coastal storm risk should be closely aligned with the sea level rise tool to the extent that existing data and research allows. More specifically, federal agencies should implement, or work toward implementing, a coastal storm risk tool that allows a user to:

- select a location along the Atlantic and Gulf coasts to evaluate storm flood risk;
- select a target decade between 2030 and 2100; and
- select a climate scenario used for sea level rise assessment (i.e., low, intermediate low, intermediate, intermediate high, and high).

E. **Support Evaluation of Storm Flood Changes Due to Rising Seas:** The most significant future change in coastal storms is the increase in storm surge heights attributable to the gradual increase in sea level. A storm risk tool should support assessment of changes in storm surges due to rising seas. It is important to note that developing an initial storm flood risk tool that simply applies the projected sea level rise to historical storm frequency and severity information would be a significant step toward describing future risk and that would fit into the existing sea level rise tool framework.

F. **Support Evaluation of Tropical Storm and Hurricane Characteristics**: A storm risk tool should apply to tropical storms (i.e., storms with winds over 34 knots) and hurricanes (i.e., storms with winds over 64 knots) and, where possible, provide information on a range of current and likely future storm characteristics including:

- storm frequency;
- storm rainfall levels; and
- storm intensity (i.e., probability of severe storms of Category 4 or 5).

This information should be provided at the most detailed geographic scale that is supported by available data and research.

G. **Graphic Output:** The sea level rise scenarios developed by the Sea Level Rise and Coastal Flood Hazard and Tools Interagency Task Force include a graphic output showing a "sea level rise curve" for a specific location, for a future date (e.g., 2100), and assuming one of five climate change scenarios. The graphic format makes it easy to visualize an array of complex information. A coastal storm risk tool should include a standard graphic output (see Attachment 2 for an example format). Presentation of results in diverse languages would improve access.

H. **Integrated Numerical Score for Current Storm Flood Risk:** A coastal storm risk tool should generate a single numerical score reflecting the historical storm flood risk at a location that is as detailed as is supported by data and research. Where possible, the tool should put this score in the context of scores of:

- other locations in the state; and
- all other locations on the Atlantic and Gulf of Mexico coasts.

I. **Integrated Numerical Score for Future Storm Flood Risk:** A coastal storm risk tool should generate a single, numerical score reflecting future storm risk at a location (i.e., sea level rise contribution to storm surge height and other storm characteristics) on a decadal basis to 2100. This future flood risk score could be compared to the comparable current storm flood risk score to provide a sense of the degree of increasing risk. Where possible, the tool should put this score in the context of scores of:

- other locations in the state; and
- all other locations on the Atlantic and Gulf of Mexico coasts.

This element of a tool may need to be developed in later iterations based on future research.

3. **Apply Coastal Storm Flood Risk Assessment Products to Inform Decisions:** The federal government should work with state, tribal, and local governments, stakeholders, the private sector, and the public to apply coastal storm risk assessment tools to a range of decisions.

Some key decisions are described below:

- **Disclose Storm Flood Risk at Time of Sale:** Awareness of storm flood risk is especially critical for people considering purchase of a home or other property. Lack of understanding of storm flood risk can result in overvaluing a property and in unplanned costs related to flood mitigation and repair.

The Federal government should encourage Congress to adopt requirements for flood risk disclosure at time of sale of a property, including disclosure of storm flood risk based on the recommended federal storm flood risk tool. In addition, many coastal states have laws requiring flood risk disclosure and the Federal government should work with states to include storm flood risk in state disclosure laws.

- **Disclose Storm Flood Risk as Part of Mortgage:** Financial institutions originating mortgages, and federal mortgage guarantee institutions, should require storm flood risk assessments as a part of a mortgage and should adjust mortgage terms to account for any increases in risks of default.

- **Coastal Planning, Zoning, and Investments:** State and local governments now develop plans and zoning ordinances to guide coastal conservation and development and to make investments in infrastructure and other assets. The federal government should work with state and local governments to provide coastal storm risk assessment information in a form that can be applied to coastal management plans, laws, and investments.

- **Army Corps of Engineers Coastal Storm Risk Management Studies:** The Army Corps of Engineers conducts large scale studies of coastal storm risk in cooperation with communities along the coast. Although these studies consider projected sea level rise implications for future storms, they commonly evaluate storm risks based on historical data rather than projected changes in storm impacts. For example, the coastal storm flood risk study for Norfolk, Va. states:

  "This study is currently using existing historical data and information for estimating storm frequency and intensity. This study does not incorporate estimates for changes in future storm frequency and intensity due to a lack of quantifiable data. Future sea level rise estimates are incorporated into the study based on scientific estimates."

  The Corps should use improved tools for assessment of coastal storms to develop coastal flood risk estimates that reflect more severe storm conditions and factor these risks into alternative project designs.

- **Insurance Rate Adjustments:** Information about relative storm flood risk today and in the future is useful for setting rates that fairly reflect risks and provide for sustainable financing of damage repairs.

The National Flood Insurance Program should review coastal storm risk assessment information and consider using this information in future risk rating systems. In addition, federal agencies should work with private insurance companies and state property insurance programs to apply coastal flood risk rating information to rate setting.

- **Federal Flood Risk Management Standard (FFRMS):** Federal agencies now implement the Federal Flood Risk Management Standard that provides for assessment of flood risk, including using a "Climate Informed Science Approach" to identify areas subject to present or future flood risk. Proposed federal investments are to be relocated to areas not subject to flood risk or, where relocation is not possible, projects are to be designed to withstand projected flooding.

  Federal agencies should consider coastal storm flood risk in implementing the FFRMS, including using storm surge flooding projections to identify flood risk areas.

- **Direct Notice of Highest Risk Property:** Relying on homebuyers and other decision-makers to affirmatively seek coastal storm flood risk information will result in many people who simply fail to consider the risk. For places where the risk information proposed in this paper indicates the very highest risk (e.g., the riskiest five percent of properties) limited understanding of the risk could result in devastating financial costs.

  For these highest risk properties, the federal government has a "duty to warn" of the storm flood risk and the future sea level rise risk. For these cases, the federal government should provide direct notice by mail periodically outlining both storm flood risk and conventional (i.e., non-storm) sea level rise risk.

4. **Establish Coastal Storm Flood Risk Assessment Research Agenda:** The federal government should establish and implement an agenda for research needed to improve the accuracy of assessment of current and future coastal storm risk.

   Some of the elements of a coastal storm flood risk assessment will require translating existing research findings into outputs that are more place-specific, linked to the climate scenarios in the reports of the Sea Level Rise and Coastal Flood Hazard and Tools Interagency Task Force, and linked to future decades (e.g., 2050, 2100). Given that changes in storm factors are now linked to a 2 degree C change in global temperature (i.e., roughly 2050), this translation can be initiated but may require additional research.

Other elements of a coastal storm risk assessment may require new research and take longer to develop. Examples of new research needed include:

- best practices for deployment of risk assessment information to effectively inform public and private decision-makers about coastal storm flood risks;
- development of methods for integrating storm factors into a single coastal storm flood risk numerical score for current and future conditions;
- development of research to support storm characteristic projections to the year 2100;
- development of reliable, long-term projections (i.e., 2100) of changes in coastal population by state under varying assumptions of climate change, including estimates of population growth in places right on the coast (i.e., within 33 feet of elevation); and
- the best application of coastal storm flood risk assessment to Pacific Ocean coasts of the United States and island territories of the United States.

Federal agencies assigned responsibility for strengthening coastal storm flood risk assessment should develop a research agenda describing research needs, setting priorities, and assigning research to appropriate federal agencies. The US Coastal Research Program, a collaboration of Federal agencies, academics, and stakeholders working to identify and address needed coastal research, is in a strong position to support this work. Research findings should be used to improve and expand coastal flood risk assessment tools and supporting information. This research agenda should be updated periodically in consultation with stakeholders and the public.

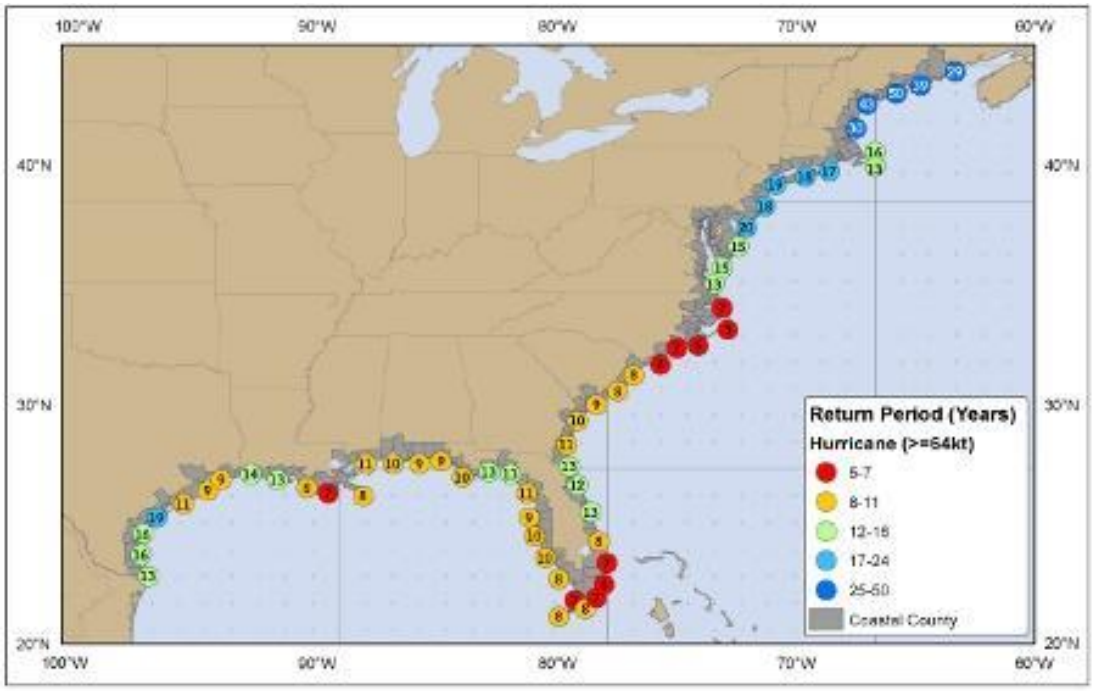
The *Coastal Flood Resilience Project* is a coalition of organizations working for stronger programs to prepare for coastal storm flooding and rising sea level in the United States. The views expressed in this *White Paper* are those of the supporters listed below and do not represent the views or endorsements of their organizations.

Supporters of this *White Paper* include:

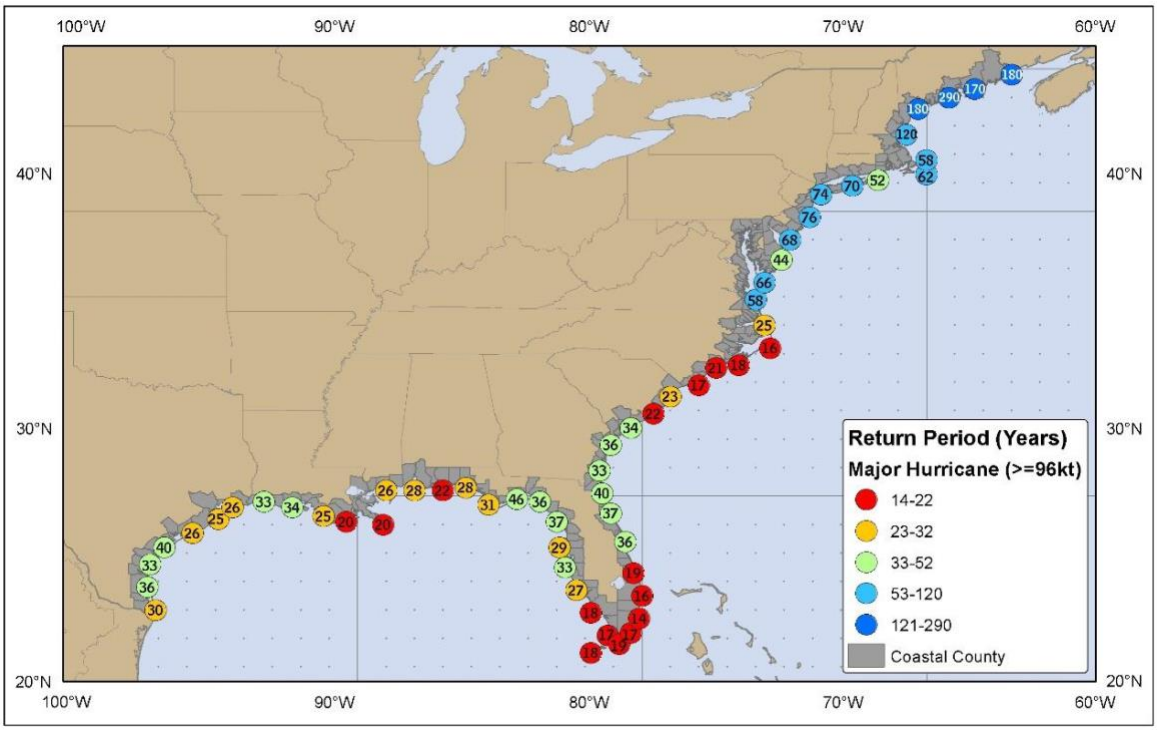
- Jay Austin; Environmental Law Institute
- Ian Blair; Wetlands Watch
- Chris Eaton; Earthjustice
- Stephen Eisenman; Anthropocene Alliance
- Harriet Festing; Anthropocene Alliance
- Sarah Guy; Ocean Defense Initiative

- Rich Innes; Association of National Estuary Programs
- Charles Lester; Director of the Ocean and Coastal Policy Center at UC Santa Barbara
- Alex Miller; Urban Ocean Lab
- Jeffrey Peterson; Environmental Law Institute and author of *A New Coast: Strategies for Responding to Devastating Storms and Rising Seas*
- Jason Scorse; Middlebury Center for the Blue Economy
- Emma Haydocy; Surfrider Foundation
- Mary Carson Stiff; Wetlands Watch
- Shana Udvardy; Union of Concerned Scientists

Attachment 1: NOAA Hurricane Return Periods



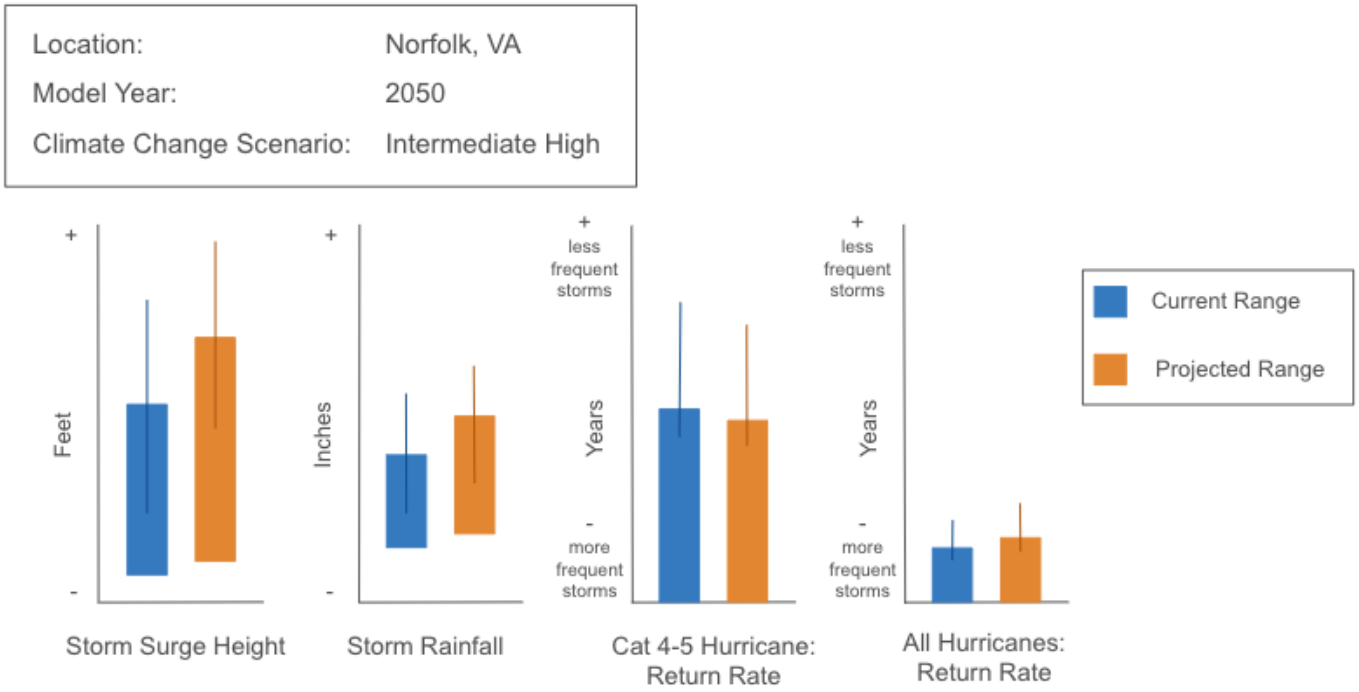
Estimated return period in years for hurricanes passing within 50 nautical miles of various locations on the U.S. Coast; see https://www.noaa.gov/stories/what-are-chances-hurricane-will-hit-my-home



Estimated return period in years for major hurricanes passing within 50 nautical miles of various locations on the coast; https://www.noaa.gov/stories/what-are-chances-hurricane-will-hit-my-home

Attachment: Hypothetical Graphic Presentation of Coastal Storm Flood Risk

A hypothetical coastal storm flood risk graphic representing risk at a specific place, for current conditions, for conditions at a future date (e.g. 2050), assuming a given climate scenario (i.e., as defined in the Sea Level Rise Scenarios Report of the Sea Level Rise and Coastal Flood Hazard and Tools Interagency Task Force). An online tool, modeled after the existing sea level rise tool supporting the Sea Level Rise Scenarios Report, should allow a user to input variables and generate a graphic product illustrating risk.



Graphic by Basia Marcks