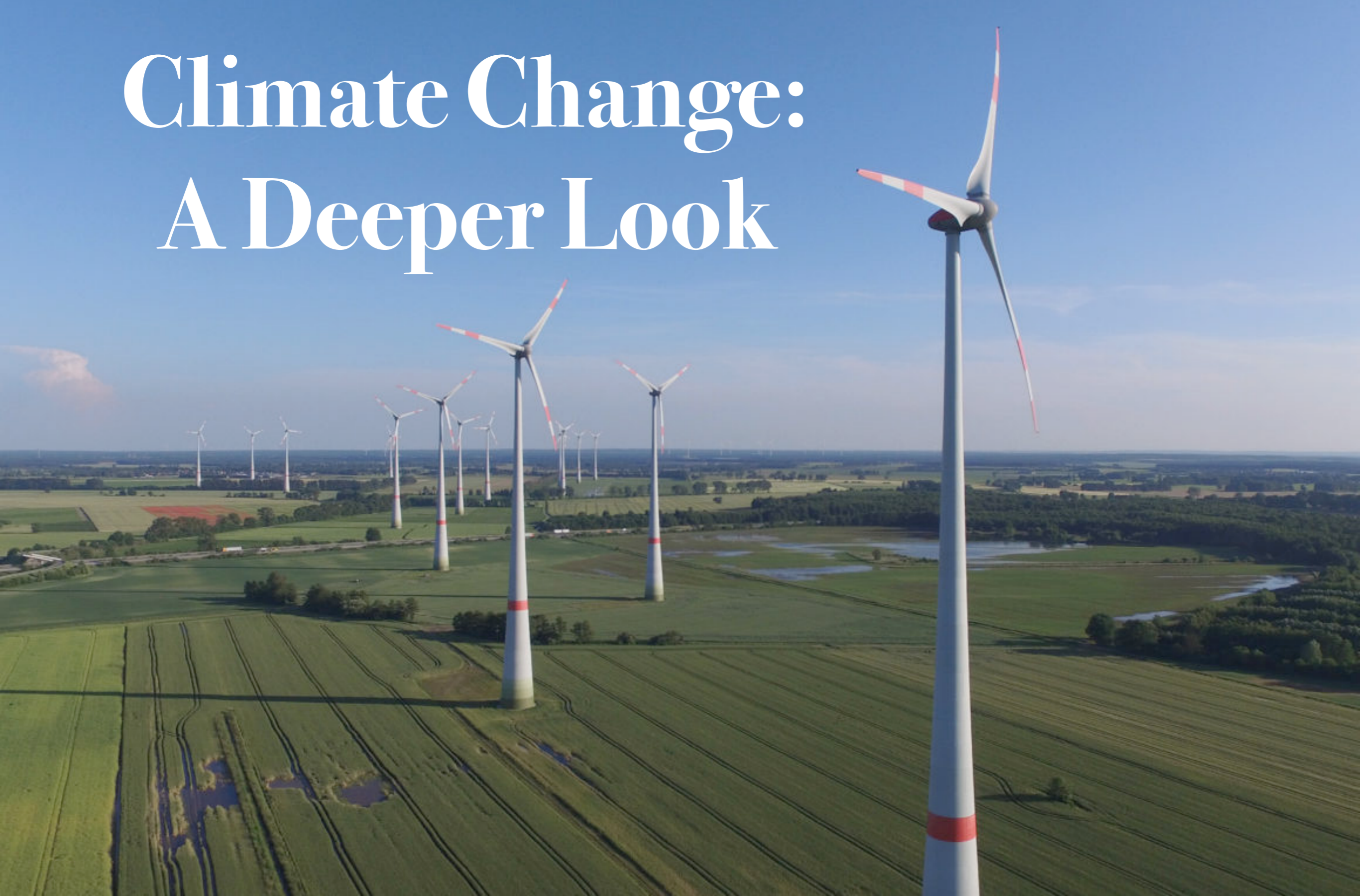


Climate Change: A Deeper Look



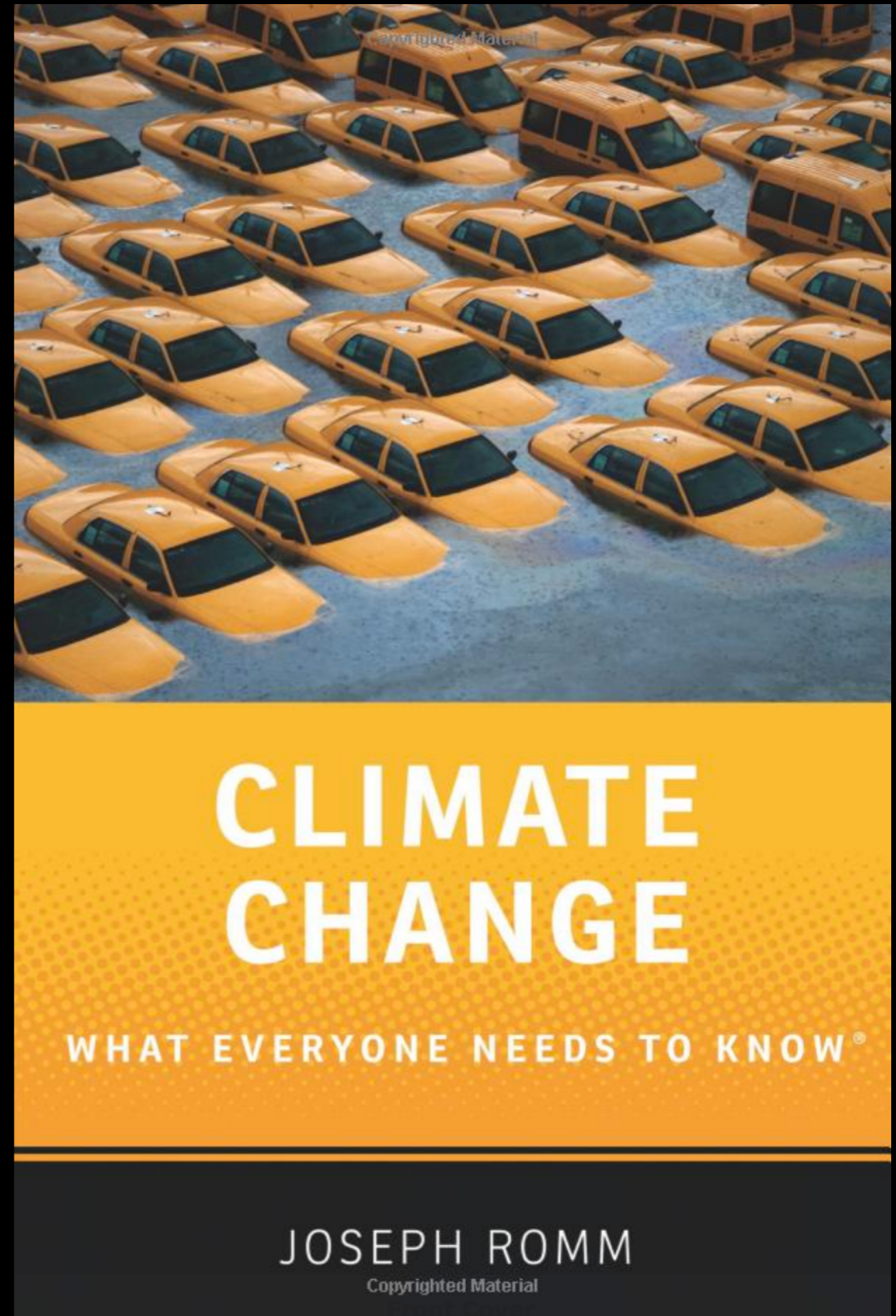
Patrick Drew

GSPS
September 7

This talk based on:

Check it out if
you want more

\$14 new on Amazon



1 Climate Science Basics

- What is the greenhouse effect and how does it warm the Earth?* 1
- Why are scientists so certain the climate system is warming?* 2
- How does global warming increase sea levels and what has been observed to date?* 4
- Where does most of human-caused warming go?* 6
- What fraction of recent global warming is due to human causes versus natural causes?* 7
- How certain are climate scientists that humans are the primary cause of recent warming?* 9
- How do scientists know that recent climate change is primarily caused by human activities?* 9
- Why has the climate changed in the past, before there were human-caused greenhouse gas emissions?* 12
- What are the climate system's amplifying feedbacks that turn a moderate initial warming into a big ultimate warming?* 13
- Is the current level of atmospheric CO₂ concentration unprecedented in human history?* 15
- Are recent climatic changes unprecedented?* 17

2 Extreme Weather and Climate Change

- What is the difference between weather and climate?* 31
- Which extreme weather events are being made worse by climate change and which are not?* 32
- What is the role of natural climatic variation, such as the El Niño–La Niña cycle, in extreme weather?* 34
- Did climate change cause Hurricane Sandy (and why is that the wrong question to ask)?* 37
- How does climate change affect heat waves?* 40

3 Projected Climate Impacts

73

- What kind of impacts can we expect this century from business-as-usual climate change?* 73
- What are the biggest sources of uncertainty in projecting future global warming?* 75
- What do previous hot periods in Earth's climate tell us about what the future may hold in store?* 78
- How could the thawing permafrost speed up global warming beyond what climate models have projected?* 80
- How could an increase in wildfires speed up global warming beyond what climate models have projected?* 85
- What are some other key positive or amplifying feedbacks affecting the climate system?* 88
- What will the impacts of sea-level rise be?* 92
- How will climate change lead to more destructive superstorms this century?* 96
- What kind of droughts can we expect this century?* 98
- What are the expected health impacts of climate change?* 103
- How does global warming affect human productivity?* 107
- Does carbon dioxide at exposure levels expected this century have any direct impacts on human health or cognition?* 112
- What is ocean acidification and why does it matter to sea life?* 118
- What is biodiversity and how will climate change impact it?* 121

Series of questions. This talk will look at some of them.

Logic of the Book:

Imagine you knew
about the internet
25 years early.

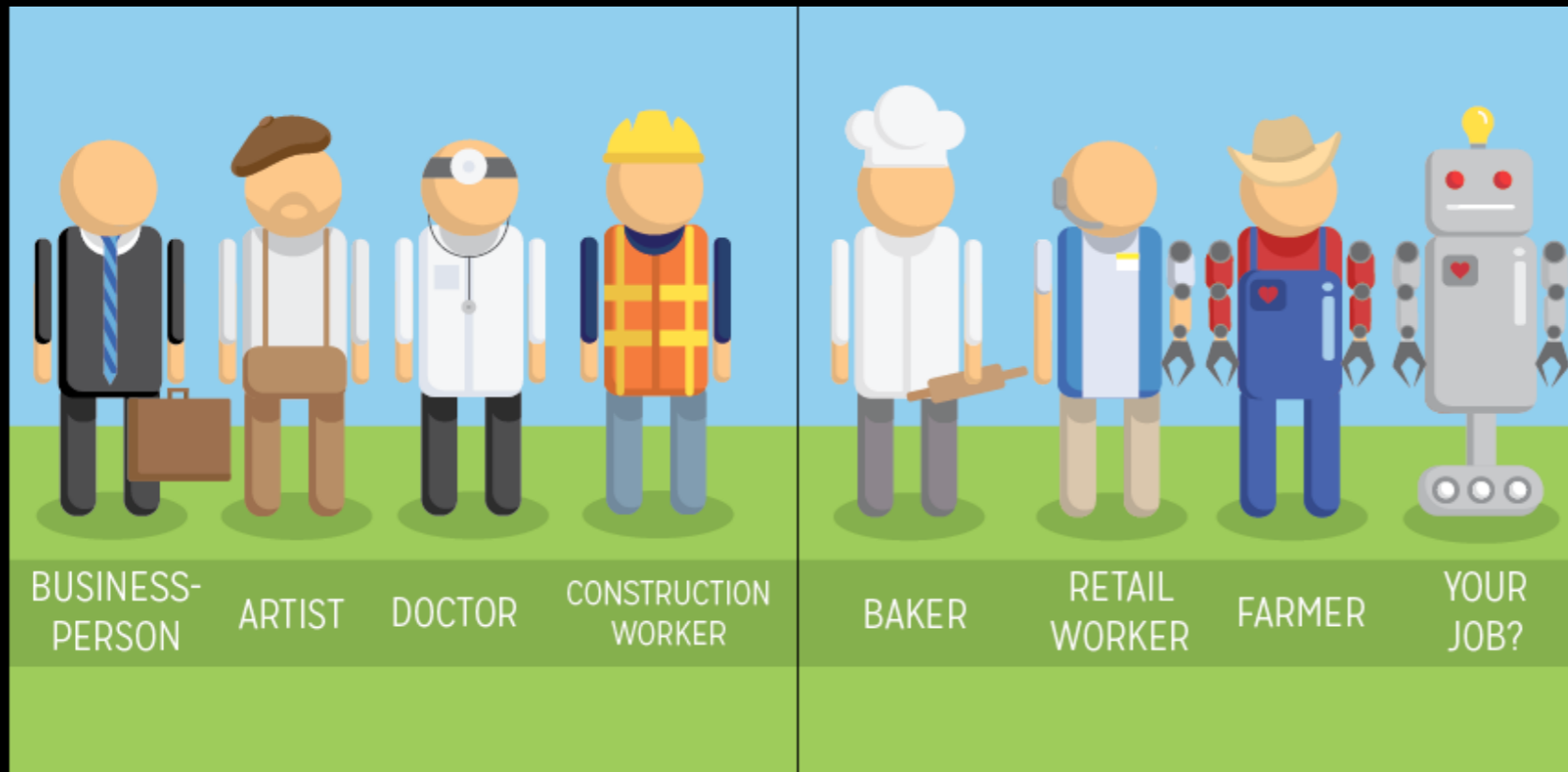


How valuable would that info be?

How would you plan for the future?

Climate Change Will Impact:

Health



Economies
Politics
Resources
Wealth
Climate (duh)
Wars
Migrant Crises
More...

What can we expect?

A satellite view of Earth at night, showing city lights and cloud patterns over the Americas. The image captures the curvature of the planet, with a thin layer of atmosphere visible at the top. The lights from cities and towns are scattered across the landmasses, with a prominent concentration in the eastern United States and Mexico. The oceans are dark, and the clouds are illuminated from below, creating a dramatic contrast against the night sky.

Disclaimer: Some of these effects are likely to be at least partially mitigated.

Humanity cannot avoid very serious climate impacts in the coming decades

Avoid
worst impacts:

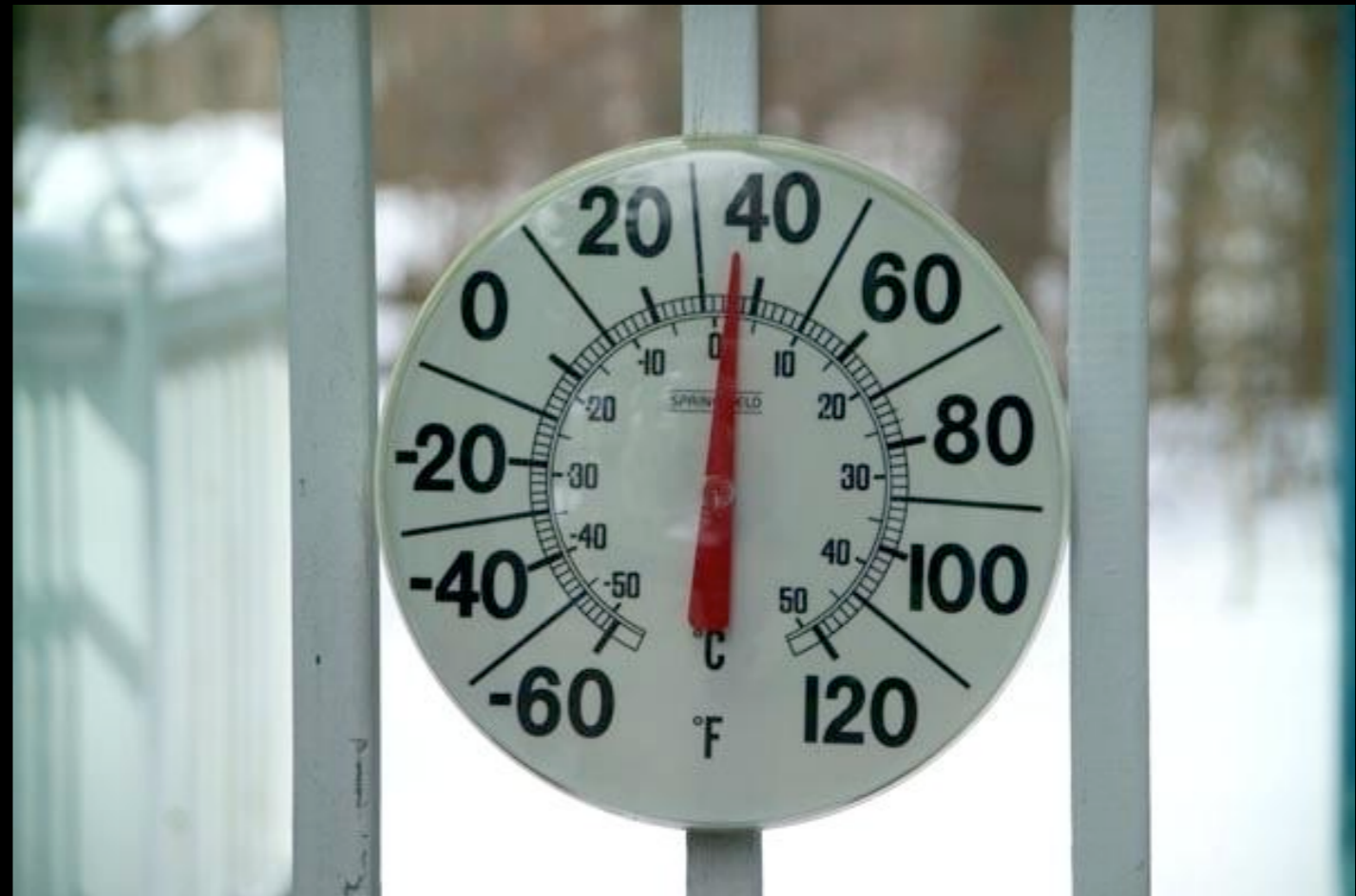
All nations to
carbon-free energy
faster than currently
scheduled

<0 carbon
emissions by 2100



Warming

- 1900-1970: +0.5 F
- 1970-present: +1 F
- 2100: +7.5 F
(business as usual)



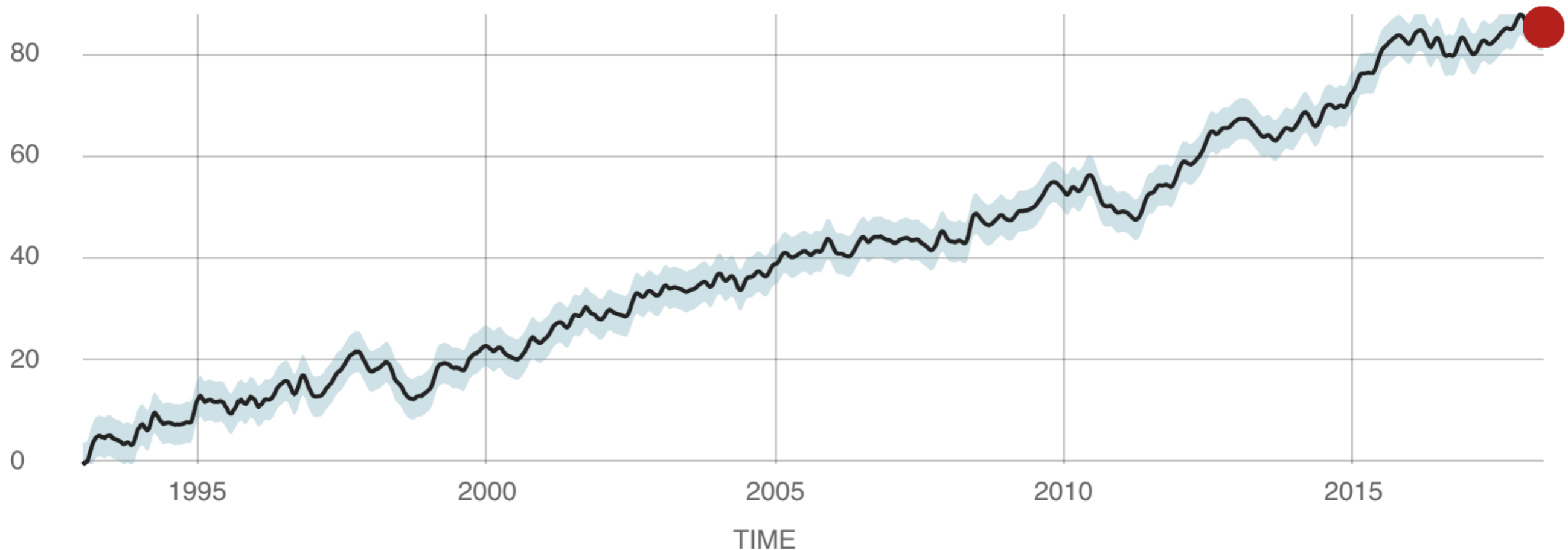
SATELLITE DATA: 1993-PRESENT

Data source: Satellite sea level observations.
Credit: NASA Goddard Space Flight Center

RATE OF CHANGE

↑ 3.2

millimeters per year



1 ft by 2050

>4-6 ft by 2100 with business as usual

Every decade after 2100, >1 ft per decade!!

(~0.08mm/day or 1mm every ~12 days)

Impact 1: Sea Level Rise



Hull, MA +6ft



SEA LEVEL RISE VIEWER

Enter an address or city



WATER LEVEL

6ft

5ft

4ft

3ft

2ft

1ft

Current MHHW

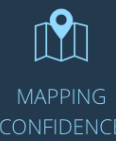
UNITS



SEA LEVEL RISE



LOCAL SCENARIOS



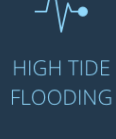
MAPPING CONFIDENCE



MARSH MIGRATION



VULNERABILITY



HIGH TIDE FLOODING



?

PEDDOCKS ISLAND

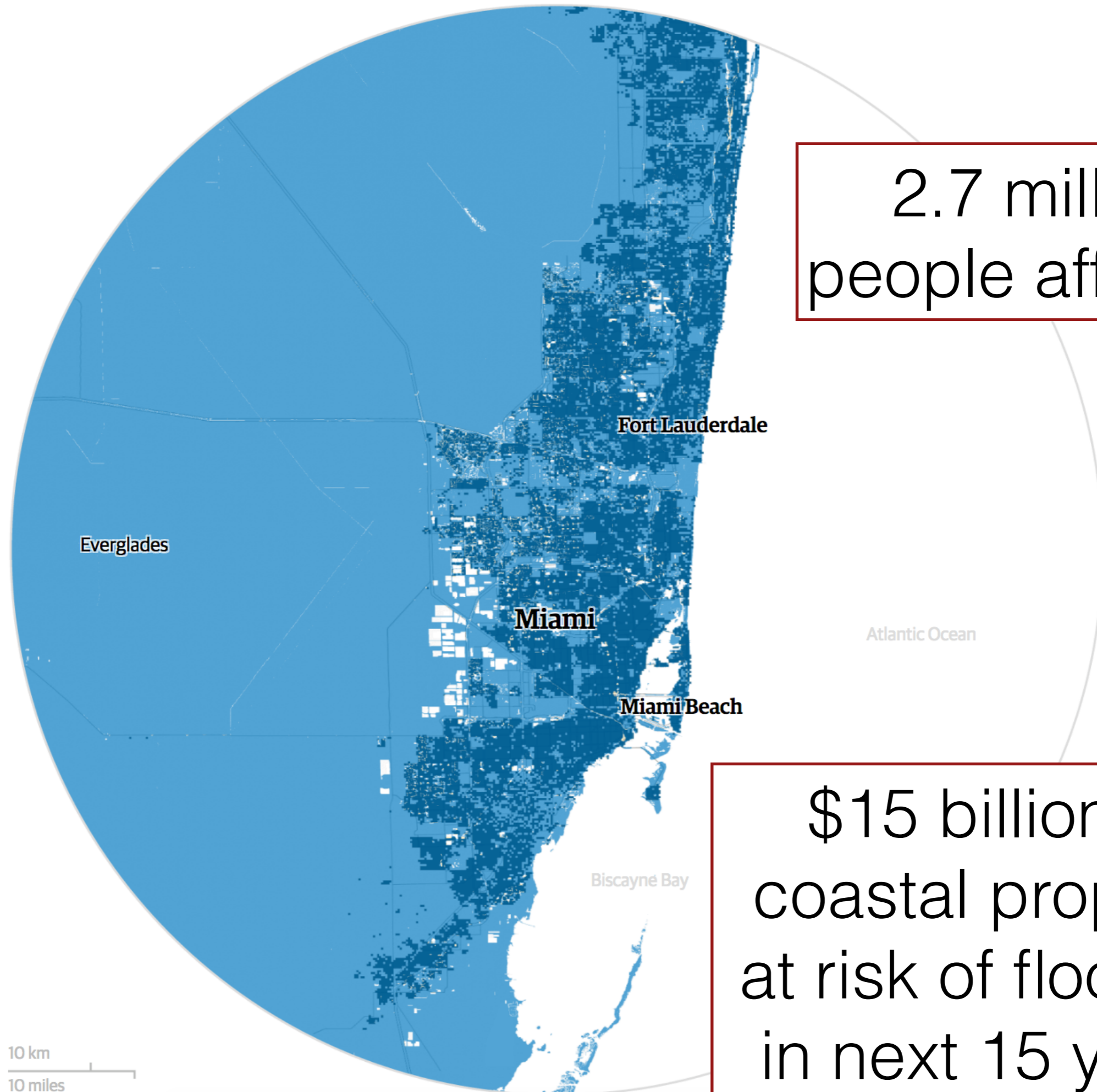
GRAPE ISLANDS

Hundreds of people affected

+

-

?



2.7 million
people affected

\$15 billion of
coastal property
at risk of flooding
in next 15 years

Florida +6ft

Even at +3 ft, 1/3 of southern Florida will swim.

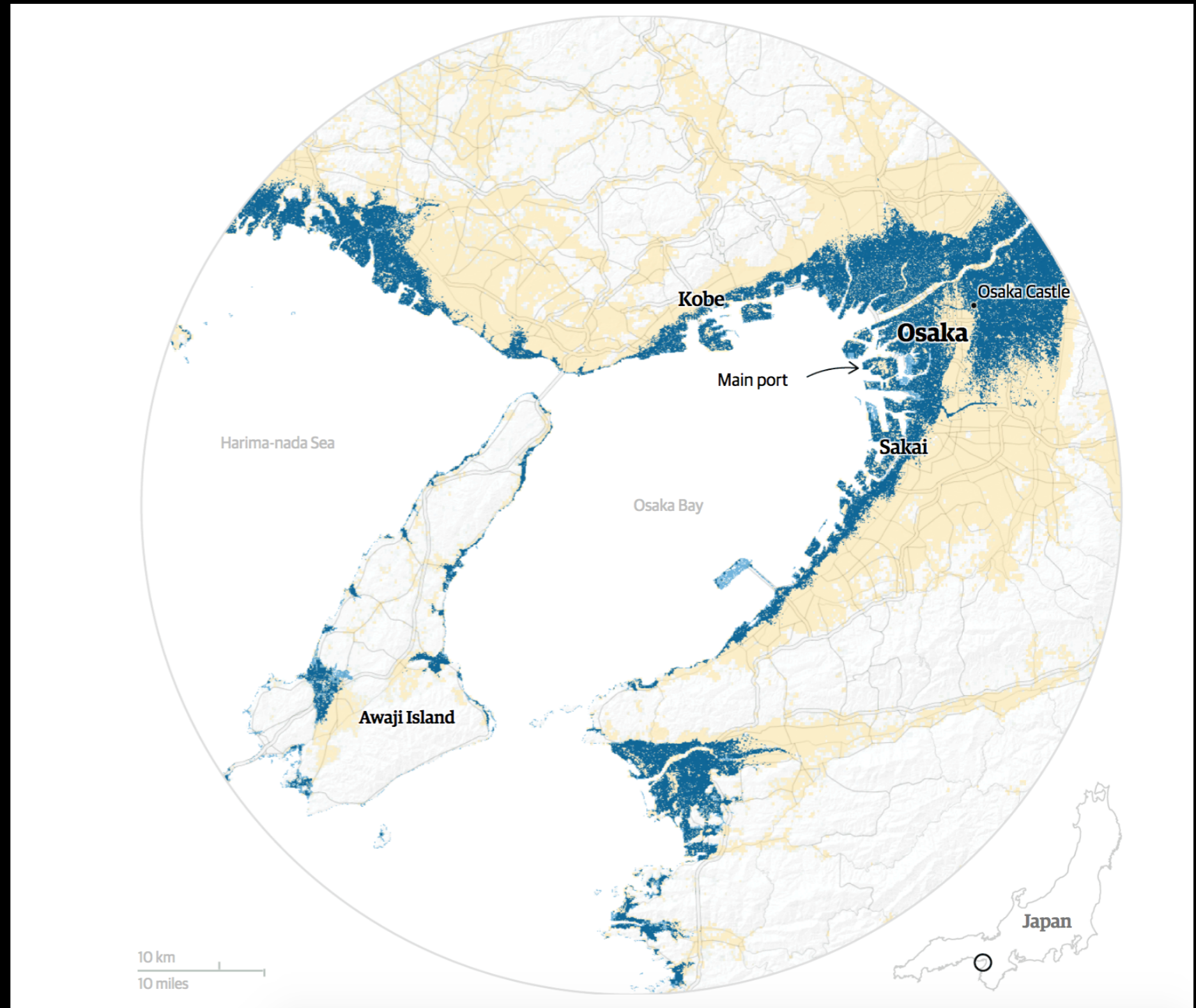
Storm surges and rising seas will cause property values to fall to nothing.

Real estate will be uninsurable.



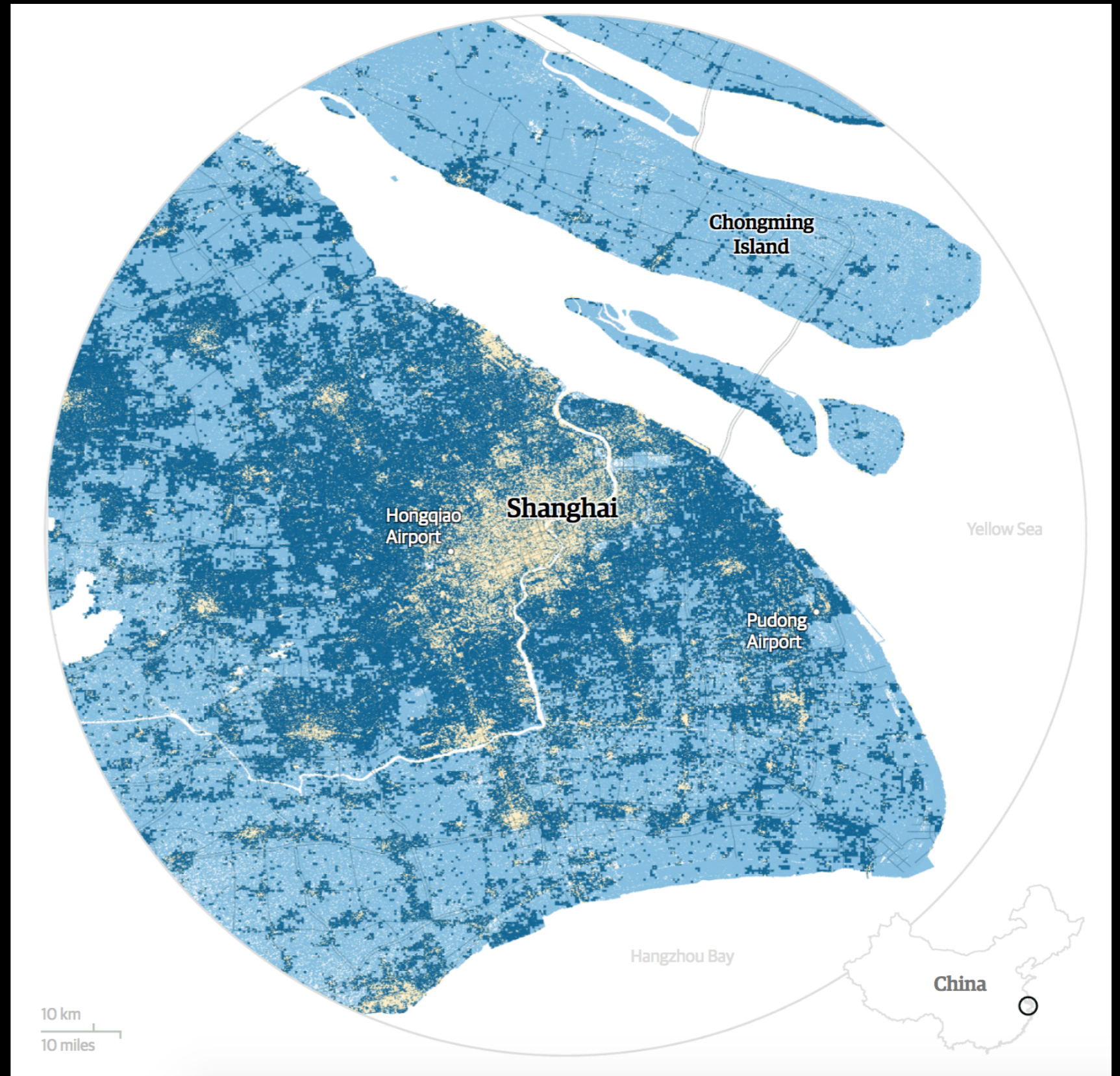
Osaka

5.2
million
people
affected



Shanghai

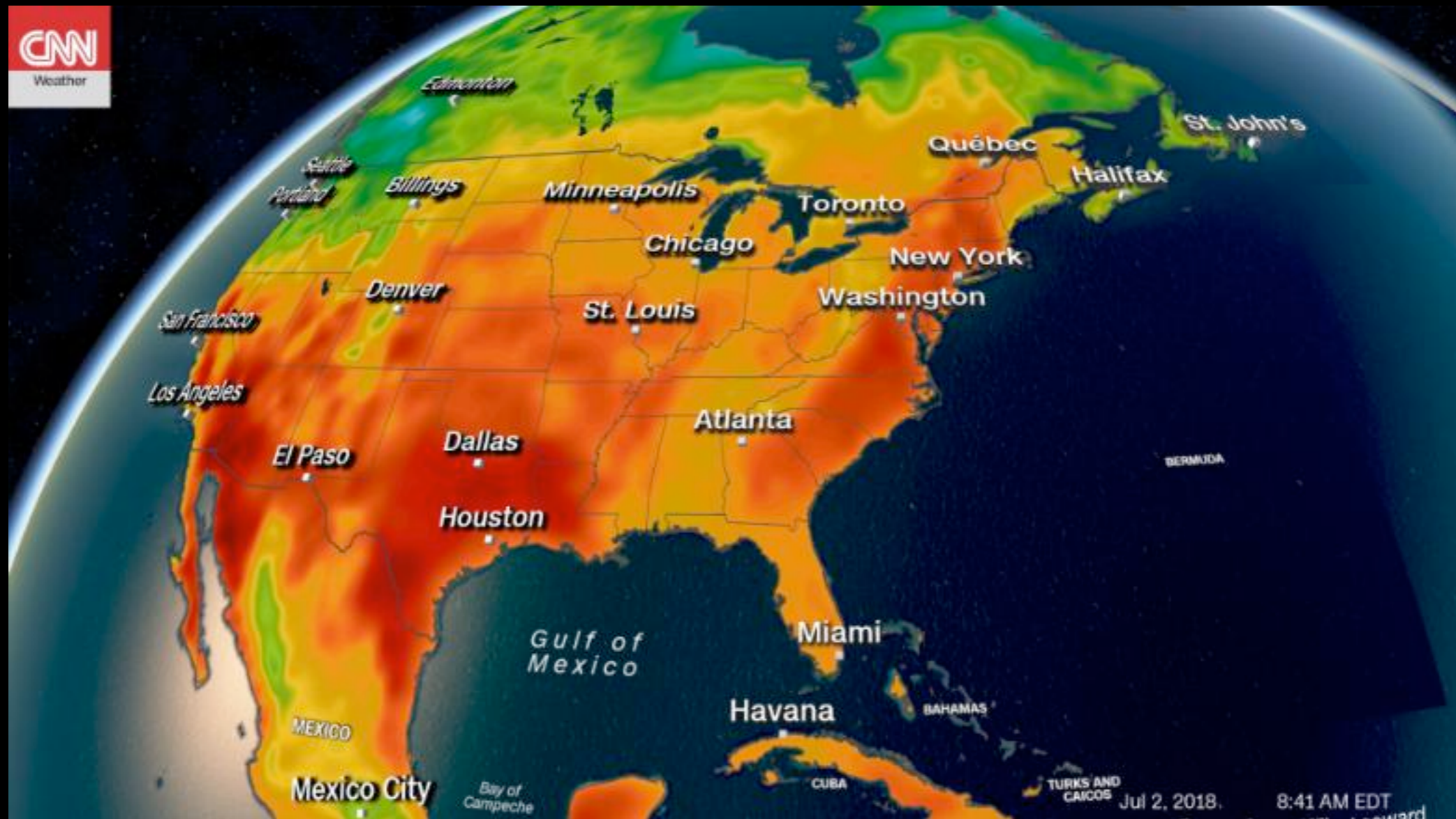
17.5
million
people
affected



Global migrant and real estate crises



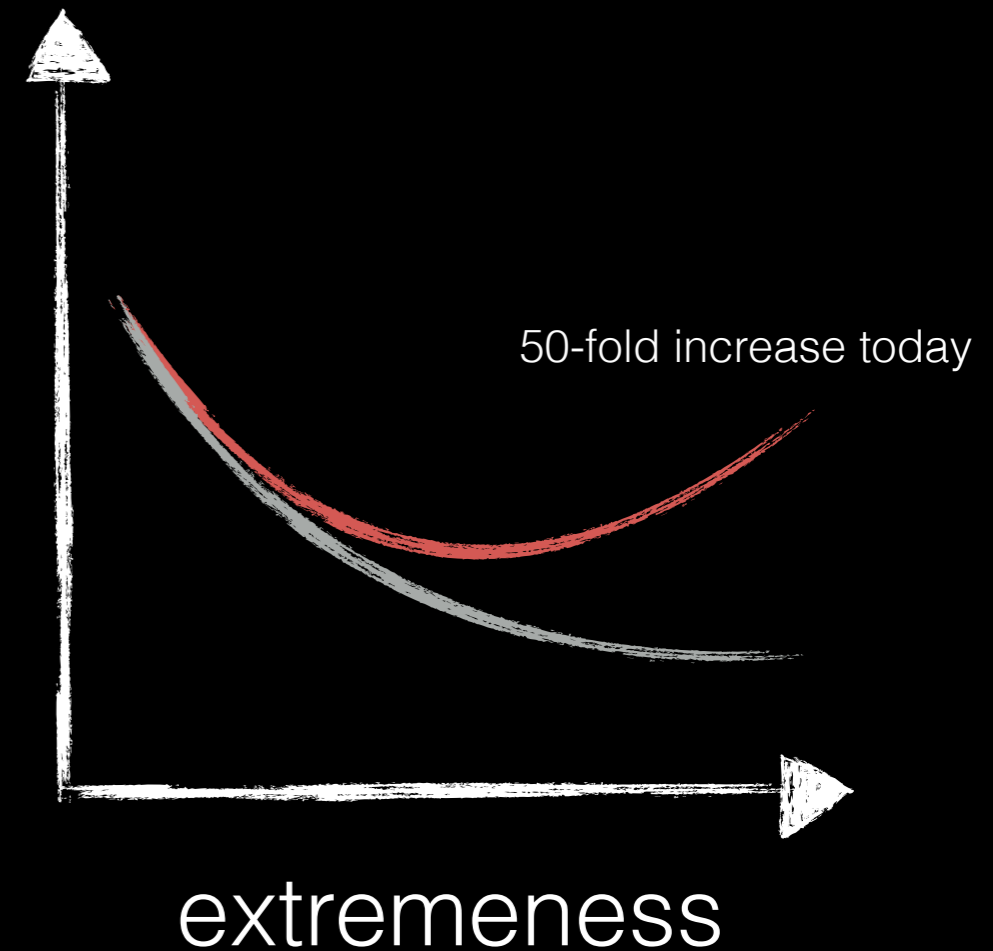
Impact 2: Heat Waves



Heat Wave Probabilities



$P(\text{extreme})$



- Probability of extreme events boosted more than moderate events

2003 European Heatwave

70,000 died,
mostly elderly,
many in France.

Culprit was lack of
AC which is
usually not
needed.

Many vulnerable
populations
worldwide



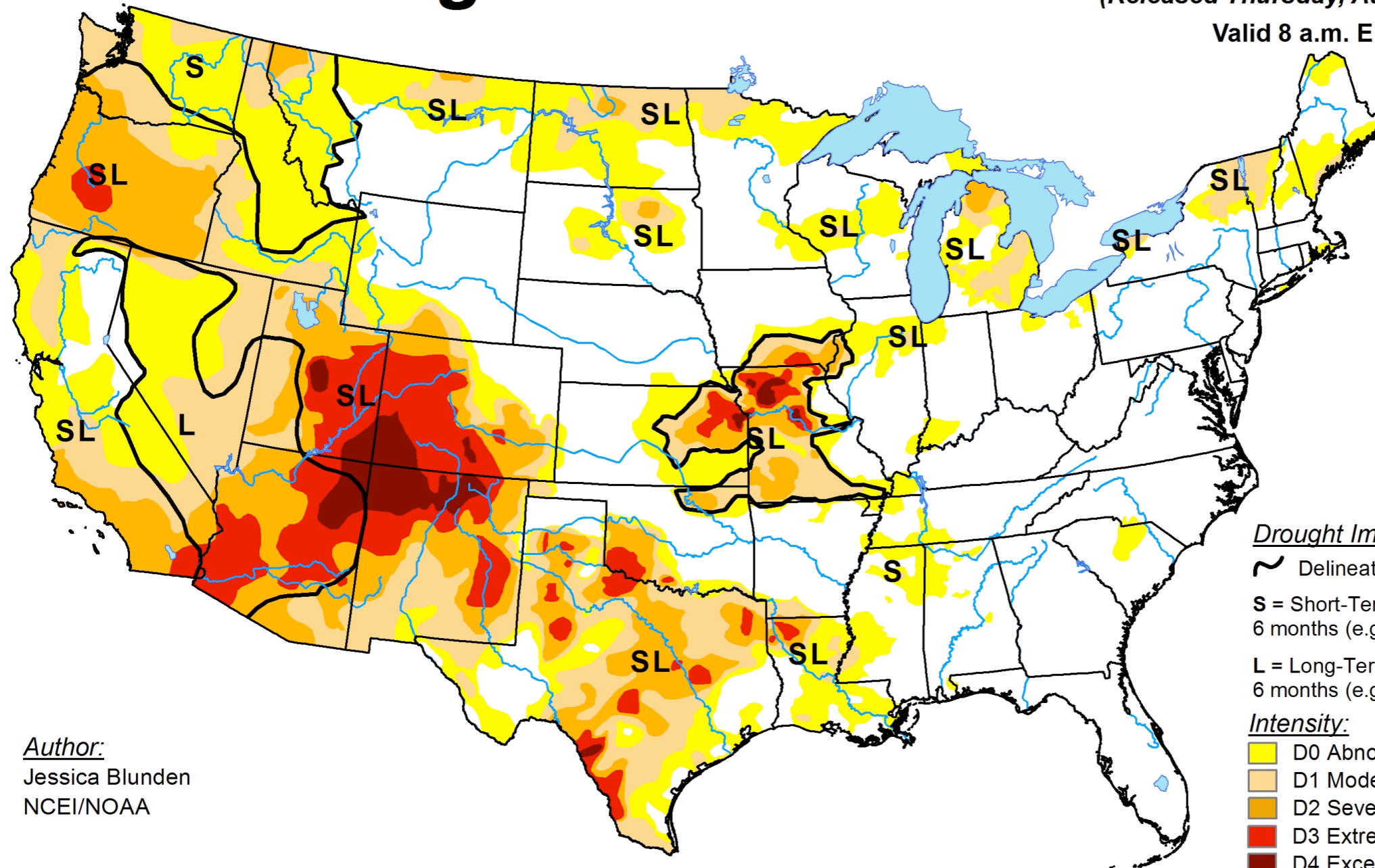
Impact 3: Deeper, more frequent, and longer droughts



U.S. Drought Monitor

August 28, 2018
 (Released Thursday, Aug. 30, 2018)

Valid 8 a.m. EDT



Author:
 Jessica Blunden
 NCEI/NOAA

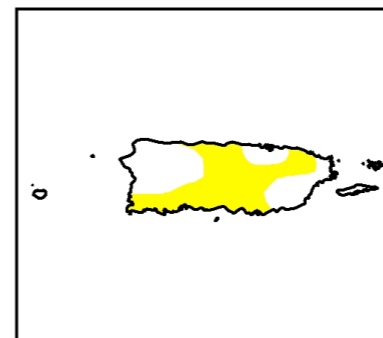
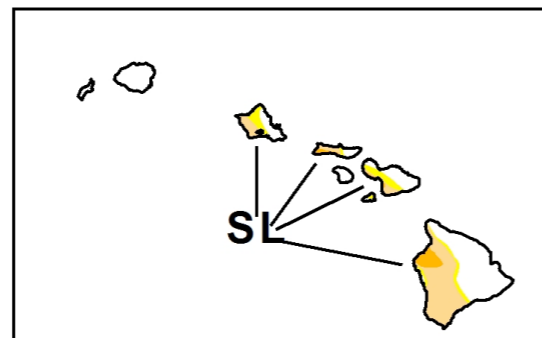
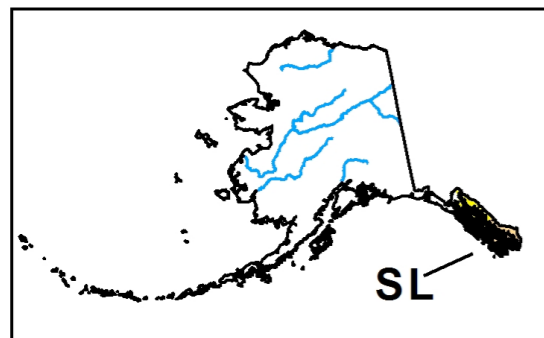
Drought Impact Types:

- ~ Delineates dominant impacts
- S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
- L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

Intensity:

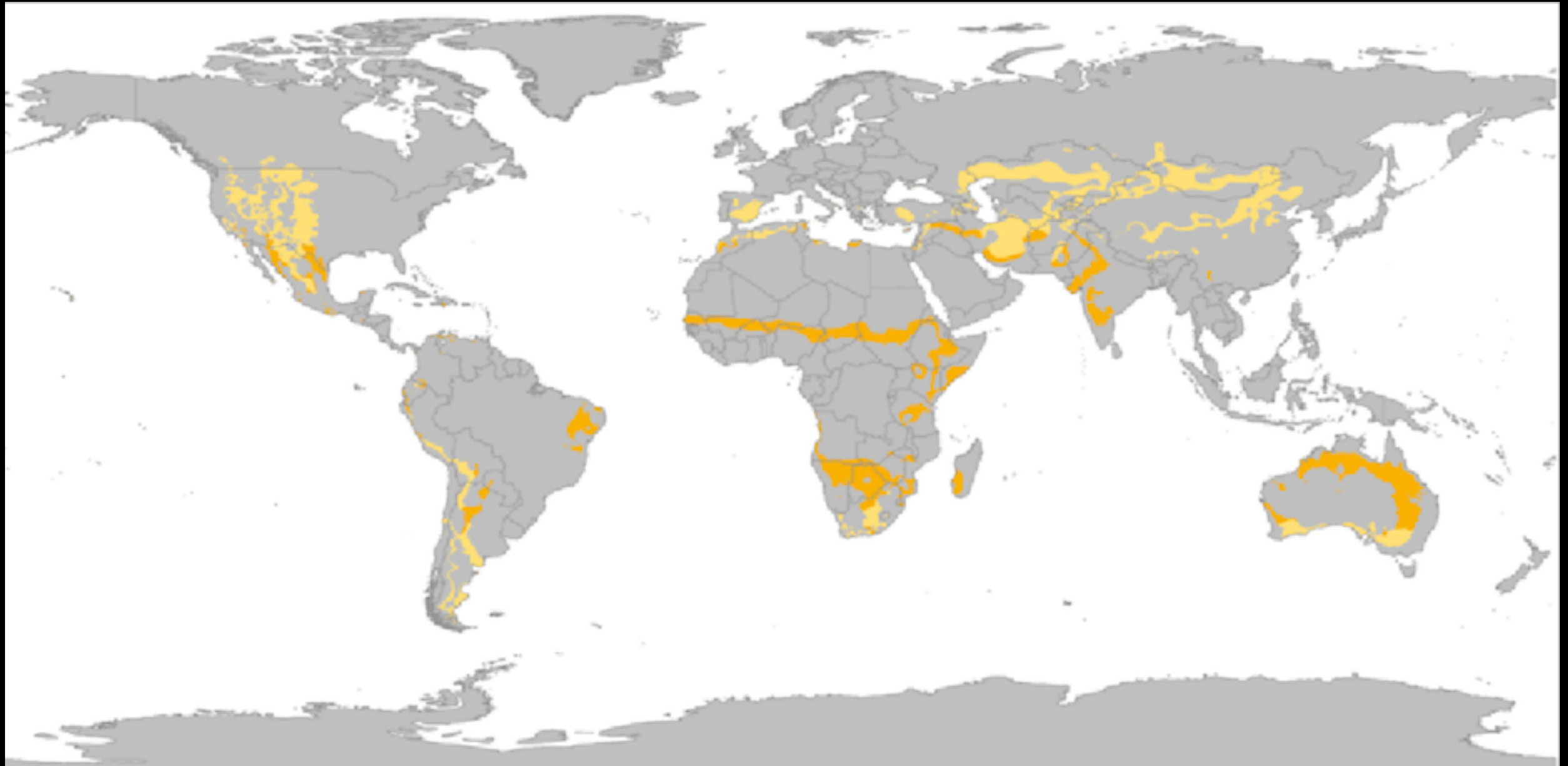
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.



<http://droughtmonitor.unl.edu/>

Semi-arid climates will
become desert



Dust bowl effects

SW US, SW Europe,
and other hot, heavily
populated and or
heavily farmed land.

Food and water
shortages.



How to prepare:

- Save more money (e.g. soaring food prices)
- Don't plan to retire to US southwest, Mediterranean, or anywhere near the coast.



Where to consider living/ buying land

- Places with relatively abundant water and arable land
- Real estate rush in coming decades
- There are no regions that “win”, however.

northern midwest



northern europe

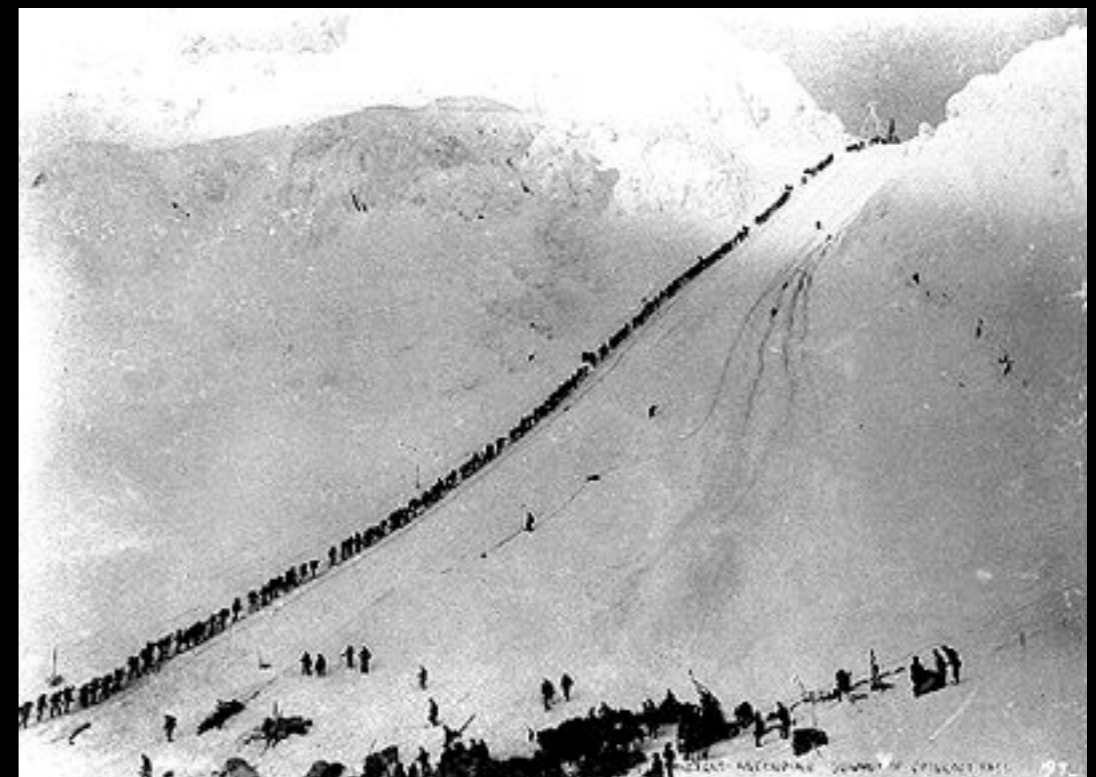


Land rush

- Nobody can say when people in US will start moving north, but it is certain to happen.
- People who plan ahead will come out ahead



(Klondike Gold Rush)



The Upside

- Energy experts say even the strongest climate change action is now super cheap.
- Makes fiscal sense to transition from fossil fuels to renewables.
- Effects visible soon will change tunes of many deniers.



79% of Hawaiians believe.
Rainfall decreased, but intensity increased



Things I didn't fit in:

- Best and worst case scenarios
- How to avoid the worst case scenarios
- How renewables have become so cheap recently
- Other dangerous climate effects
- Positive (and negative?) feedback loops
- Health impacts of climate change
- Dozens of other things. Buy the book!

Let's go to crown

- ~550 ft above sea level
- High temps :(
- Has beer



Sources

- “Climate Change” by Joseph Romm
- <https://www.jpl.nasa.gov/edu/teach/activity/graphing-sea-level-trends/>
- <https://www.businessinsider.com/miami-floods-sea-level-rise-solutions-2018-4>
- <https://www.theguardian.com/cities/ng-interactive/2017/nov/03/three-degree-world-cities-drowned-global-warming>