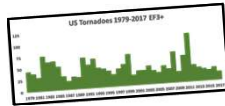
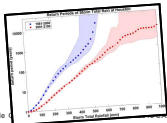
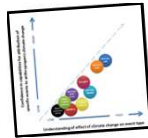
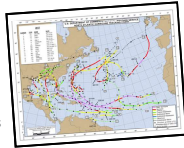


Recent Weather Extremes: Outliers or a New Normal?

Peter Sousounis, Ph.D.
AIR Worldwide
Boston, MA

Presentation Outline

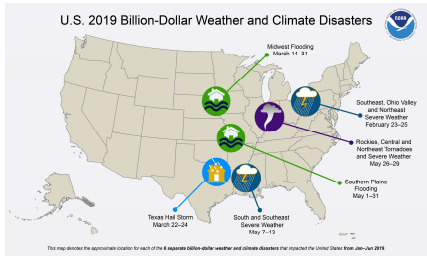
- Overview of the 2017/18 Seasons
- Extreme Event Attribution
- Expected Impacts of Climate Change on Extreme Weather
- Importance of the Historical Record
- Putting Recent Extremes into Perspective



Recent US Weather and Climate Disasters

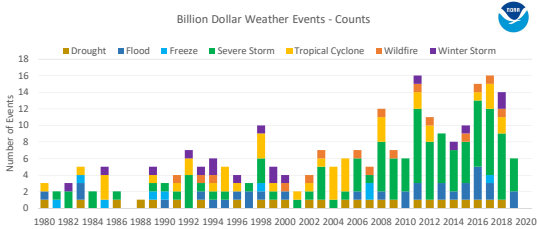


Recent US Weather and Climate Disasters



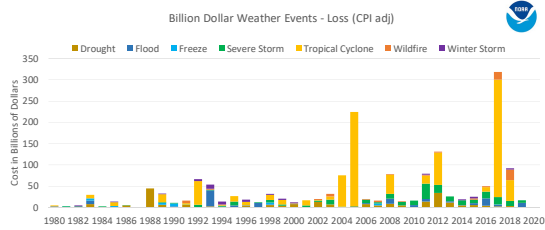
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Number of Events Increasing Mainly from Severe Storm



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Recent Losses Dominated by US Hurricane

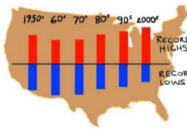
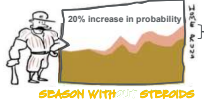


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Extreme Event Attribution

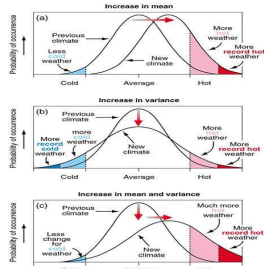
The Analogy with Baseball and Steroids

The weather on steroids



An analogy...
Climate warming is changing the weather like steroids change a baseball player.
Credit: Gerald Meehl, 2012

Changes in the Mean and/or Variability Greatly Increase Probability of Extreme Events



Assuming a normal distribution of some weather variable (temperature)...

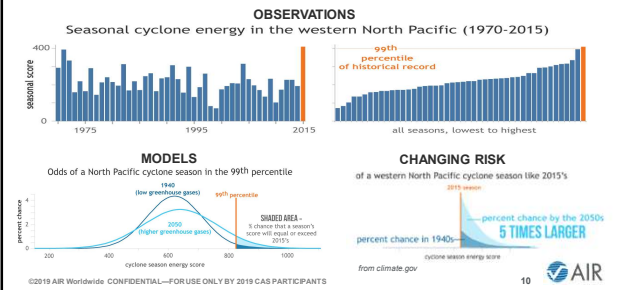
A shift of $1/3 \sigma$ in the mean will double the likelihood of an extreme event

An increase in the variance by 20% does the same

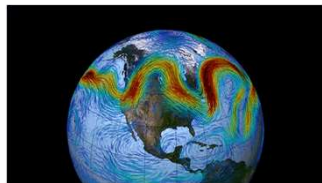
Climate change can shift the mean and (skew) the variance

This is actually happening and likely to continue

Extreme Event Attribution Typically Involves Analyzing Data and Running Climate Models



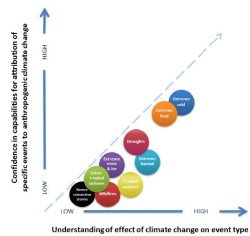
A Dynamics Explanation for Weather Extremes



Arctic ice melt has reduced the pole to equator temperature difference

large planetary waves that normally move slowly around the earth may move more slowly or become trapped, and amplify.

Which Types of Events Have Been Most Likely Influenced by Climate Change?

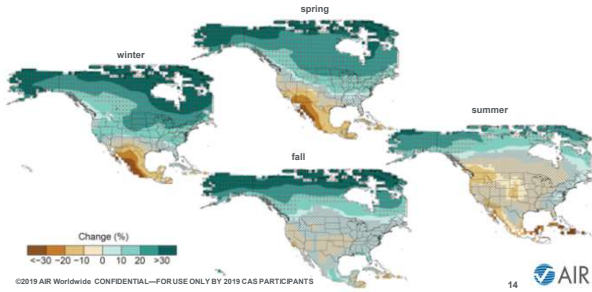


overall confidence in event attribution is strongest for extreme event types that are:

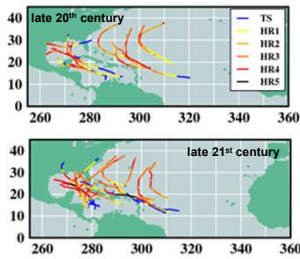
- adequately simulated in climate models
- have a long-term historical record of observations
- are linked to human-caused climate change through an understood and robustly simulated physical mechanism

Expected Impacts of Climate Change on Extreme Weather

Expected Climate Change Impacts on Precipitation

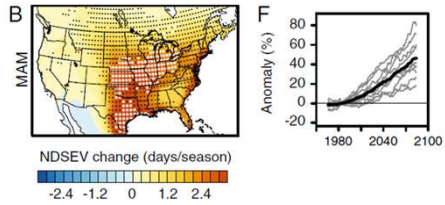


Expected Climate Change Impacts on Tropical Cyclones

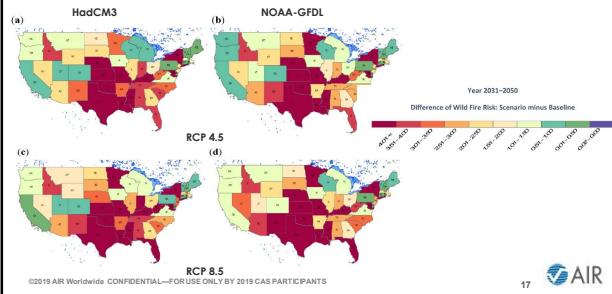


- GCMs do show increase in Cat 4s and 5s by later this century
- Overall decrease in TC numbers
- Precipitation will increase
- Storm surge threat will increase

Expected Climate Change Impacts on Severe Storms



Expected Climate Change Impacts on Wildfire

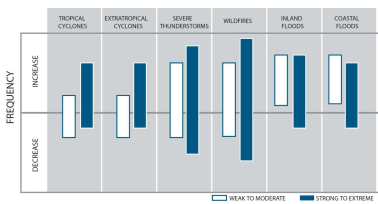


Climate Change Impacts on Extreme Weather

June 2017

Peter J. Sousounis, Ph.D.
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Boston, MA

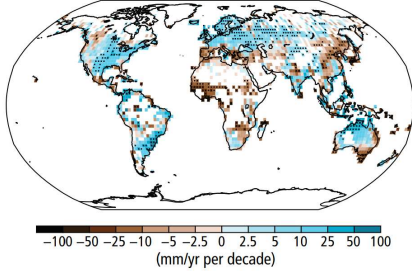
Christopher M. Little, Ph.D.
University of Massachusetts Lowell
Lowell, MA



Examining the Historical Record for Climate Trends

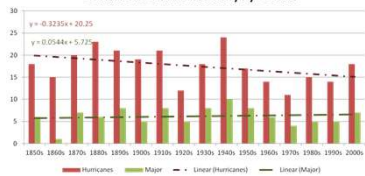
Looking at Historical Trends – Precipitation

Observed change in annual precipitation over land 1951–2010

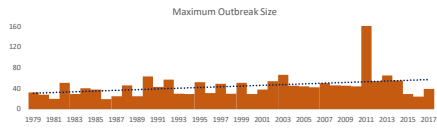
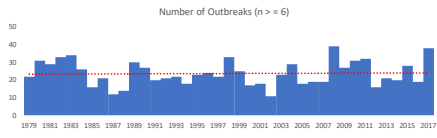


US Landfalling Hurricanes Do Not Show a Trend

US Hurricane Landfall Activity by Decade

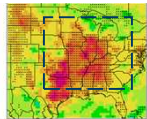


Some US Tornado Features are Showing Trends

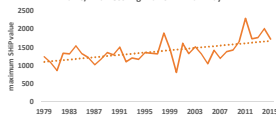


Potential For Severe Weather Has Been Increasing

Sign. Hill Parameter (SHIP) Max. Value Trends Mar-May 1979-2018



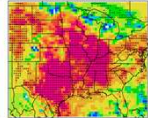
Plains/Midwest Avg Max SHIP Mar-May



Sign. Tornado Parameter (STP) Max. Value Trends Mar-May 1979-2018

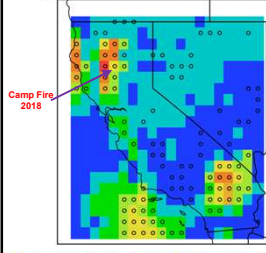


Energy Helicity Index (EHI) Max. Value Trends Mar-May 1979-2018

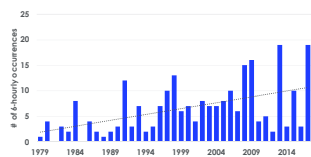


One Ingredient For Wildfires Shows Some Trend

Santa Ana Wind Trends 1979-2017



Autumn Diablo counts Butte CA

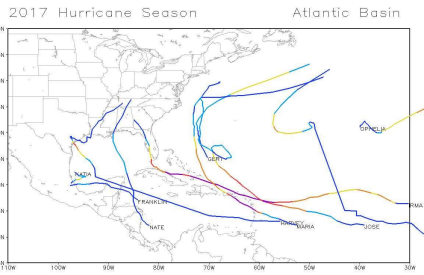


Putting the 2017 Hurricane Records into Perspective

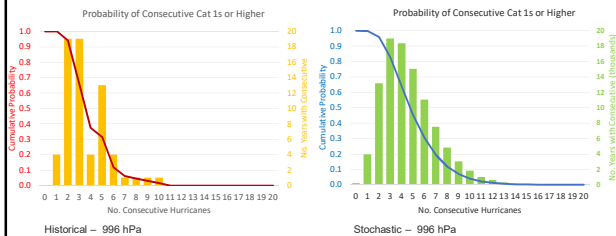
Climate Change and Weather

Some Noteworthy Records Were Set in 2017

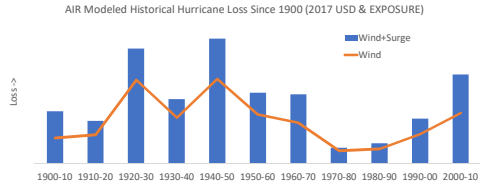
- 2 Cat 4 landfalls in 15 days
- 2 Cat 4s at the same time
- 3 hurricanes at same time
- 3 Cat 4 landfalls in US/Territories
- 4 hurricanes in August
- 10 hurricanes in a row



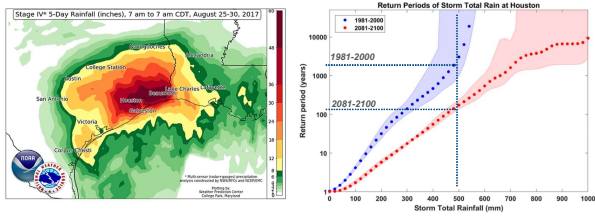
How Unique was 10 Hurricanes in a Row?



Cat Models Put Historical Losses in Proper Perspective



Events Like Harvey will Occur More Often

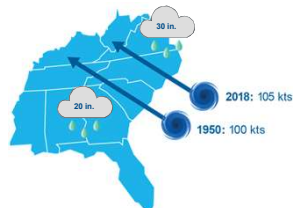


Some Climate Change Impacts on TCs are Evident Now

Impact on Hurricane Florence

- Increased Intensity 5%
- Decreased Forward Speed -25%
- Increased Moisture +7%

$$1.05 \times 1.07 / 0.75 = \sim 1.50$$



Historical record does show trend in forward speed, latitude of maximum intensity, and intensity

Putting the 2017 & 2018 Wildfires into Perspective

Climate Change and Weather

2017 and 2018 Wildfires By the Numbers



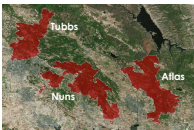
5 of the top 10 most destructive California wildfires

2 largest wildfires in California history

USD 29 billion in insured cat losses

Source: U.S. Swiss Re

2017 Wildfires By the Numbers



Northern California wildfires
October 8 – October 31

Burned area: 245,000 acres
Structures destroyed: 8,900

Costliest group of fires on record
Tubbs Fire costliest on record (until 2018 Camp)

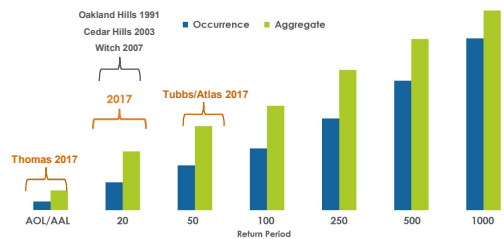


Southern California wildfires
December 4, 2017 – January 12, 2018

Burned area: 308,000 acres
Structures destroyed: 1,355

Thomas Fire largest on record (until 2018 Ranch)

Wildfire Events of 2017 and 2018 are Not Tail Loss Events



AIR Modeled Gross Losses Using 2017 Industry Exposures
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Summary

- Weather catastrophes are getting more frequent and more costly with time
- Climate change may be playing a role b/c extremes for many weather phenomena expected to increase in intensity and frequency by 2100
- Extreme Event Attribution shows promise for understanding climate change influence on individual events
- Many aspects of 2017 and 2018 US hurricane activity are within current model expected probabilities
- 2017 and 2018 California wildfire events are not tail events
- Too early to tell if we are entering a new norm for many weather & climate phenomena

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