

Impacts of Climate Change

Part 2

EES 3310/5310

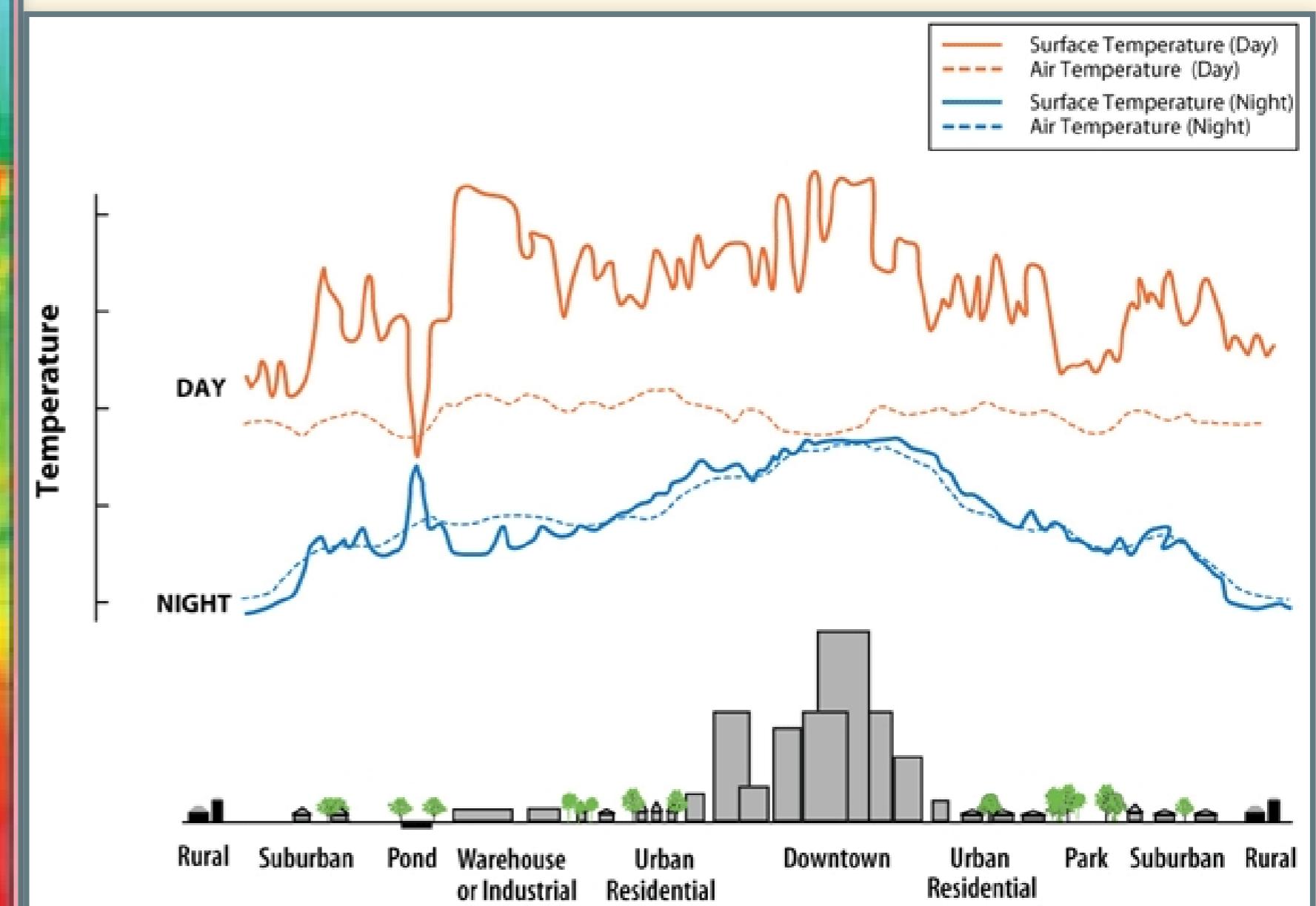
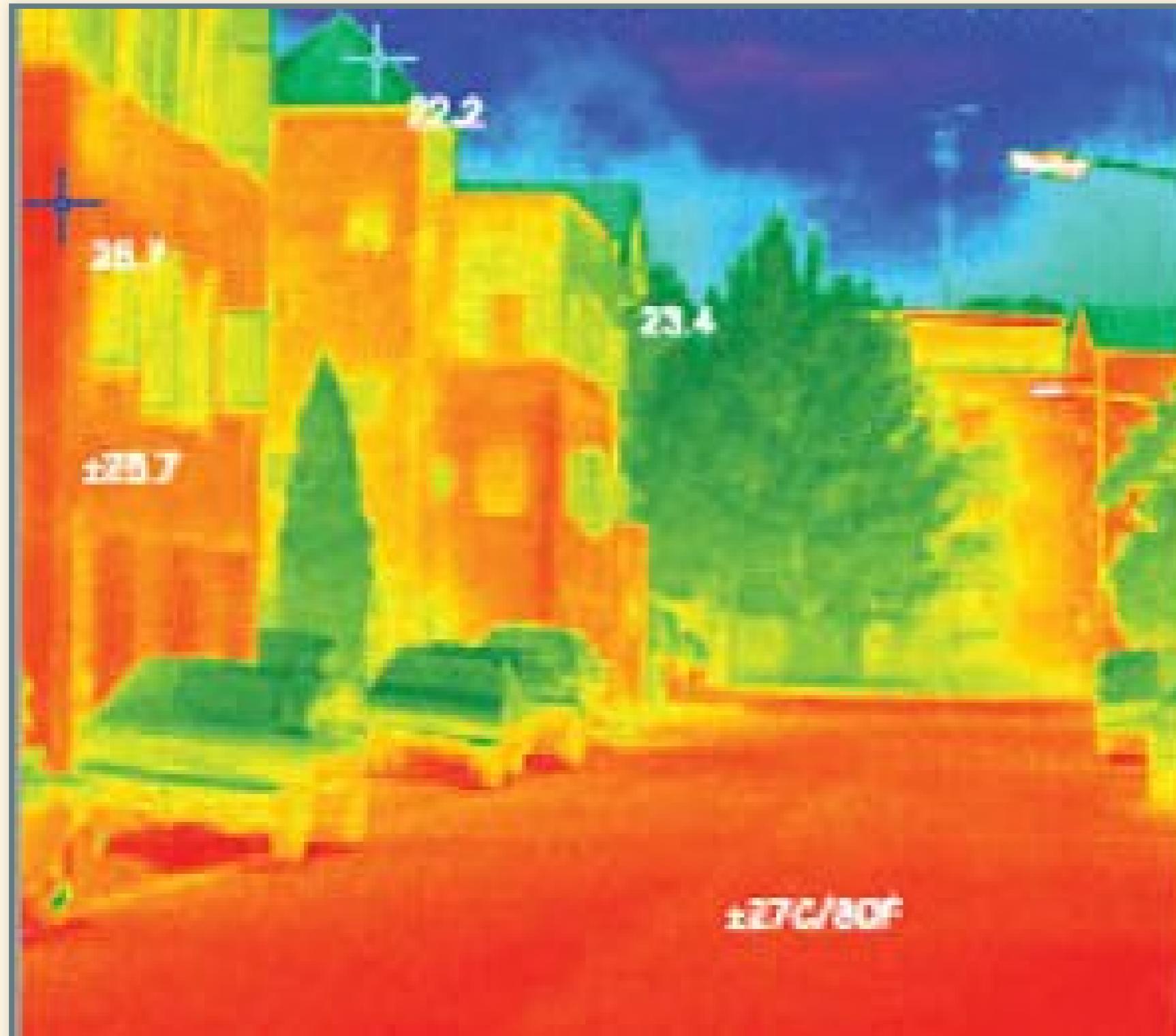
Global Climate Change

Jonathan Gilligan

Class #22: Spring 2021

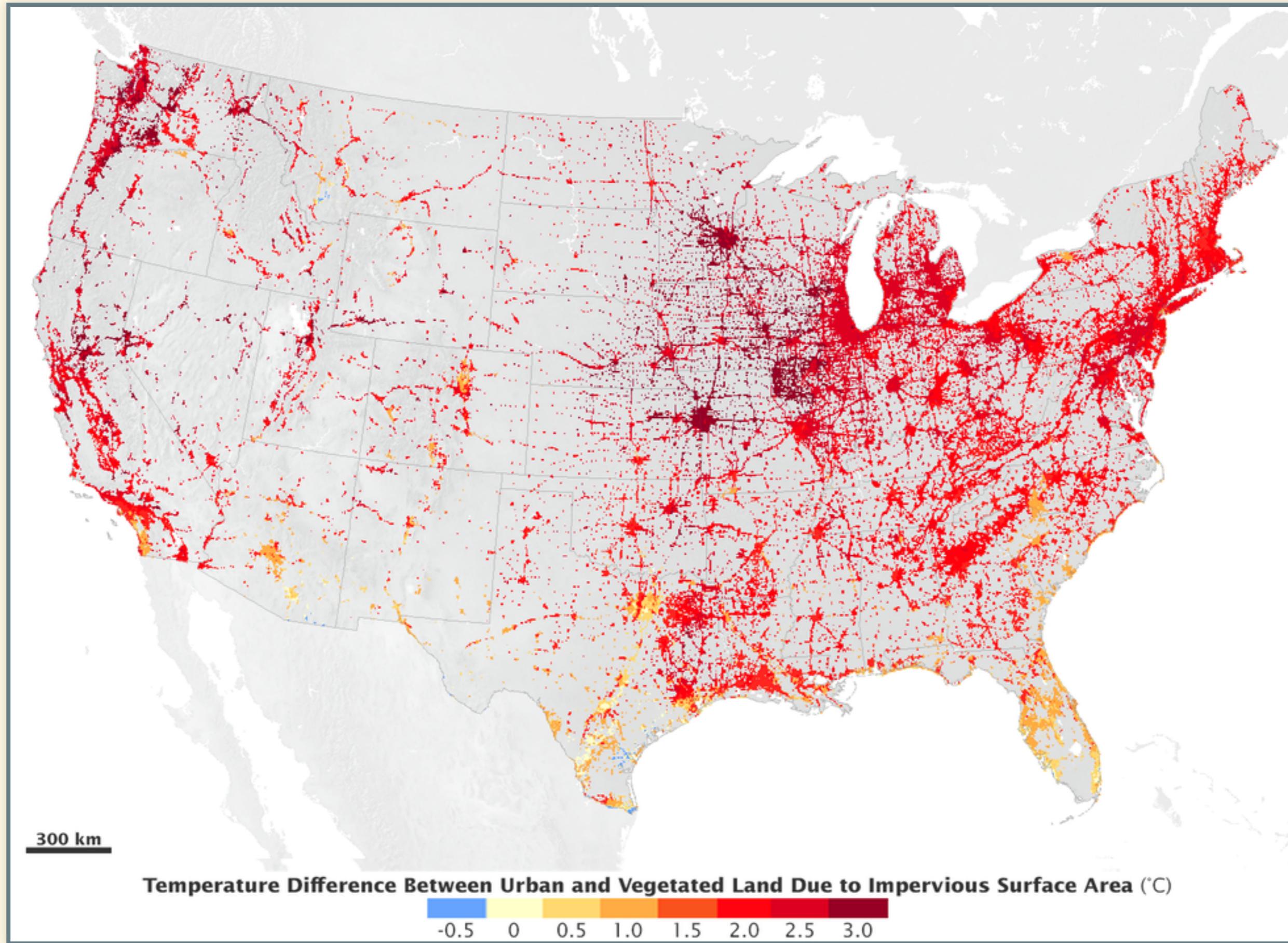
Health Impacts

Urban Heat Islands



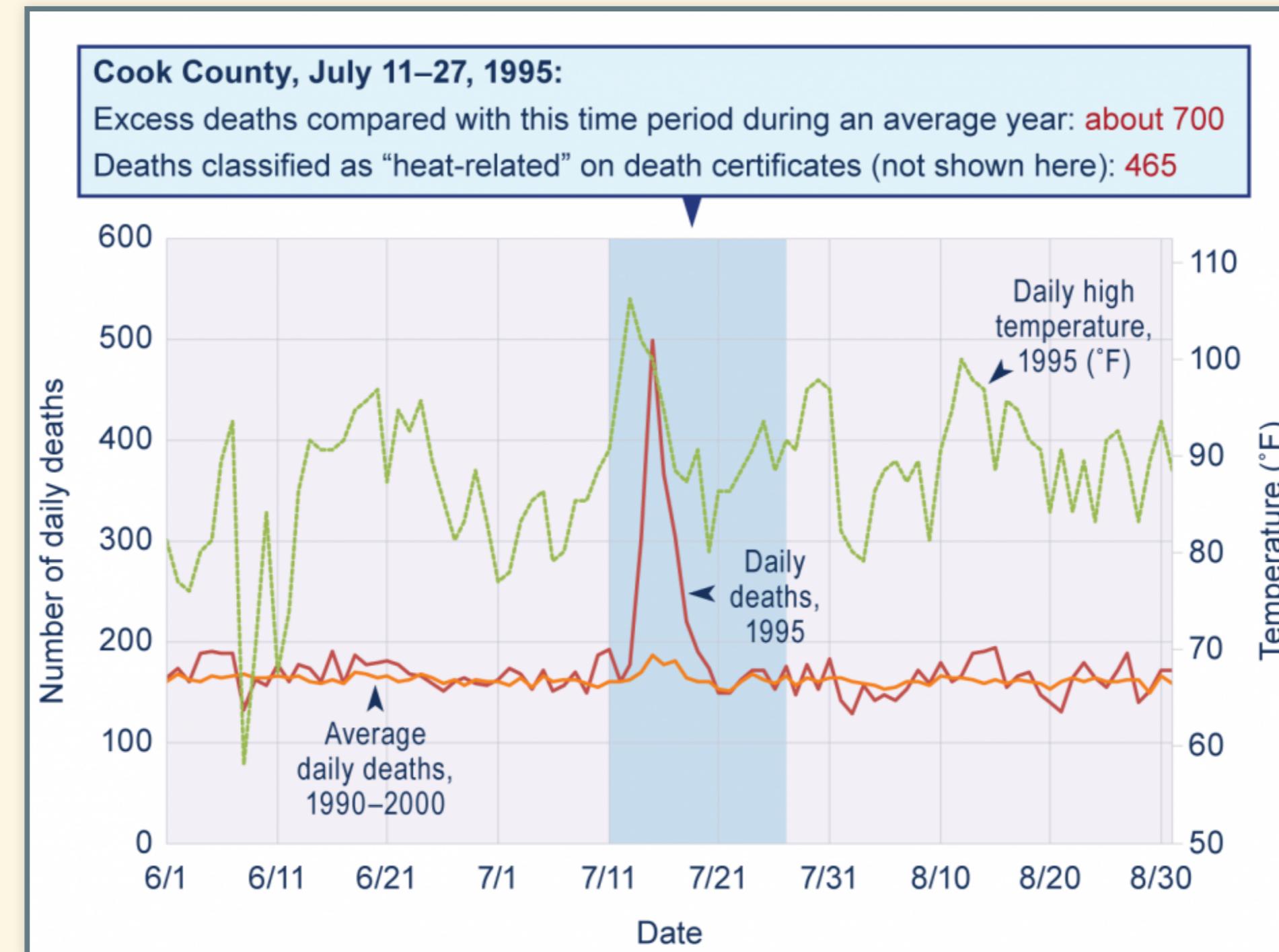
Source: Environmental Protection Agency

Urban Heat Islands in the United States



Urban Heat Mortality

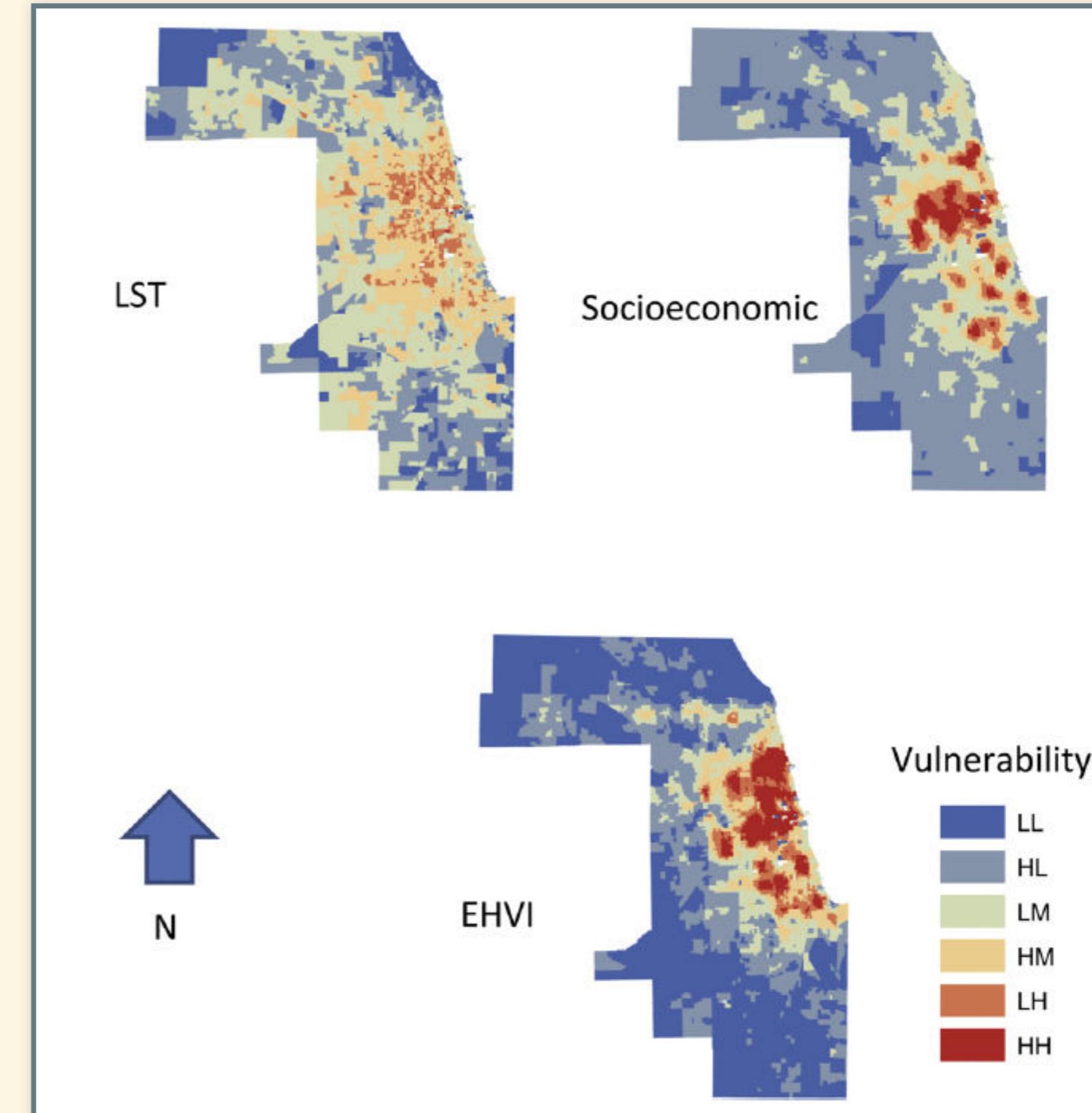
Chicago, 1995



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

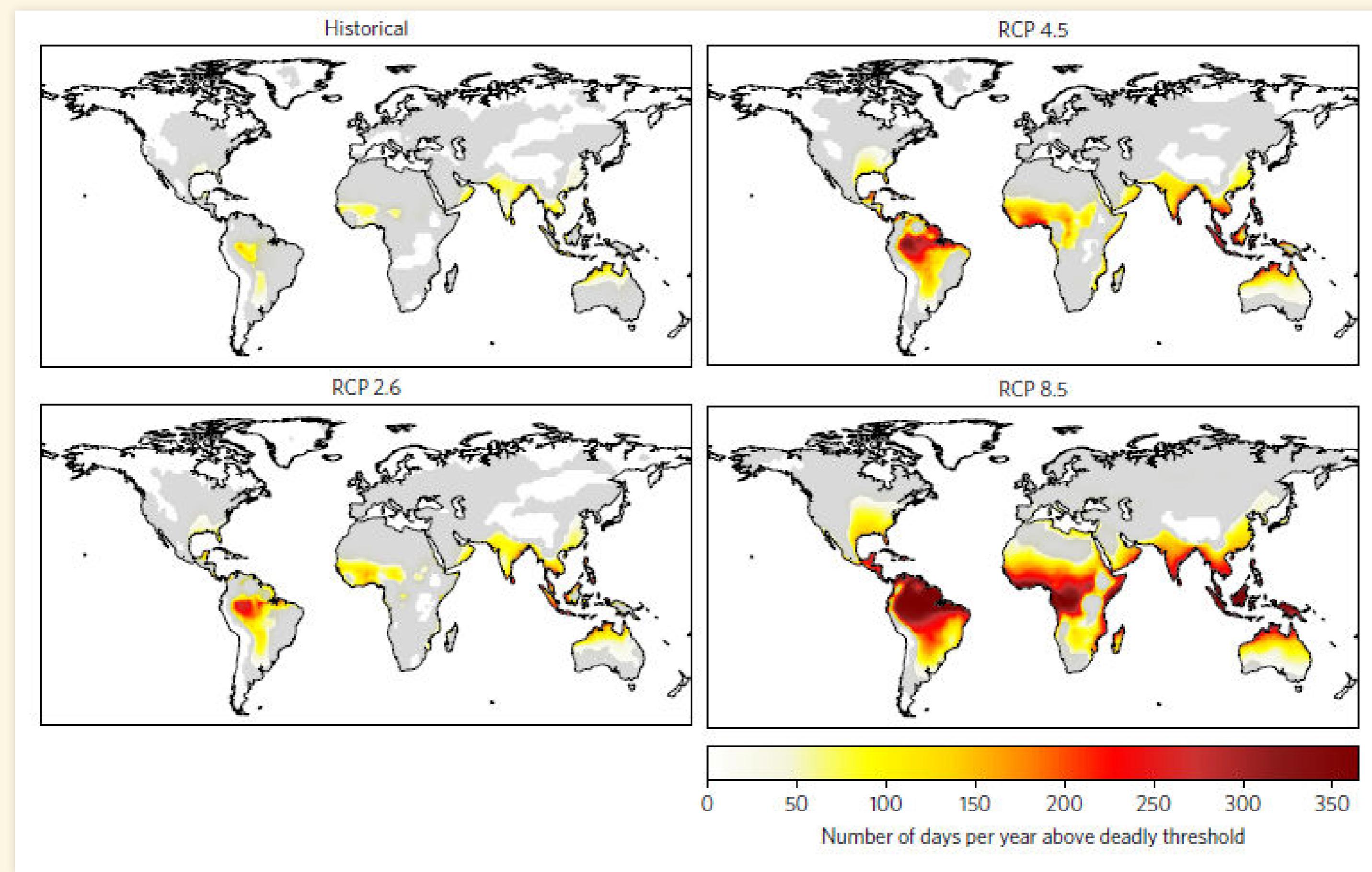
Socioeconomic Status and Vulnerability to Heat

- 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)

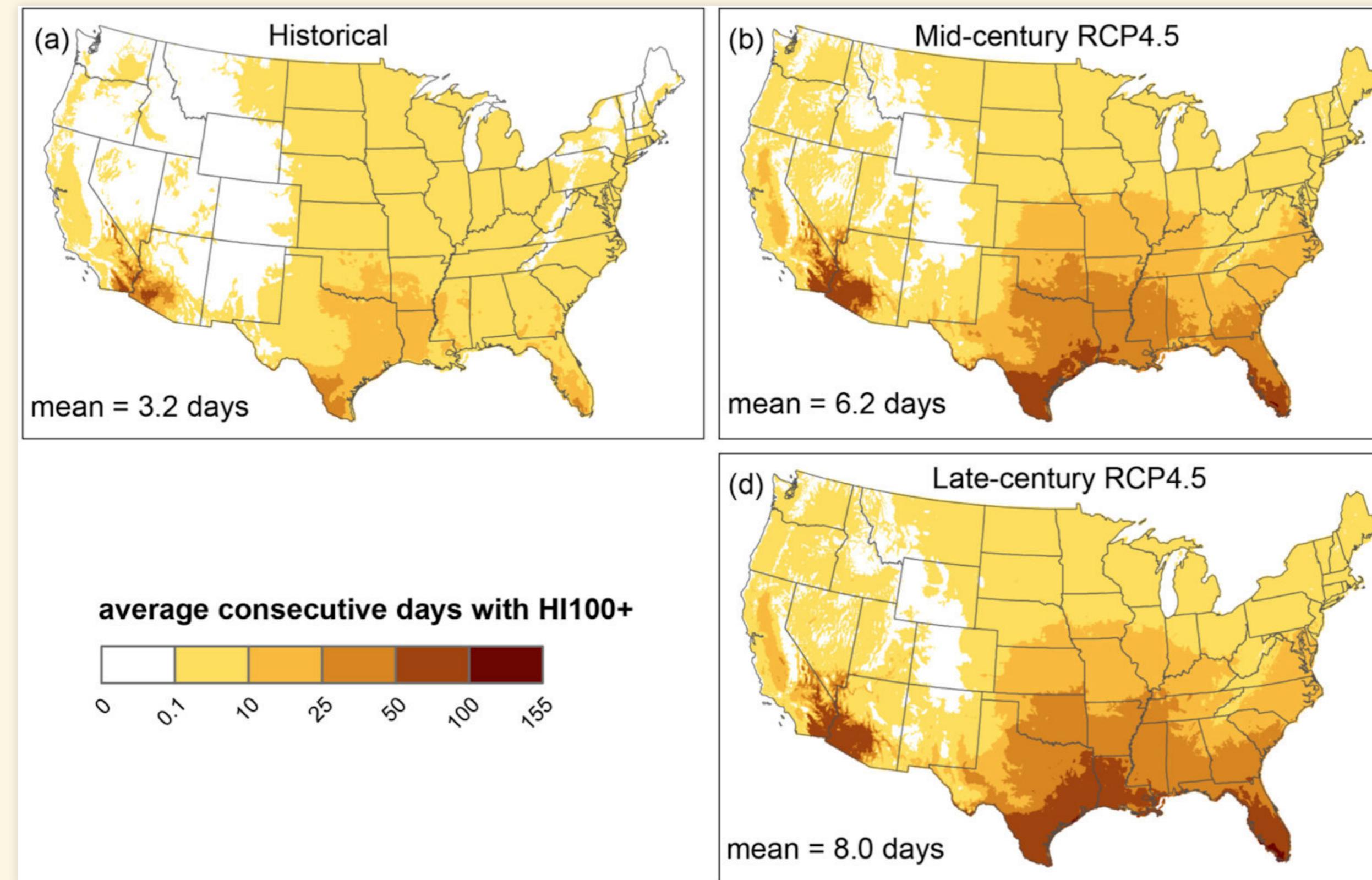
More than Deaths

- 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.



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

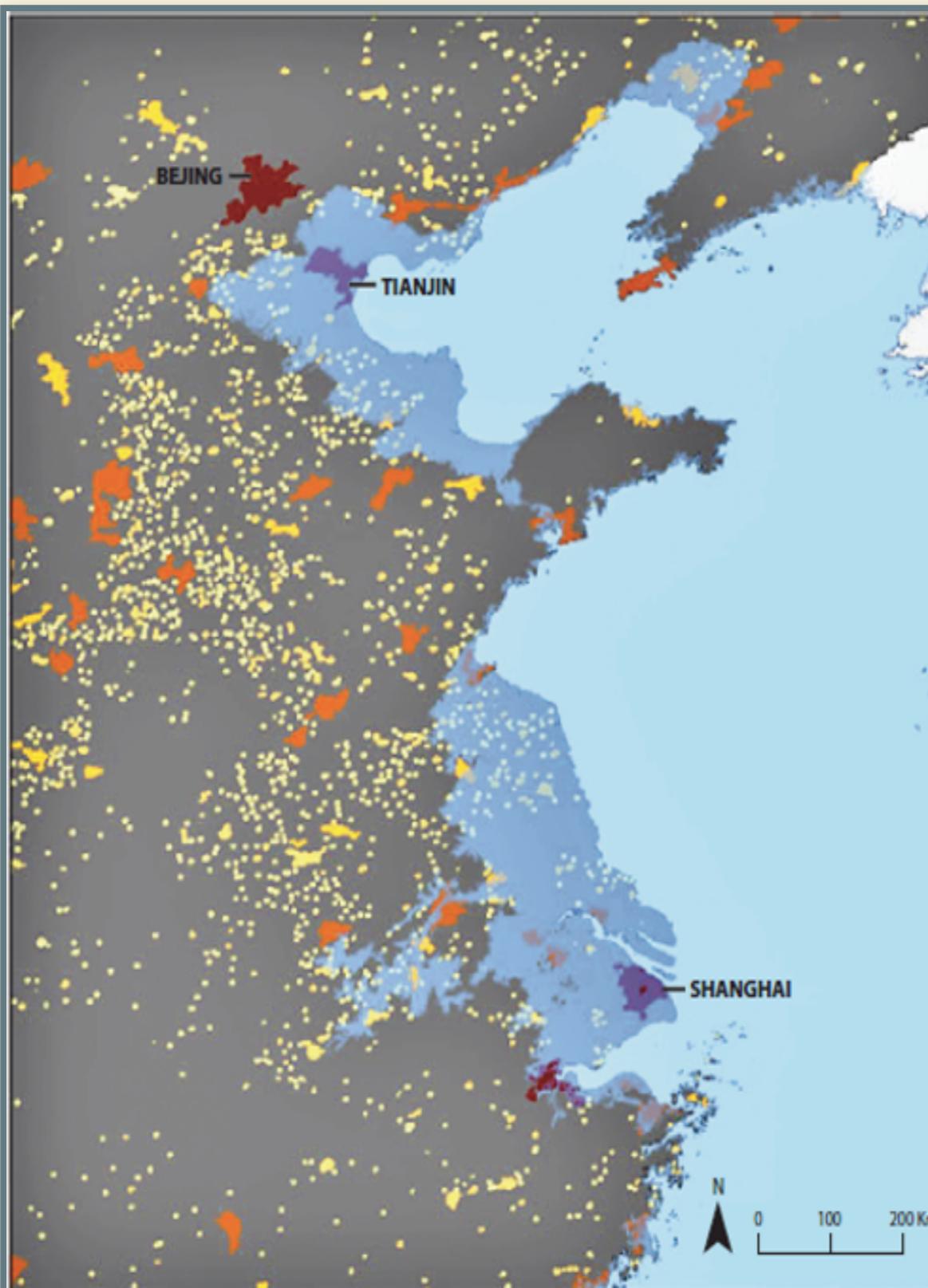
Sea-Level Rise

Sea-Level Rise

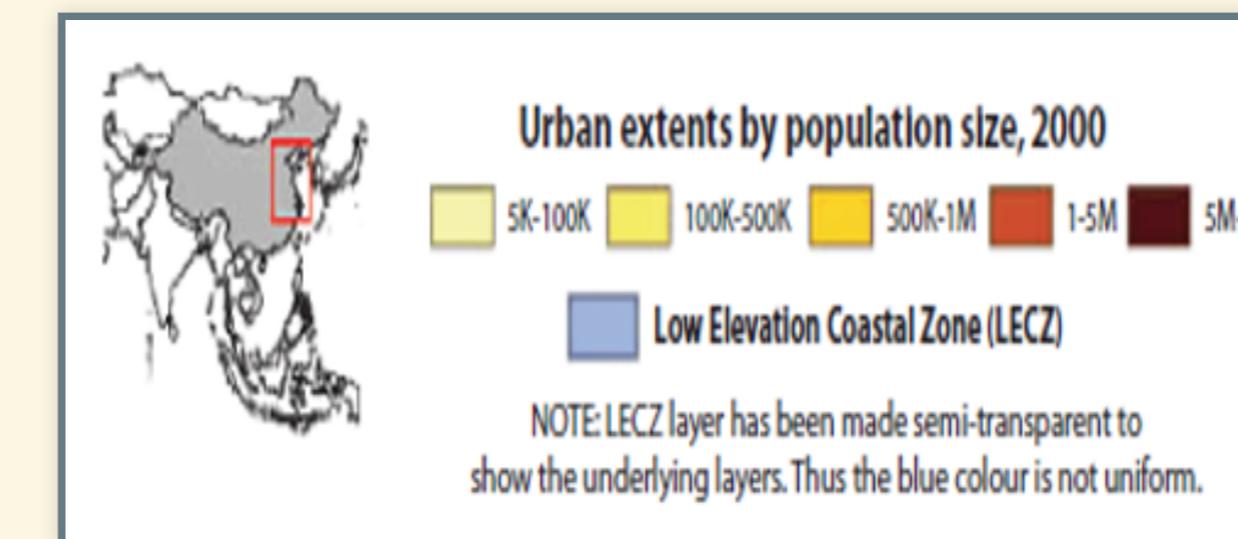
- Sea level rise is causing increasing flooding in coastal cities
 - “King tides” in Miami are flooding the city even in good weather.
 - When hurricanes come, storm surges are higher and more destructive



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

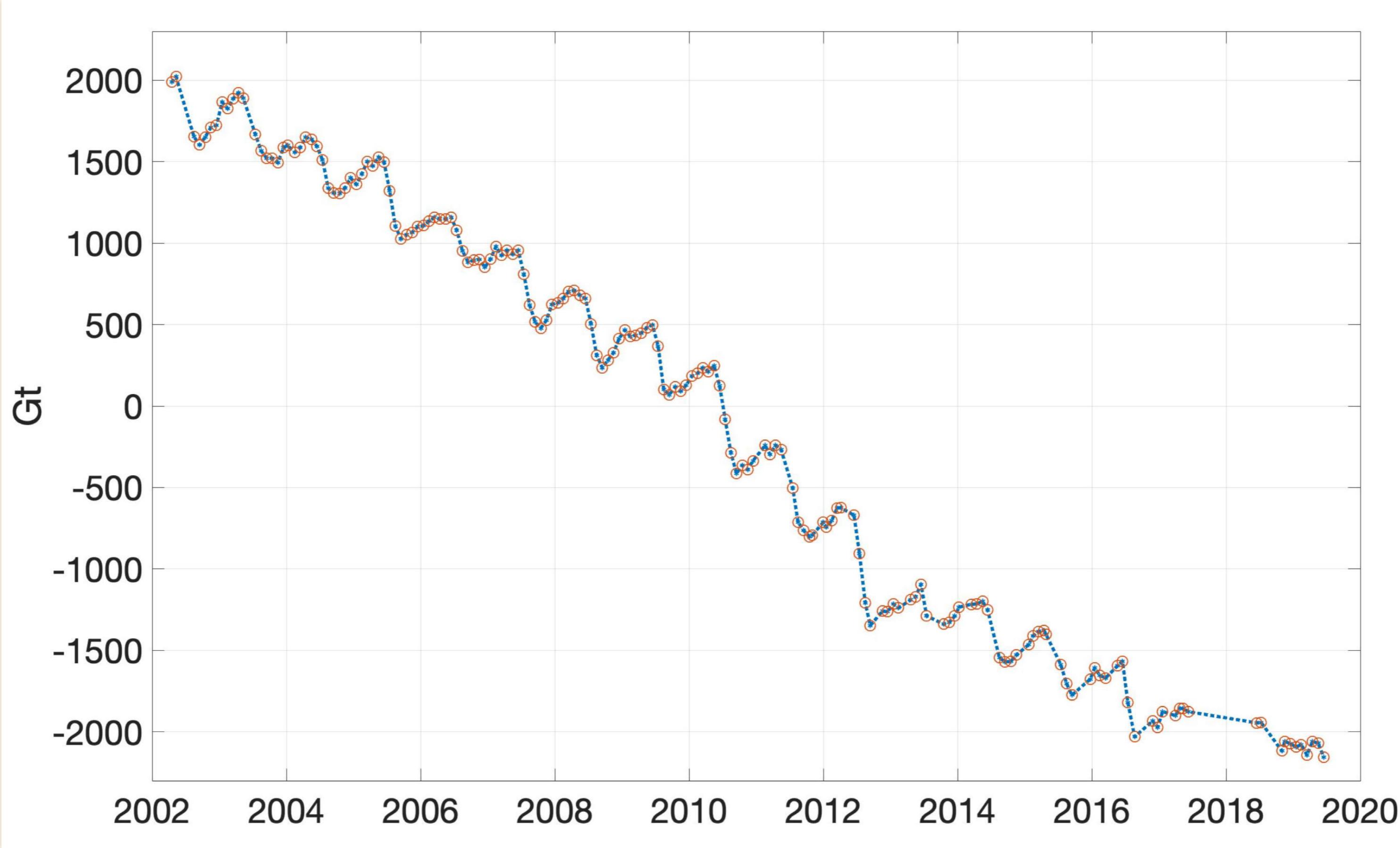
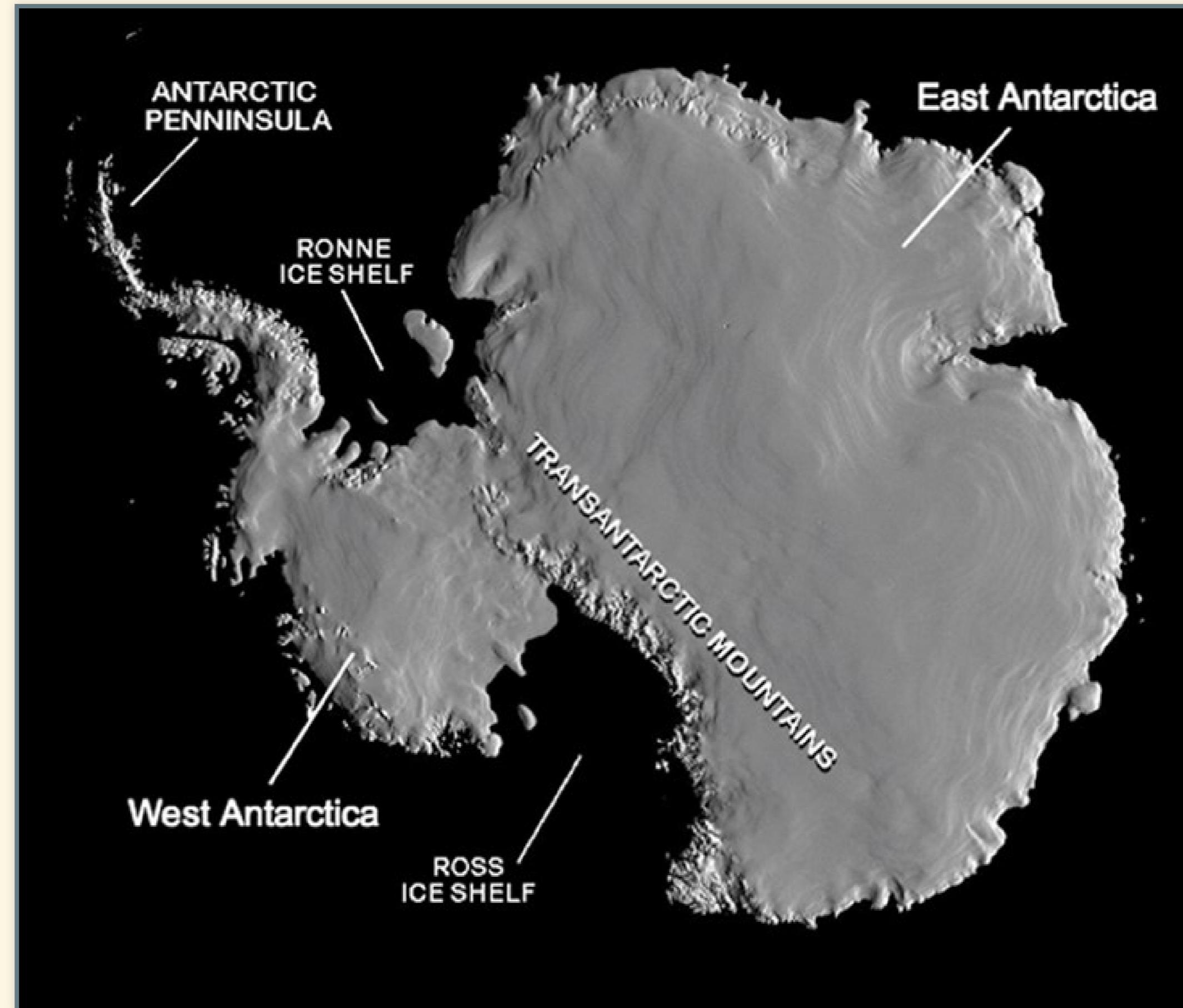


Image credit: M. Tedesco et al., NOAA Arctic Program

Antarctica

Antarctica



GRACE Satellite

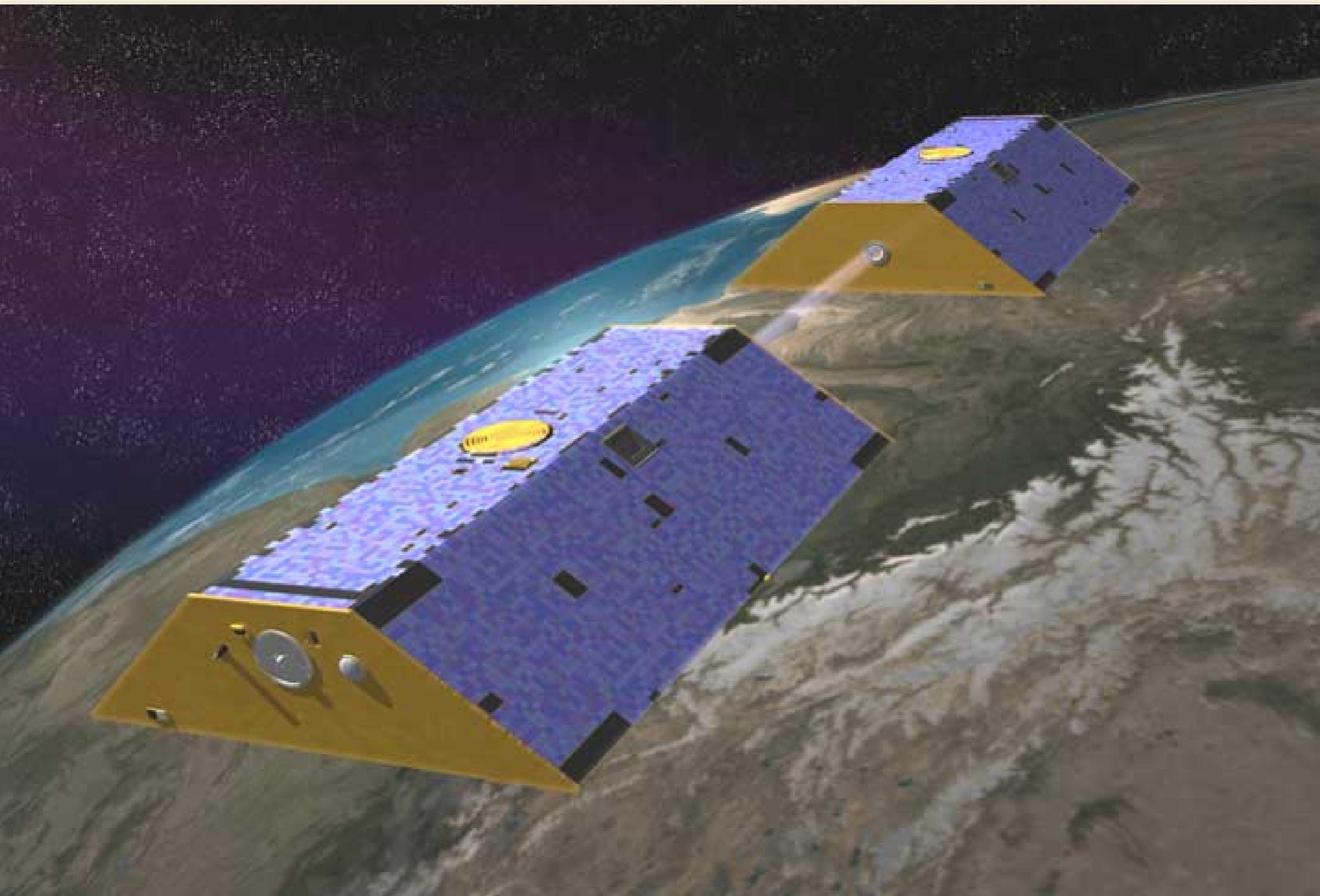
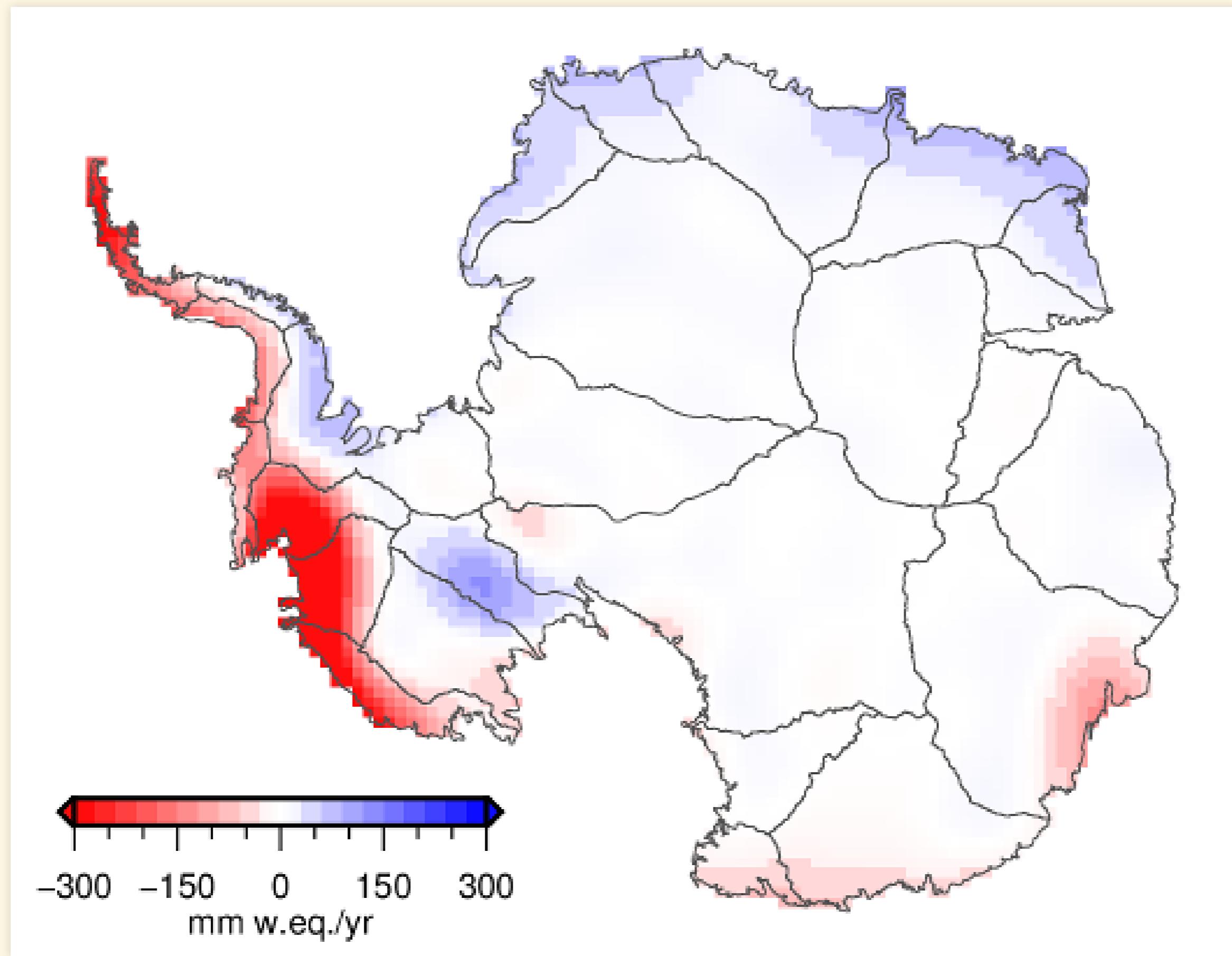
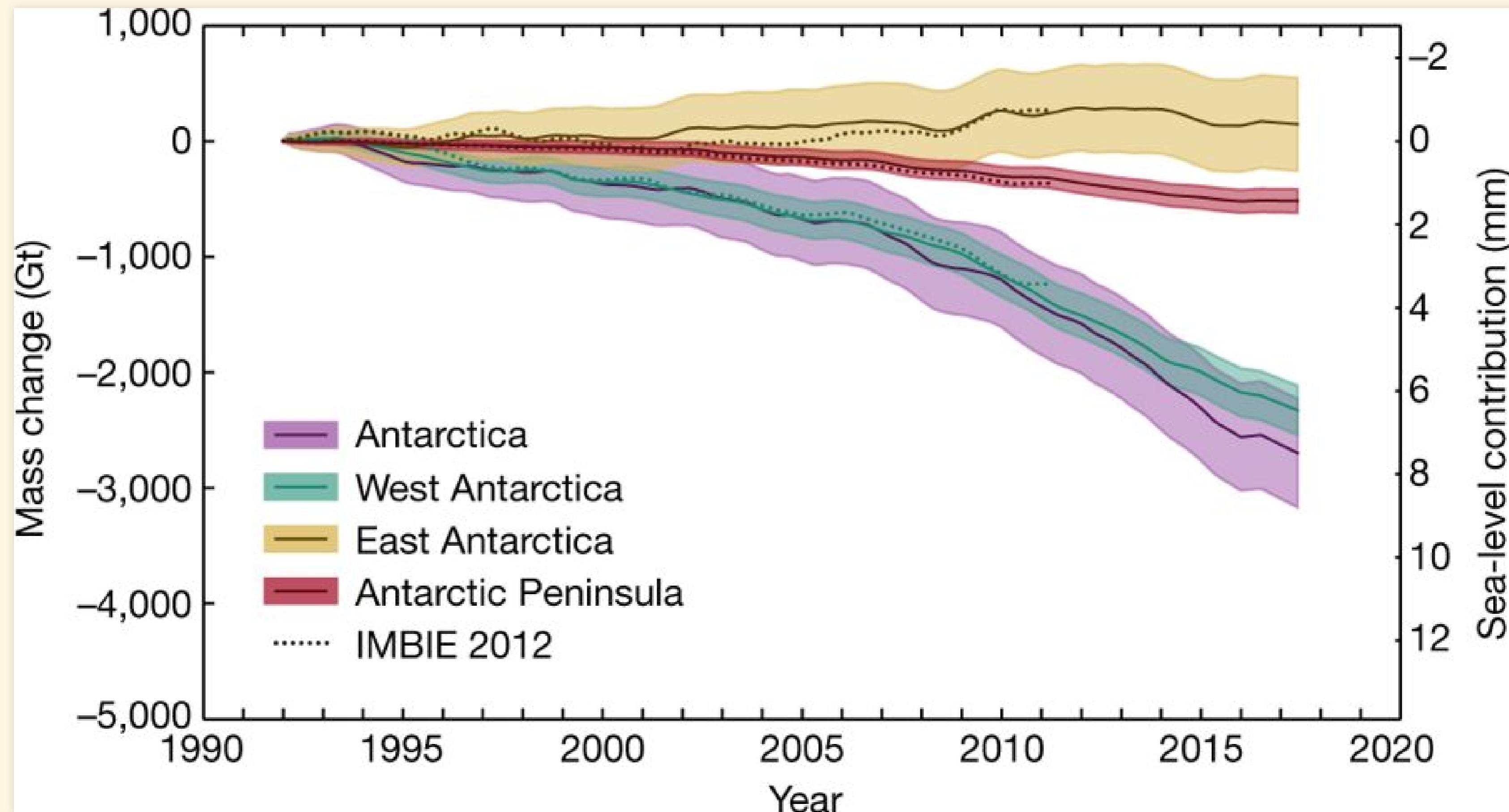


Image credit: NASA

Observations



Ice loss



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

Adding Up Damages

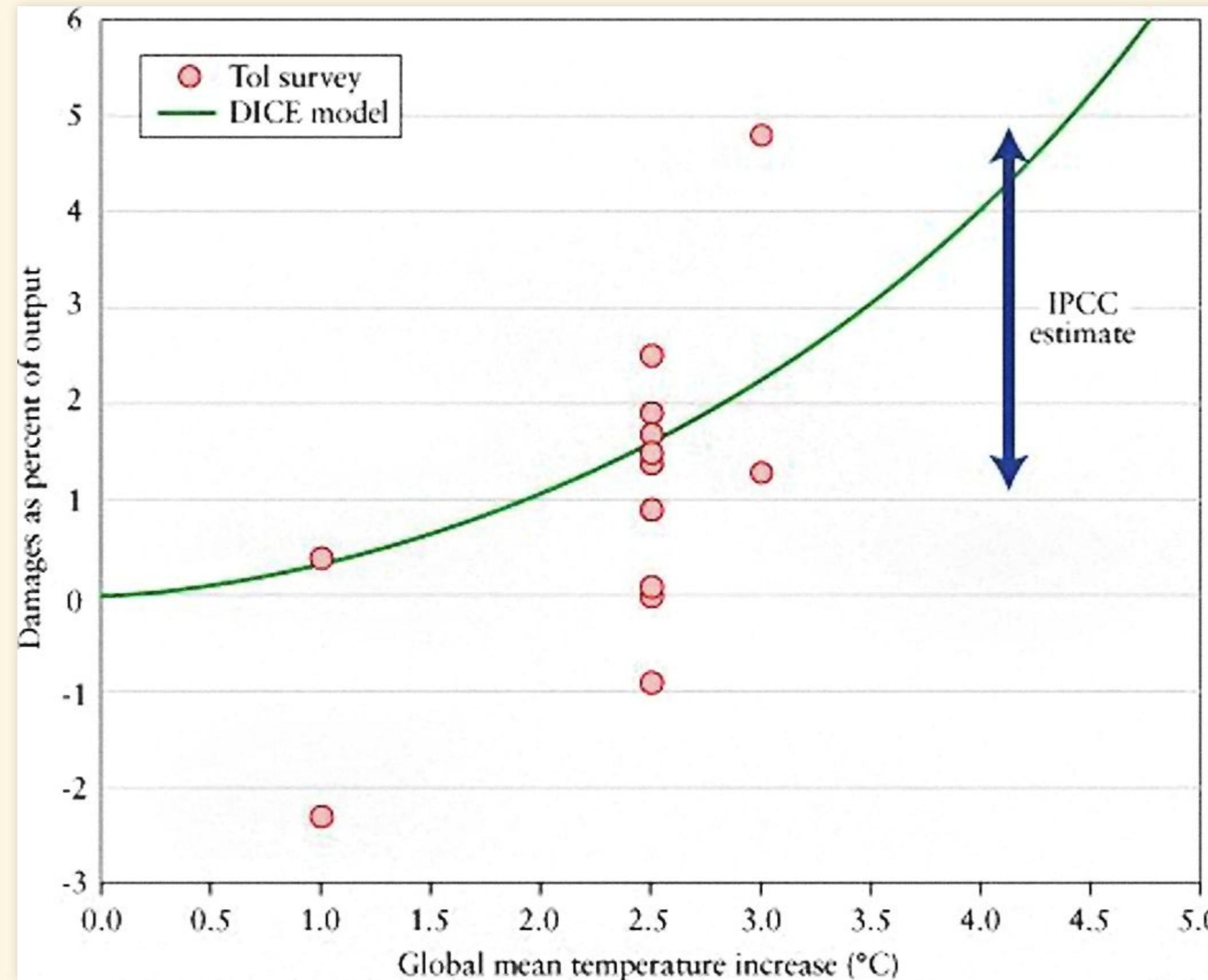
Risk Premiums

- Why do people buy insurance?
- Costs and benefits of insurance
 - How does insurance company set premiums relative to expected payouts?
 - On average do customers get more, less, or the same back as they paid in?
 - So why does anyone buy insurance?
- Is there a lesson here for climate policy?

Overview of Damage Assessment

- Climate change is an externality:
Unintended consequence of economic activity
- Zero growth would dramatically slow warming
- Climate change can slow future growth
 - If climate change causes negative growth,
economic calculations stop making sense
- Converting unmanaged → managed systems reduces damage, vulnerability
- Forecasting damage from climate change requires forecasting economies:
 - How much of economy will be managed?
 - What technology will be available to adapt & mitigate damage?
- Value of non-economic goods
(wilderness, ecosystems, biodiversity, ...)

How much damage?



Source: R.S.J. Tol, J. Econ. Perspect. 23, 29 (2009). doi:10.1257/jep.23.2.29

- Note benefits at 1.0 and 2.5 degrees...

Oops! Gremlins!

“Gremlins intervened in the preparation of my paper ... minus signs were dropped from the two impact estimates ...”

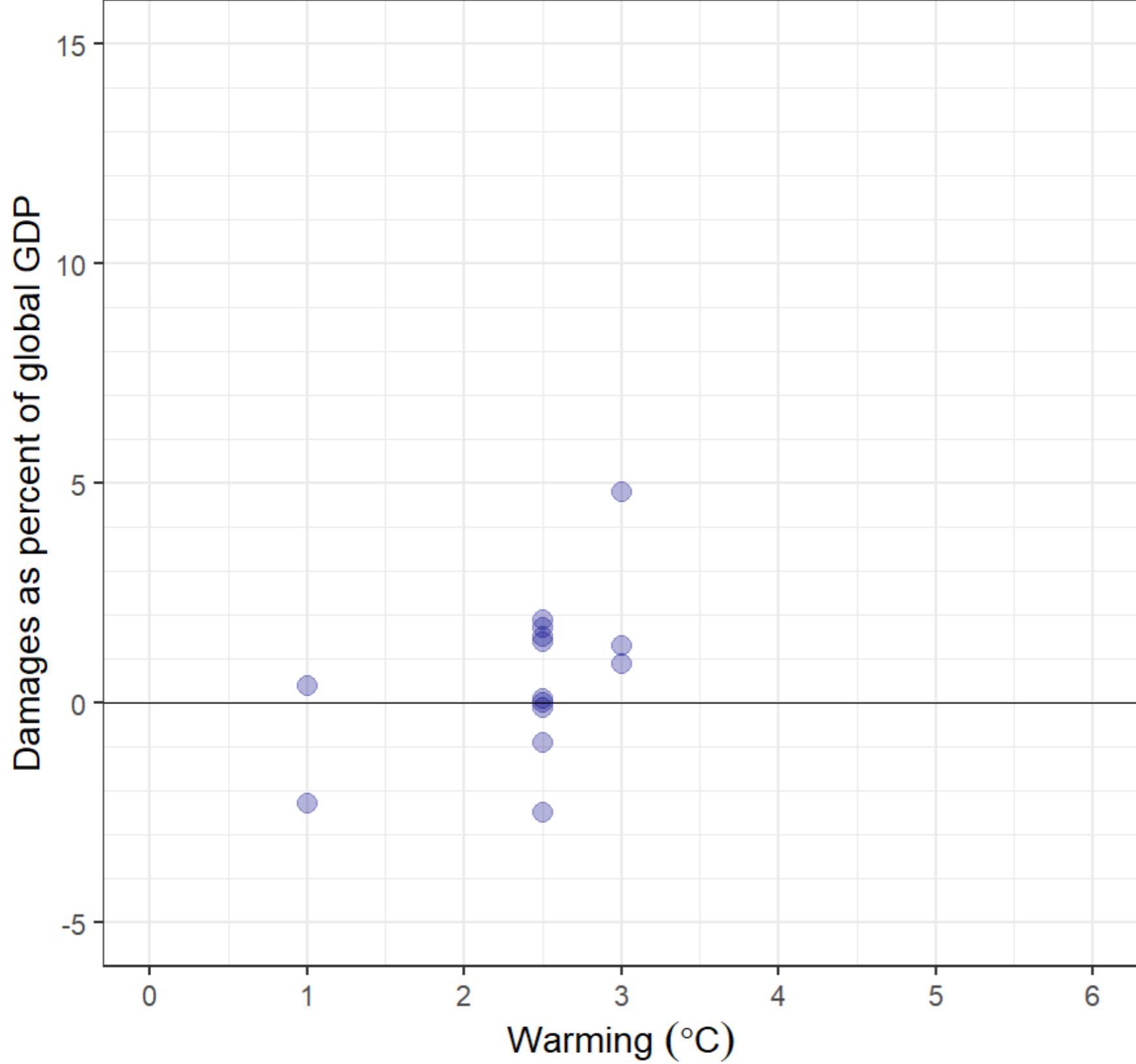
R.S.J. Tol, J. Econ. Perspect. **28**, 221 (2014) doi: 10.1257/jep.28.2.221



- Global warming was worse than Tol thought:
 - Two studies that found net harm from global warming were reported as net benefits.
 - Four studies that found net harm were simply omitted.
- Then, in 2015, more Gremlins:
 - numbers were not even calibrated correctly.

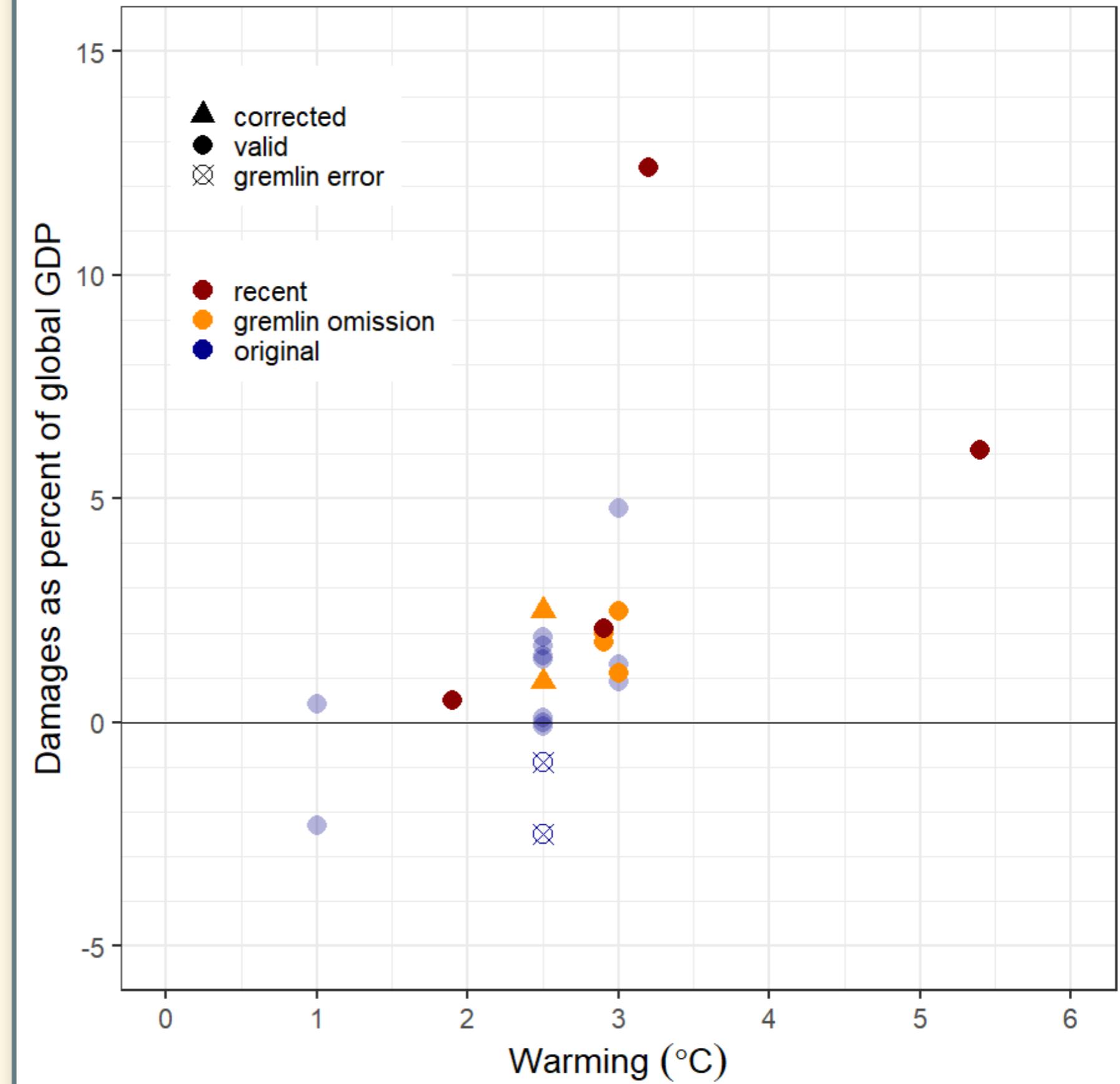
Damages from Warming

Original Figure

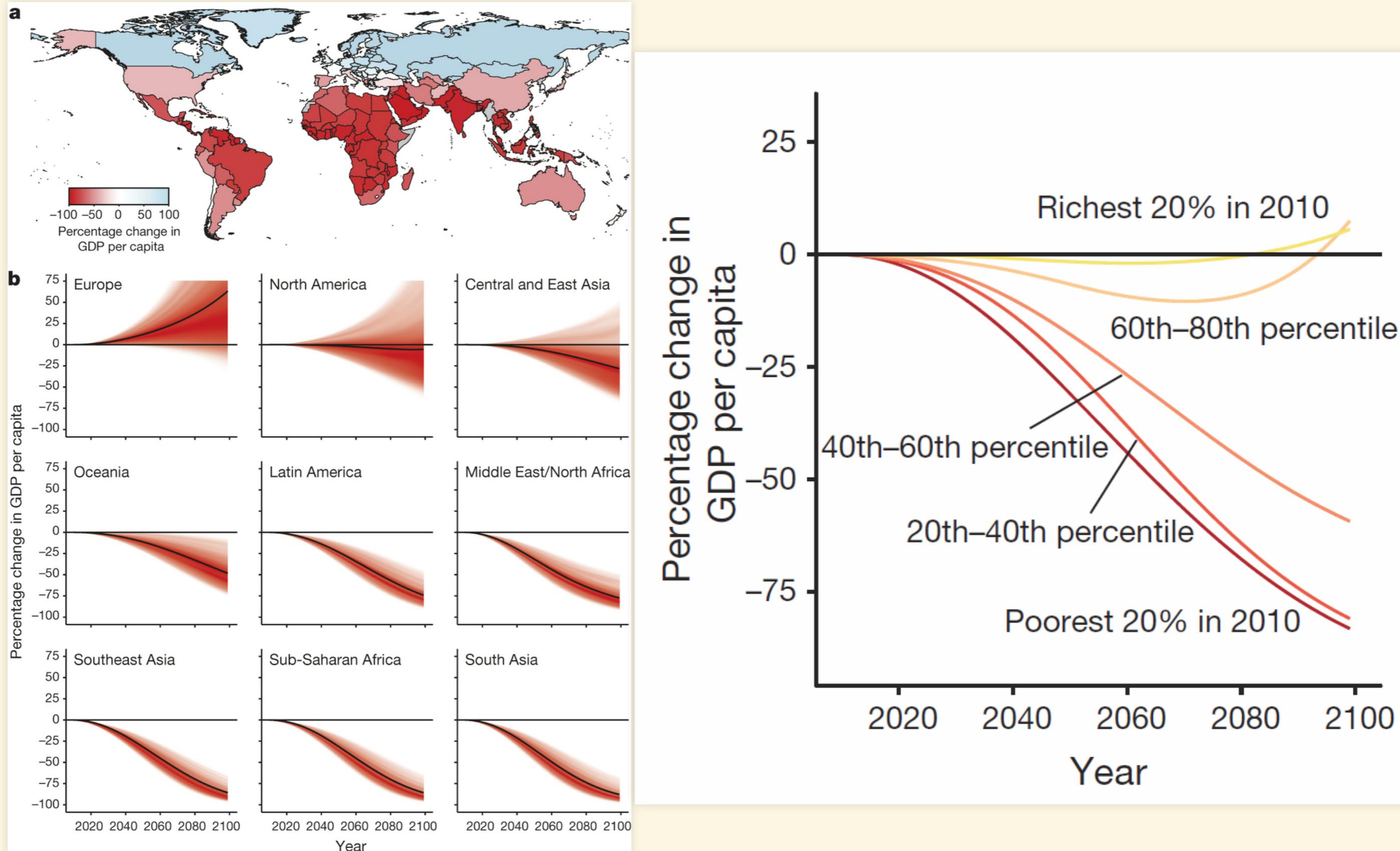


▲ corrected
● valid
⊗ gremlin error

● recent
● gremlin omission
● original



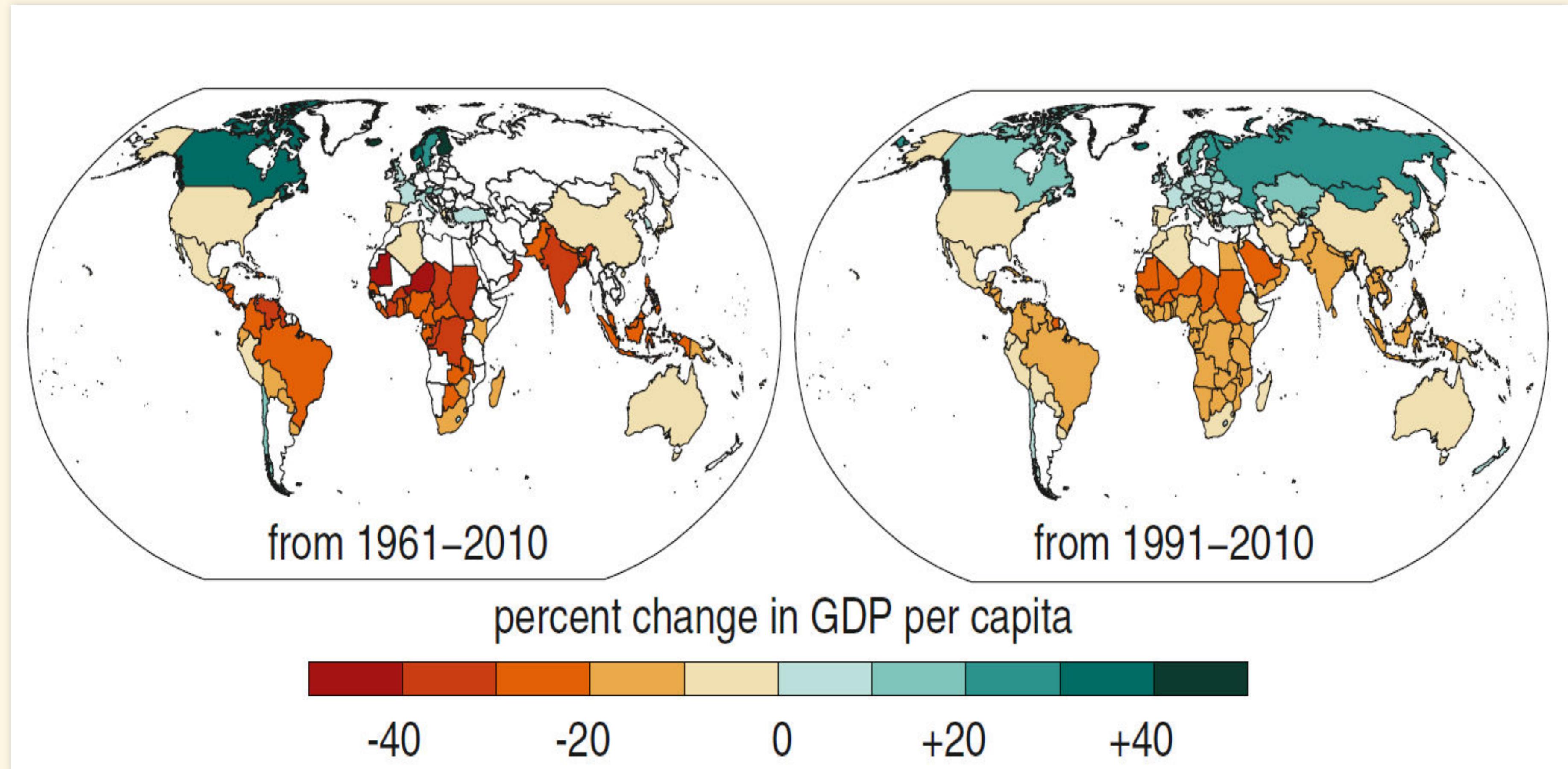
More Recent Work



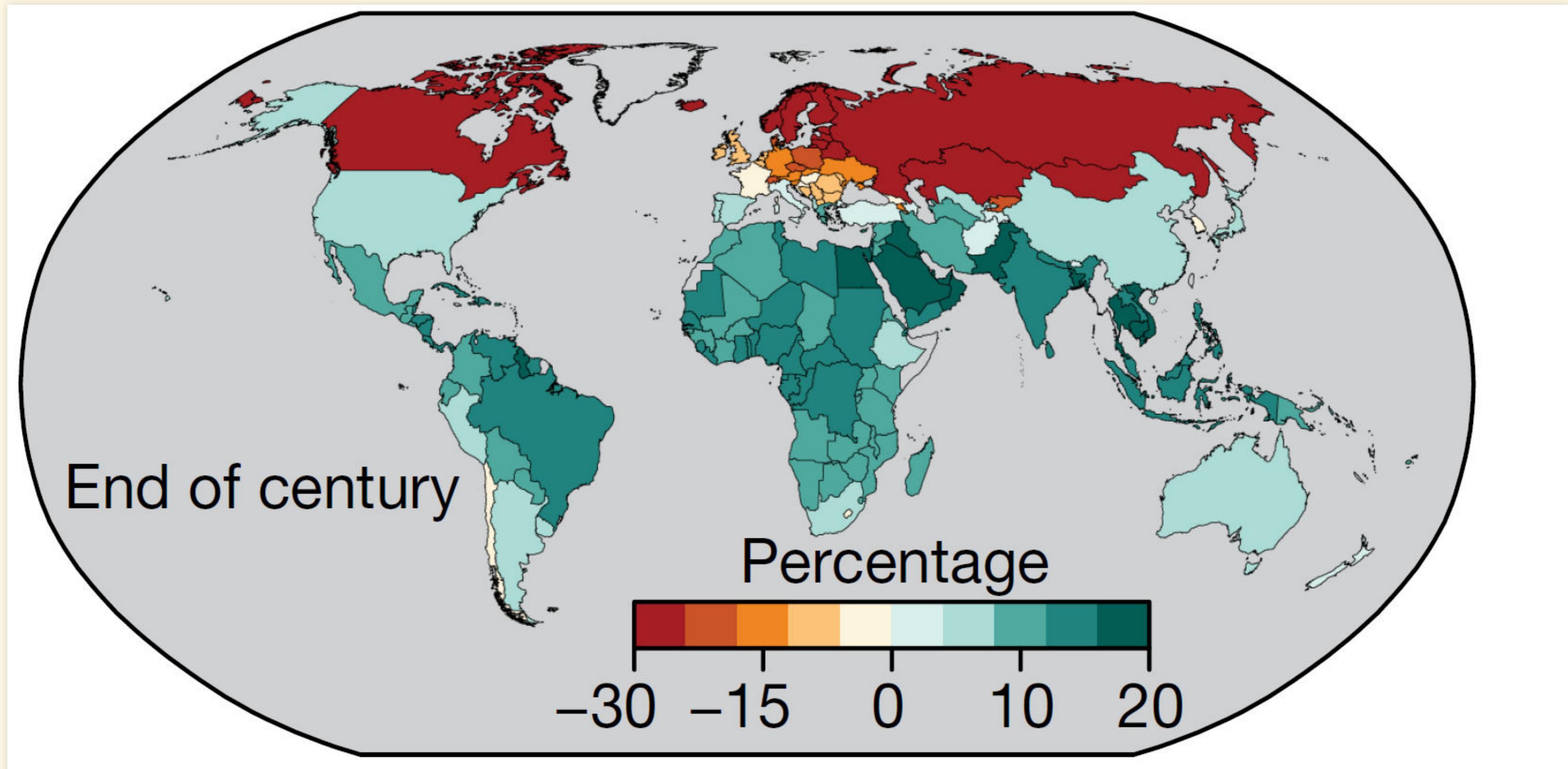
M. Burke *et al.*, Nature 527, 235 (2015). doi:10.1038/nature15725

Under a worst-case scenario

Global Warming is Already Affecting Economic Inequality



Benefits of Reaching International Climate Goals



Hurricanes

Hurricanes and Global Warming

- Hurricanes require ocean surface $\geq 80^{\circ}\text{F}$
- Hurricanes can only form with certain wind conditions
- Warming climates are expected to:
 - Increase sea-surface temperature:
 - More hurricanes
 - Stronger hurricanes
 - Hurricanes farther from tropics
 - Increase unfavorable wind conditions:
 - Fewer hurricanes
 - Expected impact:
 - Number: same or fewer
 - Intensity: greater
- Significant expert disagreement

Hurricane Controversy

- Hurricane damage is rising
- Much of this is because more people are building more valuable property near the coast
- Dispute over how much is due to climate change

Hurricane Expert Kerry Emanuel



- Many hurricanes in Atlantic Ocean
- Only a small fraction hit the US coast
- Clear trend toward more hurricane activity in North Atlantic
- Suppose bear population in woods was rising sharply...
 - Should hikers wait for clear increase in bear attacks before taking precautions?

Adaptation: Sea Level and Hurricanes

- Abandon vulnerable land
- Protect valuable land
- Raise buildings
- Build hurricane-resistant housing
- Move inland
 - Average structure lasts 50 years
 - Abandoning risky coastal real-estate over 50 years would cost around 0.01% of GDP each year