The information provided here is for informational and educational purposes and current as of the date of publication. The information is not a substitute for legal advice and does not necessarily reflect the opinion or policy position of the Municipal Association of South Carolina. Consult your attorney for advice concerning specific situations.

GUY CARPENTER

WEATHER & CLIMATE
VOLATILITY OR CHANGE IN THE AIR?

July 19, 2019

Joshua Darr, MS CCRA
Senior Vice President & Meteorologist

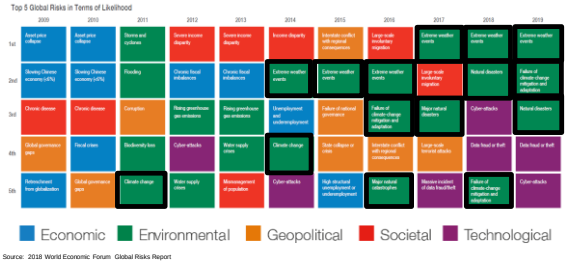
MASC Annual Meeting, Greenville, SC

MARSH & MCLENNAN COMPANIES

Volatility or Change in the Air?
Agenda

- What are the latest scientific views on changing weather patterns?
- How does the changing weather patterns impact the frequency and severity of North American catastrophe events, specifically in South Carolina?
- What the future resemble the past? What can we do about it?

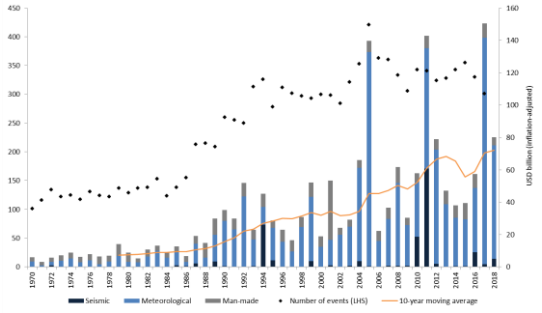
Weather Volatility
Why is it Important to Stay in Tune with the Latest Science?



Source: 2018 World Economic Forum Global Risks Report

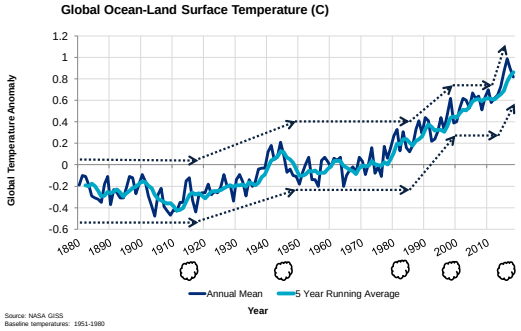
Increasing acknowledgement by many policy groups that we are witnessing an increase in cat events and extreme weather globally

Global Insured Catastrophe Losses
1970 - 2018



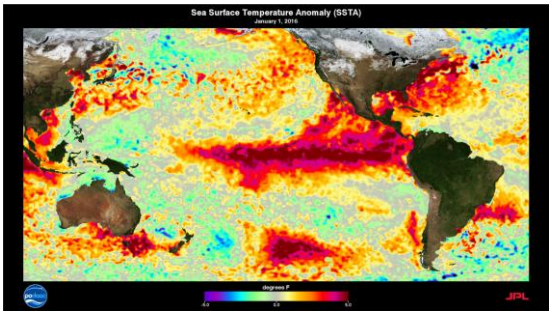
Source: Guy Carpenter, Swiss Re, includes NFIP insured losses

Global Temperatures Since 1980
Natural Cycles being Disrupted? The Disputed Pause of the 2000s

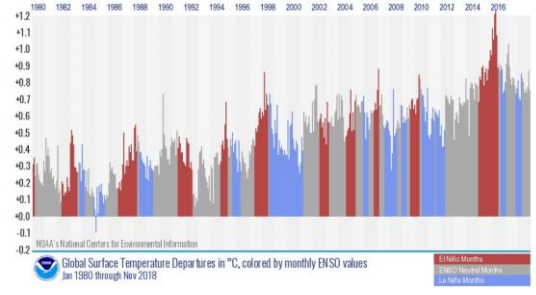


Source: NASA GISS
Baseline temperatures: 1951-1980

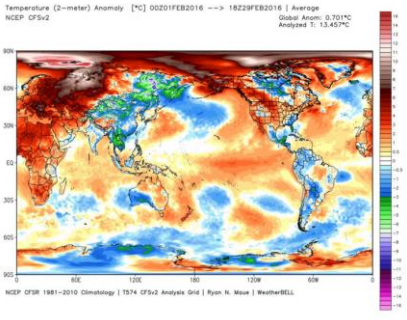
The 2016 Mega El Niño
Record Intensity



El Niño Events Naturally Warm the Globe
Warmth Released from Ocean to Atmosphere



Comparing Most Recent Mega El Niño Events
Meaningful Shift in Region of most Prominent Warming

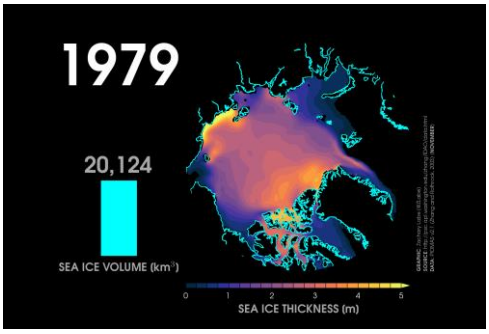


El Niño events tend to propel natural warming of the globe

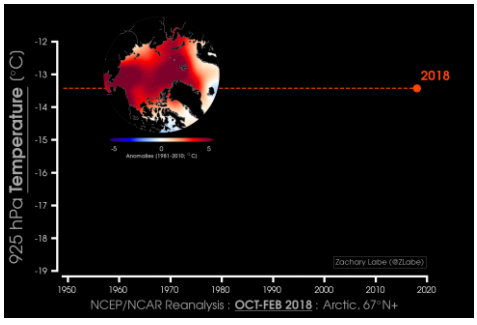
Most of the mega 2016 El Niño warming was focused in the Arctic

Winter temperatures were 8-15C (15-28F) warmer than average at peak

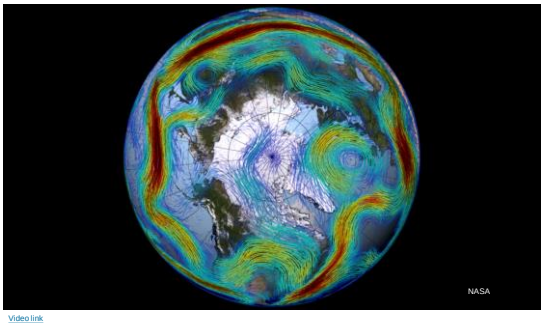
The Acceleration of Arctic Sea Ice Loss
Outsized Impact on Temperatures as Ice Shifts to Open Waters



Less Ice = Dramatic Warming Across the Arctic
Autumn Arctic Temperatures since 1950

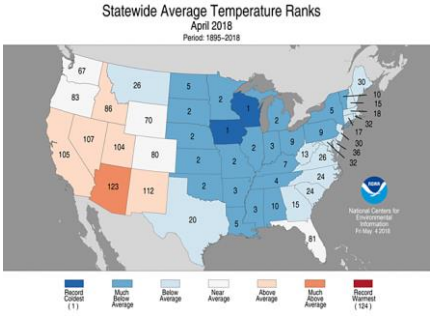


The Jet Stream
Measuring the Strength of Temperature Contrast

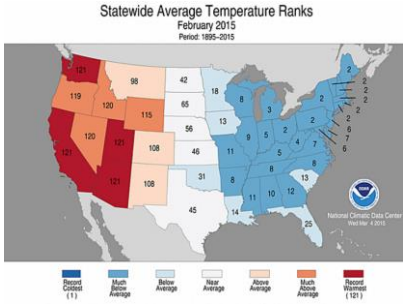


Video link

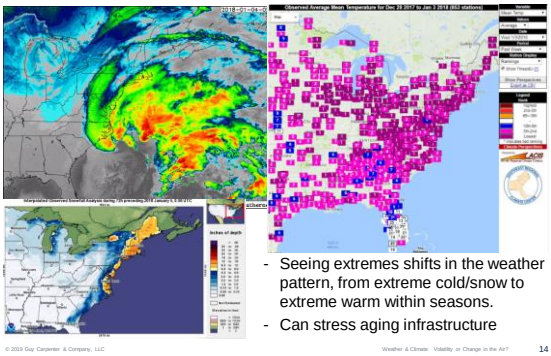
Tale of Two Springs!
Comparing April 2017 to April 2018



Tale of Two Winters
Comparing February 2015 to 2017

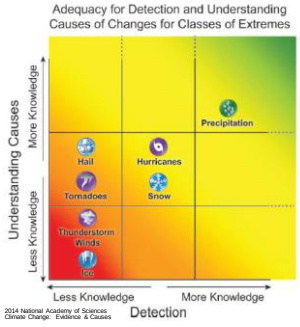


The January 4-5, 2018 Superbomb
Severe cold outbreak, intense nor'easter storm



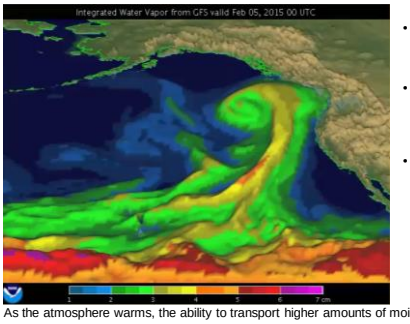
- Seeing extremes shifts in the weather pattern, from extreme cold/snow to extreme warm within seasons.
- Can stress aging infrastructure

Current Climate Change Understanding
Stacking Weather Perils Side by Side



- Is there a way to link a changing climate to any individual catastrophe peril event?
- Science evolving rapidly in this field
- Highest confidence in link to precipitation events
- Least confidence in thunderstorm and winter events

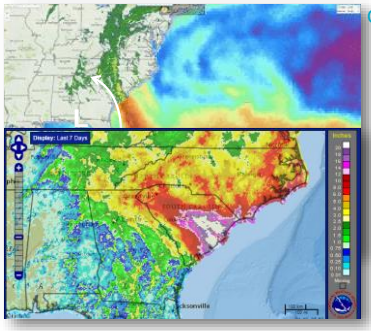
Atmospheric Rivers
The Moisture Freeway from the Tropics to Mid-latitudes



- Narrow, moisture laden corridors in the atmosphere
- A 'freeway' of moisture rich air that connects the tropics to the mid-latitudes
- Advances in satellite technology over the past 20 years have brought AR detection from research to operations

As the atmosphere warms, the ability to transport higher amounts of moisture from the tropics to the mid-latitudes increases roughly 7% for 1 degree C.

Atmospheric Rivers in South Carolina
2015, Joaquin, and an autumn cutoff low pressure system

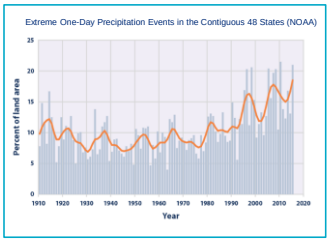


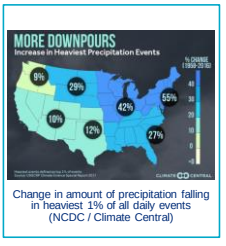
Top: Water Vapor & Radar Loop (CIMSS)
Bottom: Total Radar Rainfall (NWS)

October 3-8, 2015
- 26" max rainfall total
- 23" falling in Charleston,
- 4-10 inch range occurring over much of the mid-Atlantic

Impacts
- Long lived power outages, in part due to flooded infrastructure and downed trees
- PCS estimated damages in excess of $352M, with 70% of losses occurring in South Carolina

Extreme Rainfall Events
A Double Whammy: More Frequent and Severe

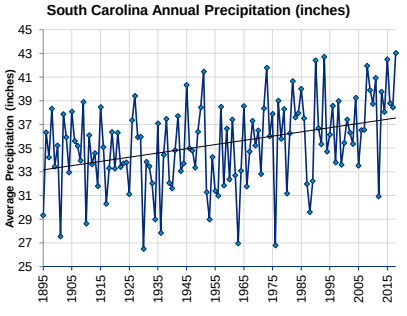




Change in amount of precipitation falling in heaviest 1% of all daily events (NCDC / Climate Central)

2016 featured 19 separate floods the US, the most since records began in 1880
2017 continued the deluge with Hurricane Harvey in Houston;
2018 brought Lane to Hawaii, Florence to Carolinas, record setting Mid-Atlantic
2019 off to fast start with record floods in central US

South Carolina Precipitation
On average 6-7" higher since early 20th century



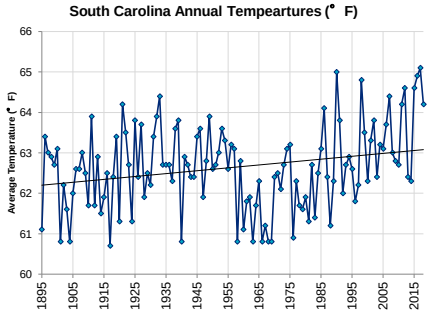
5" wetter
per year now than average of late 1800s

Above average years in early 1900s

comparable to

below average years in 2000s

South Carolina Temperatures
On average 3°F warmer than early 20th century

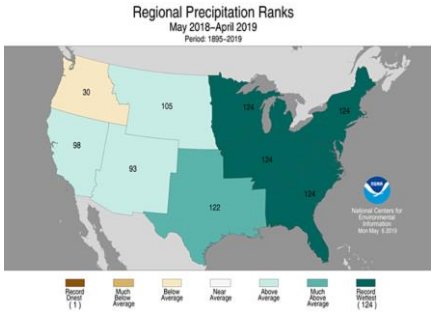


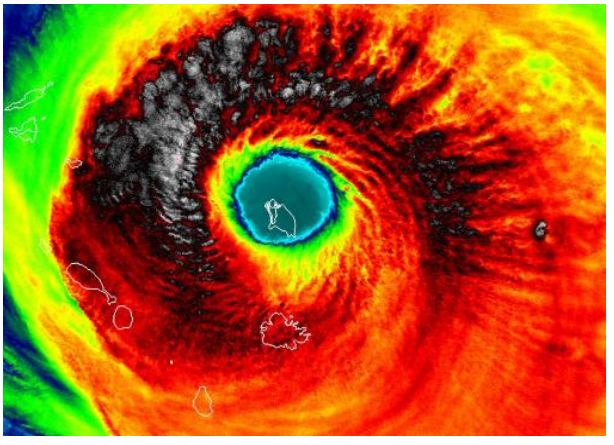
1.8°
rise in temperatures equates to

7%
more vapor being able to be held in atmosphere

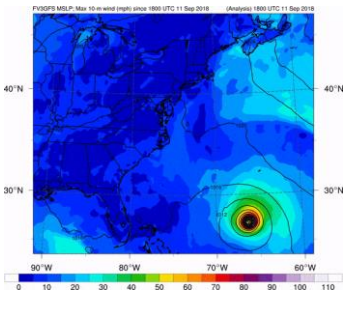
Last 10 years average
~2.0°F
warmer
than turn of the 20th century

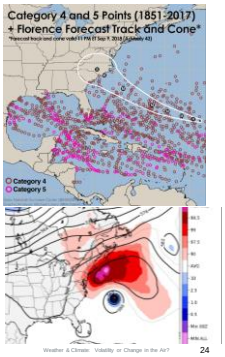
Last 12 months record wettest across eastern US
South Carolina registered wettest year on record





2018 and Florence
Very warm oceans, low wind shear, Arctic influence

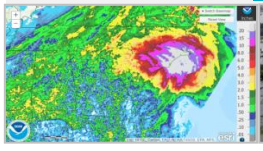




Category 1 Hurricane Florence of 2018
The Harvey of the Carolinas, 3rd wettest hurricane on record

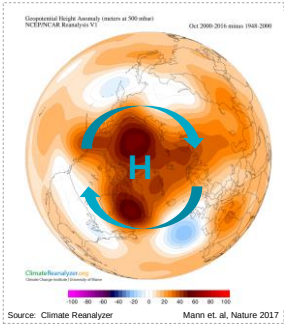
Collapse from category 4 to 1 just before landfall resulted in major storm surge into coastal Carolinas

All-time North Carolina rainfall record for a tropical cyclone with 35 inches of rain in North Carolina and 23 inches in South Carolina, **becoming the third and fourth states to break all-time hurricane rainfall records since 2017** for the contiguous U.S.



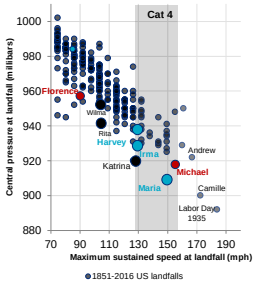
Joaquin, Florence, Harvey, Stalling Hurricanes
What is influencing extreme rain events from hurricanes?

Stalled jet stream patterns
- Increase in 'blocking high pressure systems' over northern latitudes
- Increased potential to stall tropical systems or steer further west
- Possible link due to summer warming of mid-latitudes and Arctic
- Indication that Sandy-like systems could be higher likelihood in the future

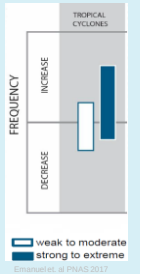


Source: Climate Reanalyzer Mann et. al, Nature 2017

Repeat seasons of intense US landfalling hurricanes
Verifying climate research or just filling in the gaps?



Future Climate Expectations

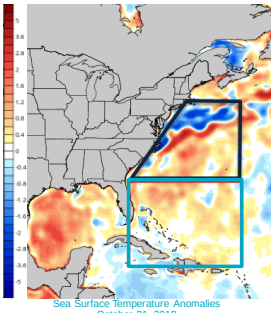


Emanuel et. al PNAS 2017

Climate and hurricane research expects **increasing frequency** of more **rapid intensification** of hurricanes

Harvey, Irma, Maria, Jose, Florence and Michael all underwent 45-65 mph increase in 24 hours

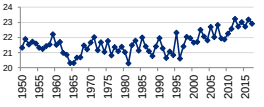
Warming trend in October oceans
Extends Late Season Hurricane Potential



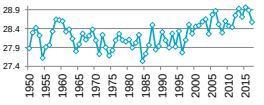
Sea Surface Temperature Anomalies
October 31, 2018

SST source data: NOAA/ESRL

Sea Surface Temperature (° C) 30-42N



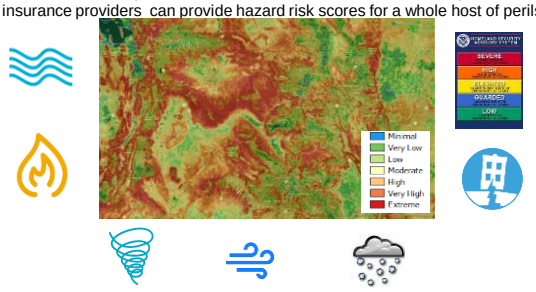
Sea Surface Temperature (° C) 15-30N



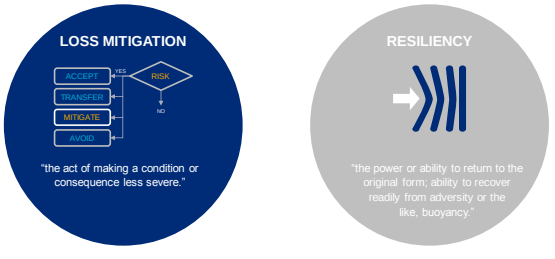
Increasing Company Strength
Leveraging Analytics to Make Objective Assessment

Risk Differentiation
Objective Analytics Driven by Insurtech Solutions

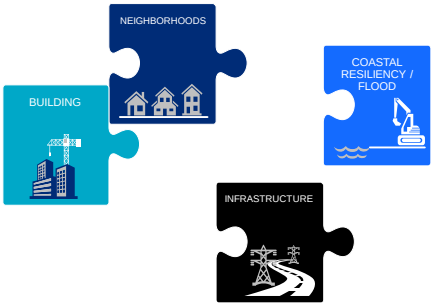
In addition to all exposure and cat model solutions, a host of companies and insurance providers can provide hazard risk scores for a whole host of perils



Exercising Resiliency
Loss Mitigation and Resiliency Defined



Exercising Resiliency
Four Main Focal Areas



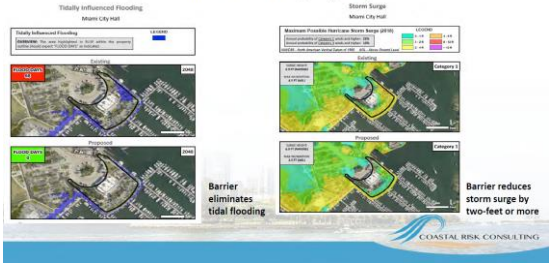
Where will mitigation be best served?
Different costs for different flood defenses

Coastal Risk Matches Flood Defense Systems with Risks

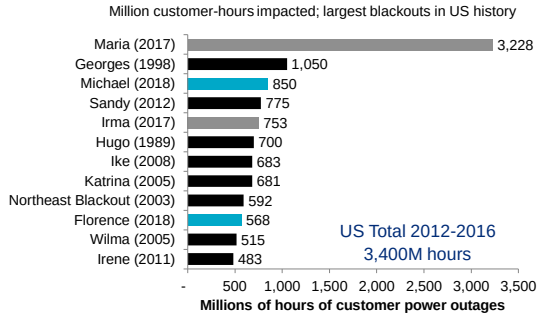
Personalized resilience-accelerating advice for individuals, businesses and governments

Risk level differentiation
How much mitigation is necessary?

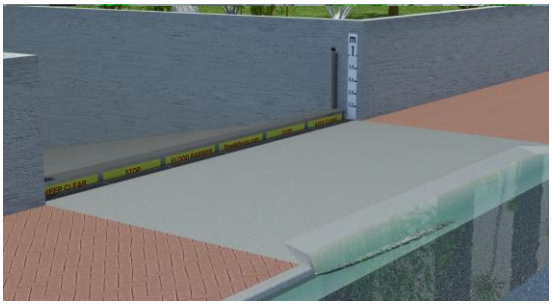
Risk Mitigation Modeling
Cost-Benefit Analysis (ROI)



Outsized Loss to Expectations
Extreme Power Outages more Prevalent



Flood Barrier Control
Automated Equipment to Protect Critical Assets



Loss Mitigation Improving Resiliency
Pre/During Event Strategies

Applying resiliency efforts in underwriting & engineering

Research & Development, Education, Implementation

Cost vs. Investment

Protect, Elevate, Move out of harm's way

$1 of investment save $6 of loss, $105 in hurricane regions

ResilientAmerica · THE WORLD BANK · FEMA · CENTER FOR RESILIENT CITIES

- Data and Functionality
- Allows claims manager to identify policyholders impacted by events

Claims

Peril Impact

- Dashboard view
- Provides loss estimates based on event and nearby locations

- Automated email
- Issues notification up to 3x per day if there is loss potential over specified

Loss Notification

CATography Predictive Analytics

Weather & Climate Patterns
Increasing Volatility or Fundamental Changes?

Is the weather getting worse?
No. However, it's getting more volatile

Why is weather getting more volatile?
Warmer Arctic as well as mid-latitudes linked to stickier weather patterns, causing longer regimes with embedded extremes

Can we say anything about the future?
Arctic ice loss expected to continue, no sign of going back to historical normals

What can be done to manage the volatility?
Insurance protection, real time monitoring & catastrophe modeling, resiliency efforts

Man made or natural climate variability?