Extreme Events in the Context of a Changing Climate

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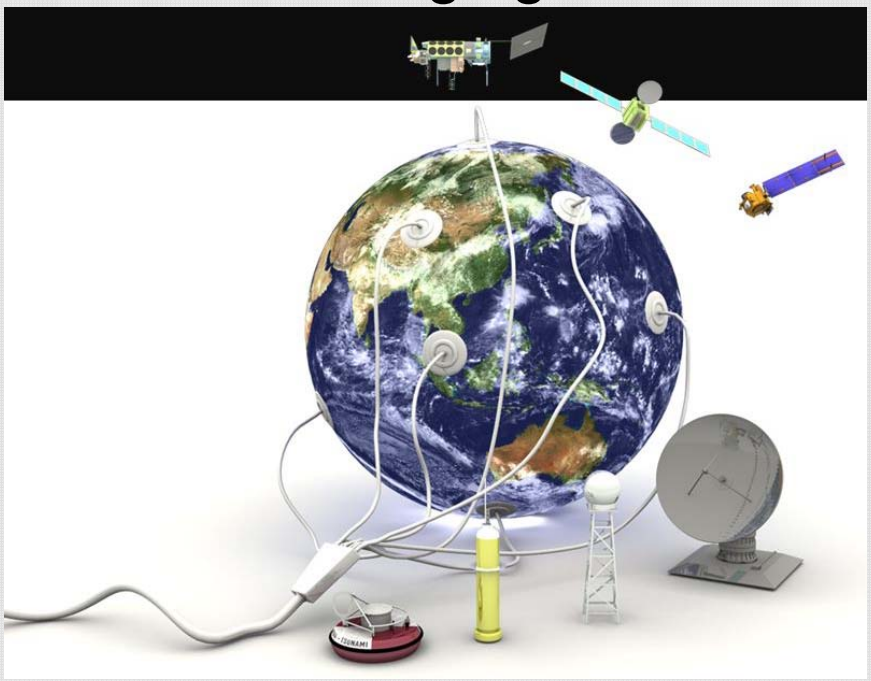
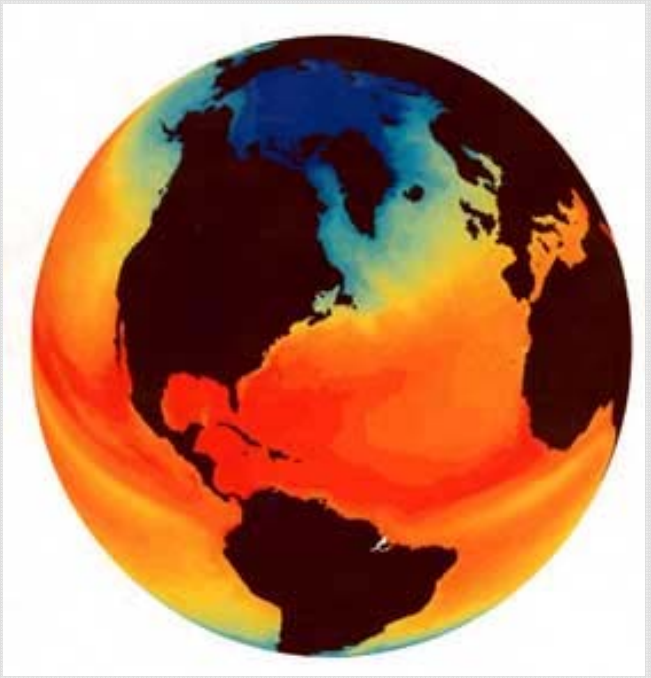
Understanding Changes in Climate

Observations:
How is the climate system changing?



Attribution:
Why is the climate system changing?



Some Extremes are Changing in a Warmer World

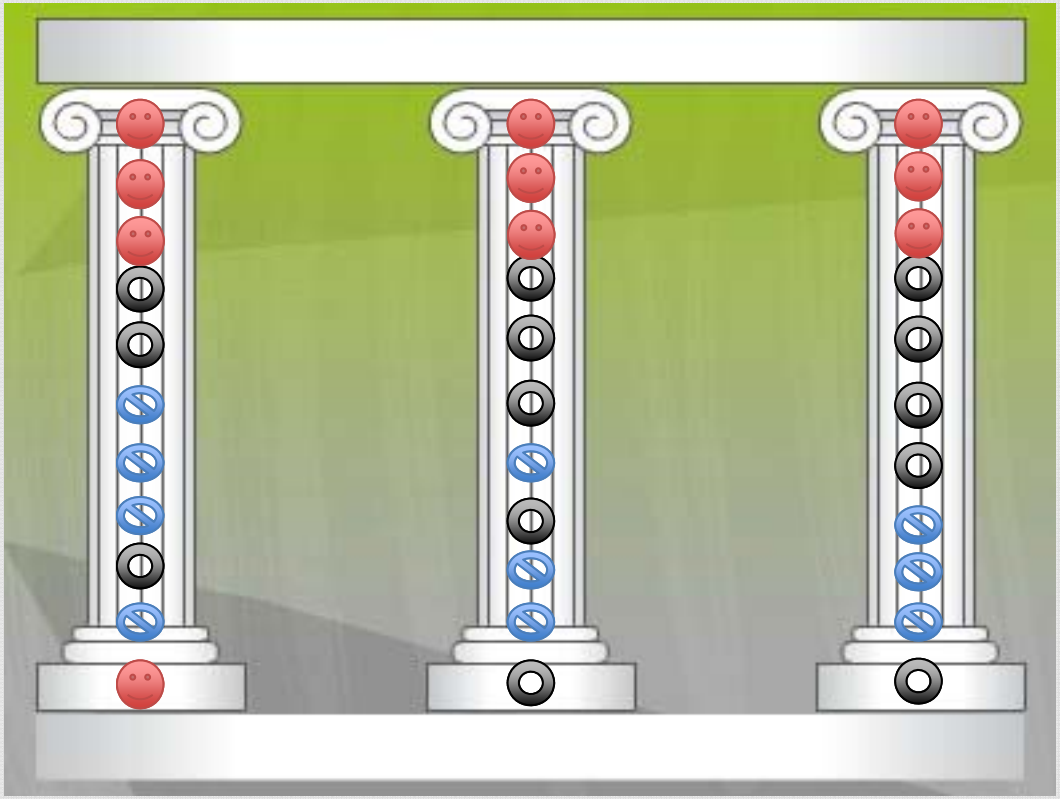
Strongest scientific evidence shows human-caused climate change is increasing heat waves and coastal flooding

Adapted from SREX 2013 report

The Three Pillars of Sound Attribution

High
Medium
Low

Extreme heat events
Extreme cold events
Coastal flooding
Droughts
Extreme rainfall
Extreme snow and ice storms
Tropical cyclones
Extratropical cyclones
Wildfires
Severe convective storms



The Role of Model Simulations

Risk of lung cancer in smokers = X

Risk of lung cancer in non-smokers = Y

Increase in risk of lung cancer for smokers = Z

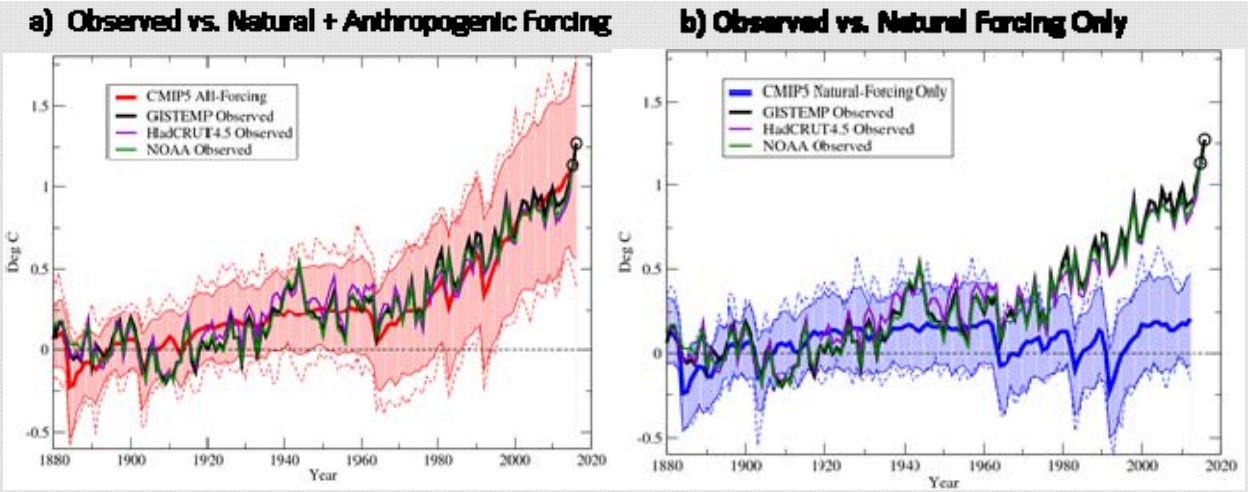
Risk of an event in a world with climate change = X

Risk of event in a modeled world without climate change = Y

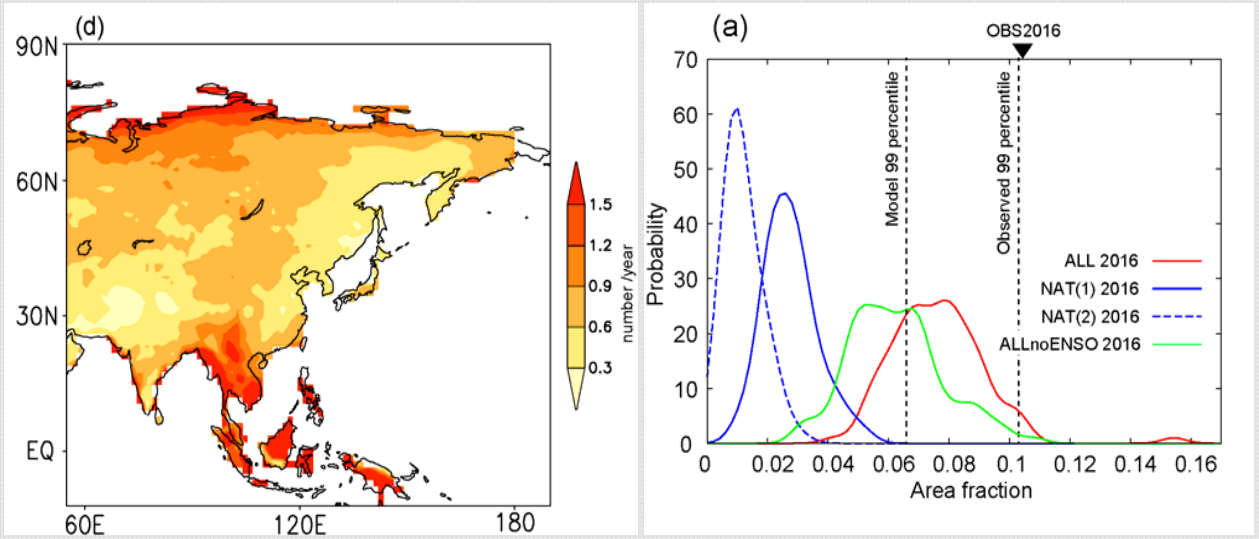
Change in event risk because of climate change = Z

Worlds With and Without Climate Change

Extreme Global Heat in 2016



Extreme Heat over Asia in 2016



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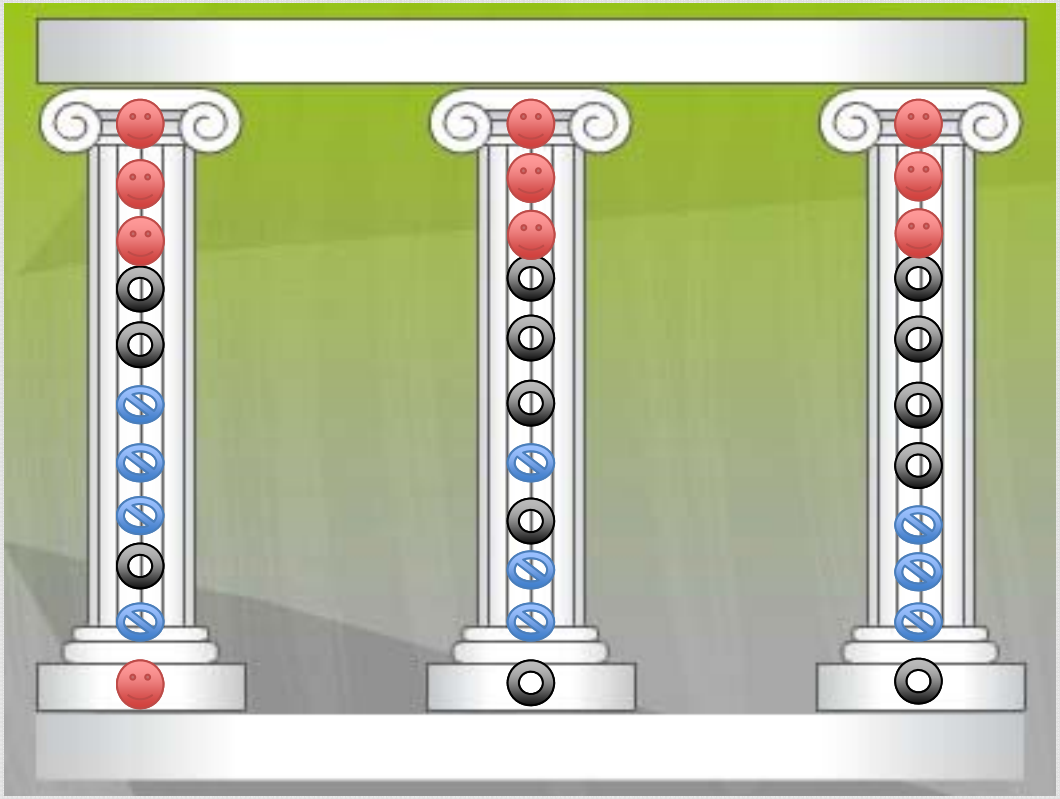

Many Factors Cause Extremes

Extreme events are born from a set of ingredients.

A combination of factors lead to a drought

- Lack of precipitation, temperature, evaporation rates, soil moisture, etc.
- Human activity such as land and water usage

The Three Pillars of Sound Attribution

High
Medium
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Quality of Observation Record

Ability of Models to Simulate

Mechanism of Changes Known

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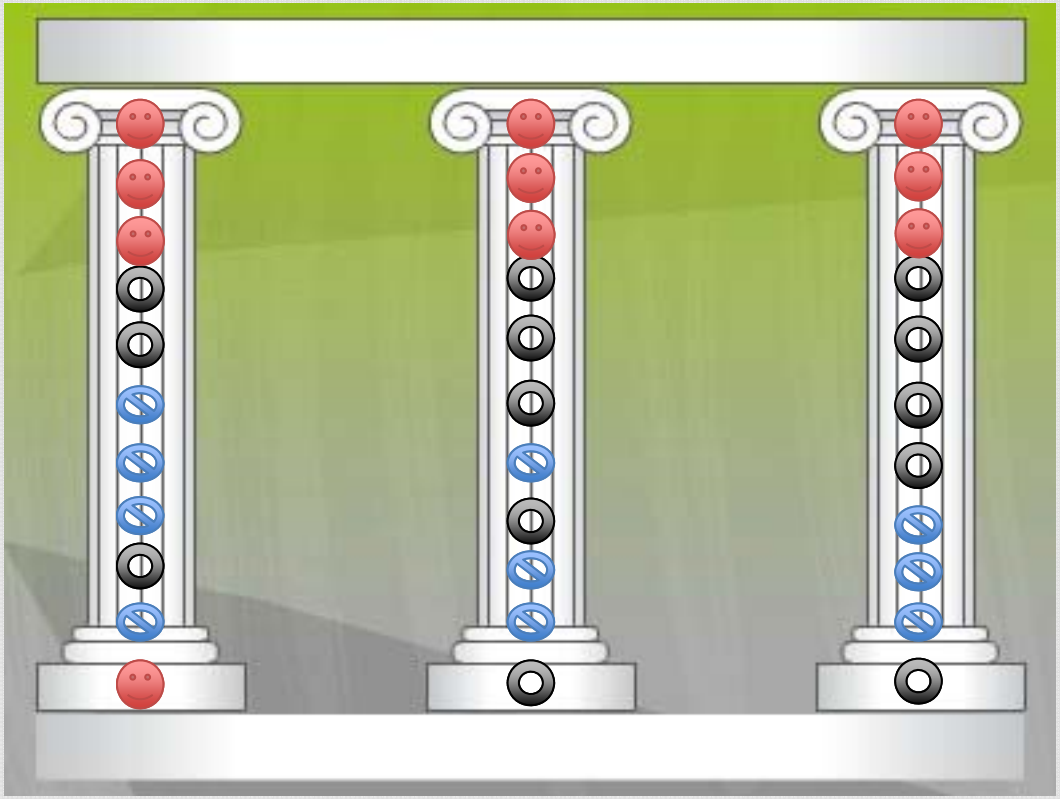
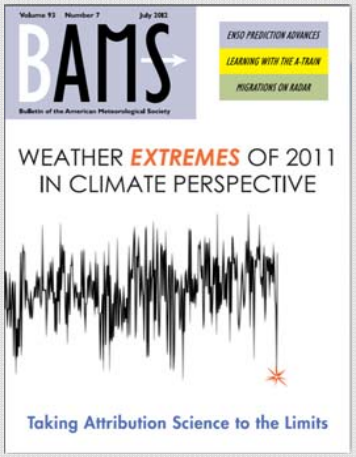
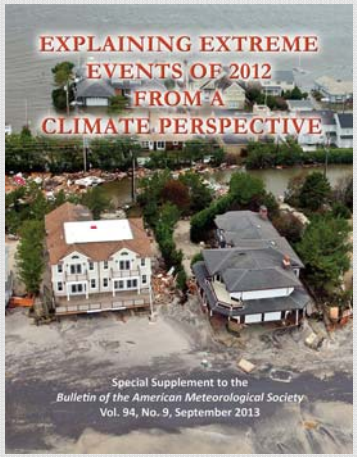


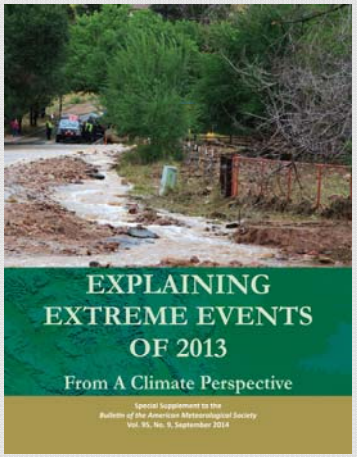
How do you do attribution of extreme events?

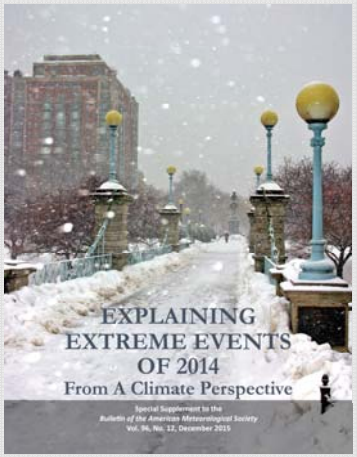
- Lots of different ways
- No single 'best' approach, in part because the tools available can vary from event to event.
  - There are best practices regardless of event type (i.e., model verification, quality observational record)

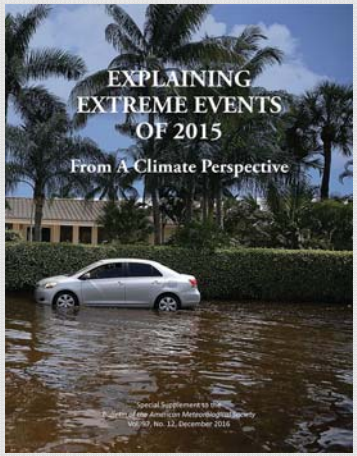
BAMS Explaining Extreme Events

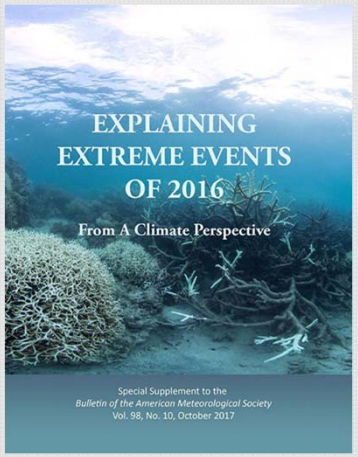










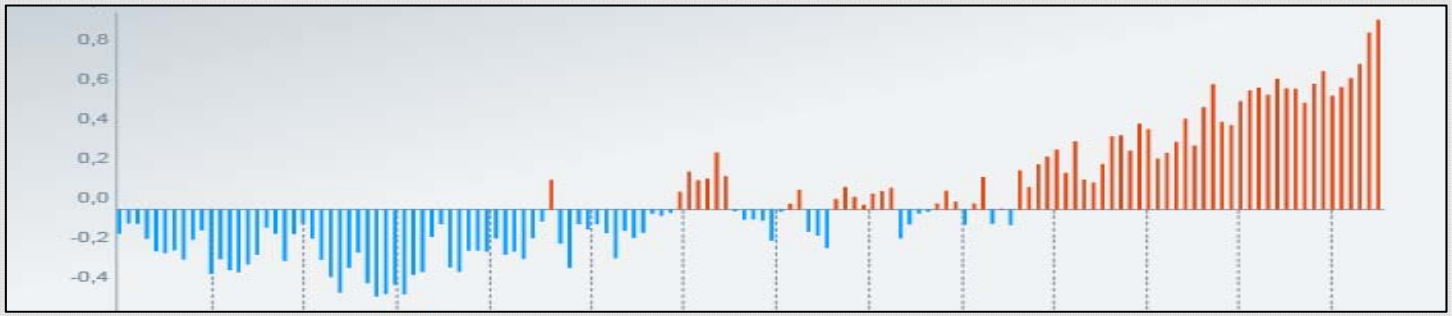


This is the 6th annual "Explaining Extreme Weather and Climate Events from a Climate Perspective", published by the *Bulletin of the American Meteorological Society* (BAMS)

AMS American Meteorological Society

Events 'Not Possible' without Human Influence

- **Global heat record** "was only possible" due to substantial human-caused warming over the last 100 years.
- **Record heat over Asia** "would not have been possible" without human-caused climate change.
- **Warm waters in the Bering Sea** (part of "the Blob") "could not be explained" without human-caused climate warming.



What Does 'Not Possible' Mean?

We are experiencing new weather, because we have created a new climate.

- Climate change is pushing events beyond thresholds achieved with natural variability alone.
- These are likely not the first events of their kind.
- Climate change doesn't act alone. Natural variability is still a player in all extreme events.
  - Although climate change may be amplifying and changing these natural variations such as El Ninõ.

The future is already here

Attribution has been a field of rapid change, and this creates unique communication challenges.

Climate Change Science Report statement on attribution was out of date almost as soon as it was published:

*"No extreme weather event observed to date has been found to have zero probability of occurrence in a preindustrial climate…. **In the future**, as the climate change signal gets stronger compared to natural variability, humans may experience weather events which are essentially impossible to simulate in a preindustrial climate."*

What's Next? Impact Attribution

- **Great Barrier Reef Bleaching and Marine ecosystems in the Pacific** were impacted by thermal stress from human-caused warming of the ocean.
- **Drought related food shortages in southern Africa** were made more intense by climate change, according to two independent studies.
- **Higher ecosystem productivity on the Iberian Peninsula in Spain** was due in part to human caused warming.

Communicating and Using Attribution Results

- Understand how the extreme event is defined
  - i.e., What type of event? Where did the event occur?
- Focus on the right question.
  - How has the risk of this event changed because of climate change?
  - What is the future risk of this event if climate change continues?
- The impacts matter.
  - Impact attribution connects change in risk to issues people care about.
- Be prepared for change.
  - For example, understanding the role of climate change on ‘natural variability’.

Thanks!

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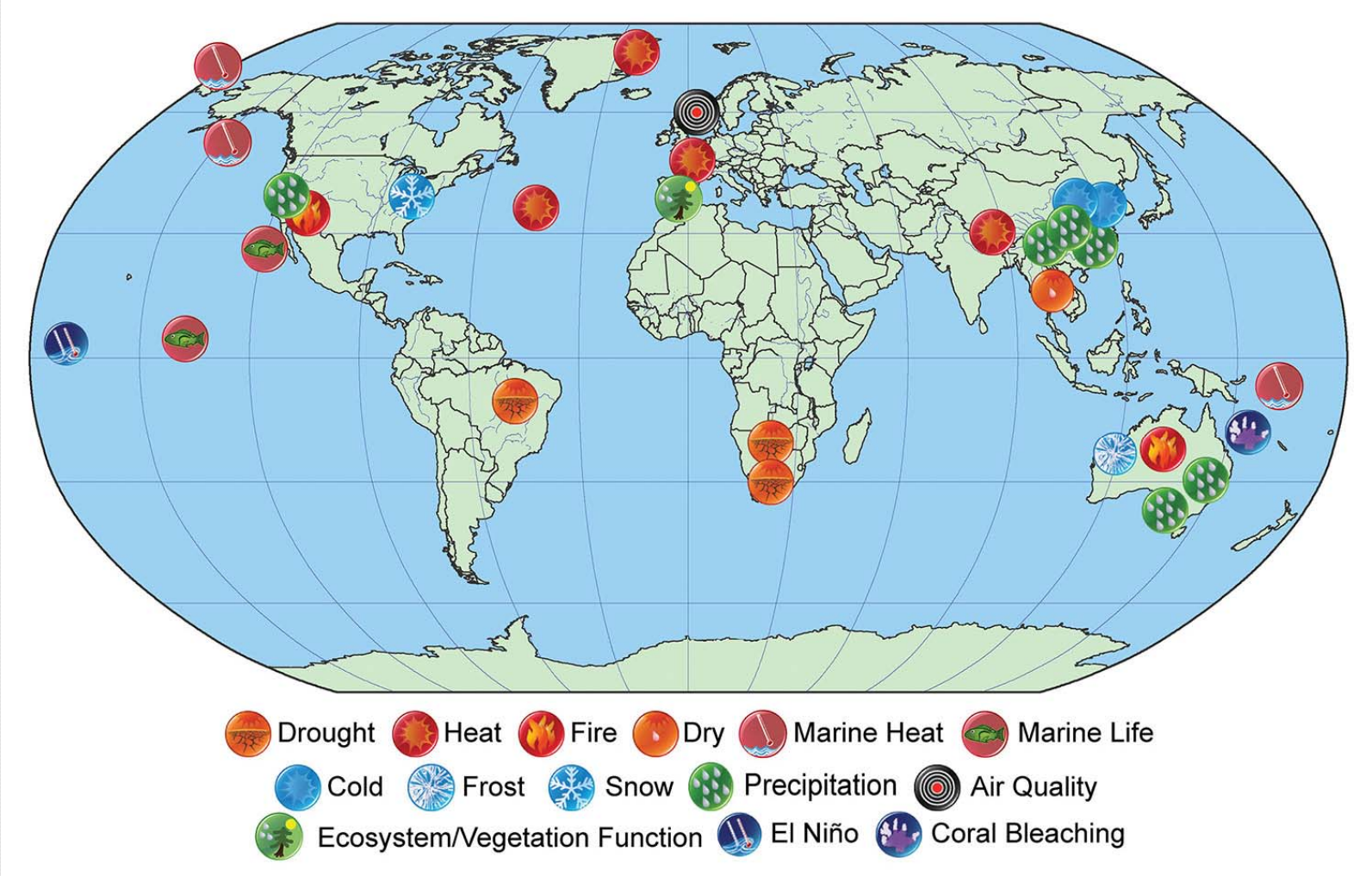
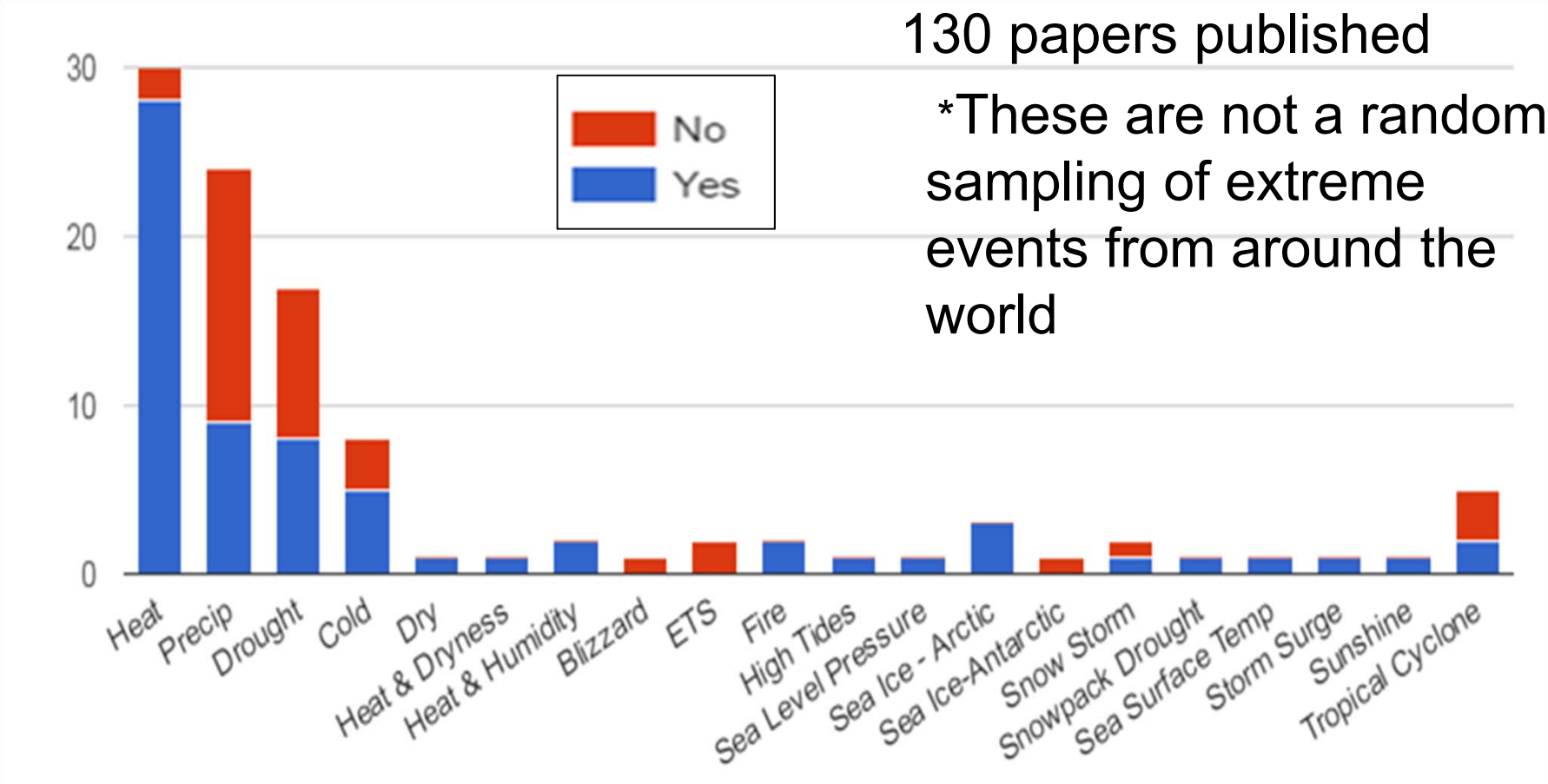
Resources

- BAMS Explaining Extreme Events
- Climate.gov webpage on attribution
- IPCC. https://www.ipcc.ch/
- Special report on extremes (SREX)
  - Fifth assessment report, working group 1 (AR5 WG1)
- National Academies report: Attribution of Extreme Weather… (DOI: 10.17226/21852)

Extreme Events of 2016



After Six Years



130 papers published

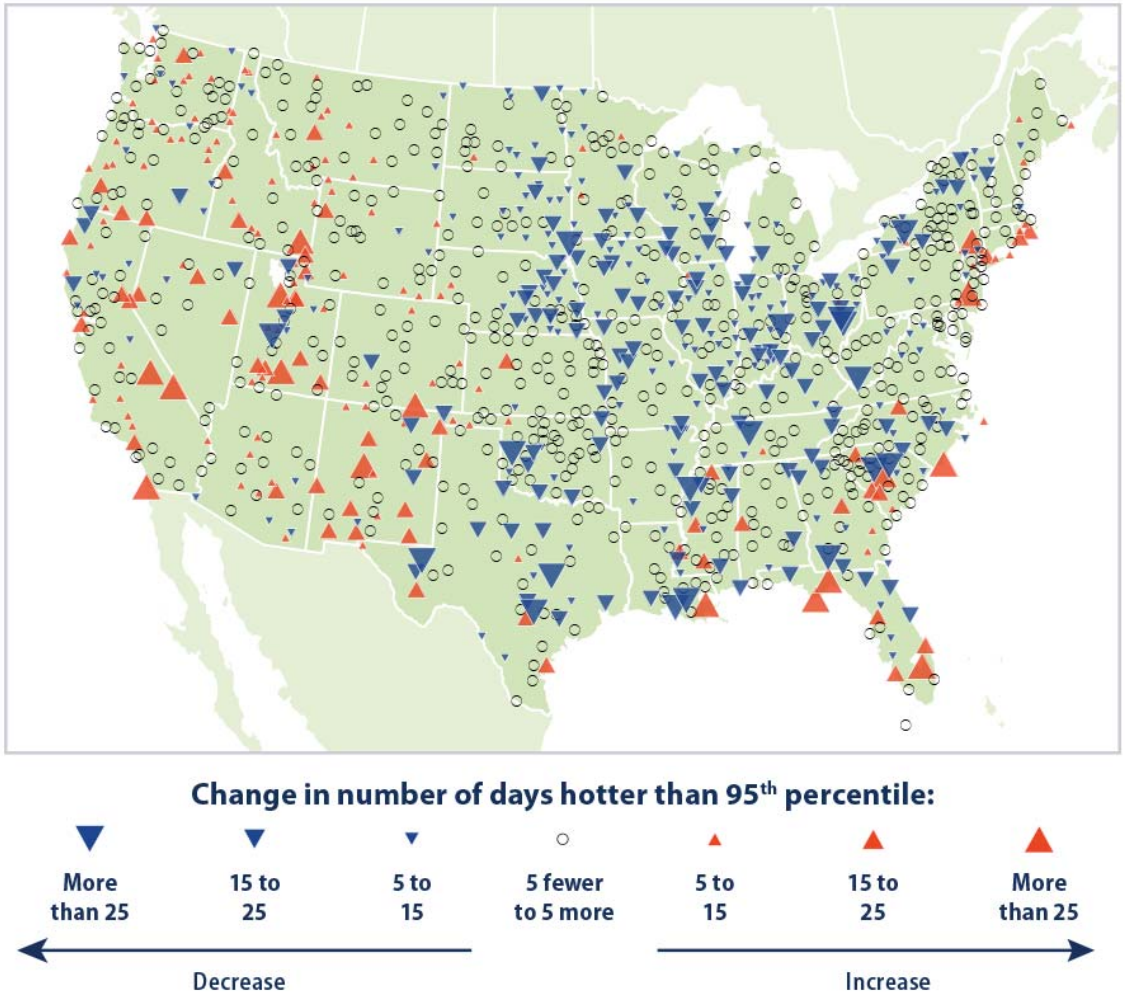
*These are not a random sampling of extreme events from around the world

About the Report

- A forum to explore and expand event attribution methodology, and connect our understanding of *how* and *why* extremes are changing.
- Not a 'score card' for human influence on extreme events. The report is neither a complete or random sampling of extremes.
- Events that have and have not been influenced by climate change are included.
  - To date 131 papers have been published: 65% find a role for climate change, 35% do not.
- No selection bias for events that find a signal. Events selected by Editors prior to knowing whether climate change played a role in the event.
- All studies are subject to a rigorous peer review process which determines which submissions meet criteria for final publication.

Central U.S. is a Global Anomaly for Heat Extremes

- While average temperatures have been rising, heat extremes have not.
- This is not expected to persist over time.
- Higher average temperatures have been due to rise in night time temperatures, and increase in moderate heat waves.



Extreme 1 Day Rain Events