Southwest Climate Change Projections – Increasing Extreme Weather Events?

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Advanced Water Education Workshop: Extreme Weather Events

July 7-8, 2015
Arizona State University
Tempe, Arizona

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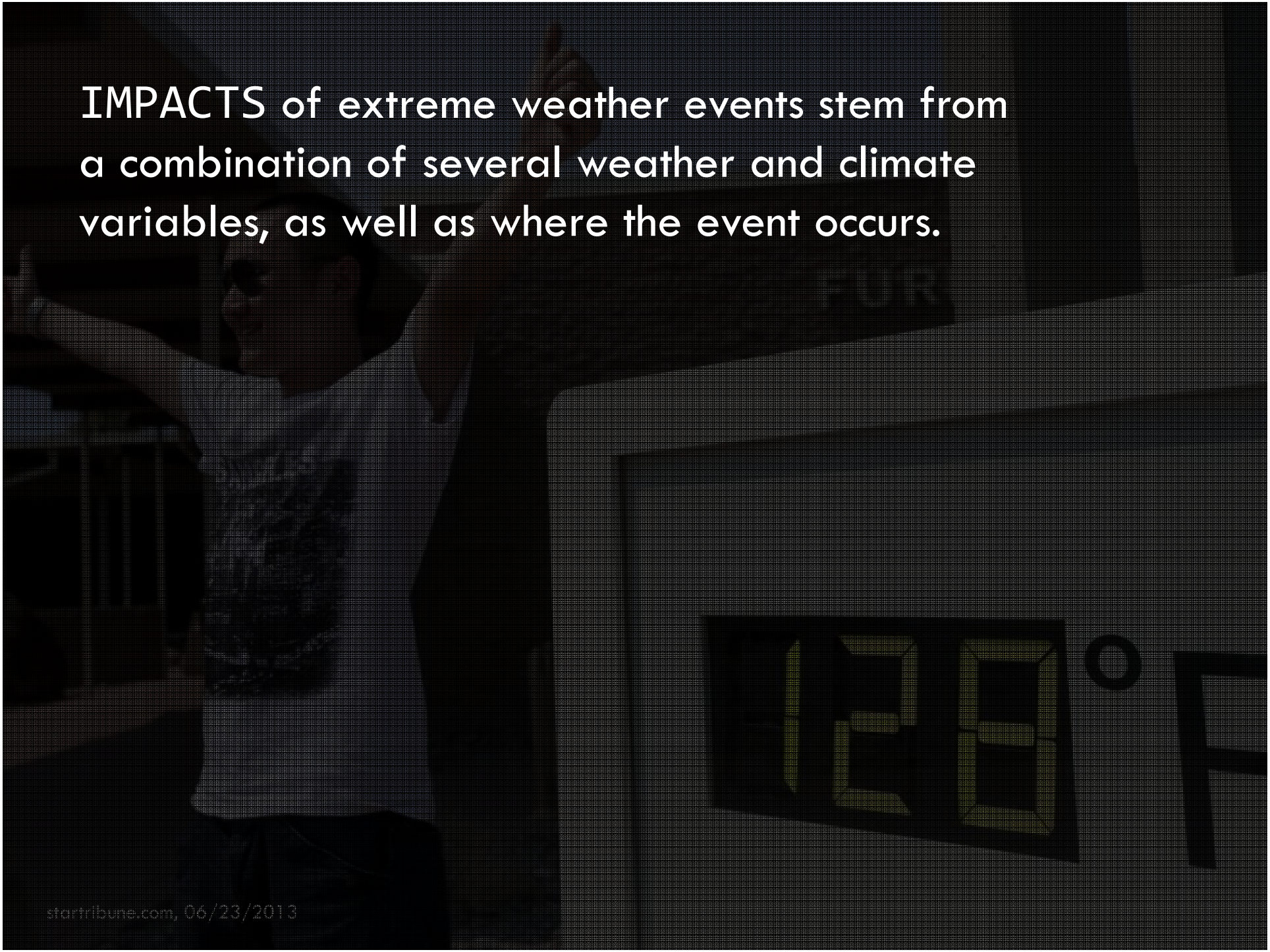
startribune.com, 06/23/2013

IMPACTS of extreme weather events stem from a combination of several weather and climate variables, as well as where the event occurs.



Urban environments can compound impacts of extreme weather events.

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Asphalt can intensify heat waves by releasing heat at night and increasing minimum temperatures.


15 Desert DOPPLER
8:47 AM
Sun City
Phoenix
Buckeye
#ab
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WEATHER ALERT
RECORD-BREAKING RAIN IN THE VALLEY
PHOENIX: I-10 & 35TH AVE
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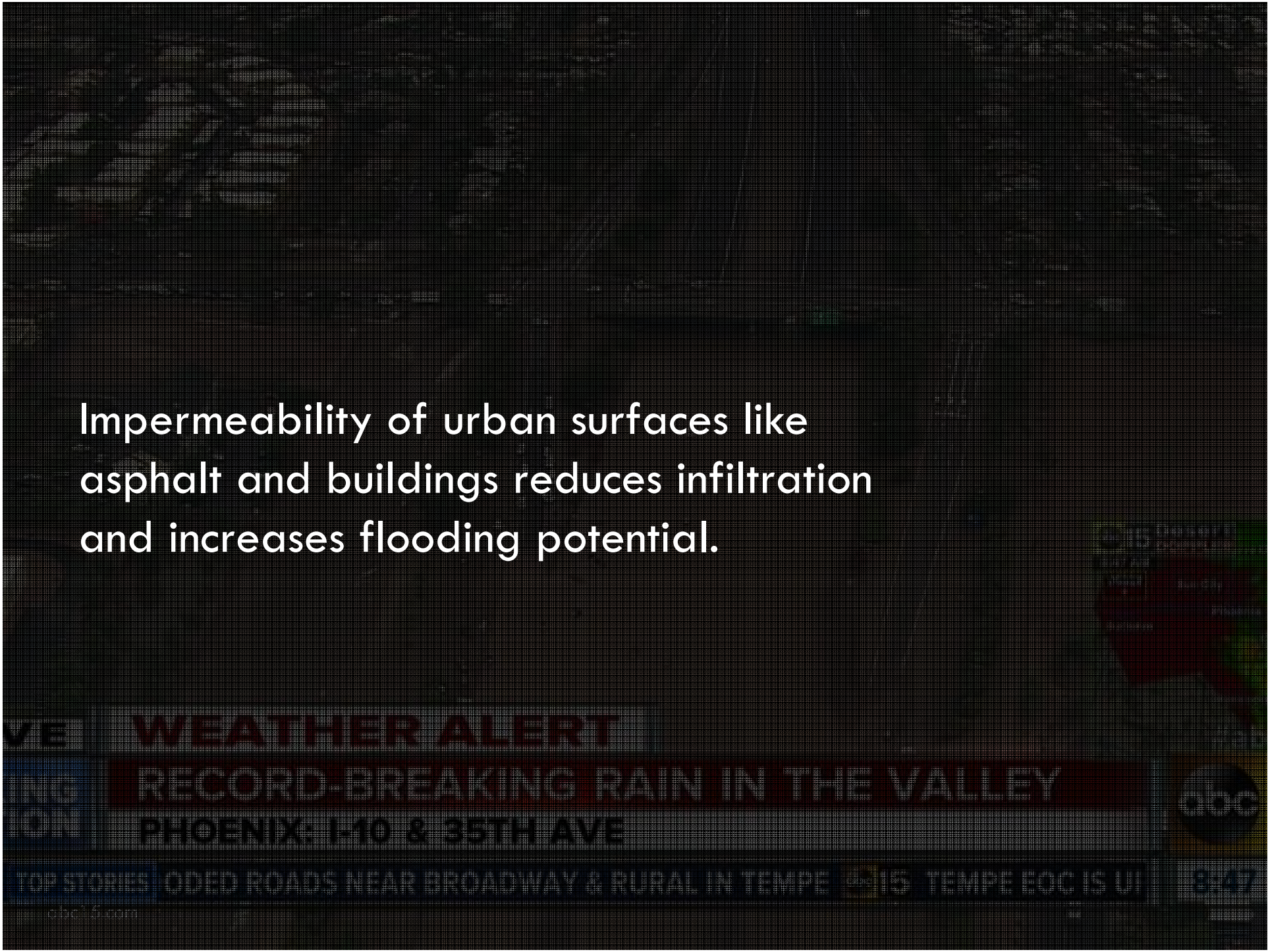
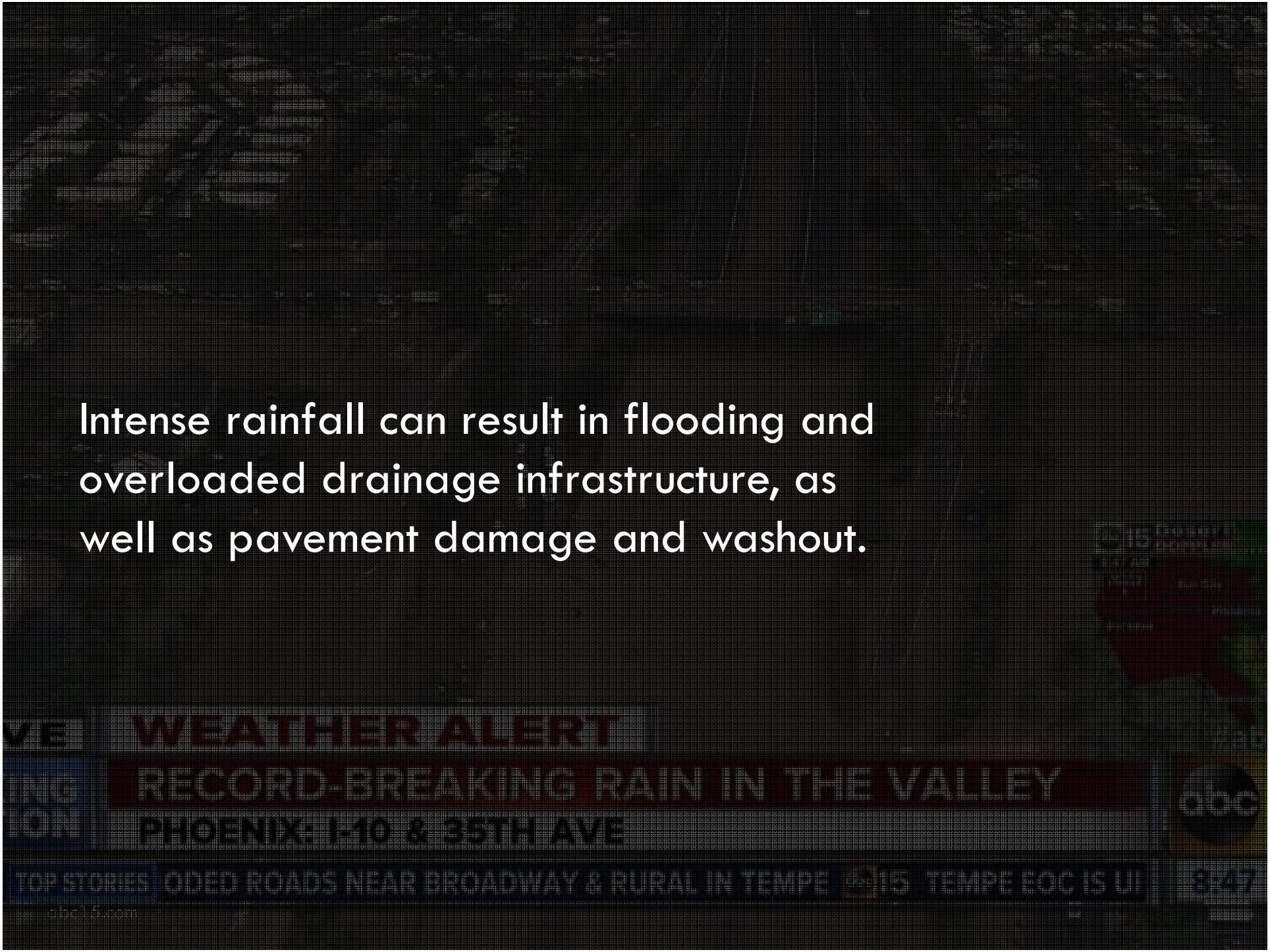


Impermeability of urban surfaces like asphalt and buildings reduces infiltration and increases flooding potential.



Intense rainfall can result in flooding and overloaded drainage infrastructure, as well as pavement damage and washout.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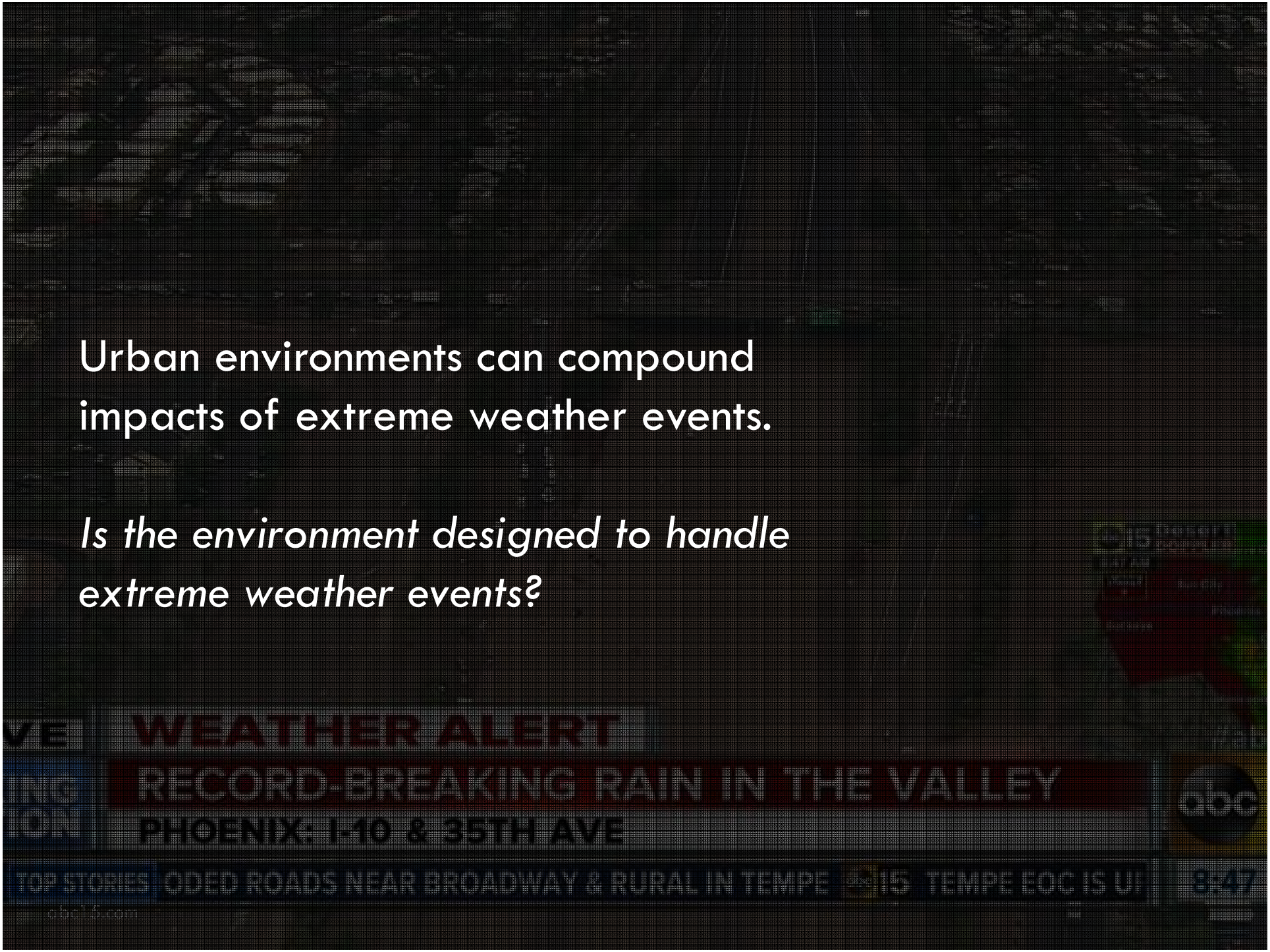

Urban environments can compound impacts of extreme weather events.

Is the environment designed to handle extreme weather events?

"Indeed, the main way in which climate change is likely to affect societies around the world is through changes in extremes."

--Trenberth et al. (2015)

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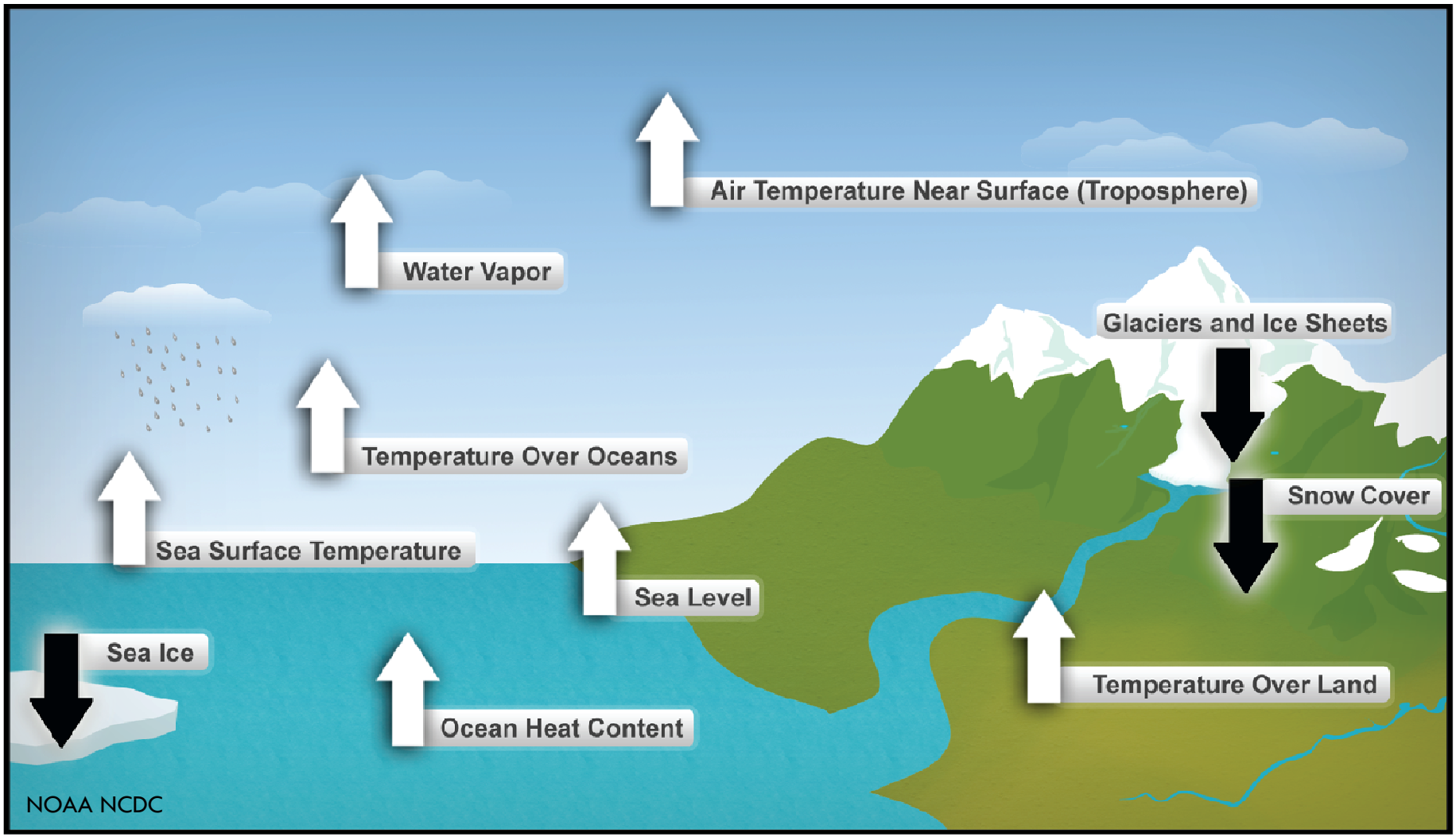
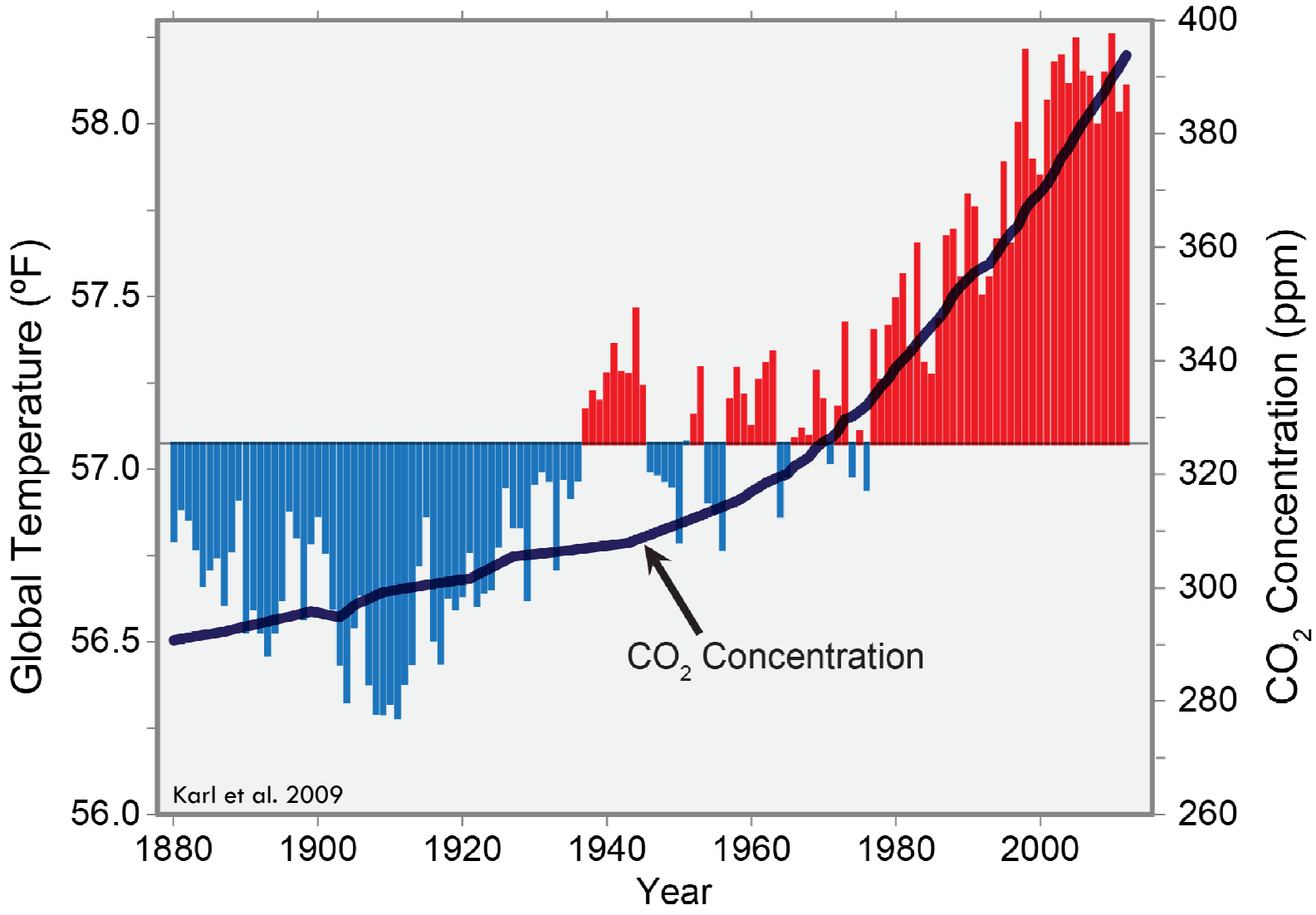
Indications of a warming world already are present.



Global Temperature and Carbon Dioxide



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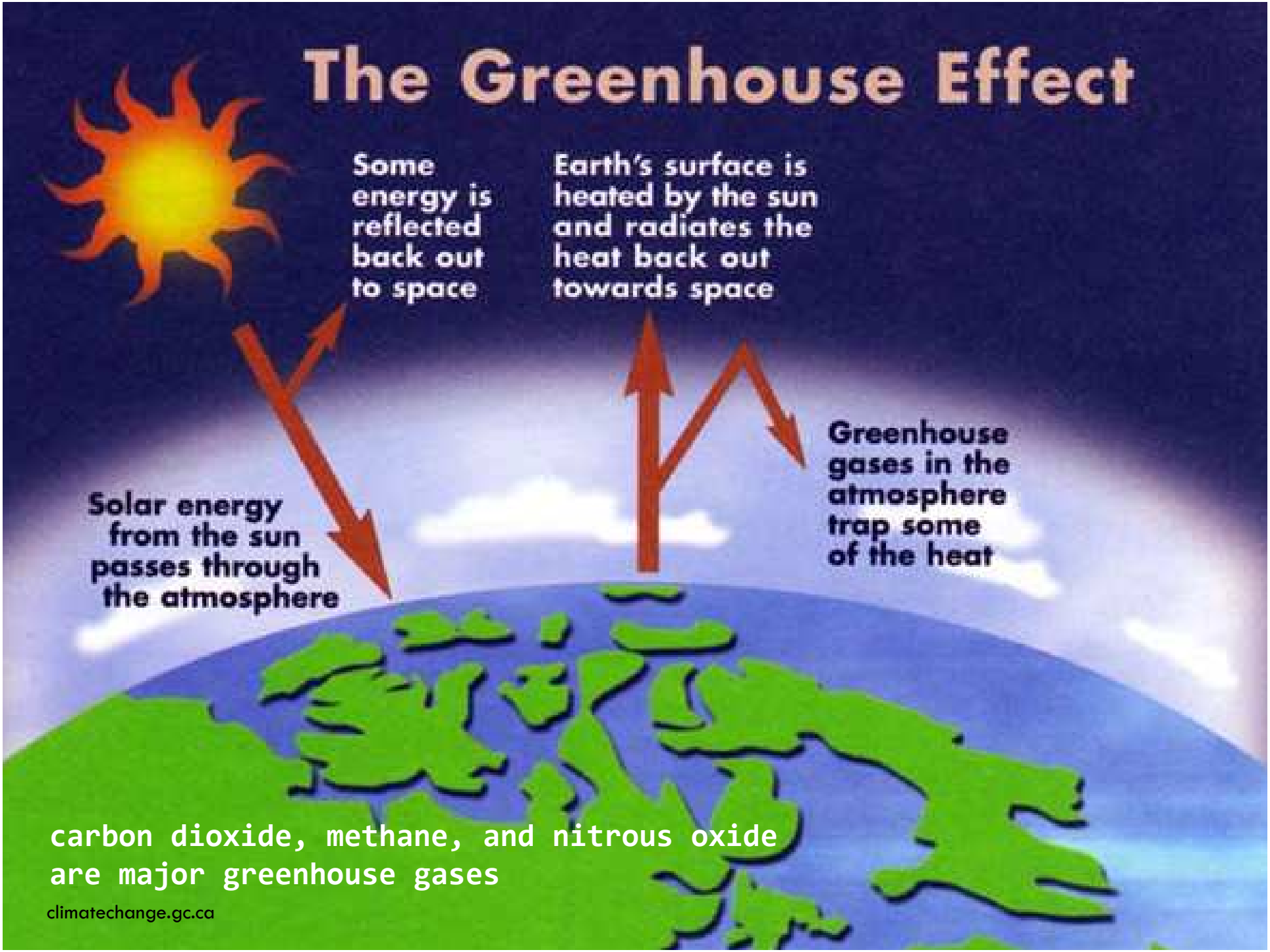
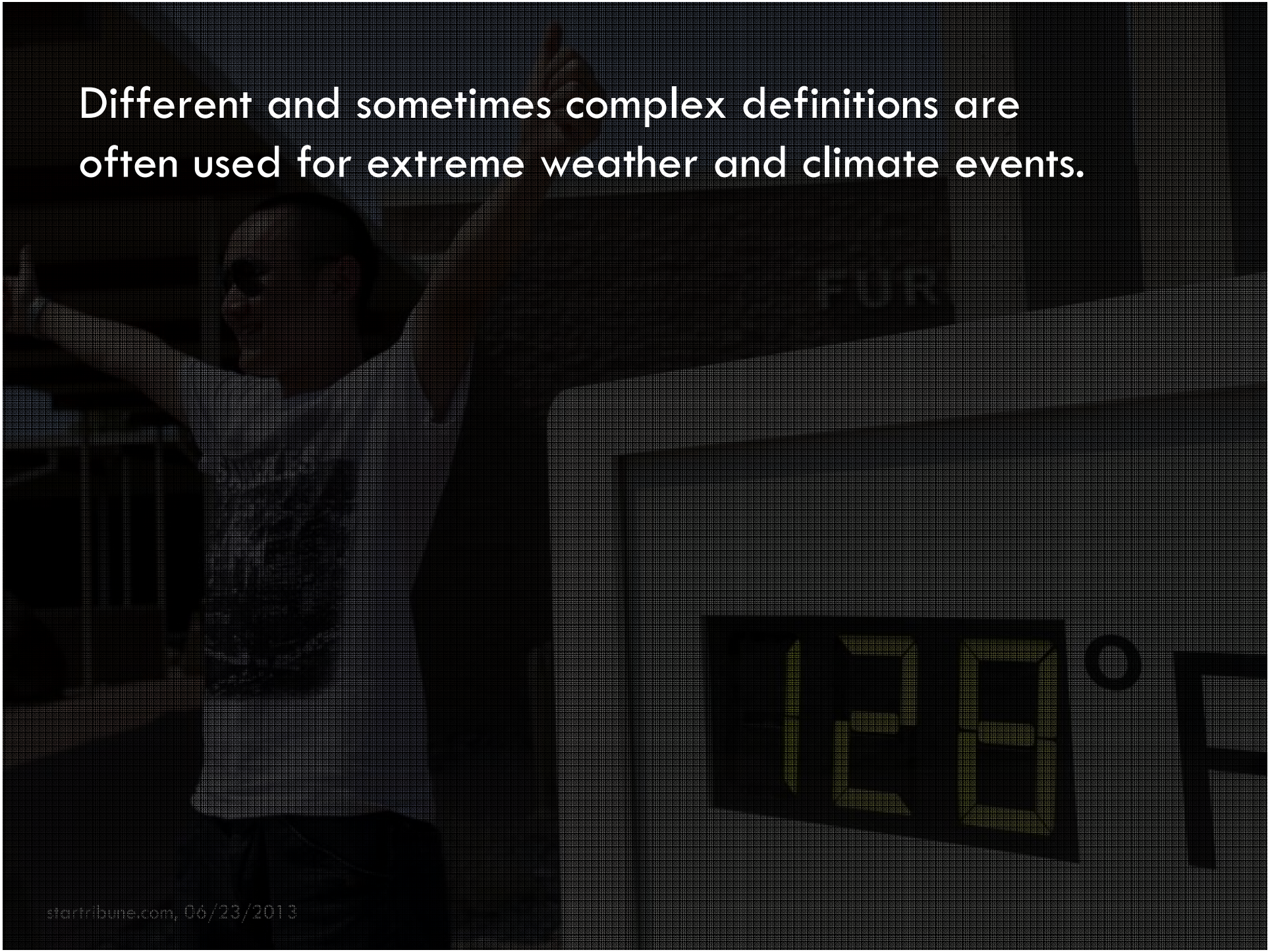

The Greenhouse Effect
Some energy is reflected back out to space
Earth's surface is heated by the sun and radiates the heat back out towards space
Greenhouse gases in the atmosphere trap some of the heat
Solar energy from the sun passes through the atmosphere
carbon dioxide, methane, and nitrous oxide are major greenhouse gases
climatechange.gc.ca

http://www.bloomberg.com/graphics/2015-whats-warming-the-world/

Different and sometimes complex definitions are often used for extreme weather and climate events.

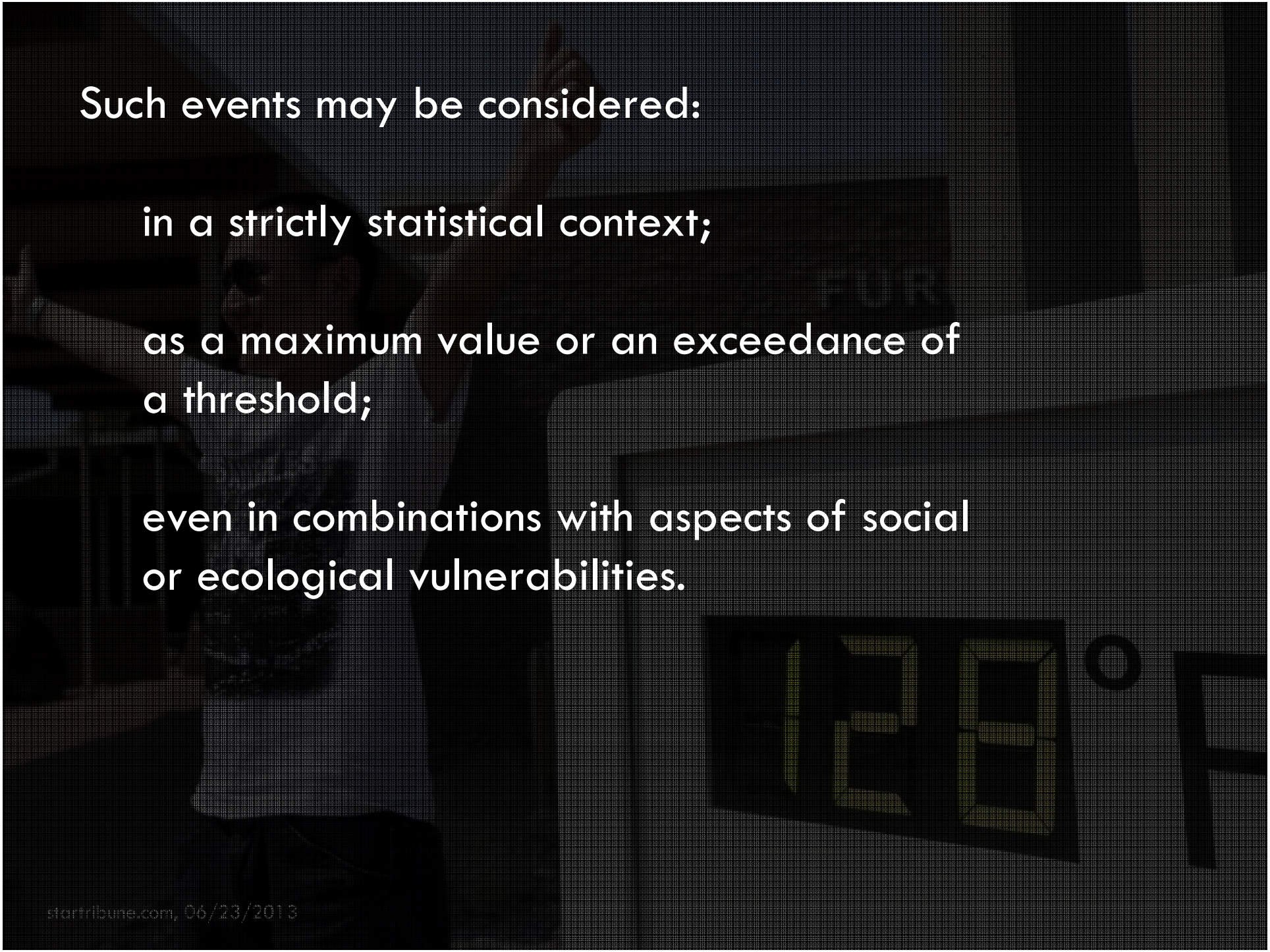


Such events may be considered:

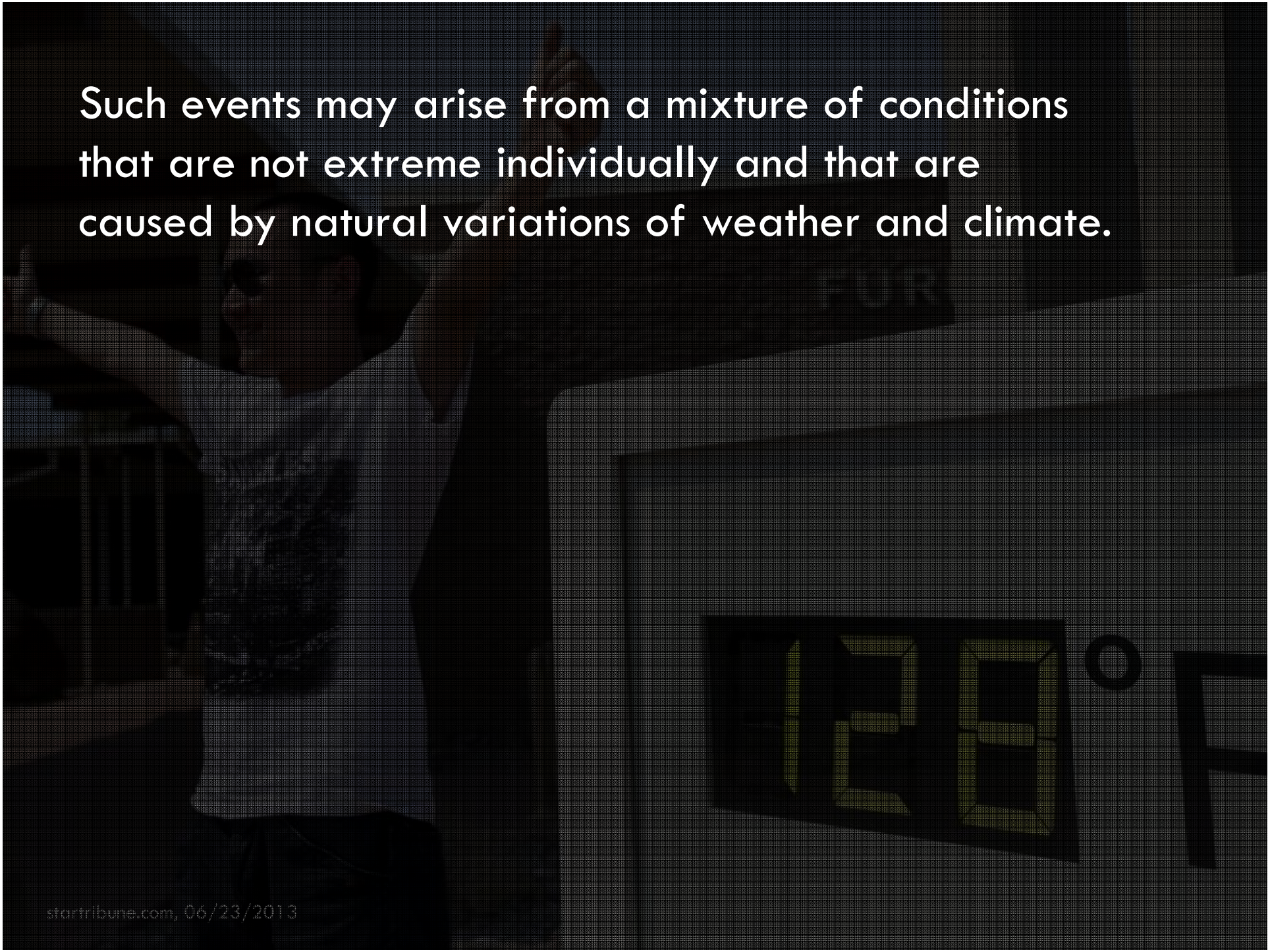
in a strictly statistical context;

as a maximum value or an exceedance of a threshold;

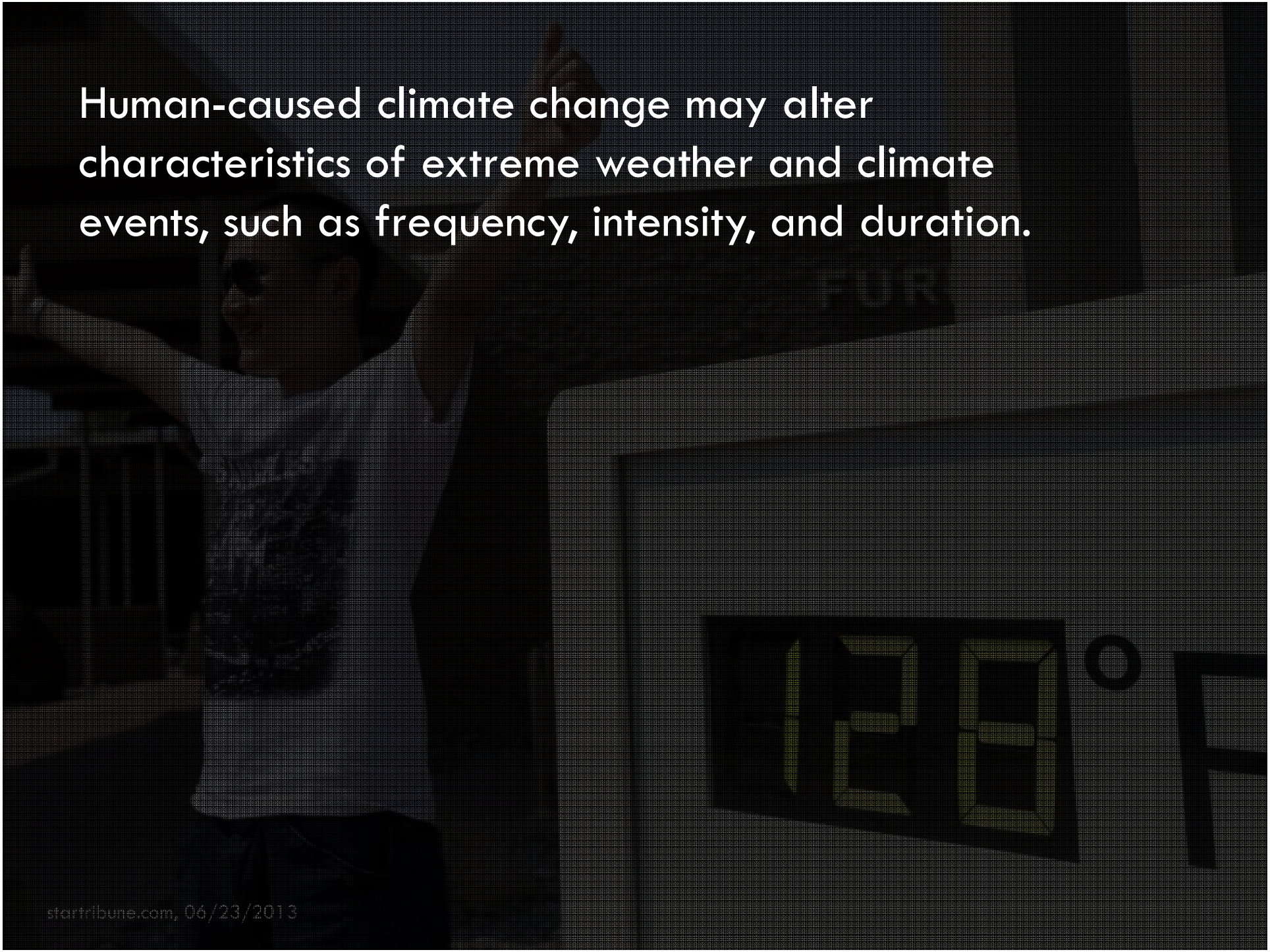
even in combinations with aspects of social or ecological vulnerabilities.

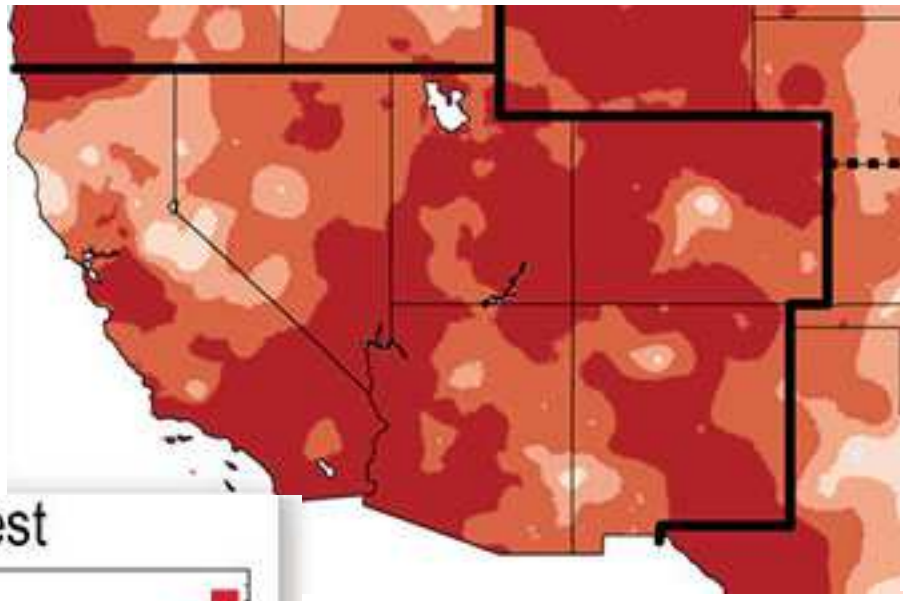


Such events may arise from a mixture of conditions that are not extreme individually and that are caused by natural variations of weather and climate.

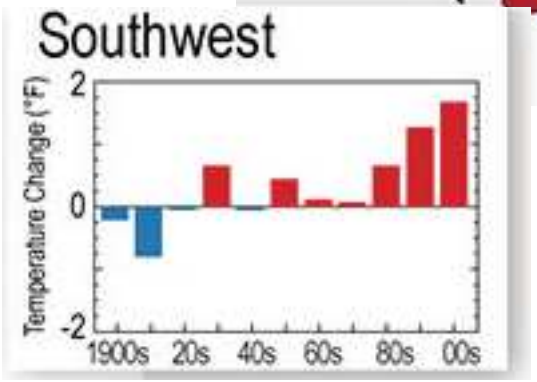


Human-caused climate change may alter characteristics of extreme weather and climate events, such as frequency, intensity, and duration.





1991-2011 compared to 1901-1960 average
(NCA 2014)



differences by decade compared
to 1901-1960 average
(NCA 2014)

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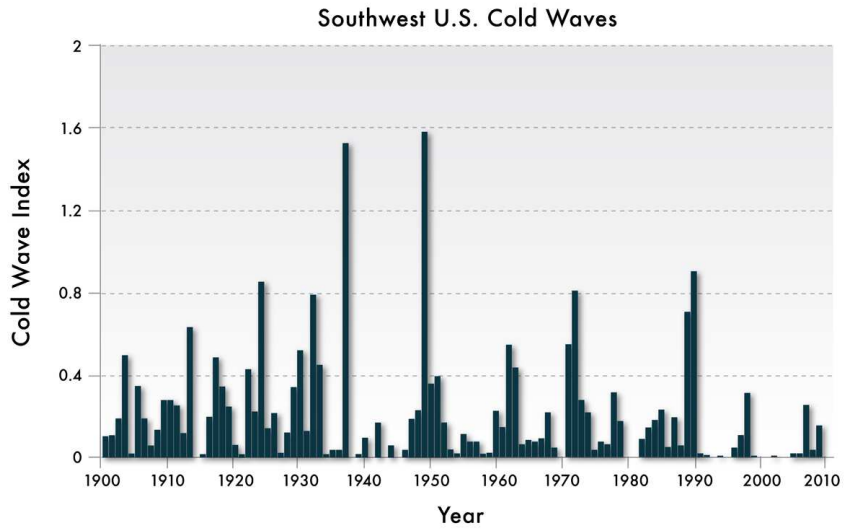

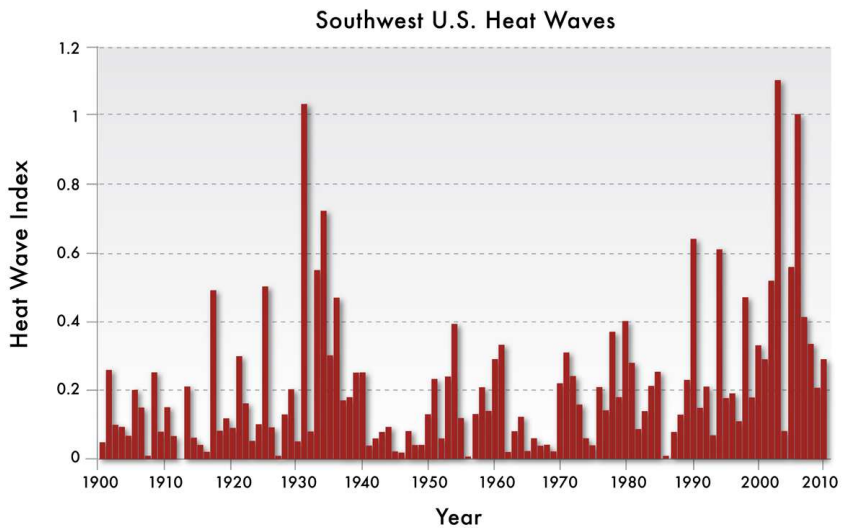

four-day periods colder (left) and warmer (right) than one in-five-year occurrence, 1901–2010 (SWCCAR 2013)

Relatively small shifts in mean climatic conditions can lead to relatively large changes in the occurrence of extreme events.

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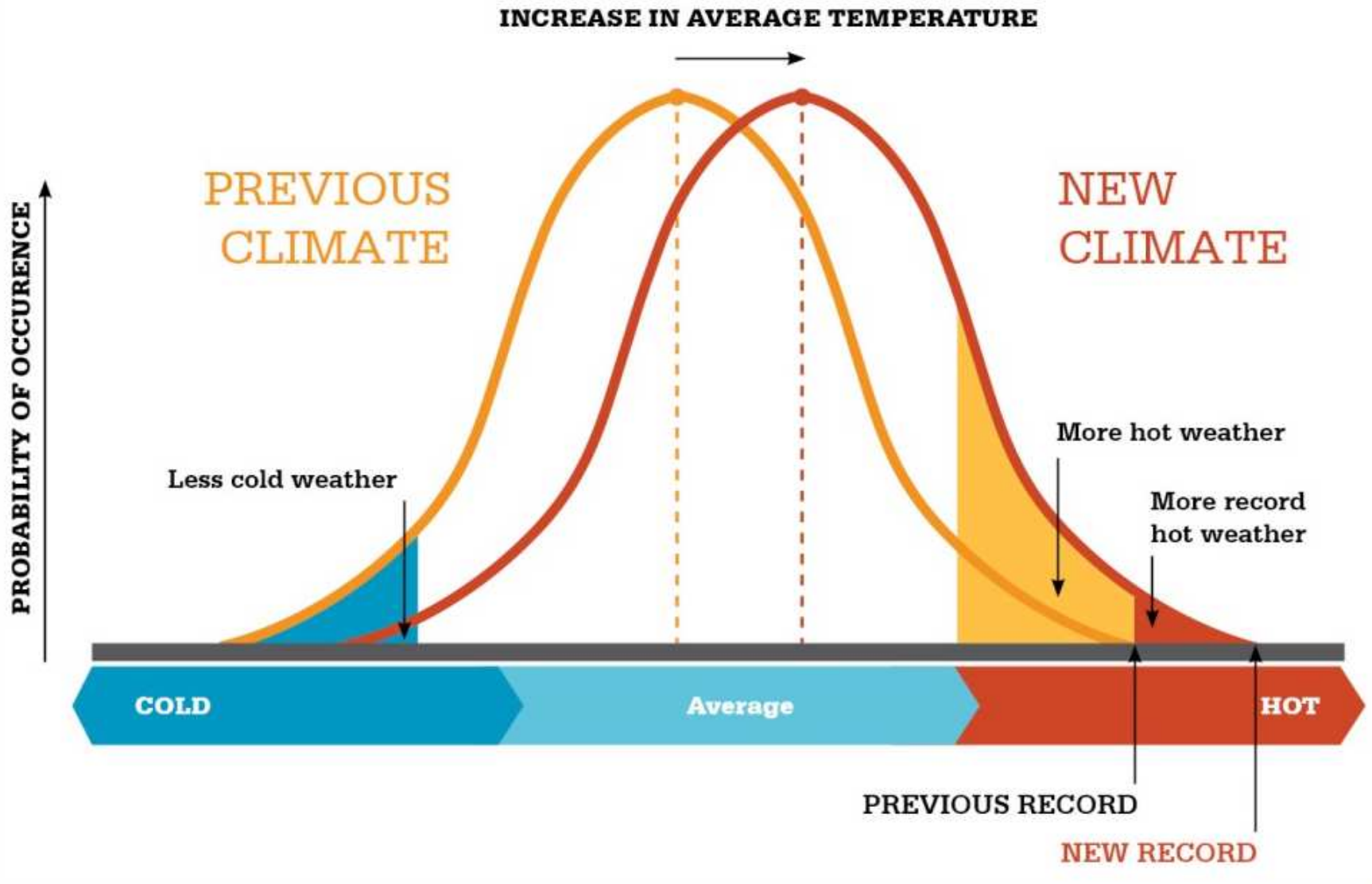
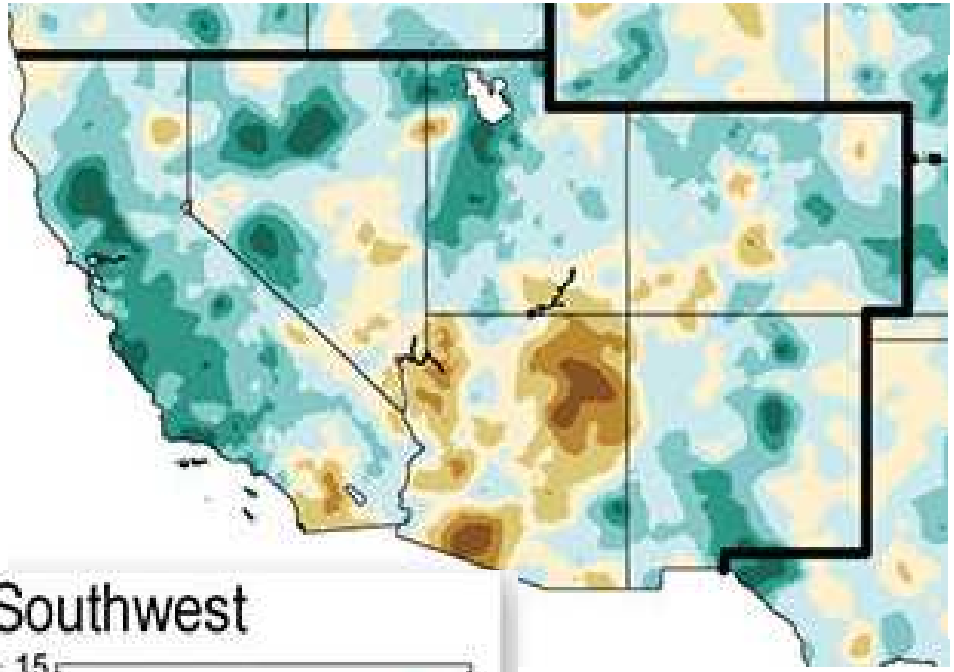
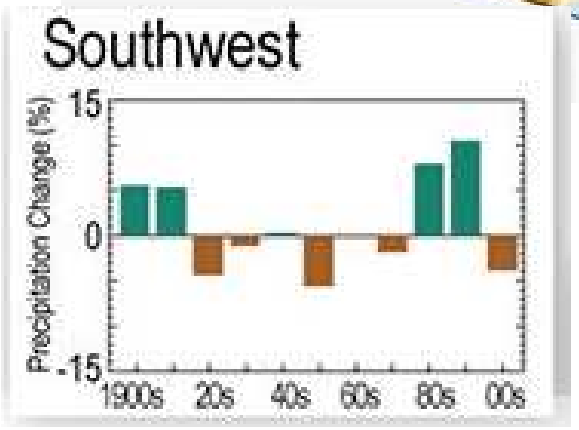
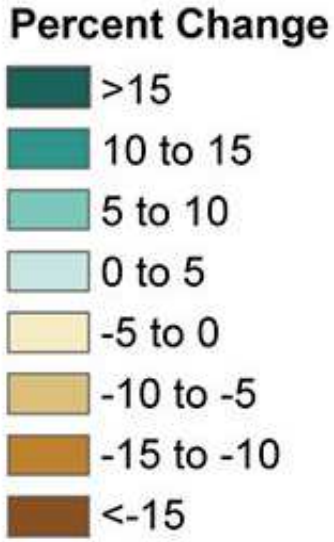


climatecommission.gov.au

Observed Precipitation Change







1991-2011 annual total compared to 1901-1960 average (NCA 2014)

differences by decade compared to 1901-1960 average (NCA 2014)

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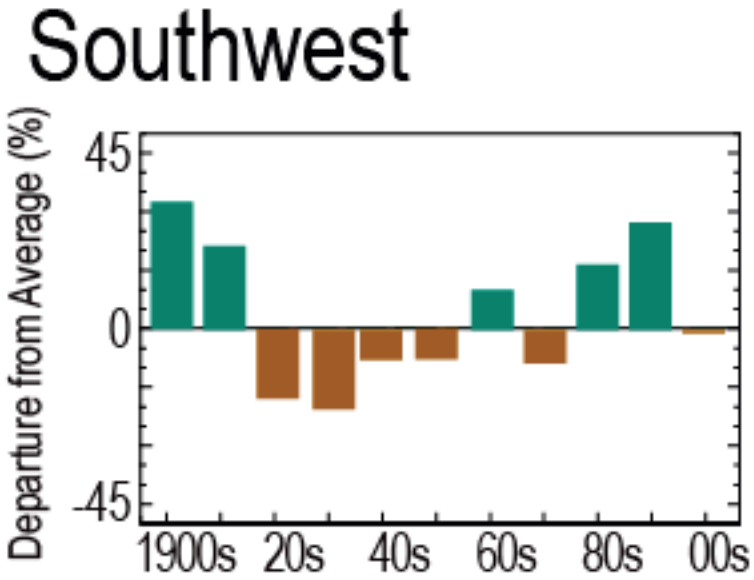
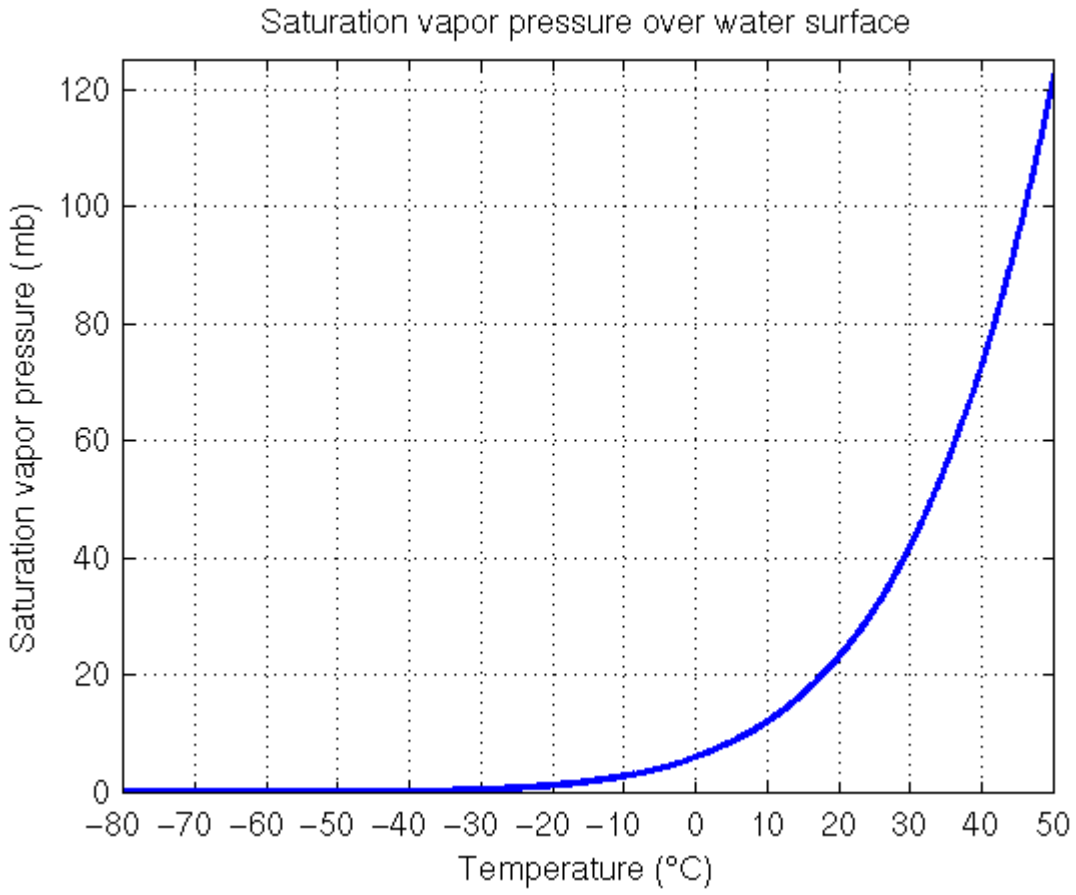


Observed Changes in Very Heavy Precipitation

Heaviest 1% of daily events 1901-2011 compared to 1901-1960 average (NCA 2014)



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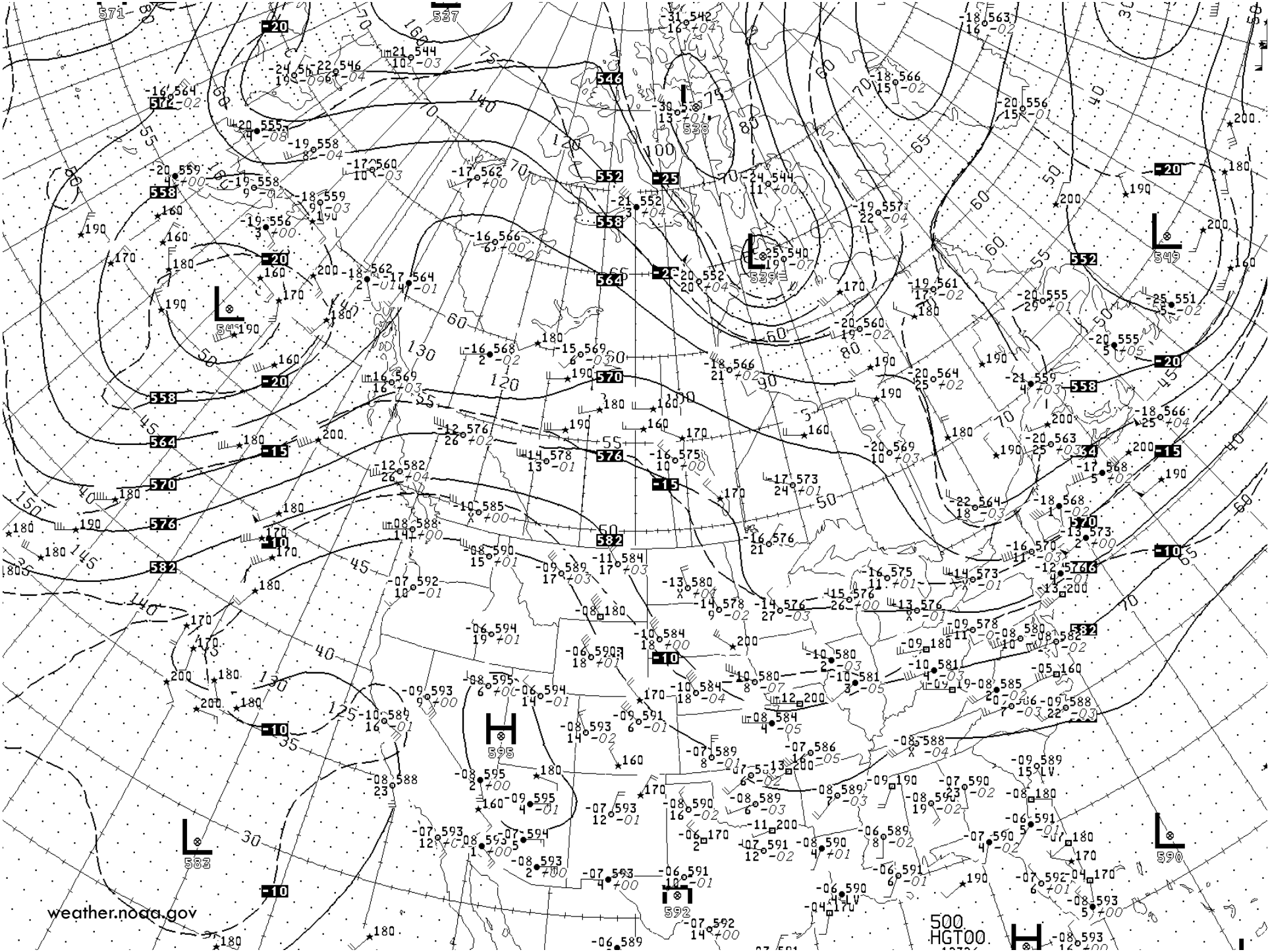
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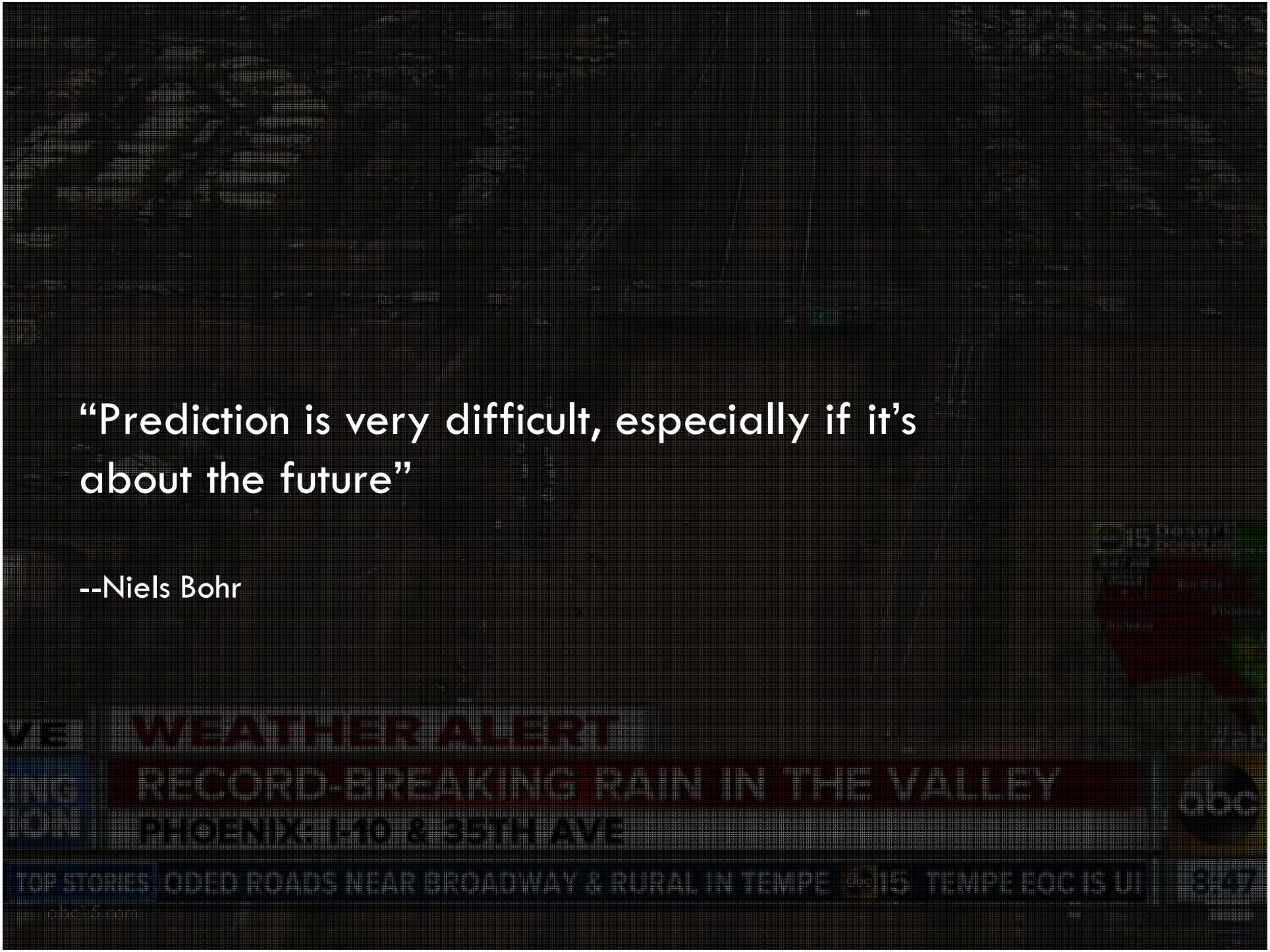
"Prediction is very difficult, especially if it's about the future"
--Niels Bohr
WEATHER ALERT
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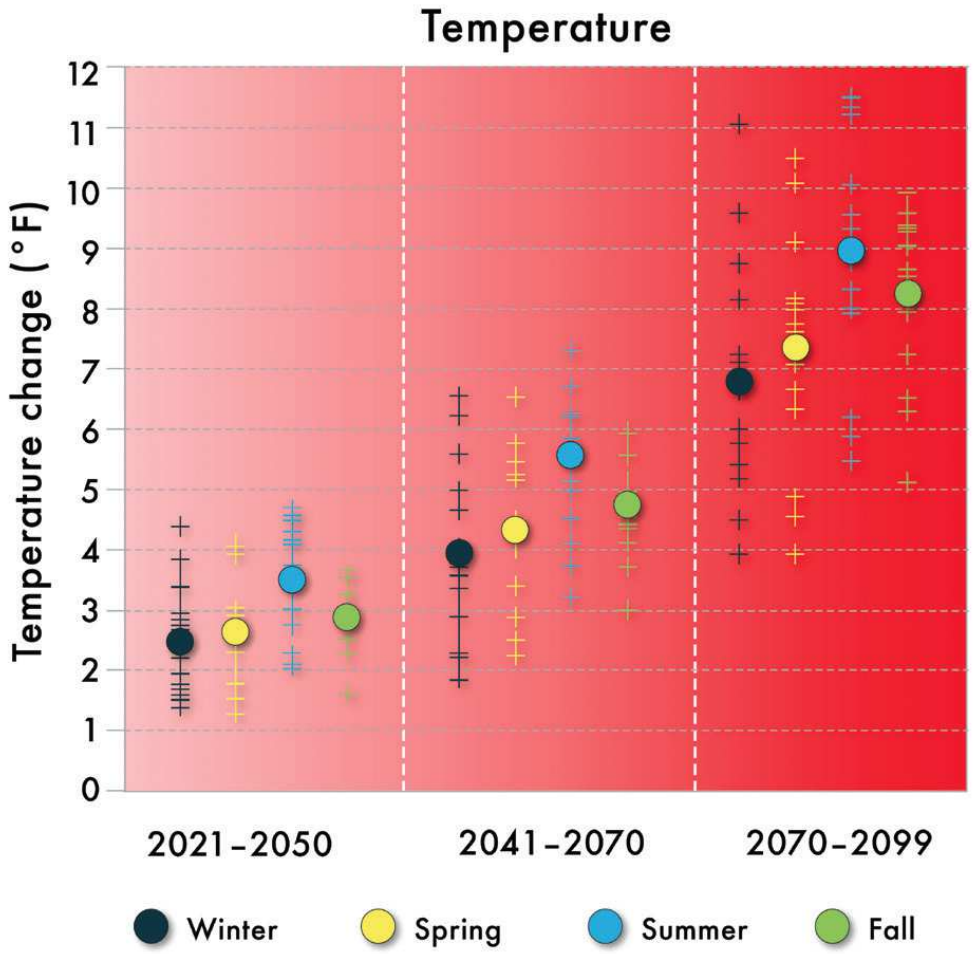
PHOENIX: I-10 & 35TH AVE



seasonal changes compared to 1971-2000 (SWCCAR 2013)

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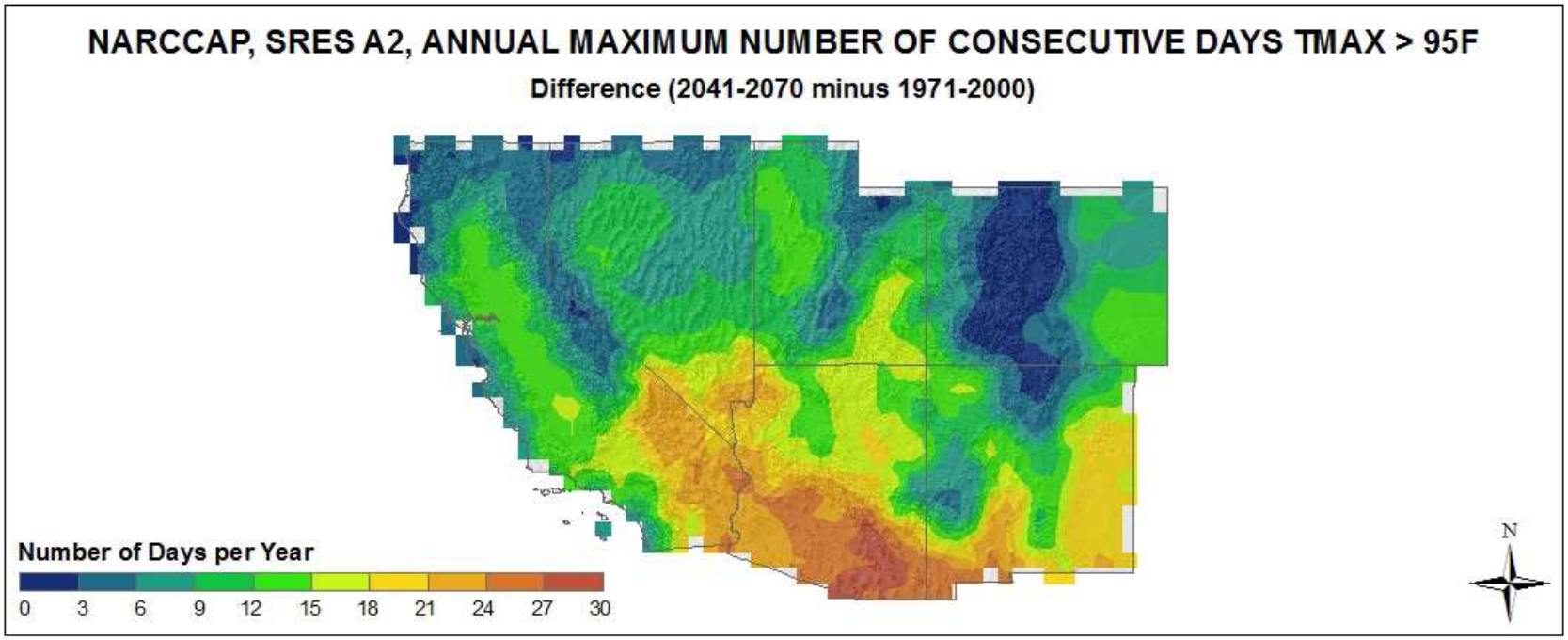


(Kunkel et al. 2012, prepared for NCA 2014)

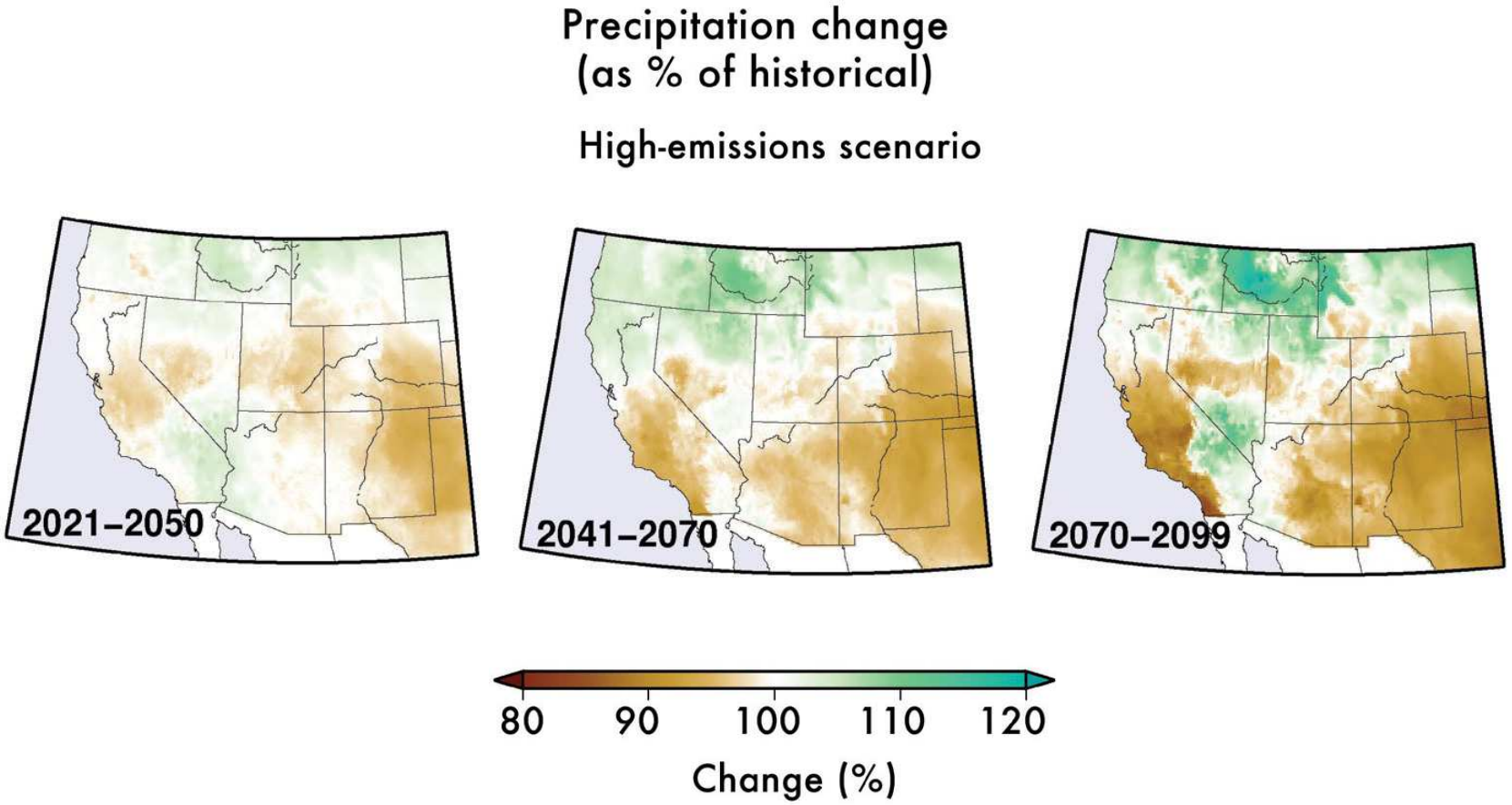
parameter	direction of change	confidence
average annual temperature	increase	high
seasonal temperatures	increase	high
heat waves	increase	high
cold snaps	decrease	medium-high

(SWCCAR 2013)

"a subjective judgment of the reliability of an assertion, based on systematic evaluation of the type, amount, quality, and consistency of evidence, and the degree of agreement among experts"

--SWCCAR 2013

Confidence in projections of extreme events varies by type and season, as well as by the scientific understanding of processes that drive these events.

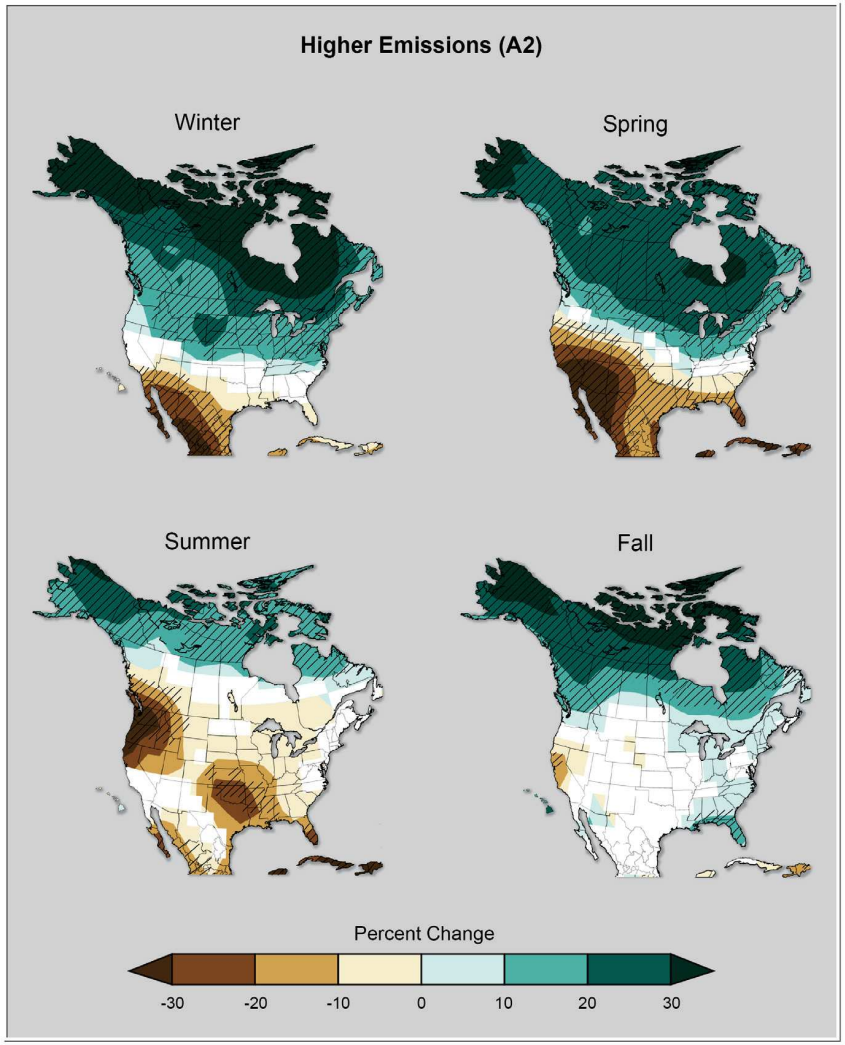


annual changes compared to 1971-2000 (SWCCAR 2013)

Projected Precipitation Change by Season

WINTER

SPRING

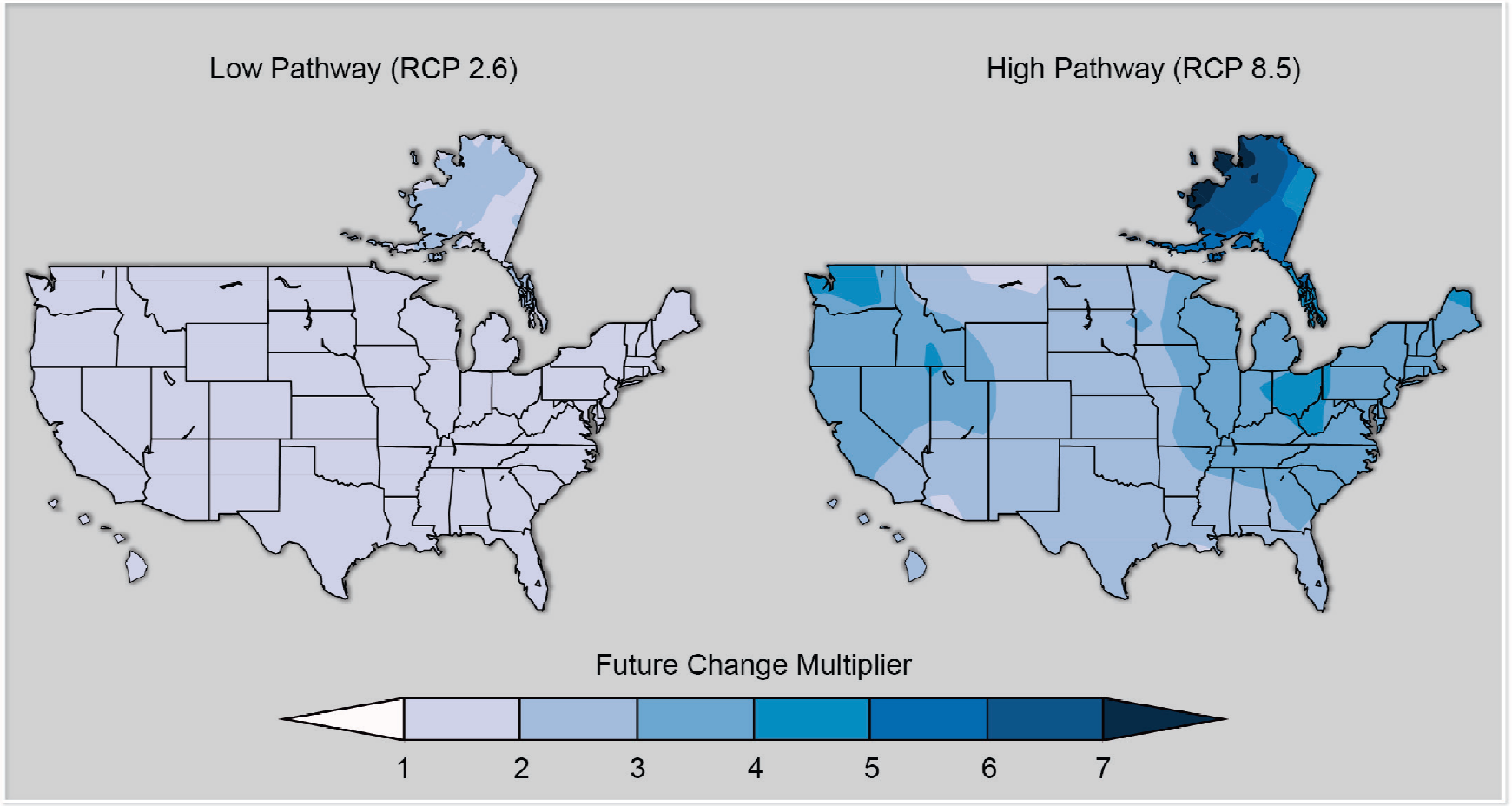


SUMMER

FALL

seasonal change by 2070-2099 compared to 1901-1960 (NCA 2014)

Rare Heavy Precipitation Events Become More Common



increase in frequency by 2081-2100 compared to 1981-2000 (NCA 2014)

parameter	direction of change	confidence
average annual precipitation	decrease	medium-low
spring precipitation	decrease	medium-high
extreme daily precipitation	increase	medium-low

(SWCCAR 2013)

photo credit : Jeremy Weiss

Projections of future ENSO variability and frequency of El Niño and La Niña events are inconsistent.

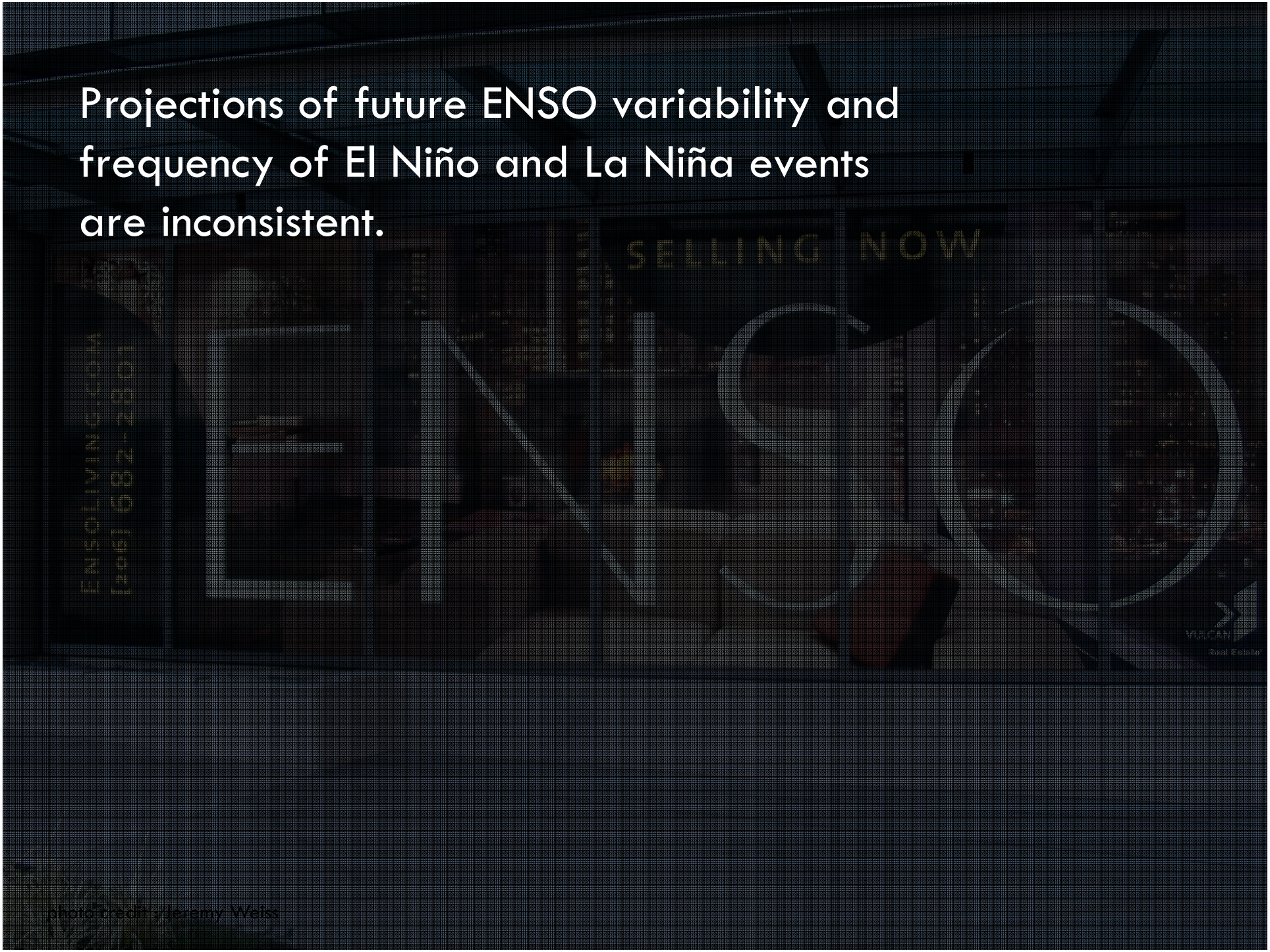


photo credit: Jeremy Weiss

Because of this large uncertainty, the IPCC assigned 'low' confidence to projected changes in the intensity and spatial pattern of this phenomenon.

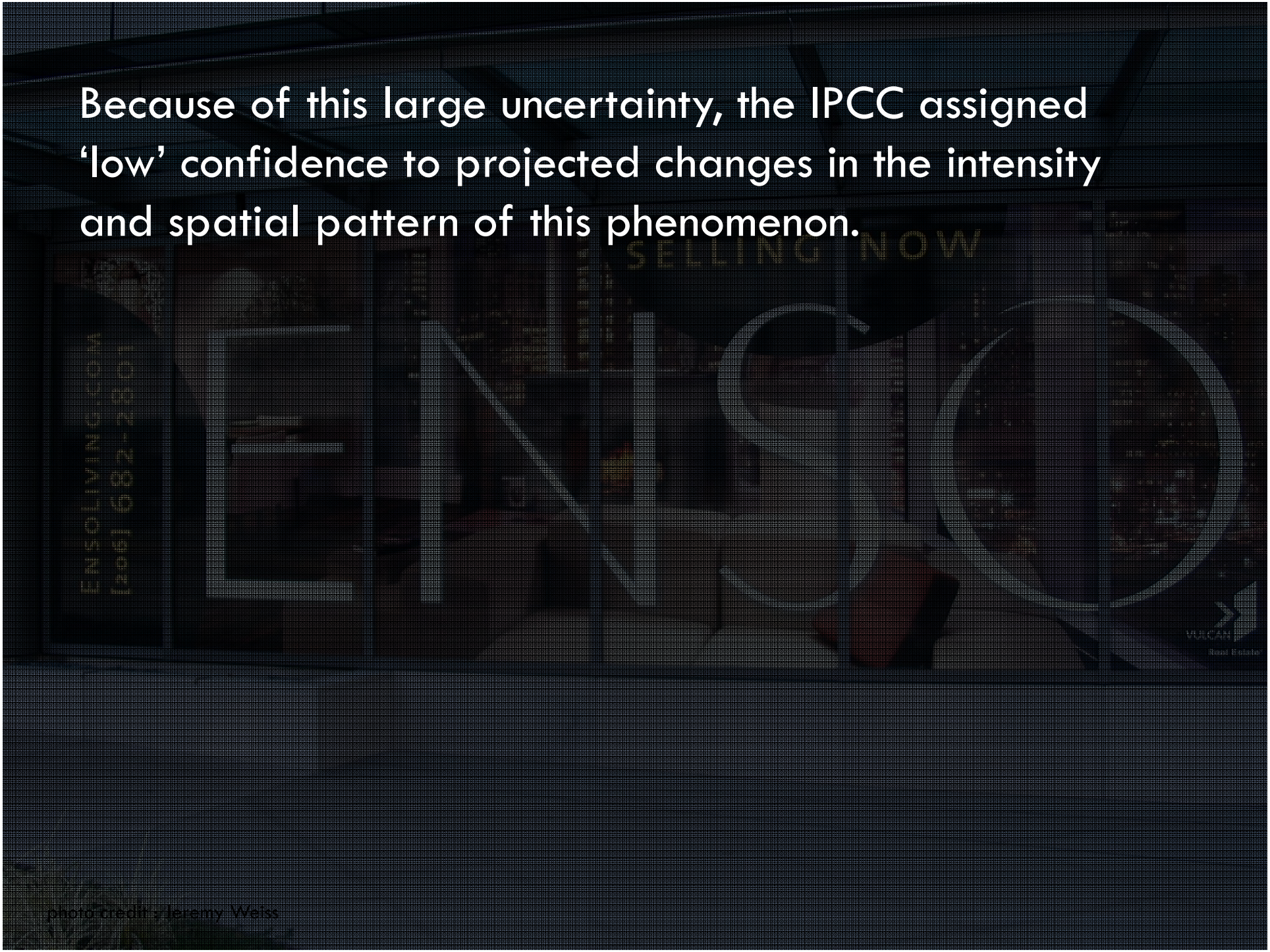


photo credit: Jeremy Weiss

However, there is ‘high’ confidence in ENSO dominating year-to-year variations in global climate.

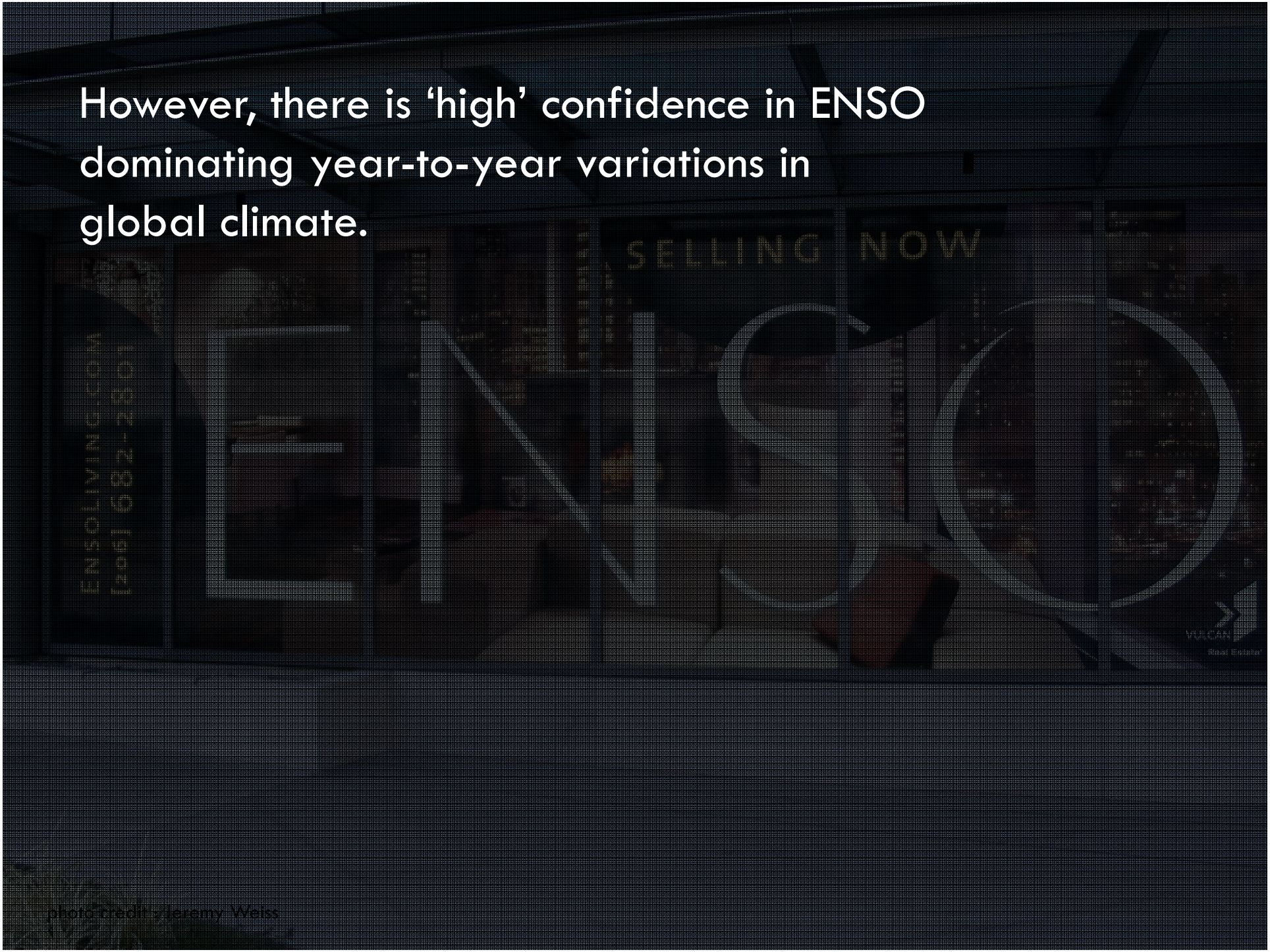
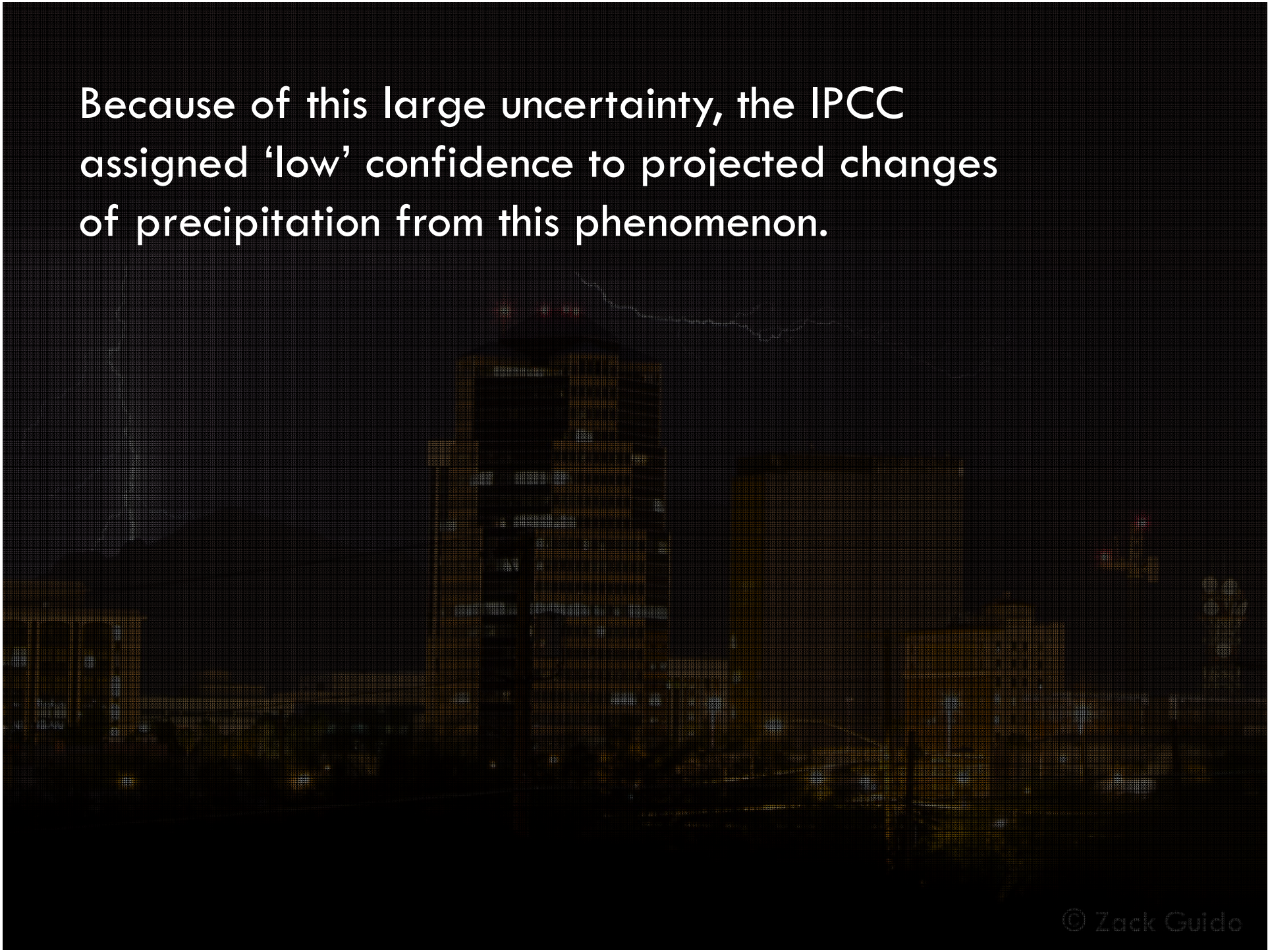


photo credit: Jeremy Weiss


© Zack Guido

Modeling and projecting future variability of the North American monsoon is extremely challenging.

Because of this large uncertainty, the IPCC assigned ‘low’ confidence to projected changes of precipitation from this phenomenon.



However, there is ‘high’ confidence that precipitation extremes will increase.


photo credit : Daniel Ferguson

Inconsistent projections of these global- and regional-scale phenomena, however, make projections of drought difficult.

photo credit : Daniel Ferguson

Nonetheless, other aspects of dryness or aridity that relate additionally to temperature can provide insight into the nature of droughts that possibly occur in coming decades.

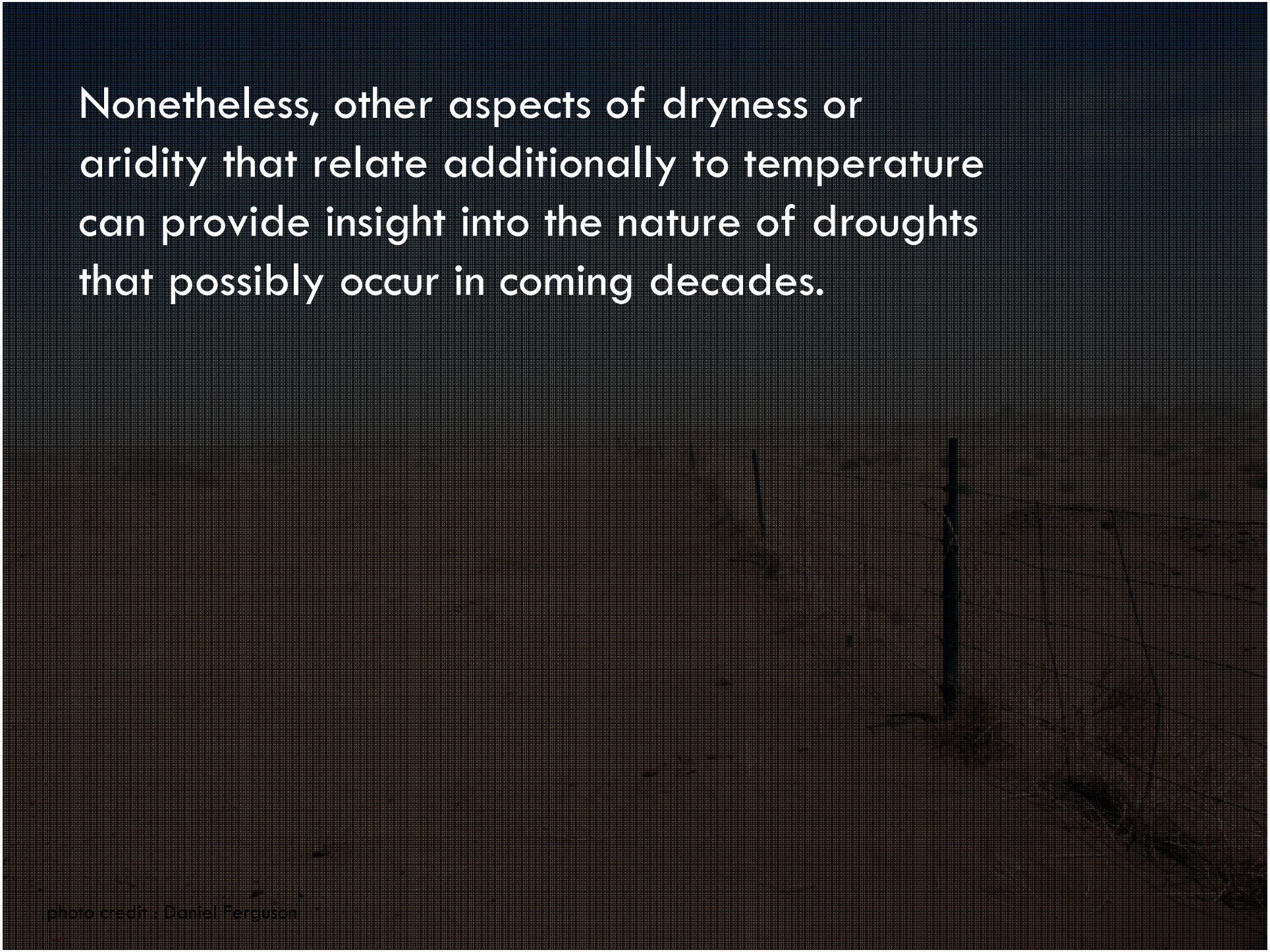


photo credit : Daniel Ferguson

There is ‘high’ confidence that droughts will become more severe under warmer temperatures as soil moisture decreases with greater atmospheric demand for evaporation and transpiration.

photo credit : Damel Ferguson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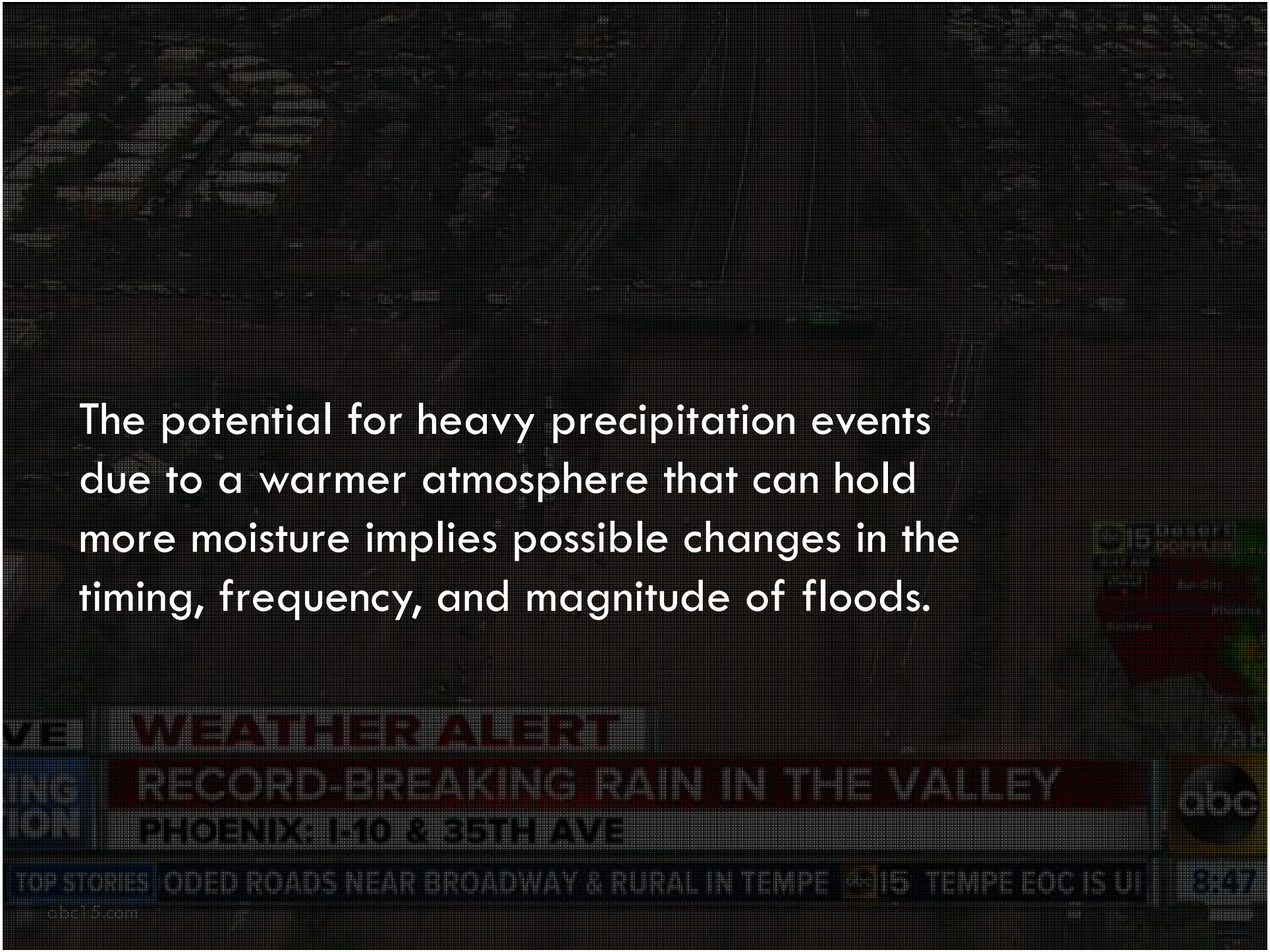
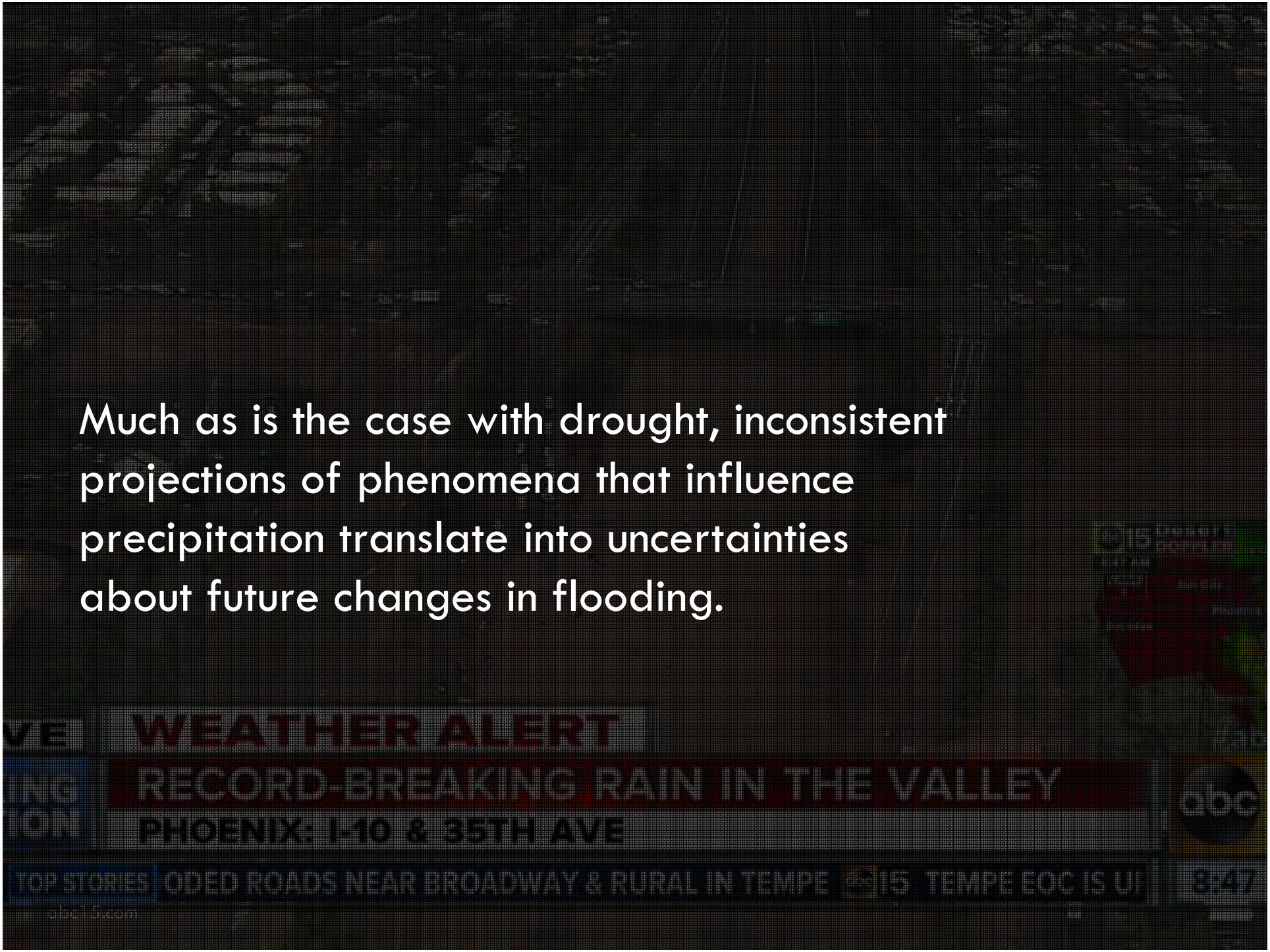


The potential for heavy precipitation events due to a warmer atmosphere that can hold more moisture implies possible changes in the timing, frequency, and magnitude of floods.



Much as is the case with drought, inconsistent projections of phenomena that influence precipitation translate into uncertainties about future changes in flooding.

There is ‘high’ confidence that climate in the Southwest will continue to change in coming decades, but not all aspects – such as extremes – can be projected with equal confidence.

commons.wikimedia.org

Nonetheless, current knowledge is sufficient to identify impacts from possible changes in future extreme weather events.

commons.wikimedia.org

RESOURCES

Southwest Climate Change Assessment Report
www.swcarr.arizona.edu

National Climate Assessment
nca2014.globalchange.gov

IPCC AR5
www.ipcc.ch/report/ar5

IPCC SREX
ipcc-wg2.gov/SREX

<extra information>

www.ipcc.ch/report/ar5/wg1/

“Overall, the most robust global changes in climate extremes are seen in measures of daily temperature, including to some extent, heat waves. Precipitation extremes also appear to be increasing, but there is large spatial variability“

"There is limited evidence of changes in extremes associated with other climate variables since the mid-20th century”

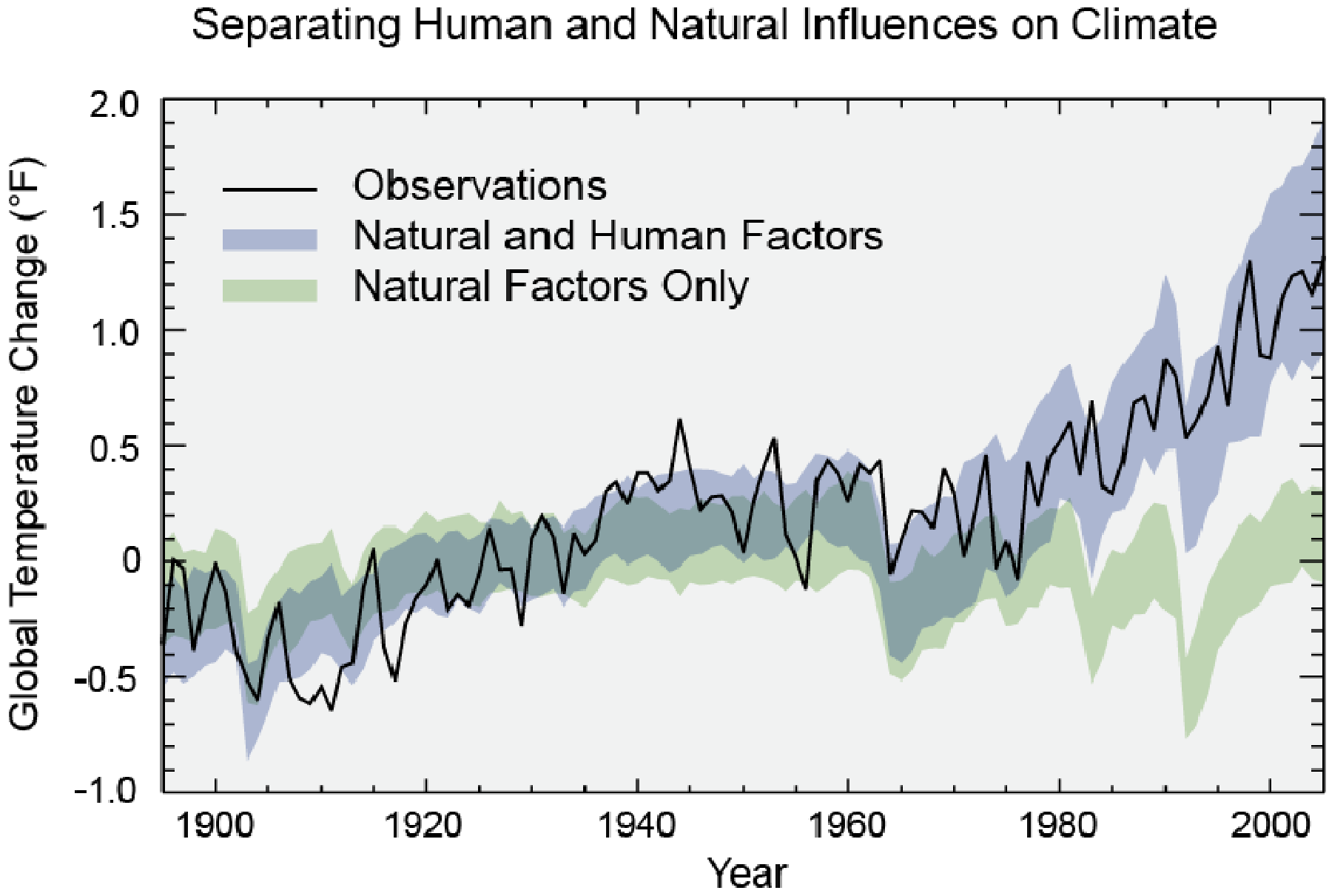
“Current datasets indicate no significant observed trends in global tropical cyclone frequency over the past century … No robust trends in annual numbers of tropical storms, hurricanes and major hurricanes counts have been identified over the past 100 years in the North Atlantic basin”

“In summary, there continues to be a lack of evidence and thus low confidence regarding the sign of trend in the magnitude and/or frequency of floods on a global scale”

“In summary, there is low confidence in observed trends in small-scale severe weather phenomena such as hail and thunderstorms because of historical data inhomogeneities and inadequacies in monitoring systems”

“In summary, the current assessment concludes that there is not enough evidence at present to suggest more than low confidence in a global-scale observed trend in drought or dryness (lack of rainfall) since the middle of the 20th century due to lack of direct observations, geographical inconsistencies in the trends, and dependencies of inferred trends on the index choice.”

“In summary, confidence in large scale changes in the intensity of extreme extratropical cyclones since 1900 is low. Likewise, confidence in trends in extreme winds is low, owing to quality and consistency issues with analysed data.”


Separating Human and Natural Influences on Climate
Observations
Natural and Human Factors
Natural Factors Only
Global Temperature Change (°F)
2.0
1.5
1.0
0.5
0
-0.5
-1.0
1900
1920
1940
1960
1980
2000
Year

NCA 2014