AGENDA
VOLATILITY OR CHANGE IN THE AIR?

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?

What lessons have been learned? What can we do about the future?
WEATHER VOLATILITY
WHY IS IT IMPORTANT TO STAY IN TUNE WITH LATEST SCIENCE?

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

GLOBAL INSURED CATASTROPHE LOSSES
1970 TO 2018
GLOBAL TEMPERATURES SINCE 1880
DID THE GLOBAL PAUSE OF THE 2000S EXIST?

Global Ocean-Land Surface Temperature Anomaly (°C)

Source: NASA GISS
Baseline temperatures 1951-1980
EL NIÑO 2016
RECORD STRONG INTENSITY

EL NIÑO 2016
RECORD STRONG INTENSITY – PROPELS NATURAL WARMING
WHERE IS THE WARMING TREND MOST SIGNIFICANT?

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 8-15°C (15-28°F) warmer than average

THE ACCELERATION OF ARCTIC ICE LOSS
IMPACT ON ARCTIC TEMPERATURES DUE TO MORE OCEAN
LESS ICE = DRAMATIC WARMING ACROSS ARCTIC
AUTUMN ARCTIC TEMPERATURES SINCE 1950

THE JET STREAM
MEASURING THE STRENGTH OF TEMPERATURE CONTRAST
TALE OF TWO WINTERS  
COMPARING FEBRUARY 2015 TO 2017

Statewide Average Temperature Ranks  
February 2015  
Period: 1895-2015

TALE OF TWO SPRINGS!  
COMPARING APRIL 2017 TO 2018

Statewide Average Temperature Ranks  
April 2018  
Period: 1895-2018
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

2014 National Academy of Sciences
Climate Change: Evidence & Causes
Extremes Rainfall Events
More Frequent and Severe

2016 was the year of the flood in the U.S. with 19 separate floods swamping 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.

Atmospheric Rivers
The Moisture Freeway Out of the Tropics of the Earth

- 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.
MOISTURE AVAILABILITY IN THE ATMOSPHERE
WARMER AIR = MORE ABILITY TO STORE MOISTURE TO RAIN

1.8°F rise in temperatures equates to 7% more vapor being able to be held in atmosphere

3.0°F Lower 48 average temperature increase since 1900

NOT JUST THE CITIES, THE ENTIRE NORTHEAST US
58 NOTABLE TO Crippling Snowstorms SINCE 1950
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

THE MARCH 2018 PARADE LIKED ONLY BY SKIERS
GROUNDHOG’S DAY IN MARCH??!!?
THE HEART OF THE 2017 HURRICANE SEASON
VERY WARM OCEANS, LOW WIND SHEAR, LOWER DUST

Source: NASA
VERIFYING CLIMATE RESEARCH ON HURRICANES?

RECORD SEASON OF INTENSE US LANDFALLS

FUTURE CLIMATE EXPECTATIONS

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

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

SLOWER STORMS CAPABLE OF PRODUCING MORE RAIN

Florence: 5 mph; 40+ inches of rain

Harvey: stalled; 60+ inches of rain
SLOWING HURRICANES, UNUSUAL APPROACH
FLORENCE, HARVEY, SANDY

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 systems moving slower and to the west could be higher likelihood in the future

Source: Climate Reanalyzer

MAJOR THEMES FOR SHIFTING HURRICANE RISK
THE DROUGHT OF US LANDFALLS 2006-16 HAS FLIPPED

- Hawaii frequency increase due to warmer SSTs
- High SSTs: increased risk of rapid intensification?
- 4 category 4 U.S. landfalls in 2 years after decade of drought
- Florence/Sandy approach from east highly unusual
- Jet stream blocked in part due to warm autumns
- Evidence ties shift to Arctic warmth and ice loss
- Published research of slower hurricane forward speed
- Warmer atmosphere able to carry more moisture
- Top three hurricane rainfalls for U.S. in 2017-18
- Event sets may struggle to capture landfall characteristics
- Are SST trends from the past valid for the future?
- Trend of lengthy loss development due to legal environment
WILDFIRE: POSTER PERIL FOR NEW NORMAL?
RECORD SETTING BACK-TO-BACK YEARS OF WILDFIRE

California Wildfires Loss vs. Structures Damaged/Destroyed

- Tubbs 2017
- Woolsey 2018
- Atlas 2017
- Paradise 2018
- Oakland Hills 1991
- Cedar 2003
- Valley 2015
- Butte 2015
- Carr 2018
- Camp 2018
- Woolsey 2018

Insured Loss vs. # Structures Damaged/Destroyed

Weather & Climate: Volatility or Change in the Air? March 2019 AGRiP Governance and Leadership Conference
1) Later onset, earlier end to winter wet season

![Graph showing change in precipitation over time.]

2) Earlier onset of spring heat, persisting through summer

![Heat map showing temperature changes from 1900 to 2010.]
TIMELINE OF A DISASTER
ANTECEDENT CONDITIONS AND FOREST HEALTH

NOW, A WET WINTER NOT NECESSARILY A GOOD THING
WILDFIRE: PLETHORA OF FACTORS AT PLAY

Source: NOAA, Jan 2017 precip anomaly
TIMELINE OF A DISASTER
TREE MORTALITY ON THE RISE IN NORTHERN SIERRA

Sierra Nevada Mortality 2017

WILDFIRE SEASON 2018
MOST STRUCTURES BURNED IN HISTORY – CAMP FIRE

Ember Driven
Transition from wildland fire to structure / urban fire
WHAT LESSONS HAVE WE LEARNED? WHAT DO WE NEED TO MAKE PROGRESS ON?

INCREASING ENTITY STRENGTH
LEVERAGING ANALYTICS TO MAKE OBJECTIVE ASSESSMENT

Risk differentiation

Leveraging cat experience to propel financial stability via analytical solutions

Risk mitigation & Insurtech

Outsized loss to expectations

Efficient claims response
EARLY ENTRY TO INSURTECH WORLD
COMMERCIAL CATASTROPHE MODELING

RISK DIFFERENTIATION
OBJECTIVE ANALYTICS DRIVEN VIA 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.
WHERE WILL MITIGATION BE BEST SERVED?
DIFFERENT COSTS FOR DIFFERENT 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 & EFFICIENT CLAIMS RESPONSE
PRE-EVENT AND 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

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

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 threshold

CATography Predictive Analytics

Weather & Climate: Volatility or Change in the Air? March 2019 AGRI Governance and Leadership Conference

OUTSIZED LOSS TO EXPECTATIONS
POWER OUTAGES MORE PREVALENT

Million customer-hours impacted; largest blackouts in US history

<table>
<thead>
<tr>
<th>Event</th>
<th>Hours Impacted</th>
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</thead>
<tbody>
<tr>
<td>Maria (2017)</td>
<td>3,228</td>
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<tr>
<td>Georges (1998)</td>
<td>1,050</td>
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<tr>
<td>Michael (2018)</td>
<td>850</td>
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<tr>
<td>Sandy (2012)</td>
<td>775</td>
</tr>
<tr>
<td>Irma (2017)</td>
<td>753</td>
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<td>Hugo (1989)</td>
<td>700</td>
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<tr>
<td>Ike (2008)</td>
<td>683</td>
</tr>
<tr>
<td>Katrina (2005)</td>
<td>681</td>
</tr>
<tr>
<td>Northeast Blackout (2003)</td>
<td>592</td>
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<tr>
<td>Florence (2018)</td>
<td>568</td>
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<tr>
<td>Wilma (2005)</td>
<td>515</td>
</tr>
<tr>
<td>Irene (2011)</td>
<td>483</td>
</tr>
</tbody>
</table>

US Total 2012-2016
3,400M hours

Millions of hours of customer power outages
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

JLT Re Real-time monitoring of disasters

US Climate Extremes Index

<table>
<thead>
<tr>
<th>Year</th>
<th>CEI % Lower 48 Under Extreme Conditions</th>
</tr>
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<tbody>
<tr>
<td>1910</td>
<td>10</td>
</tr>
<tr>
<td>1920</td>
<td>15</td>
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<tr>
<td>1930</td>
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<tr>
<td>2000</td>
<td>55</td>
</tr>
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<td>2010</td>
<td>60</td>
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