Impacts of Climate Change, Pt. 1

EES 3310/5310

Global Climate Change

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Class #21: Monday, February 24 2020

Framework for Thinking about Climate Change

Sources of Vulnerability

Types of systems:

- Managed Systems
- Unmanaged Systems
- Unmanageable

- Examples?

Systems

Extensively Managed	Partially Managed	Unmanageable

• Most economic sectors:
  ▪ *Manufacturing*
  ▪ *Health care*
• Most human activities:
  ▪ *Sleeping*
  ▪ *Surfing the Internet*
	• Vulnerable economic sectors:
	  ▪ *Agriculture*
	  ▪ *Forestry*
	• Nonmarket systems:
	  ▪ *Beaches and coastal ecosystems*
	  ▪ *Wildfires*
		• *Hurricanes*
		• *Sea-level rise*
		• *Ocean acidification*

Managed, Unmanaged, & Unmanageable Systems

- Relevance?
  - Climate impacts?
- Transformations:
  - Unmanaged → managed
  - Unmanageable → manageable
- “Focal Policy”
  - What is it?
  - Examples?
  - Advantages and disadvantages?

Scientific Uncertainty

- Nordhaus:

  “A sensible policy would pay an insurance premium to avoid playing the roulette wheel.”

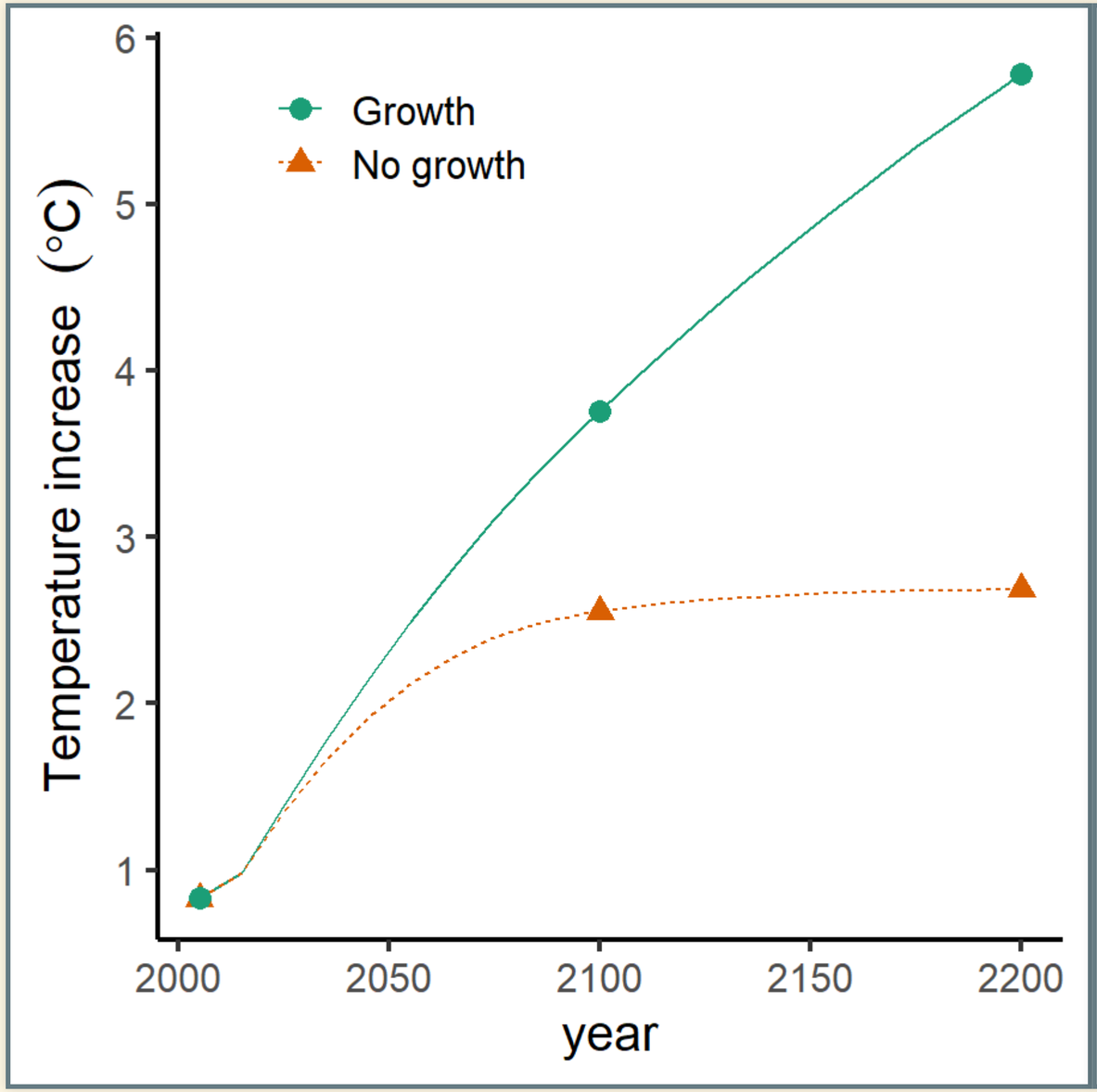
  “The cost of delaying action for 50 years … is [estimated] as $6.5 trillion.”

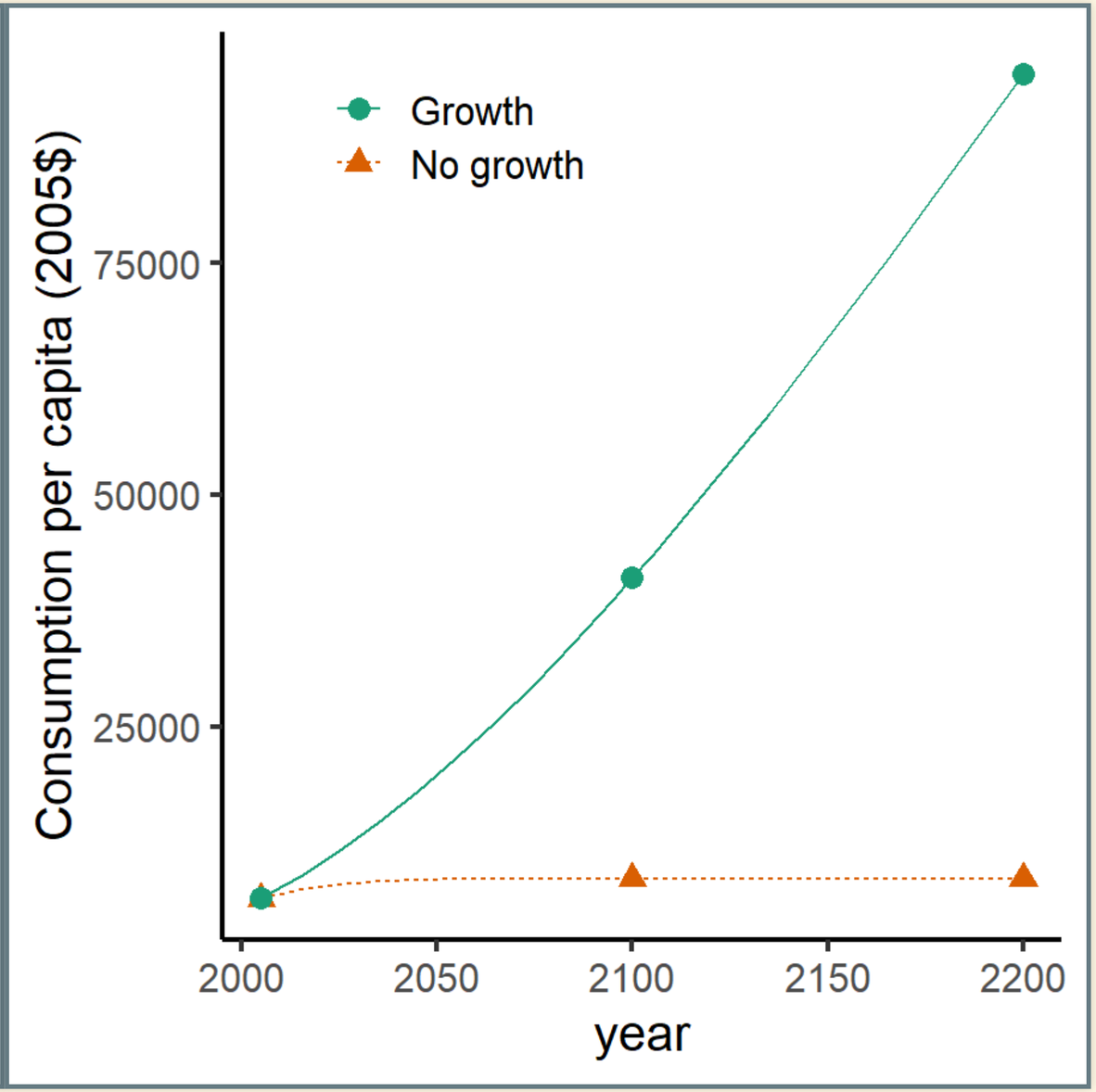
- Pielke:

  “Policy makers routinely make decisions … with a similar (or even less well-developed) state of understanding.”

Economic Growth

Economic Growth





Mitigating Factors

Mitigating Factors

- What are mitigating factors?
- Note:
  - Most policy analysis defines mitigation = reducing the **amount** of climate change (e.g. by cutting GHG emissions).
  - Nordhaus also uses the term to mean reducing the **impacts** of climate change
- Examples?
  - Carbon fertilization
  - Longer growing seasons at high latitudes
  - Higher temperature more snow falling on Antarctica
- Artificial Mitigation
  - Geoengineering

Adaptation

What kinds of things can people do to adapt to climate change?

Crop Yields

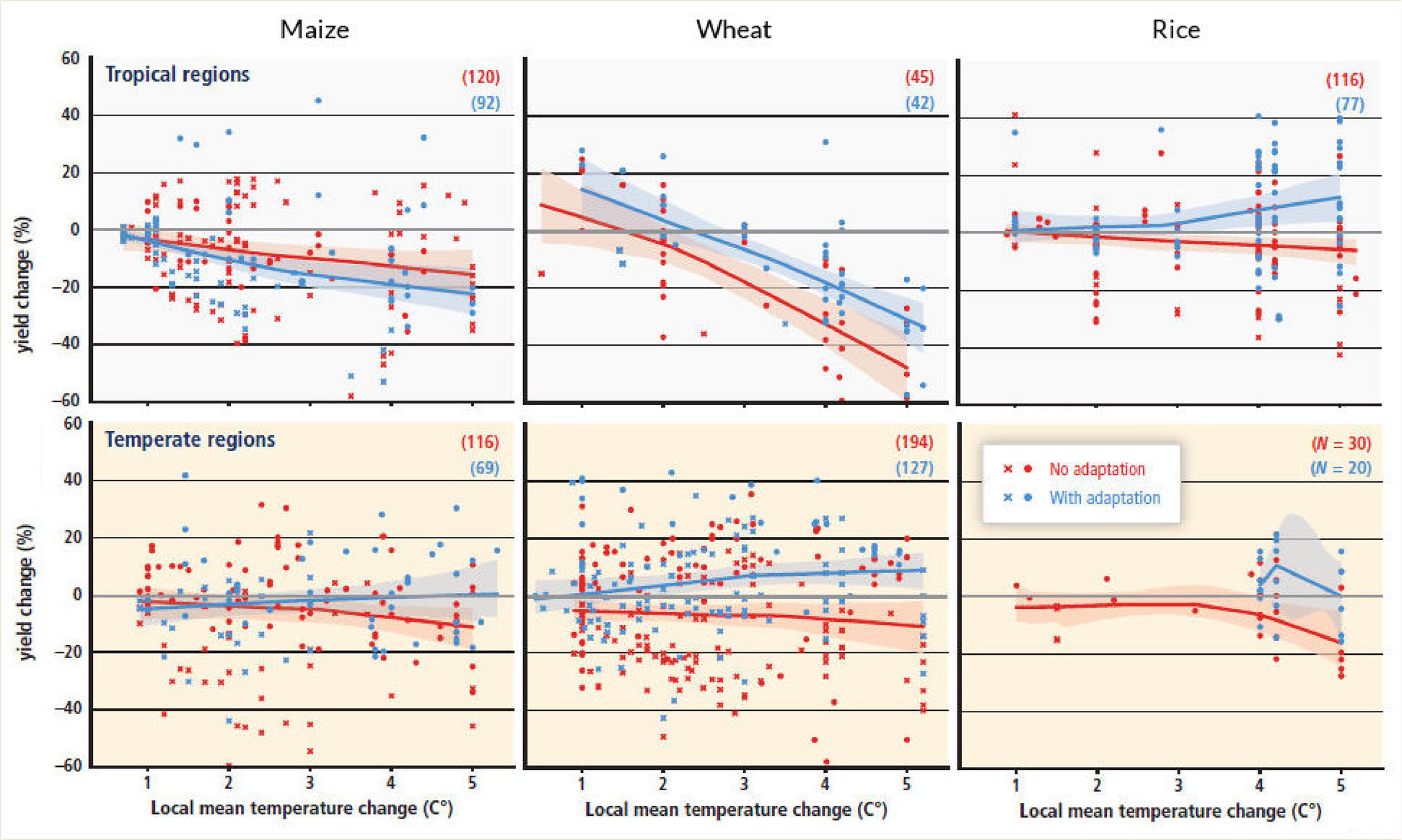
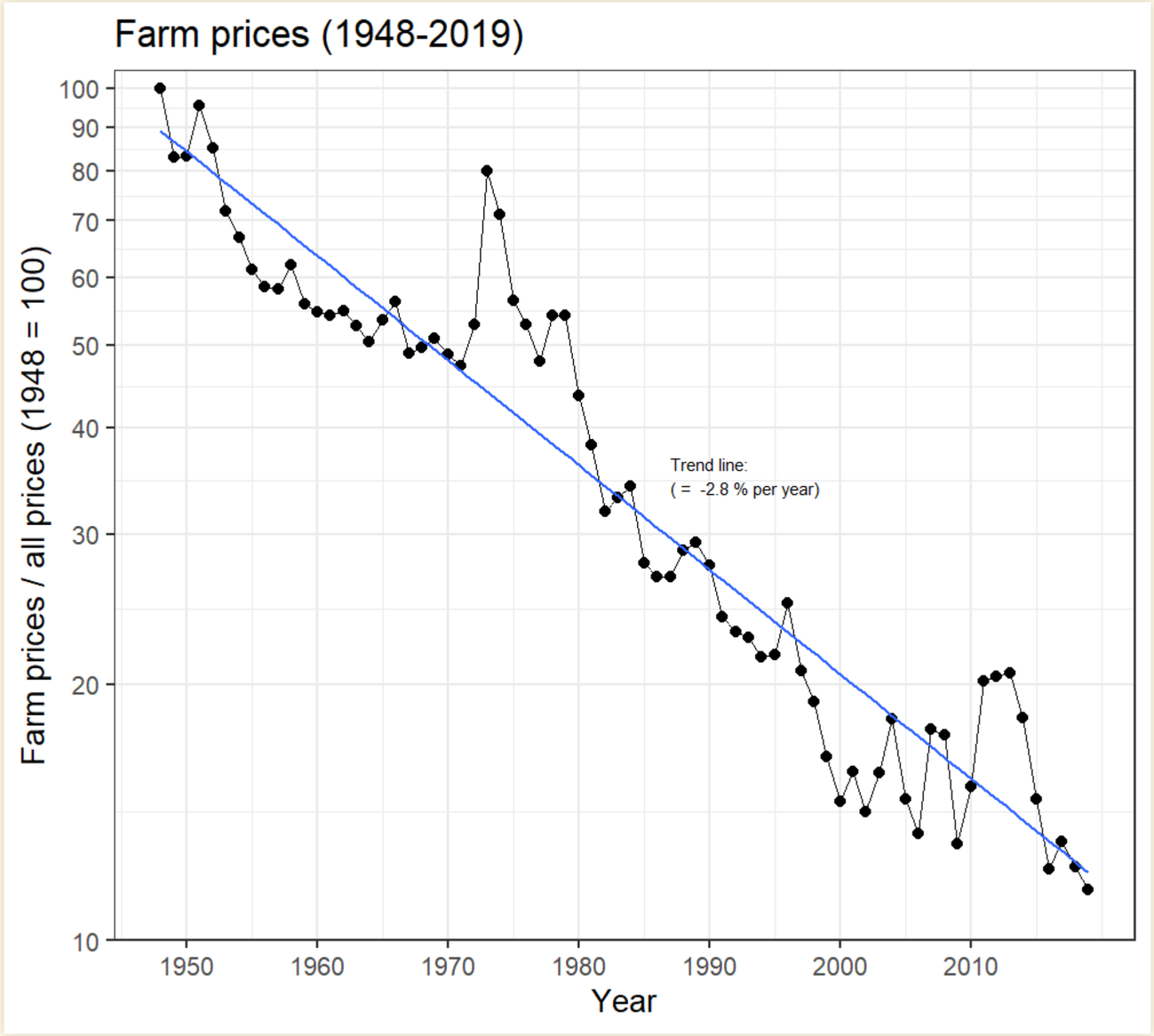


Image credit: IPCC Fifth Assessment Report, Working Group 2, Chapter 7

Prices of Farm Products



Data source: U.S. Bureau of Economic Analysis

Impact of Declining Food Prices

Category	% of income	Expense	25% price rise	as % of income
Income	100%	$60,000		
Housing	20%	$12,000	$3,000	5%
Food	5%	$3,000	$750	1%

Agricultural Price Shocks

Image credit: IPCC Fifth Assessment Report, Working Group 2, Chapter 7

Winter Temperatures

- Cold winters are important
  - Freezing temperatures kill pests
  - Many trees need cold winters to tell them to reset for growing in the spring
    - Peach trees need more than 800 hours below 40° F to make good fruit
    - The winter of 2016–2017 had less than 500 “cold-soaking” hours in Georgia
    - 85% of the Georgia peach crop was lost.

Health Impacts

Deaths due to Climate Change

Years of life lost per 1,000 persons

Region	Total	Diarrheal disease	Malaria	Malnutrition
Africa	14.91	6.99	7.13	0.80
Wealthy countries	0.02	0.02	0.00	0.00

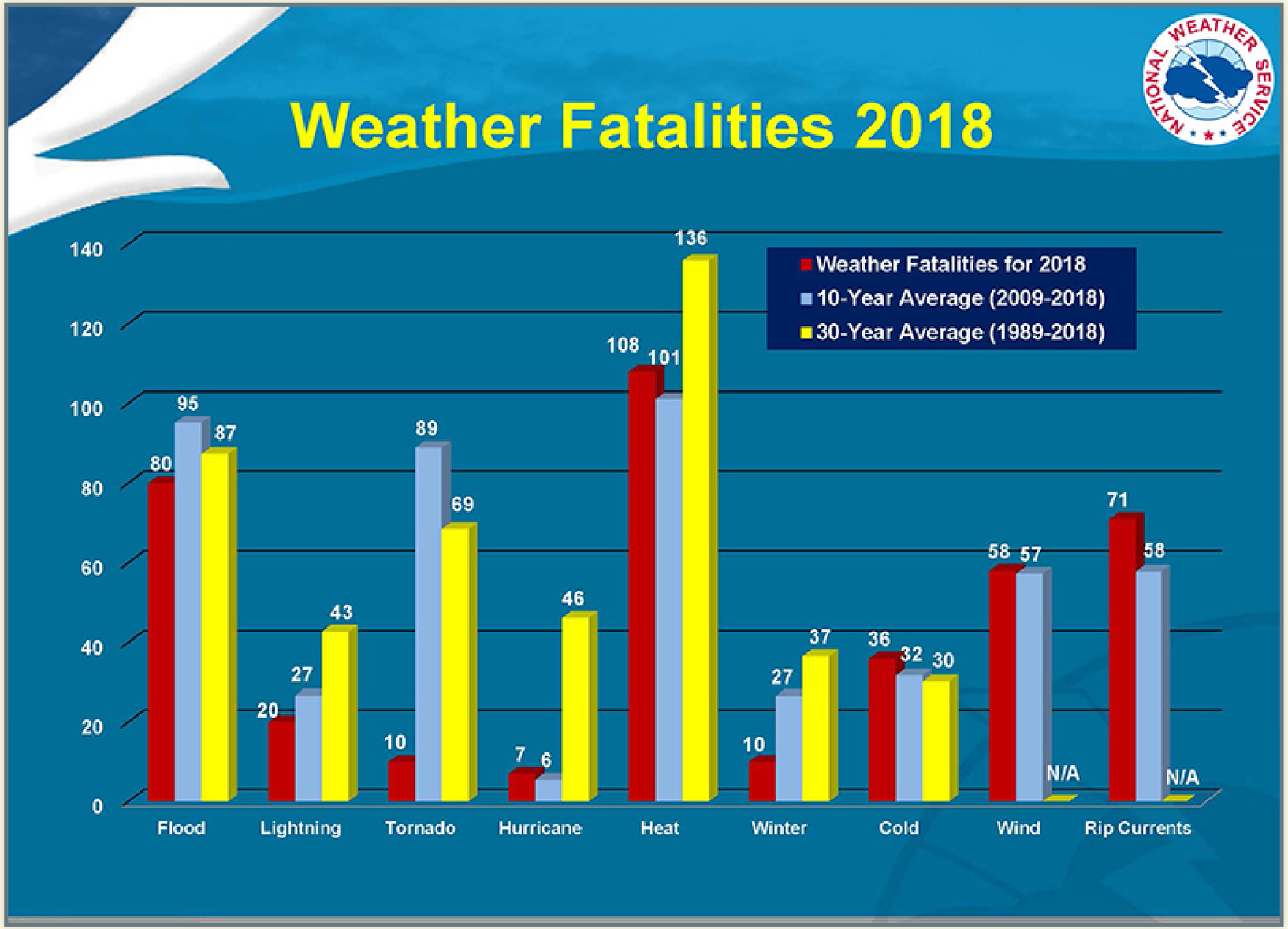
As % of all deaths

Region	Total	Diarrheal disease	Malaria	Malnutrition
Africa	2.92	1.37	1.40	0.16
Wealthy countries	0.01	0.01	0.00	0.00

Heat Waves

- Extreme summer heat that was **practically non-existent** before 1989 now affects about **10% of the earth's land surface** in a typical summer.
- Two of the ten deadliest heat waves in history happened in 2015.
- Six of the ten deadliest heat waves happened since 2000
  - Western Europe 2003: 70,000 deaths
  - Russia 2010: 56,000 deaths
  - **These could be typical summer heat by 2100.**

Heat versus Cold

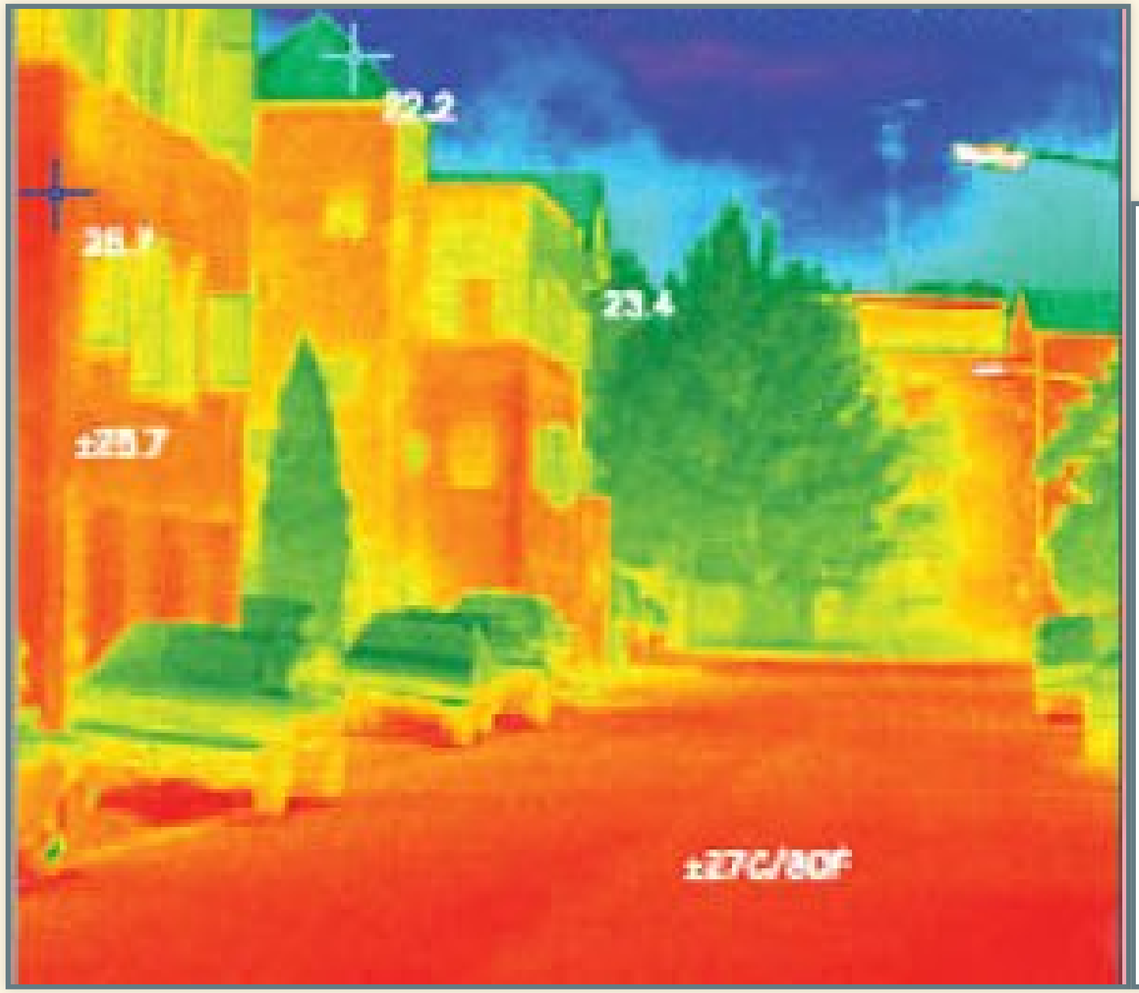


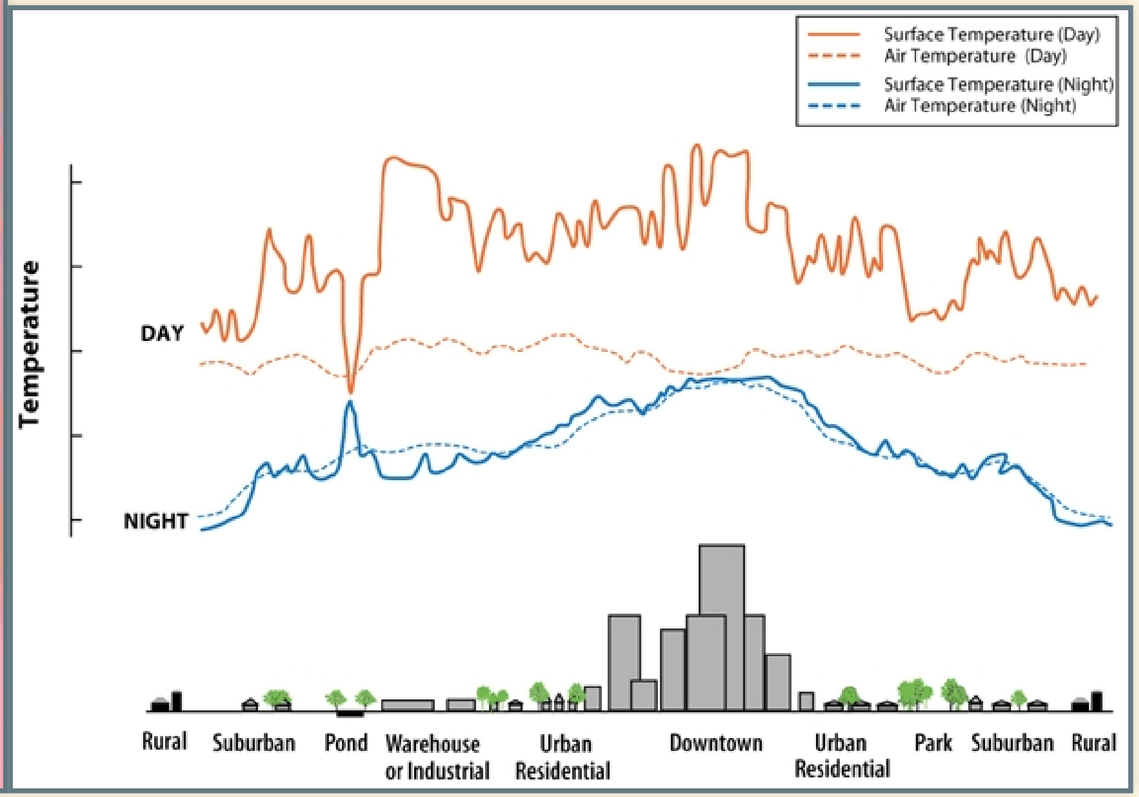
Source: https://www.weather.gov/hazstat/

Heat versus Cold

- More people die during cold months than hot months each year
  - Confounding factor: Seasonality of diseases (flu, etc.)
  - Deaths from cold are relative: it’s about acclimation
  - Deaths from heat are absolute: threshold temperatures
- Adding extremely hot days raises moretality much more than adding extremely cold days

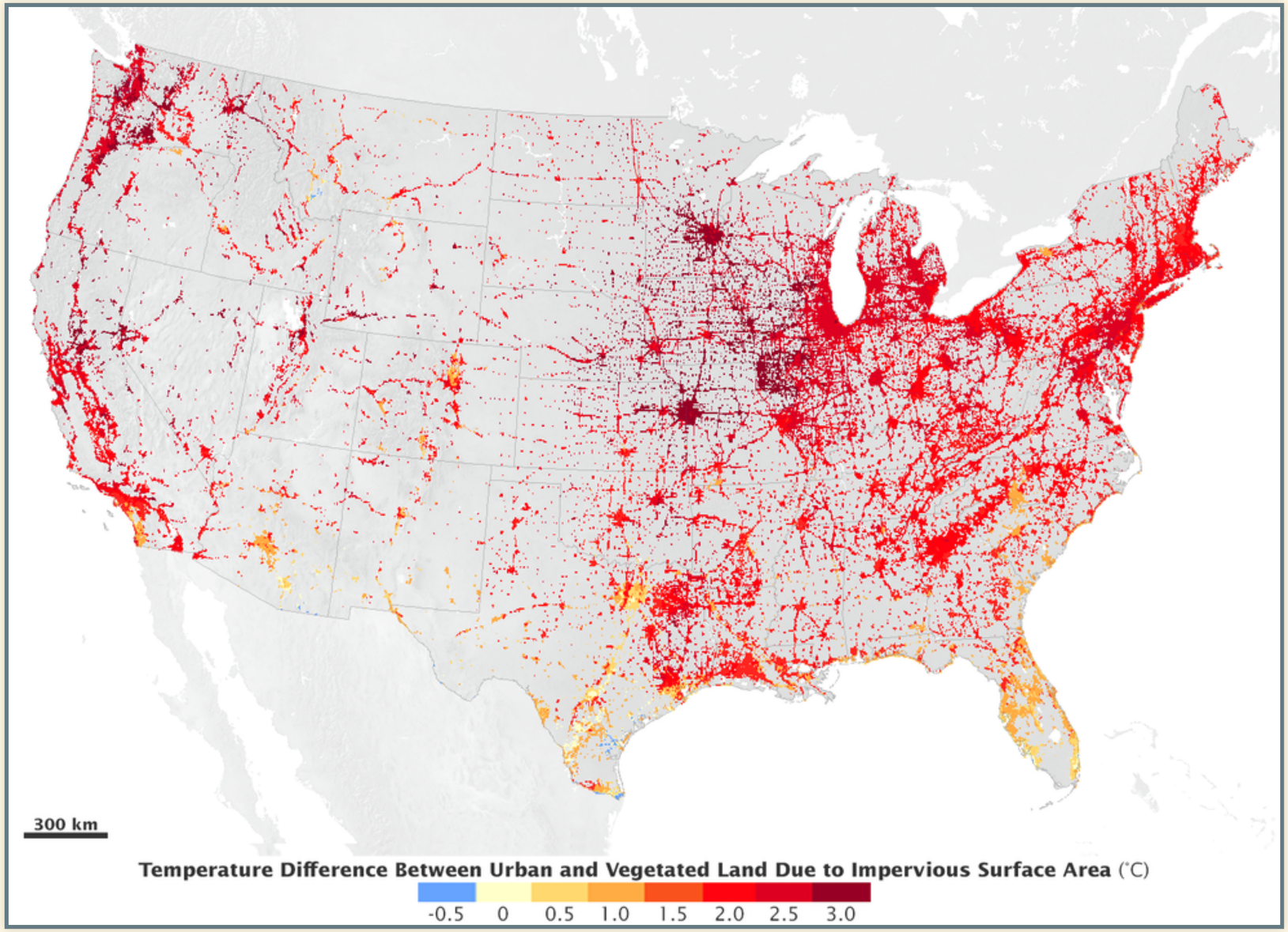
Urban Heat Islands





Source: Environmental Protection Agency

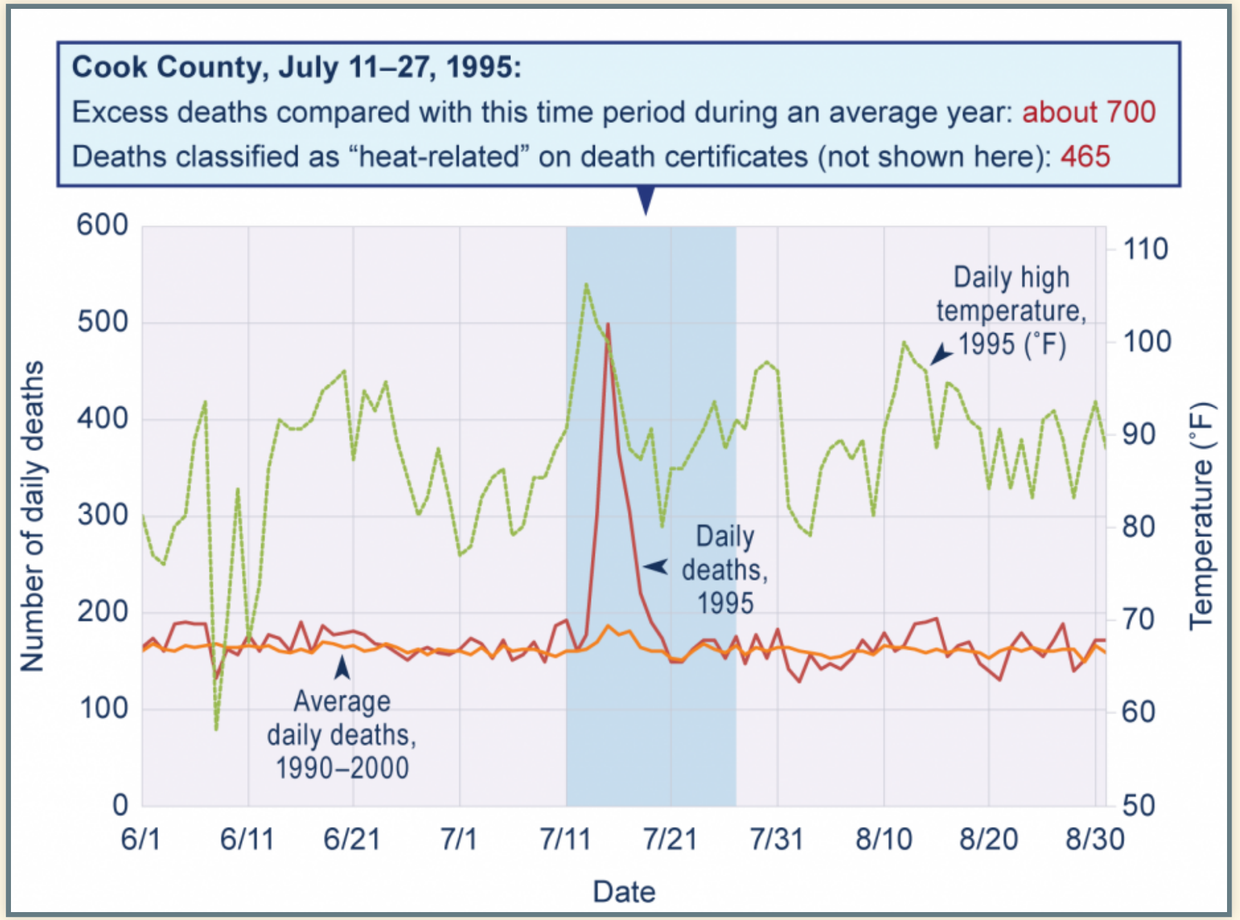
Urban Heat Islands in the United States



Source: https://landsat.gsfc.nasa.gov/vegetation-essential-for-limiting-city-warming-effects/

Urban Heat Mortality

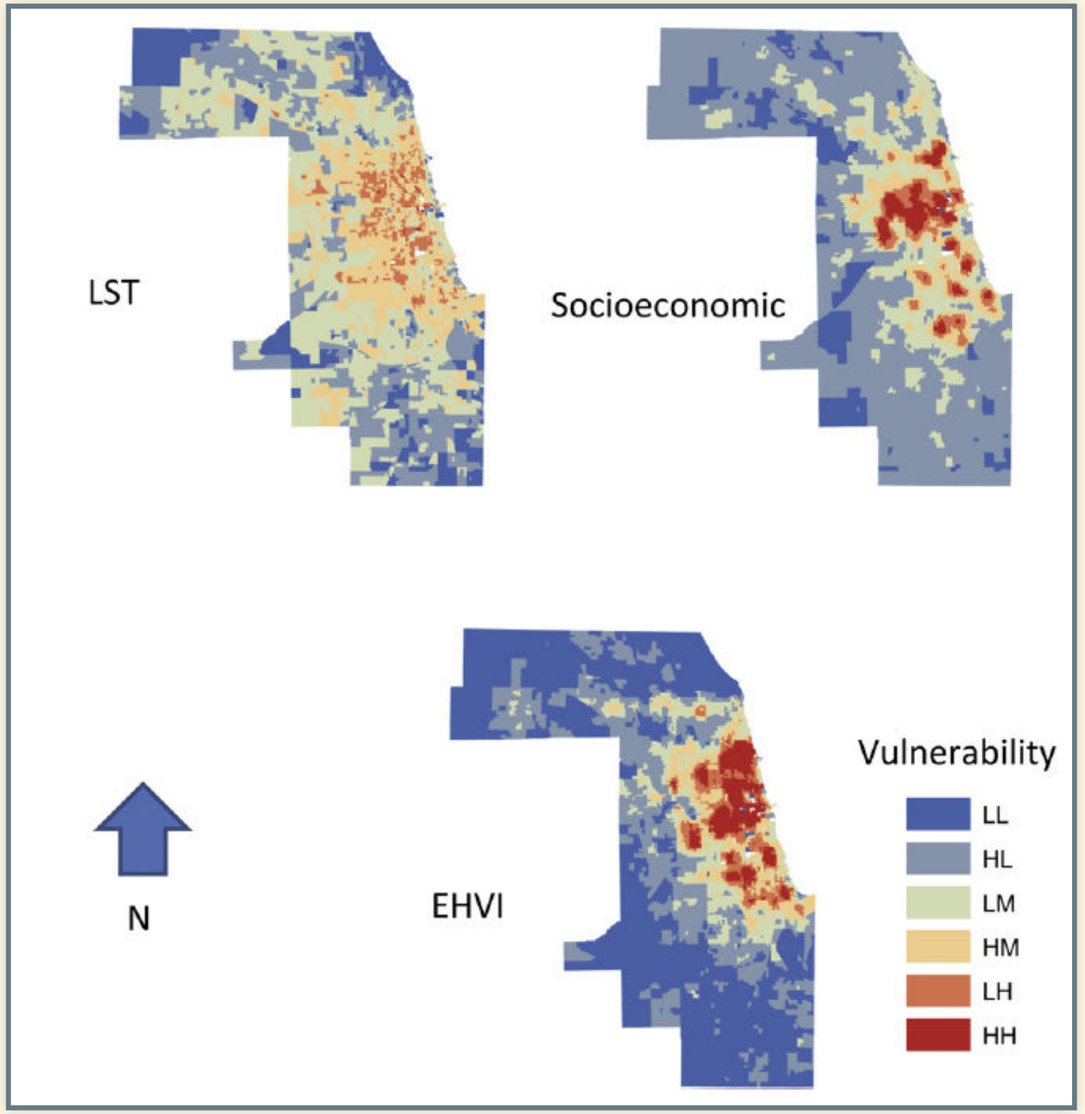
Chicago, 1995



Source: USGCRP, *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment* (2016).

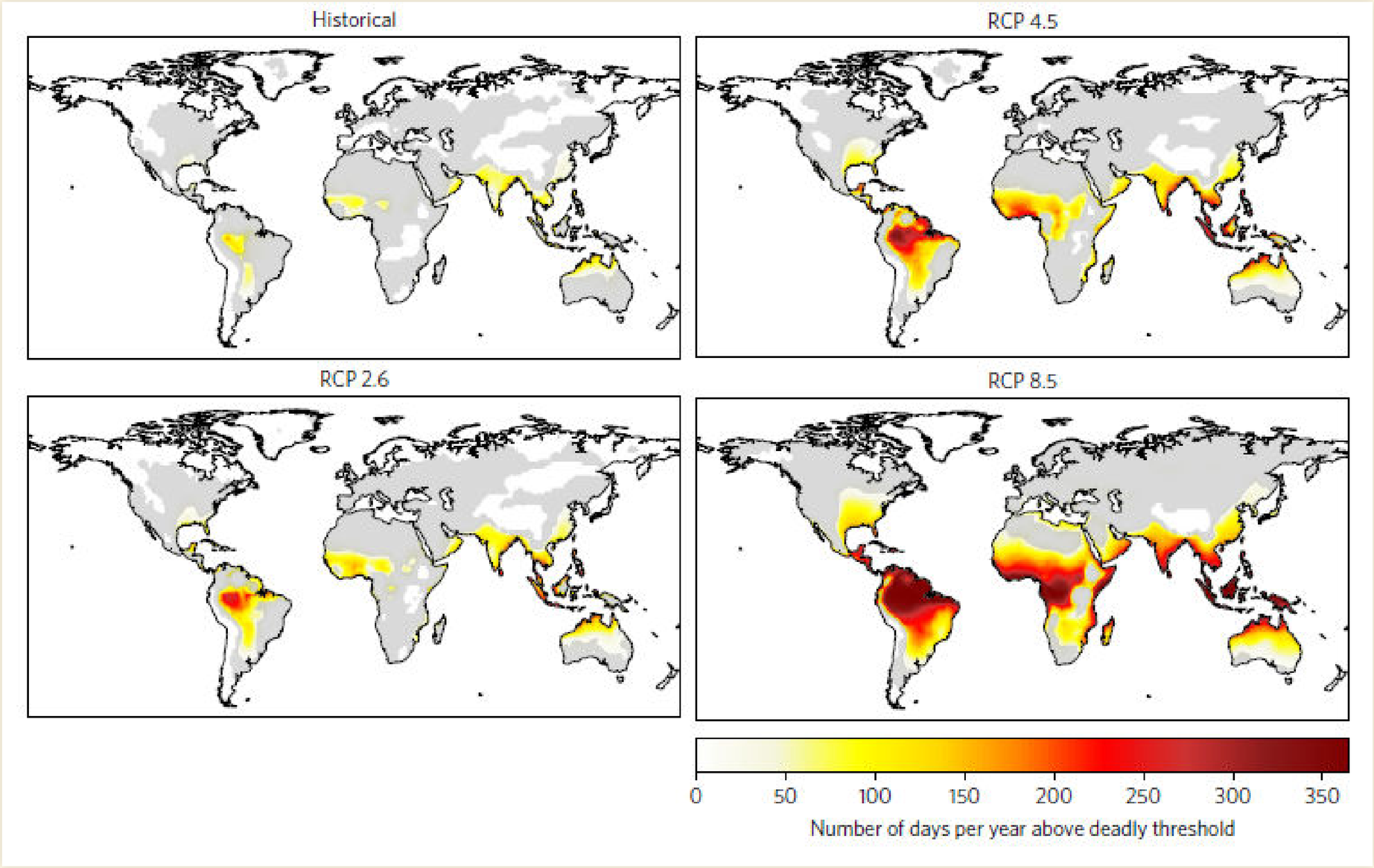
Socioeconomic Status and Vulnerability to Heat

- LST = Urban heat island effect
- EHVI = extreme heat vulnerability index
- EHVI correlates very strongly with socioeconomic variables



Source: D.P. Johnson *et al.*, Appl. Geography **35**, 23 (2012).

Climate Change and Deadly Heat



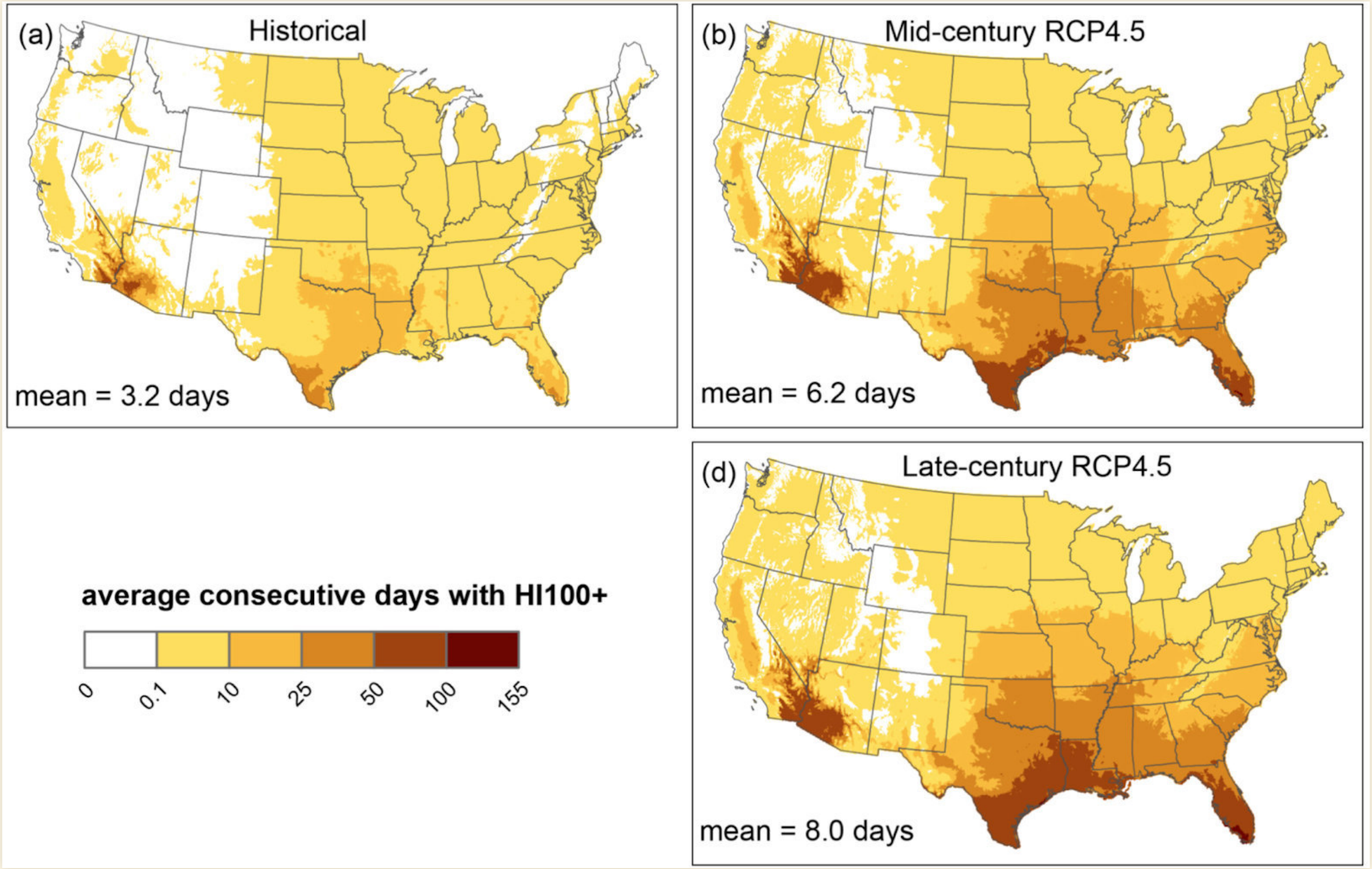
Source: C. Mora *et al.*, Nature Climate Change **7**, 501 (2017)

More than Deaths

- In the South, many people work outside
  - Construction, farming, logging, etc.
  - Summer heat waves could make it dangerous to be physically active outdoors
  - Loss of working hours, lower economic productivity, less money

Severe Heat Waves

- Severe heat waves even with serious emission reductions.



K. Dahl *et al.*, Environ. Res. Commun. **1**, 075002 (2019), doi:10.1088/2515-7620/ab27cf

Football Practice in Heat

Football practice health/safety rules:

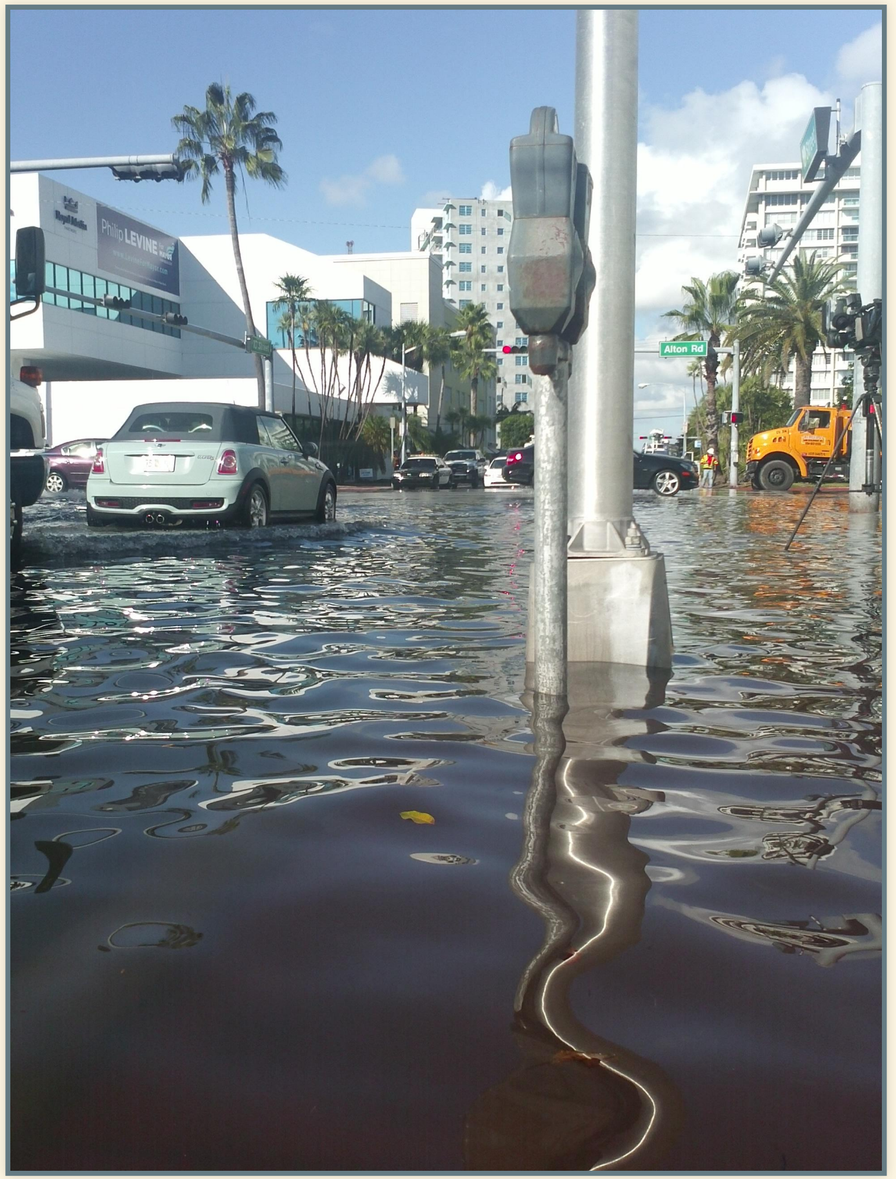
- Heat index of 104 or more is considered **dangerous**
  - Constant observation and supervision for overheating
  - No pads or equipment
  - 5 minutes mandatory rest and water break every 15 minutes
- After 2070:
  - Average of 3 weeks per year in Southeast & Midwest
  - 2 months per year in Texas, Louisiana, Southern Florida

Photo credit: Nathaniel Rutherford/RTI

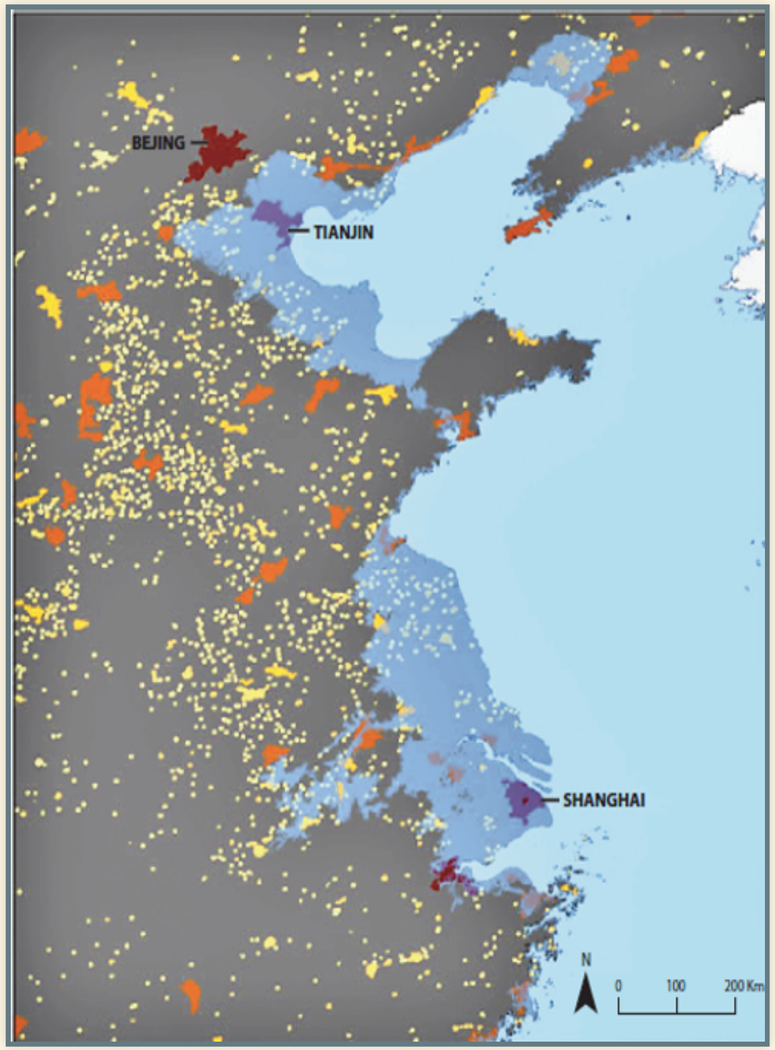
Sea-Level Rise

Sea-Level Rise

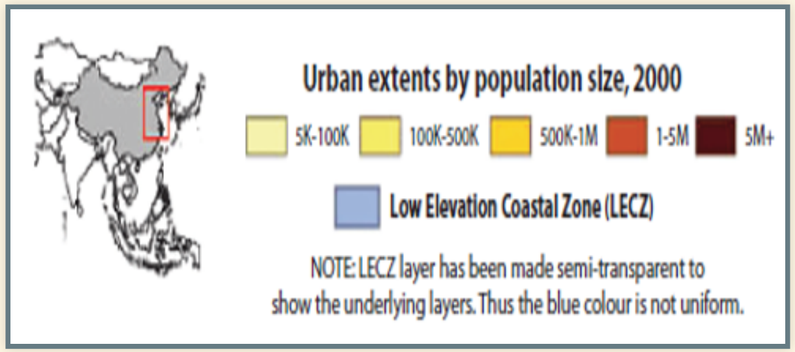
- Sea level rise is causing increasing flooding in coastal cities
  - “King tides” in Miami are flooding the city even in good weather.
  - When hurricanes come, storm surges are higher and more destructive



Low-Elevation Coastal Zone



- Within 10 meters of sea level
- 2/3 of cities with >5 million people
- 10% of world population



Greenland

- Melt descending into Moulin
  - Meltwater lubricates base of glacier
  - Accelerates ice-flow
  - Speeds up melting

Peterman Glacier 2009

Peterman Glacier 2011

Ice Loss from Greenland

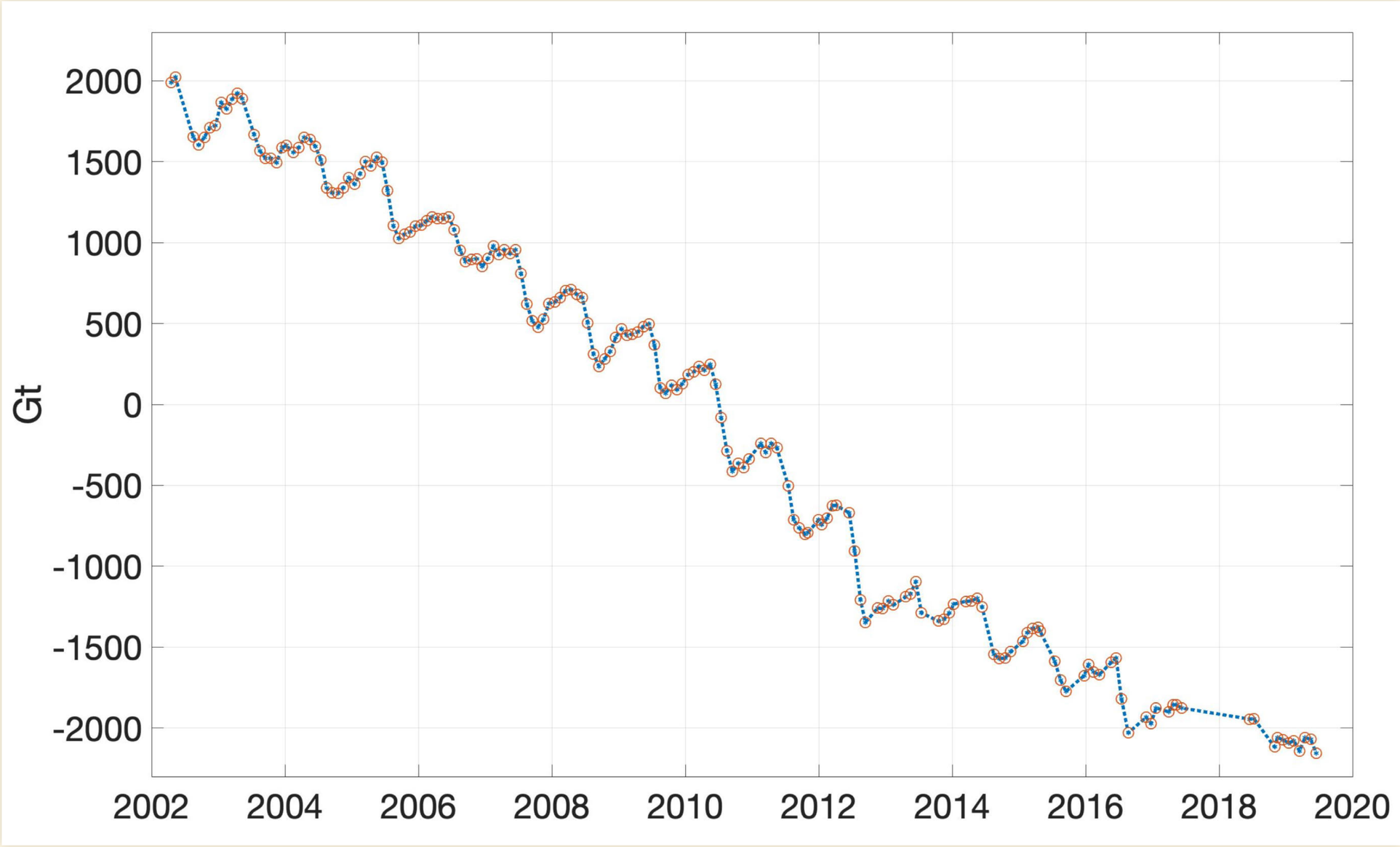
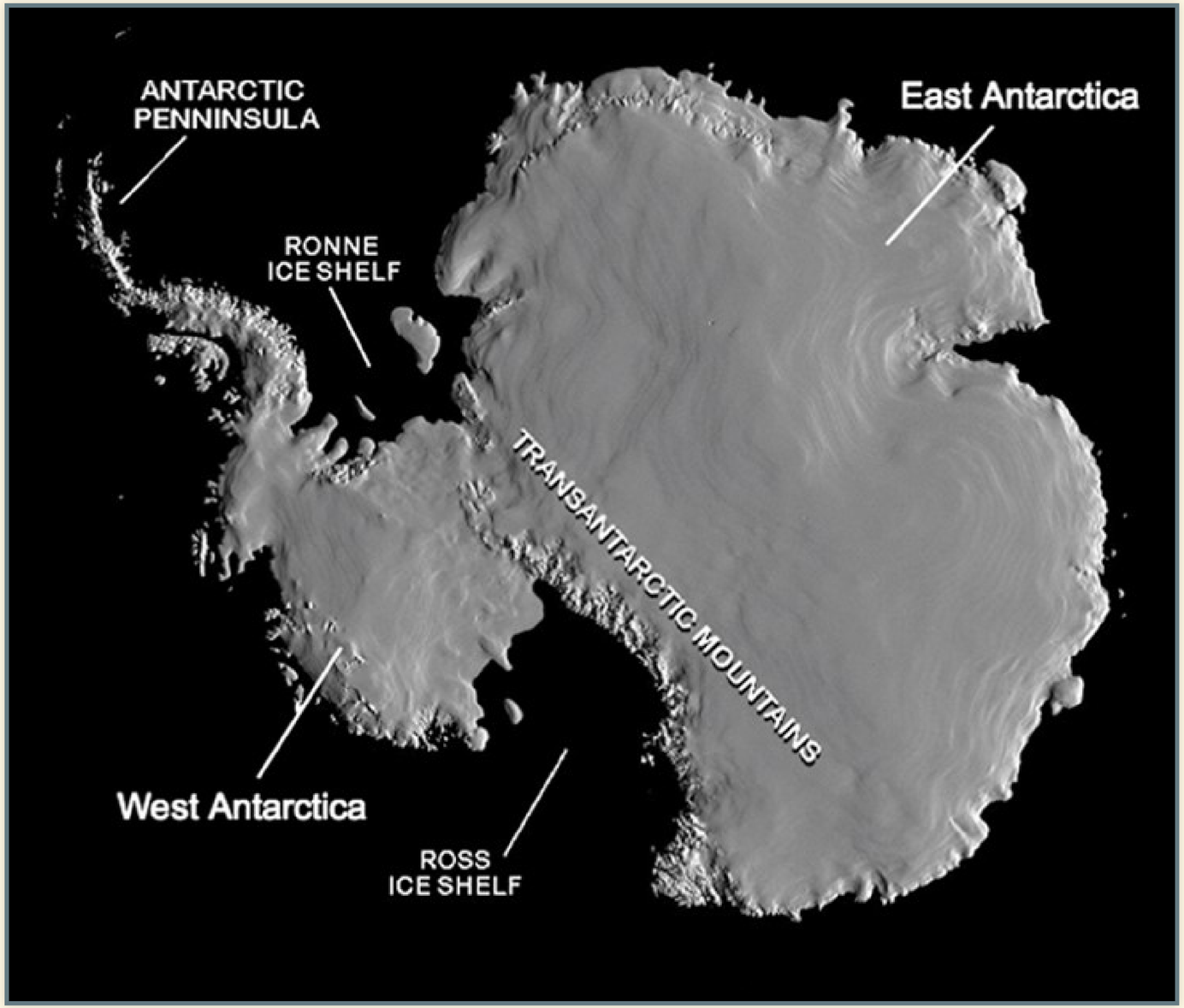


Image credit: M. Tedescoo *et al*., NOAA Arctic Program

Antarctica

Antarctica


ANTARCTIC
PENNINSULA
East Antarctica
RONNE
ICE SHELF
TRANSANTARCTIC MOUNTAINS
West Antarctica
ROSS
ICE SHELF

GRACE Satellite

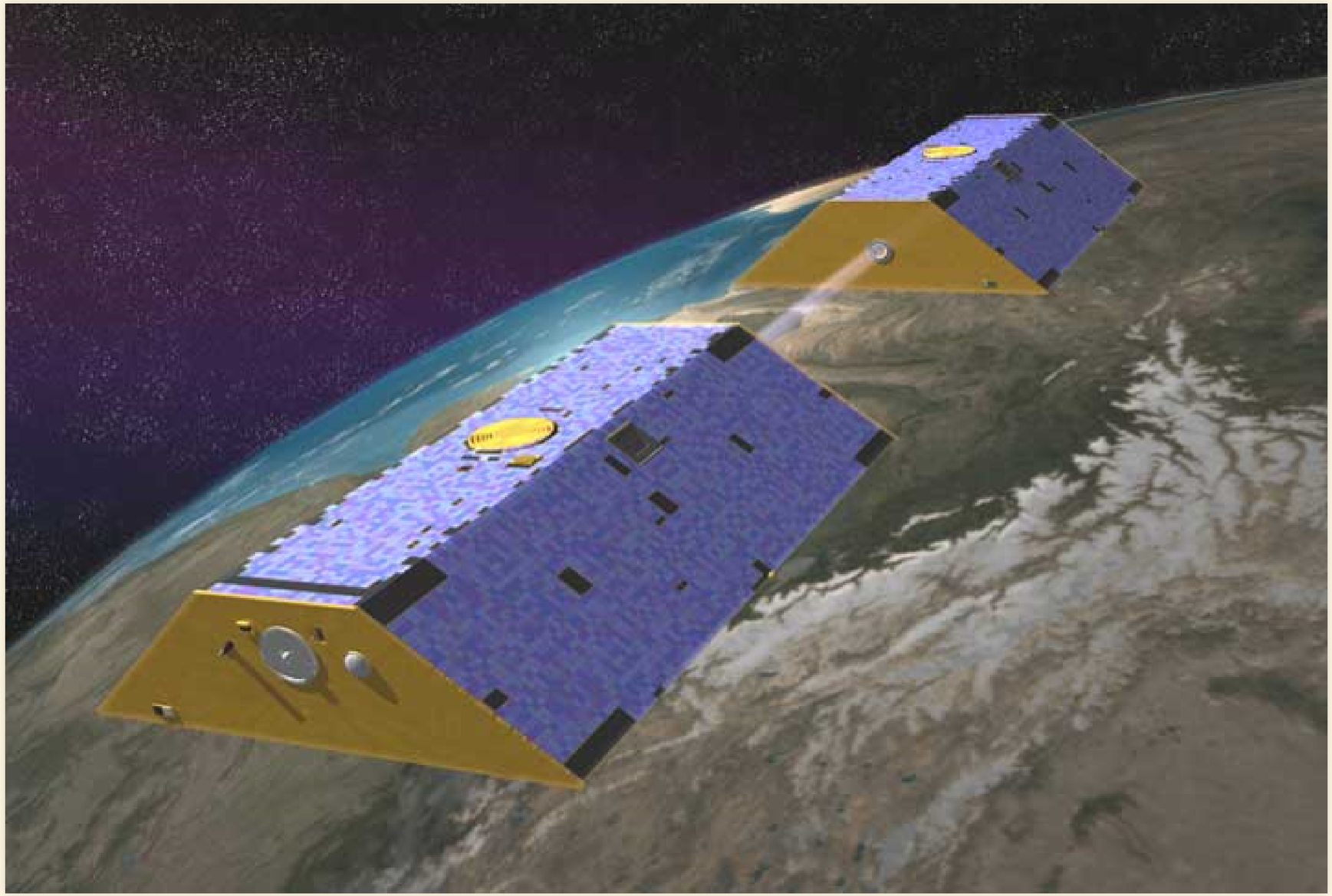


Image credit: NASA

Observations

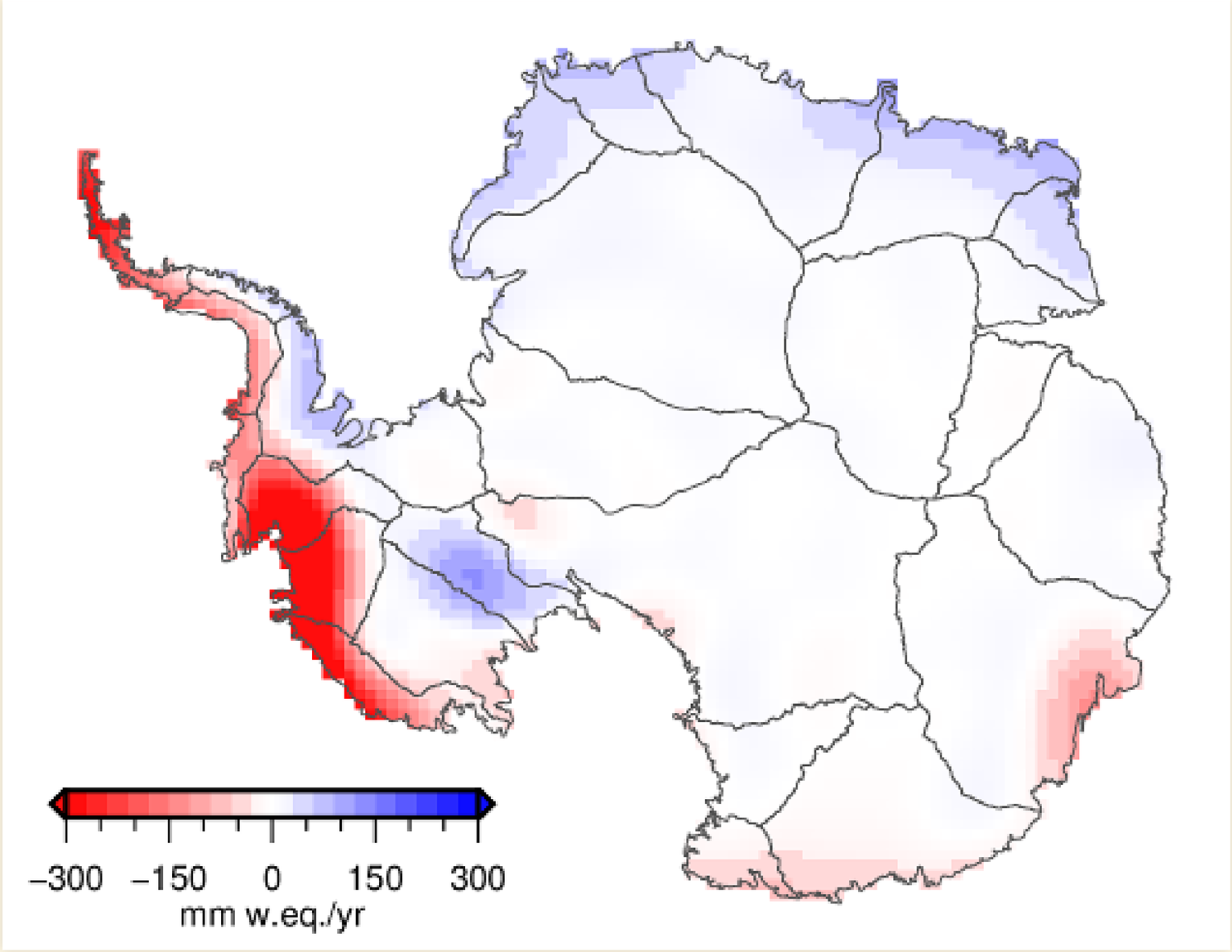


Image credit: Arnoud Jochemsen, Technical University of Dresden

Ice loss

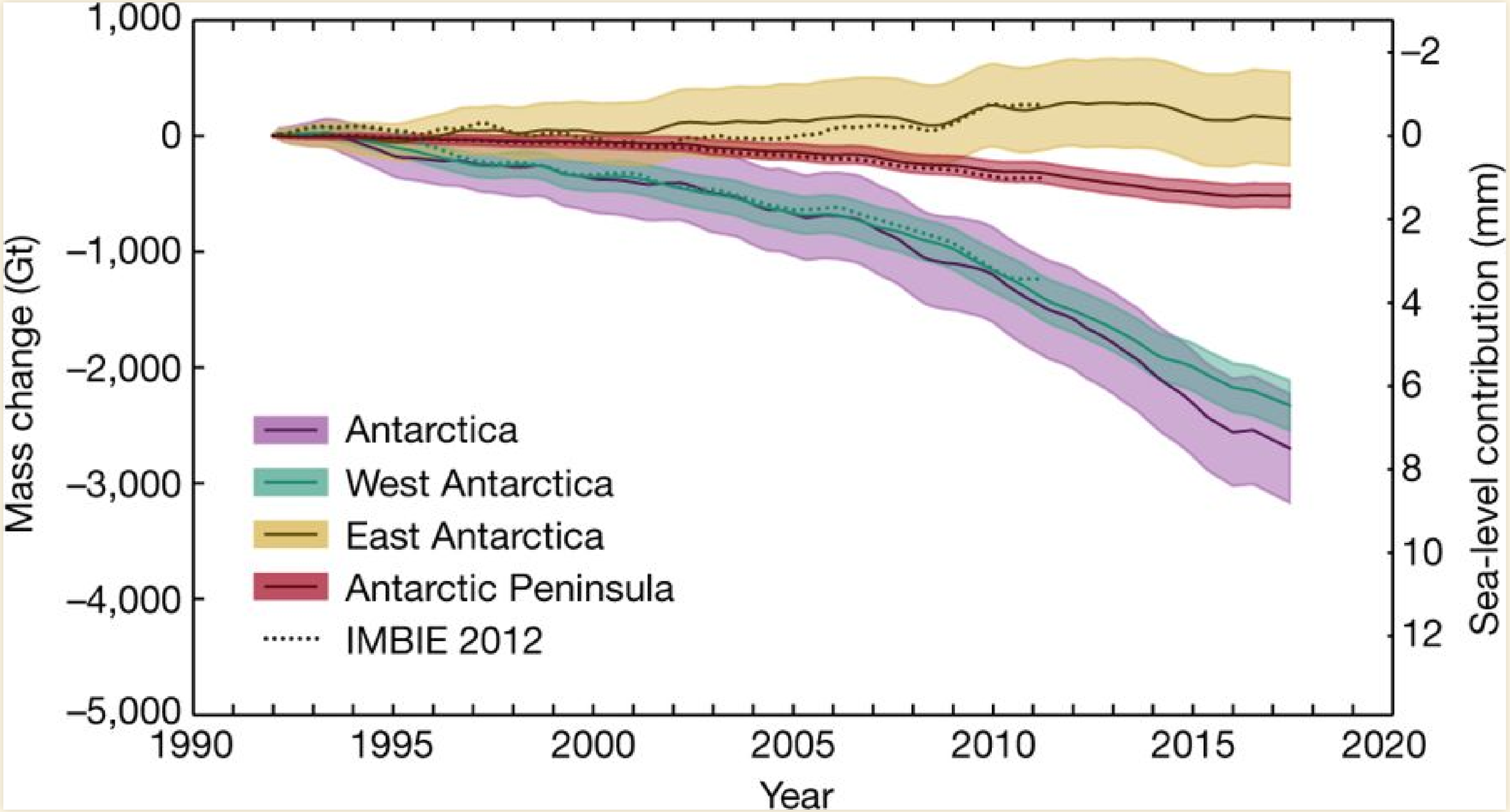


Image credit: IMBIE Team, Nature **558**, 219 (2018) doi: 10.1038/s41586-018-0179-y

GRACE Results

- Greenland melting faster than previously thought
  - Almost 150 cubic miles per year
  - Loss is accelerating
    - Melting more than 7 times faster than in 1990s.
- Antarctica is losing ice instead of gaining
  - 150 cubic miles per year

Bottom Line:

- Sea level is rising
- Hard to estimate future rise:
  - Glacier dynamics is very uncertain
- Rate matters!
  - Rapid sea-level rise makes it hard to adapt

Impacts

- Population displacement, migration
- Amplified impacts of coastal storms
- Coastal ecosystems
- World Heritage Sites

Photo credit: Soumyajit Nandy

Adaptation

- Abandon vulnerable land
- Protect valuable land
- Raise buildings
- Move inland

Photo credit: Wikipedia

Summing Up

Perspective

- Cost of cutting emissions vs. cost of adapting or living with climate change
- Extreme positions versus balanced mixture
- What about uncertainties, tipping points, and irreversibility?

End