World Congress of Epidemiology 2024

Climate change: what should all epidemiologists be thinking about?

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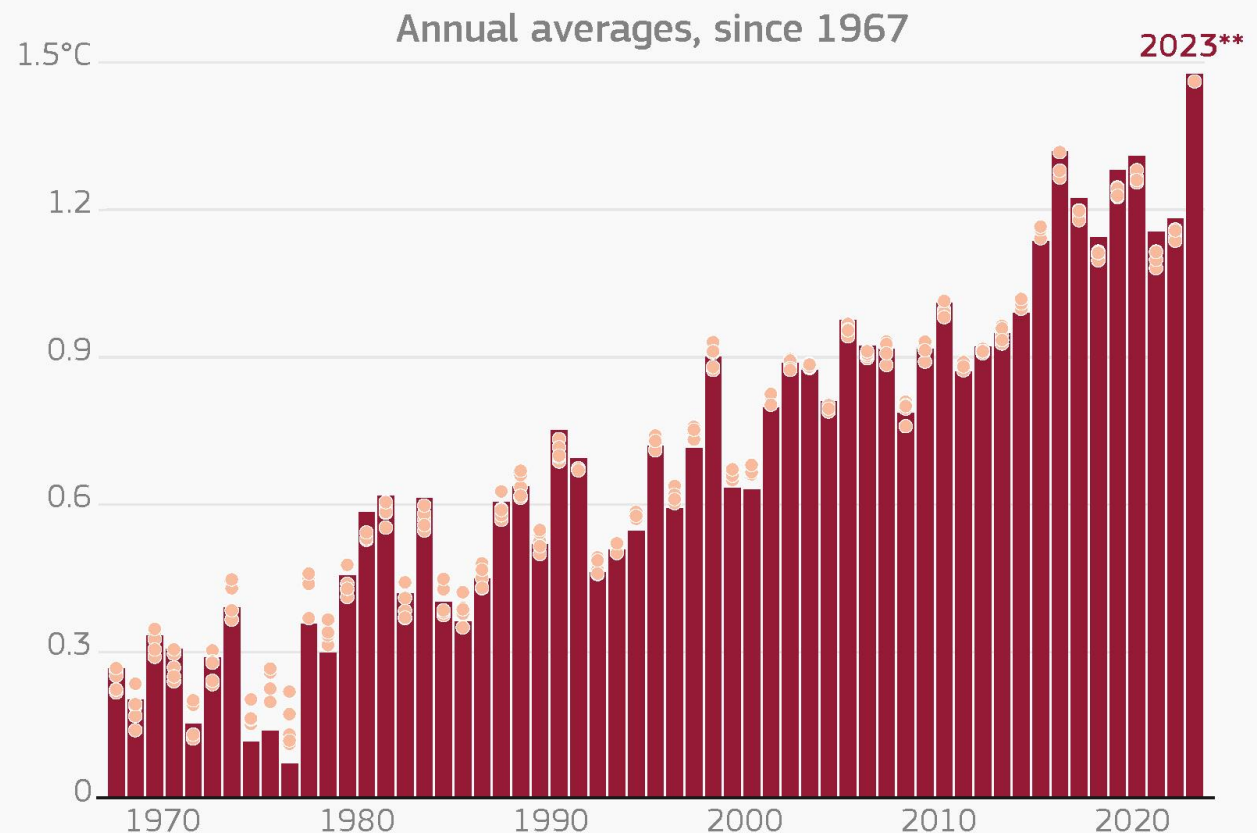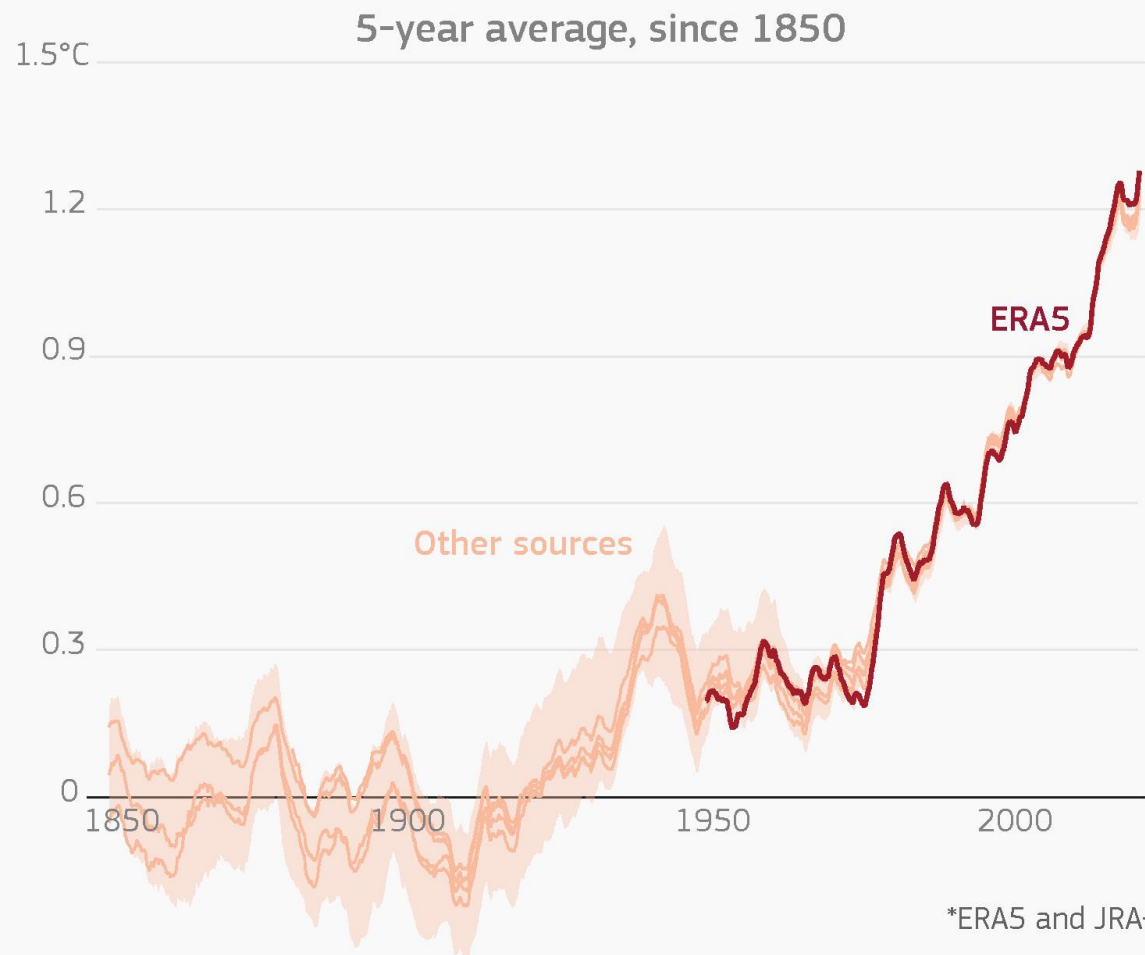Co-Faculty Director, Yale Center on Climate Change and Health
27 September 2024
Cape Town, South Africa

GLOBAL SURFACE TEMPERATURE: INCREASE ABOVE PRE-INDUSTRIAL LEVEL (1850-1900)

■ ERA5 data ● Other sources* (including JRA-3Q, GISTEMPv4, NOAAGlobalTempv5, Berkeley Earth, HadCRUT5)

5-year average, since 1850

ERA5

Other sources

Annual averages, since 1967

2023**

*ERA5 and JRA-3Q data are only shown from 1948. Shaded area represents the uncertainty for HadCRUT5 data
**Estimate for 2023 based on ERA5 and JRA-3Q data only
Credit: C3S/ECMWF

PROGRAMME OF THE
EUROPEAN UNION

Copernicus
Europe's eyes on Earth

ECMWF

Climate
Change Service
climate.copernicus.eu

Climate extremes: devastating wildfires, floods, and droughts across the world

FILE - The hall of historic Waiola Church in Lahaina and nearby Lahaina Hongwanji Mission are engulfed in flames along Wainee Street, Tuesday, Aug. 8, 2023, in Lahaina, Hawaii.

1:03 Satellite Images Show Damage From Deadly Flooding in Pakistan @New York Times

Drought in Poyang Lake, China August, 2022 @BBC News

The epidemiologic silver lining of climate change

To help dispel the scientific fog that shrouds the climate change impact on public health over the decades to come.

Thigpen Tart et al, *Epidemiology*. 2017

Challenges for epidemiology in relation to climate change

In 2001, **Tony McMichael** outlined three challenges:

1) Retrospective analyses of **associations** between climate-sensitive environmental exposures and health outcomes

2) Surveillance for current public health impacts highly likely to be attributable to climate change (**attribution**), and

3) Scenario-based health risk assessments of **projected** climate change health impacts.
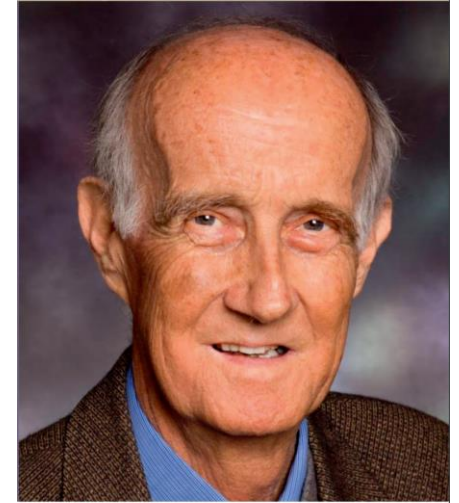
NATIONAL ACADEMY OF SCIENCES

Epidemiologists should be "*moving out of the comfort zone of empiric studies—and also relinquishing any residual professional delusions that epidemiologic research is exclusively about the discovery of novel risk factors.*"-Tony McMichael, *Am J Public Health, 2001.*

- Hess J. Climate change health impact projections: Looking into the future. In: *Global Climate Change and Human Health: From Science to Practice*. 2015. John Wiley & Sons.

Key *current* research directions in climate epidemiology

| Study Population | ✖ | Baseline Rate of Health Outcome | ✖ | Expected Change in Exposure | ✖ | Exposure Response Function | = | Health Impact |

1. Investigating **understudied** health outcomes and exposures to obtain exposure-response functions **(associations)**

2. Estimating health burden of historical climate change **(attributions)**

3. **Scenario-based projections** incorporating uncertainty from socioeconomic scenarios, climate model outputs, exposure-response functions, and population projections **(projections)**
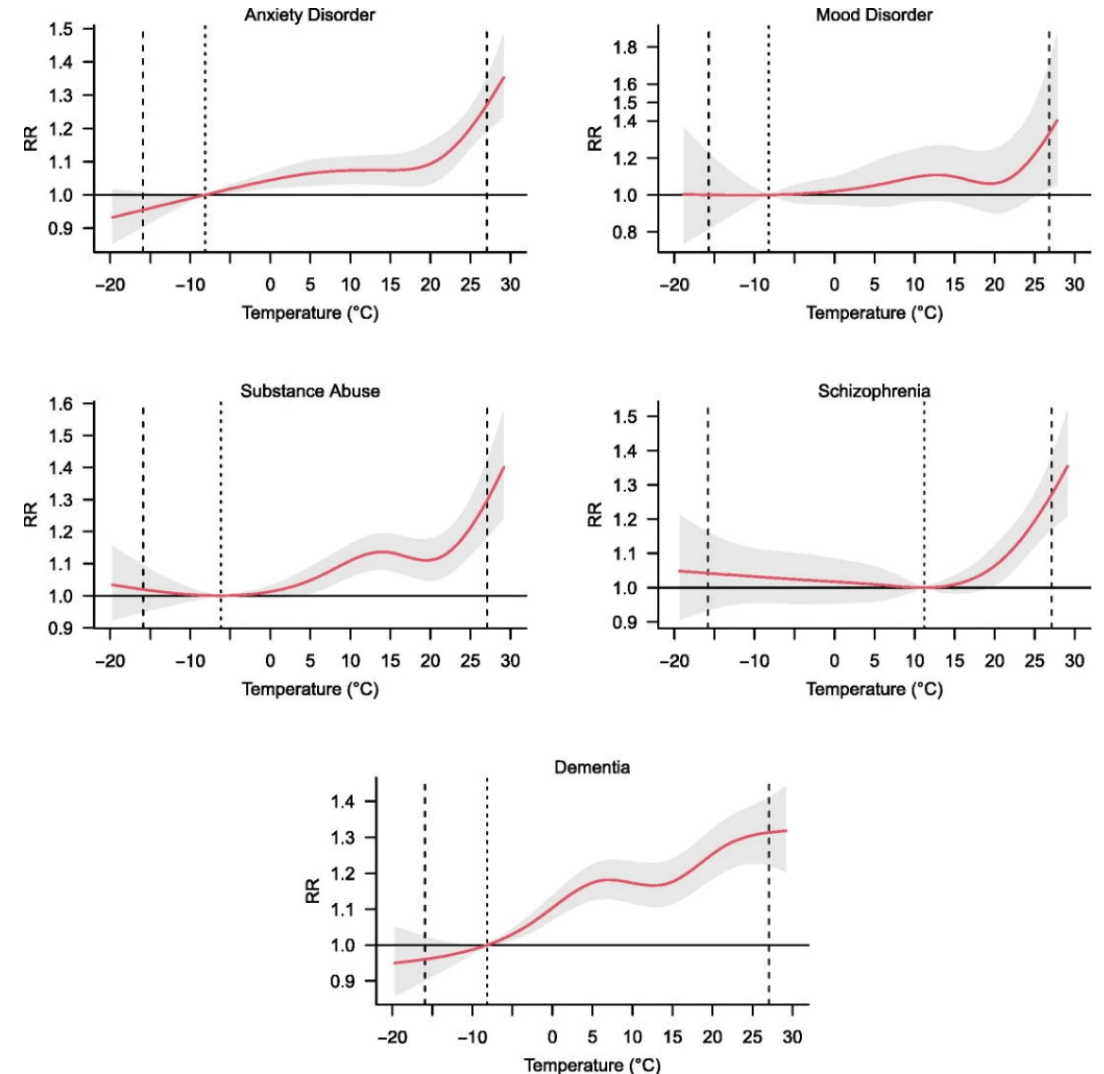
Myocardial Infarction Registry in Augsburg, Germany
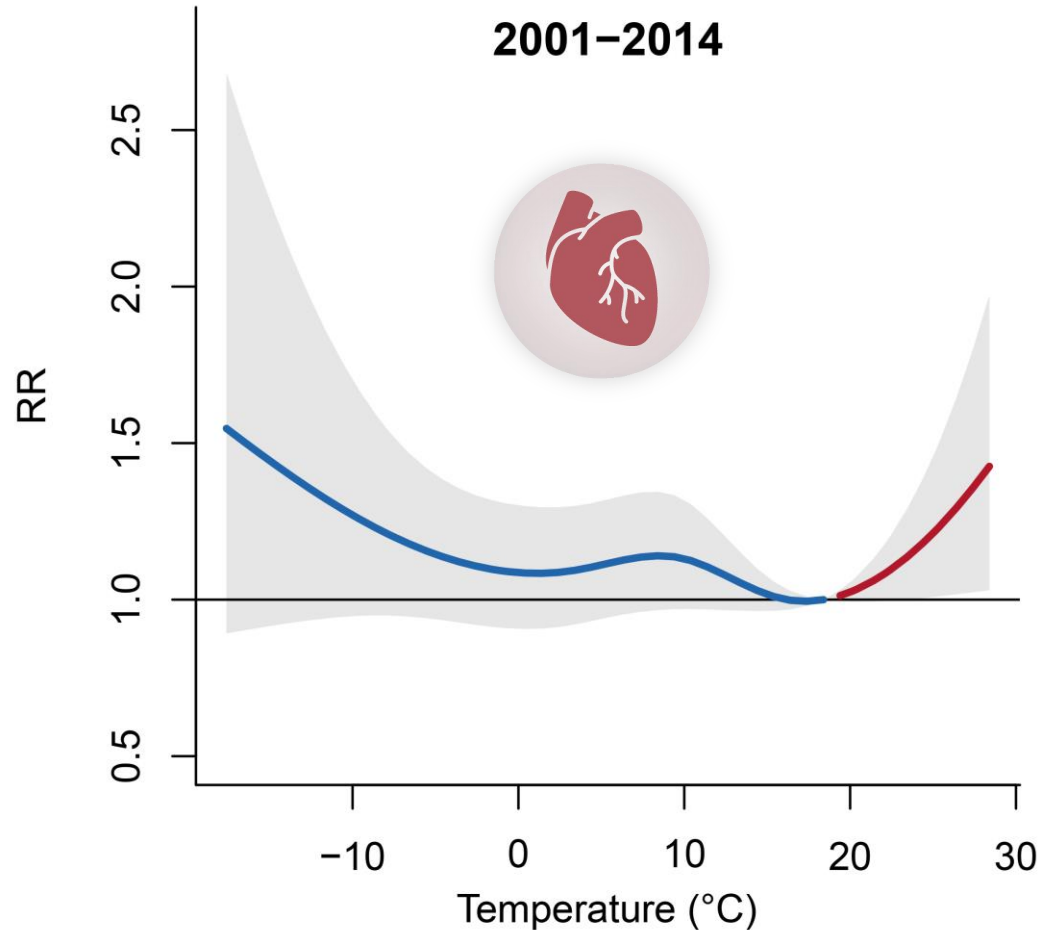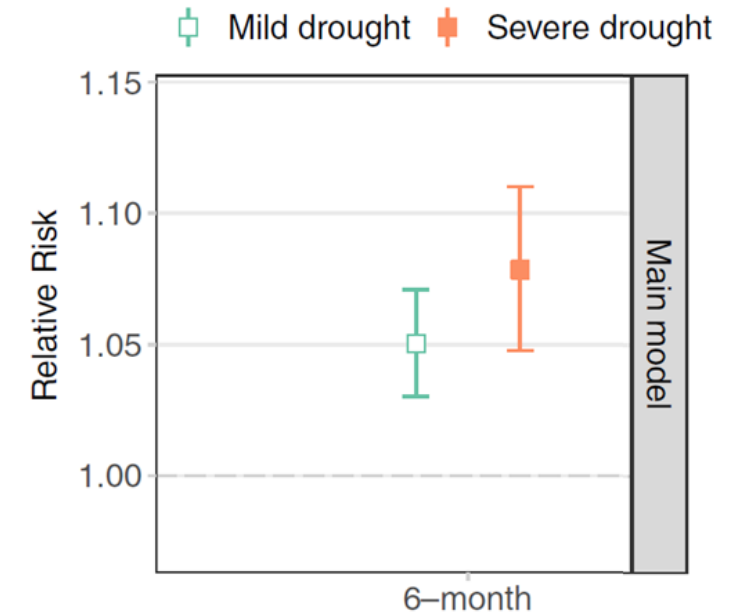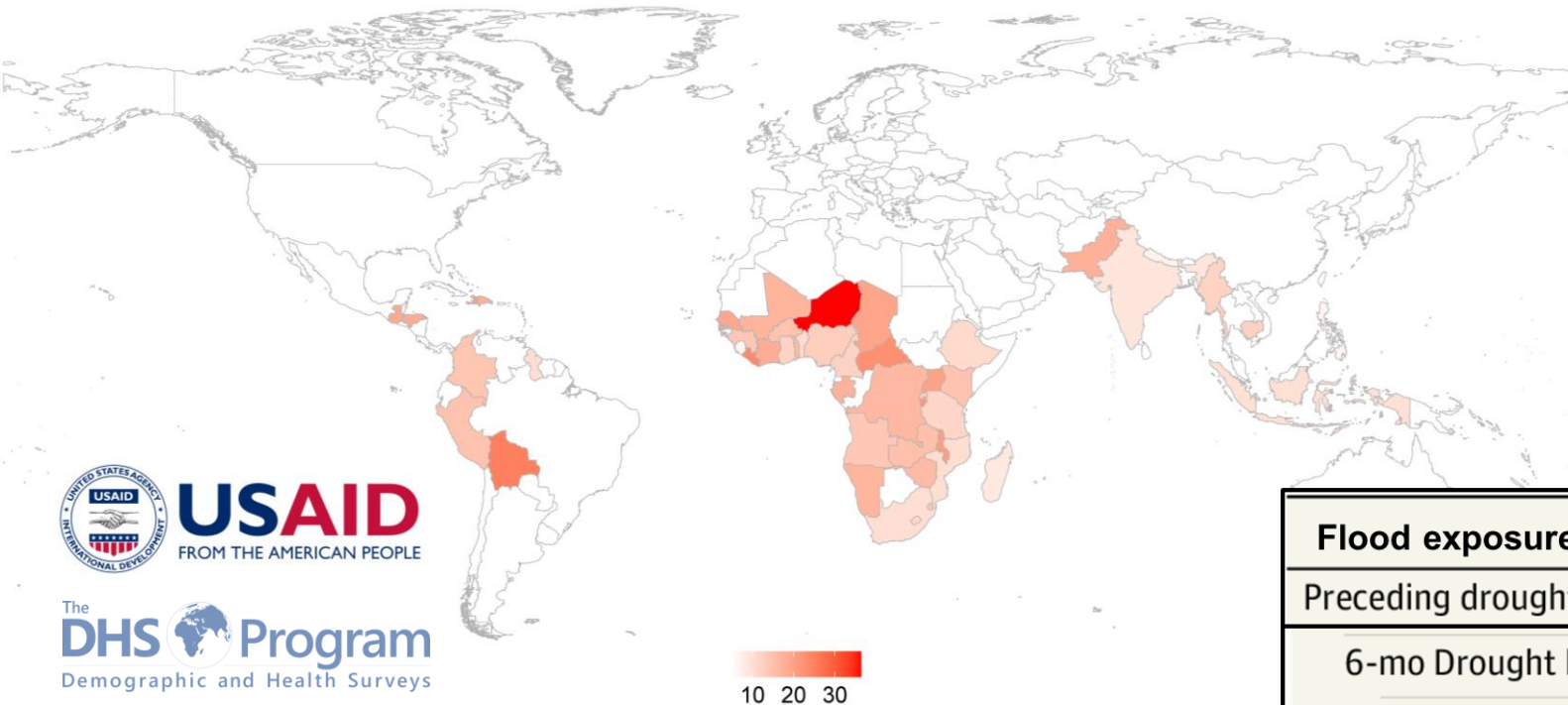

ER visits in New York State (2009-1026)

- **Chen** et al, *Eur Heart J,* 2019; **Yoo** et al. *Sci Total Environ*. 2021.

Drought and flood increased the diarrhea risk in children under 5 in LMICs

2-week diarrhea incidence in the latest Demographic and Health Surveys (%)

Flood exposure at lag 3-4 weeks	Odds ratio (95% CI)	P value[a]
Preceding drought		
6-mo Drought before floods		
No	1.16 (0.94-1.42)	.005
Yes	1.96 (1.45-2.66)	

- **Wang** et al, *Nature Communications.* 2022; **Wang** et al, *JAMA Pediatrics.* 2023.
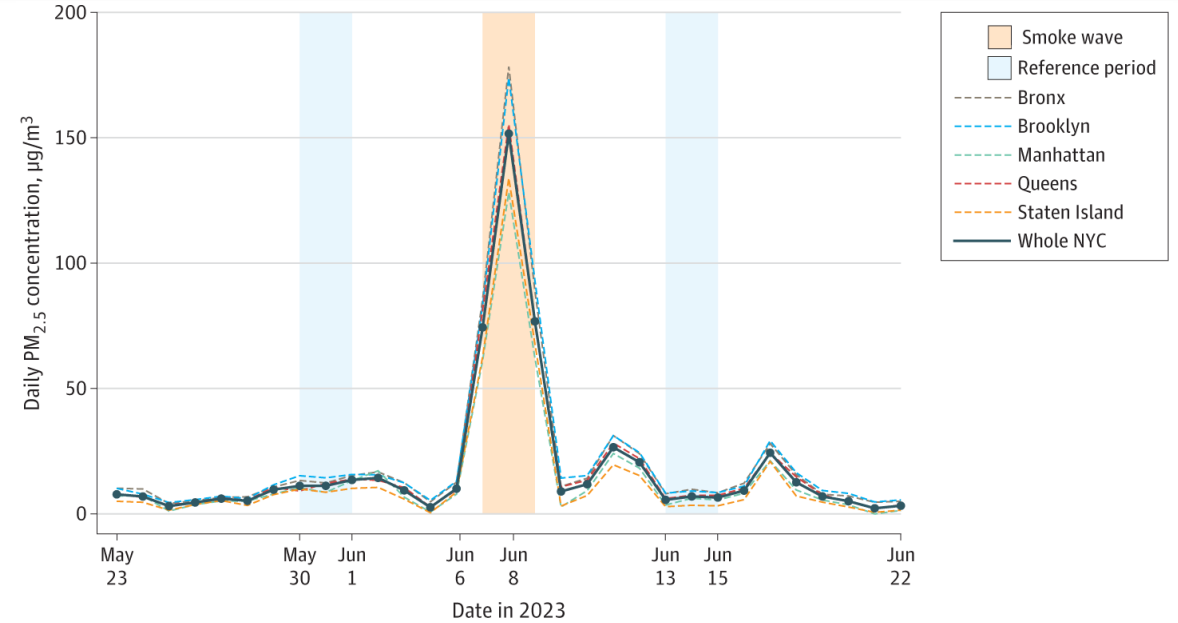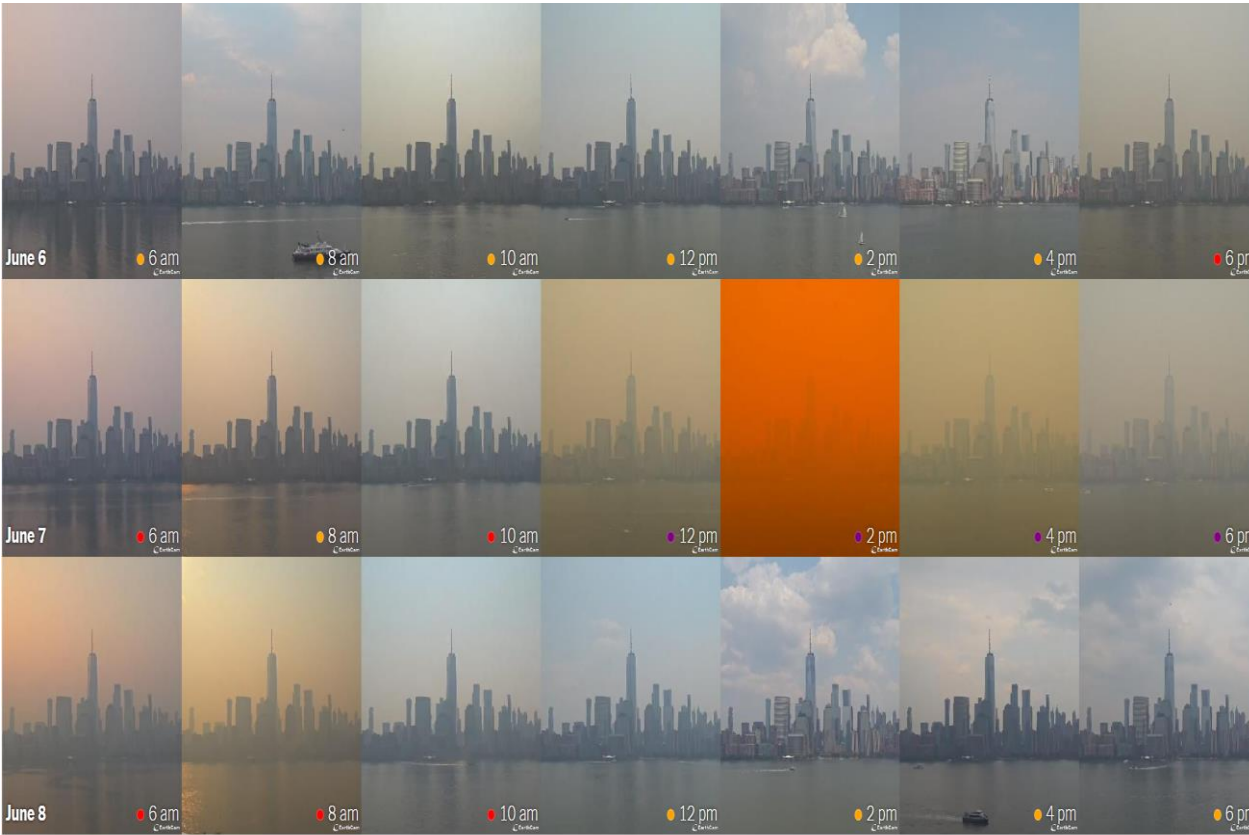
The New York City Skyline in June 2023

Table. Asthma Syndrome ED Visits by Age Groups and Boroughs in New York City Before, During, and After the Wildfire Smoke Wave in June 2023[a]

| | | No. of ED visits | | | |
	Population	Before smoke wave (May 30-June 1)	Smoke wave (June 6-8)	After smoke wave (June 13-15)	IRR (95% CI)
New York City					
All age groups	8 335 897	523	783	566	1.44 (1.31-1.58)
Age 0-4 y	516 826	19	28	31	1.12 (0.71-1.78)
Age 5-17 y	1 225 377	87	112	83	1.32 (1.04-1.67)
Age 18-64 y	5 334 974	344	562	394	1.52 (1.36-1.70)
Age ≥65 y	1 258 720	73	81	58	1.24 (0.94-1.63)

- **Chen** et al, *JAMA.* 2023.

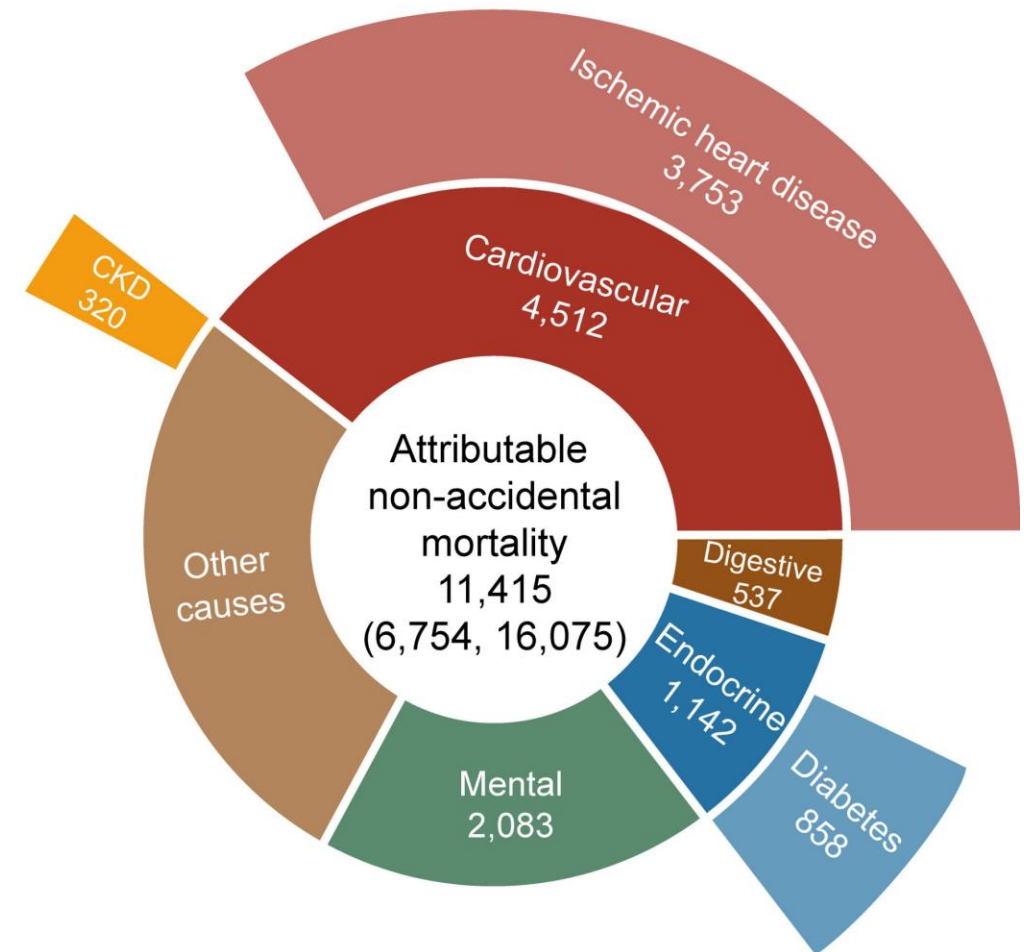# Cause-specific mortality burden attributable to long-term smoke PM$_{2.5}$ exposure in the US
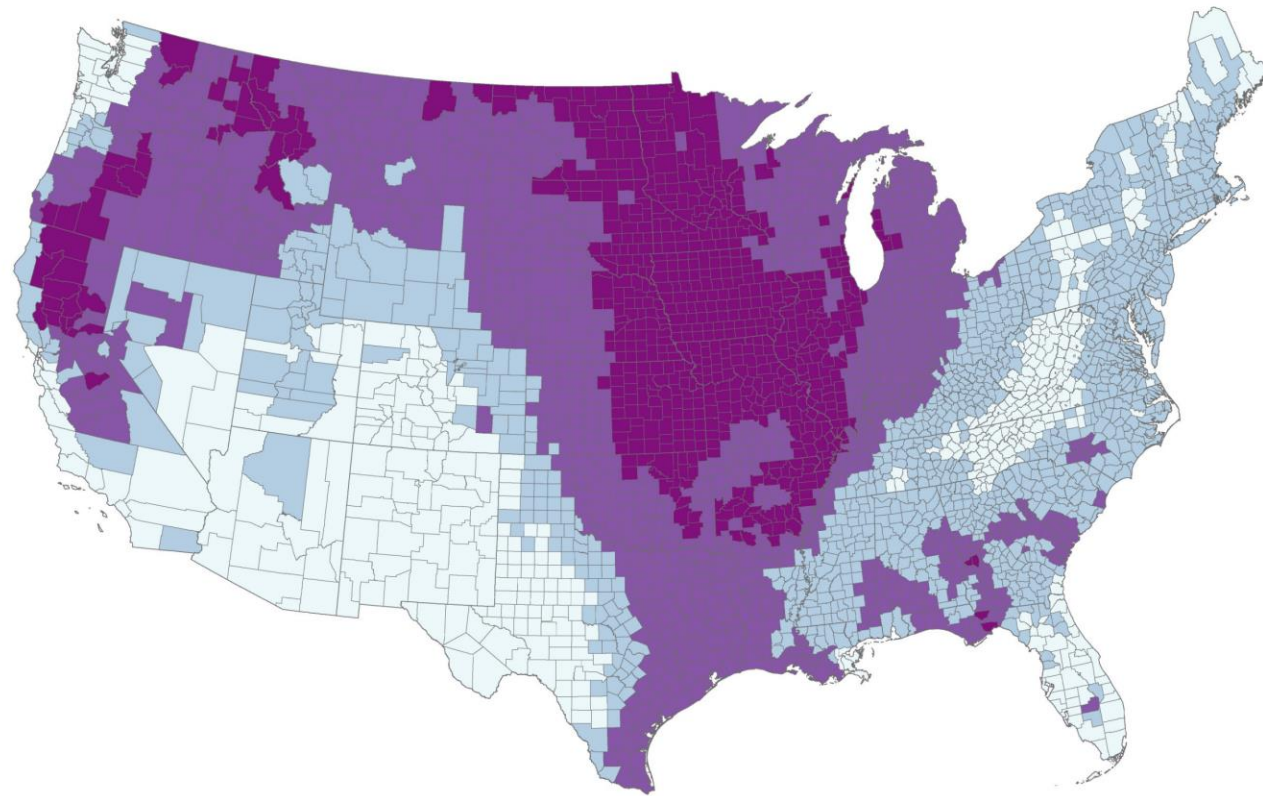
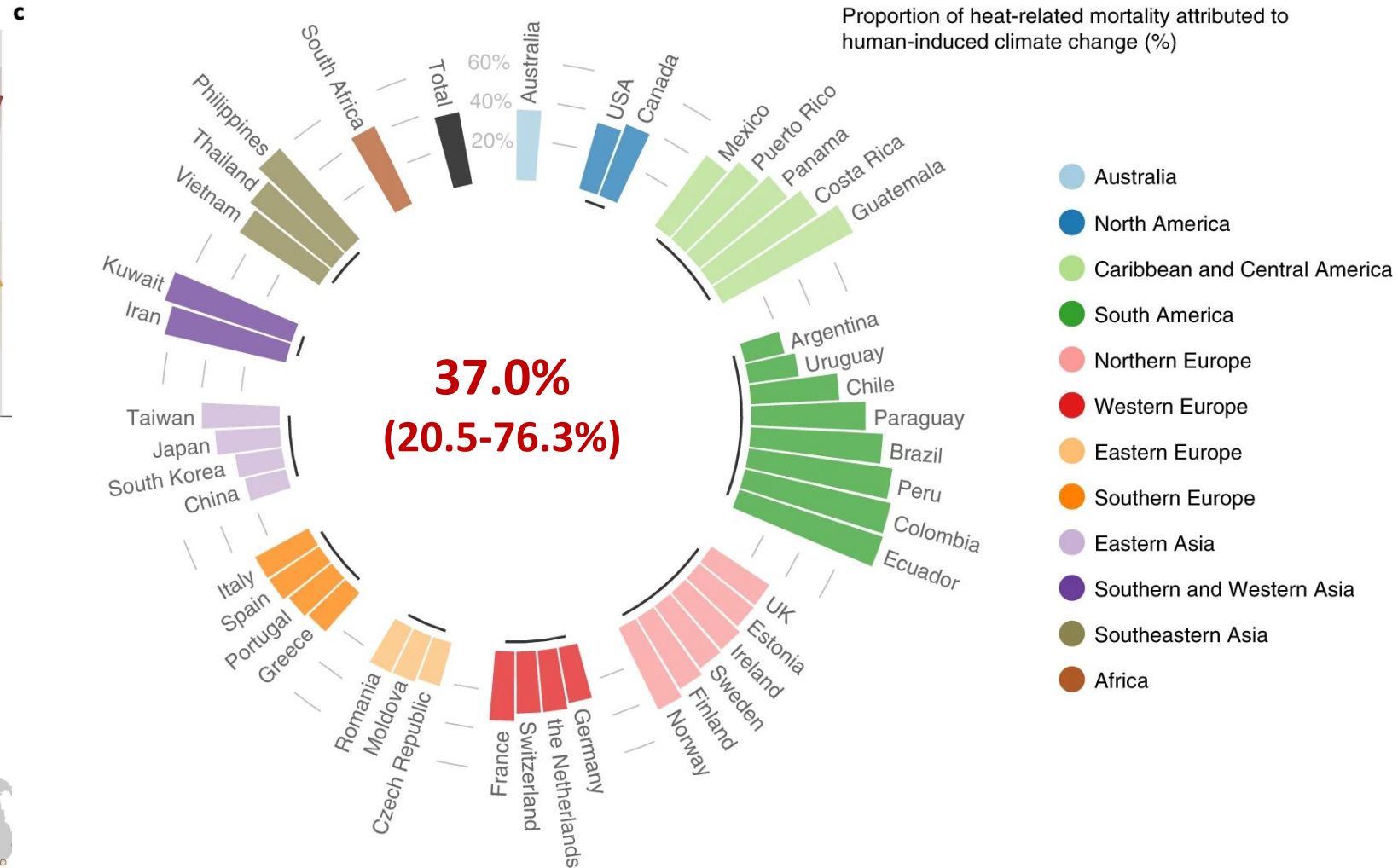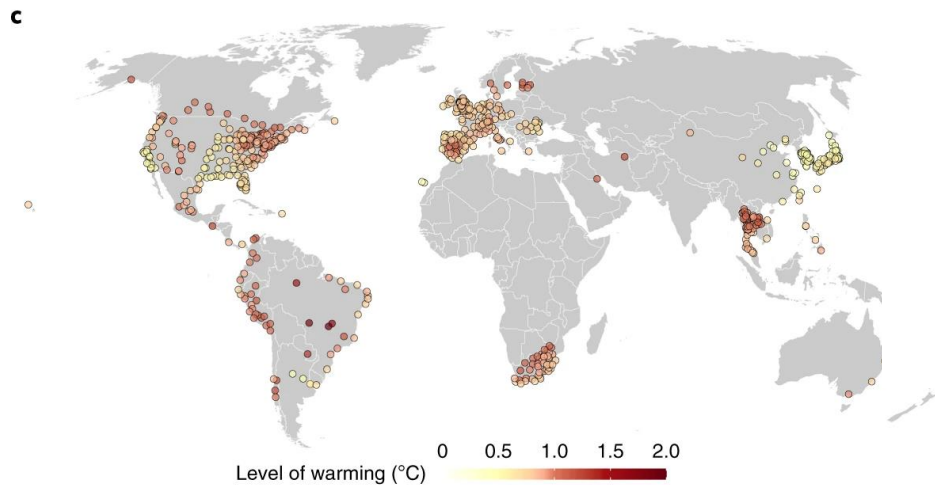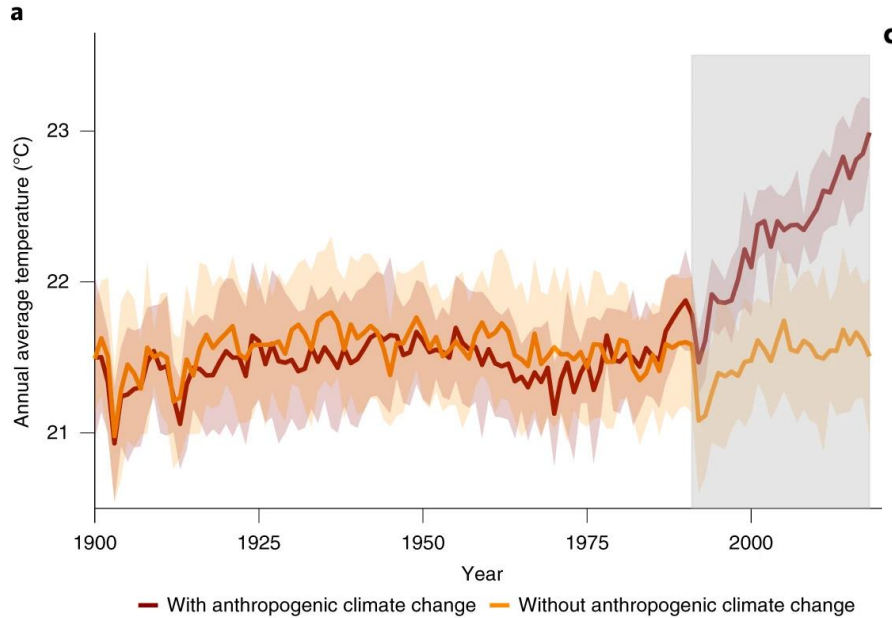A — Average annual attributable non-accidental deaths per 100,000 people: 0.7-3.0, 3.0-4.0, 4.0-5.0, 5.0-7.9

B — Attributable non-accidental mortality 11,415 (6,754, 16,075); Ischemic heart disease 3,753; Cardiovascular 4,512; Digestive 537; Endocrine 1,142; Diabetes 858; Mental 2,083; Other causes; CKD 320

- **Ma** et al, *Proc Natl Acad Sci USA*. 2024.

a

c

Proportion of heat-related mortality attributed to human-induced climate change (%)

37.0%
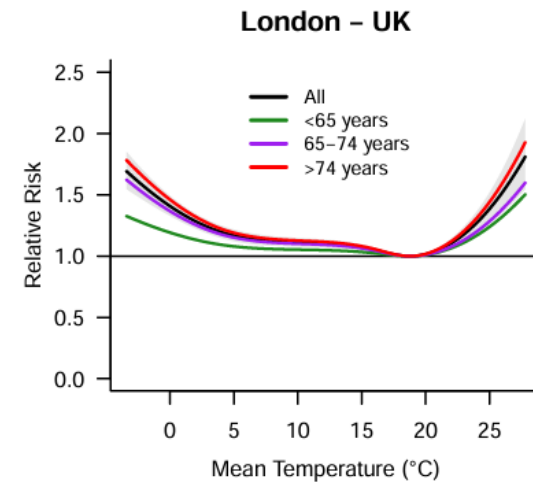**(20.5-76.3%)**

- Australia
- North America
- Caribbean and Central America
- South America
- Northern Europe
- Western Europe
- Eastern Europe
- Southern Europe
- Eastern Asia
- Southern and Western Asia
- Southeastern Asia
- Africa

- Vicedo-Cabrera, AM et al. *Nat. Clim. Chang.* 2021.
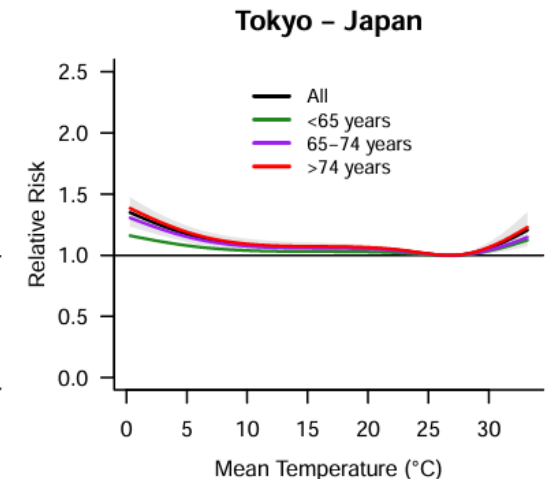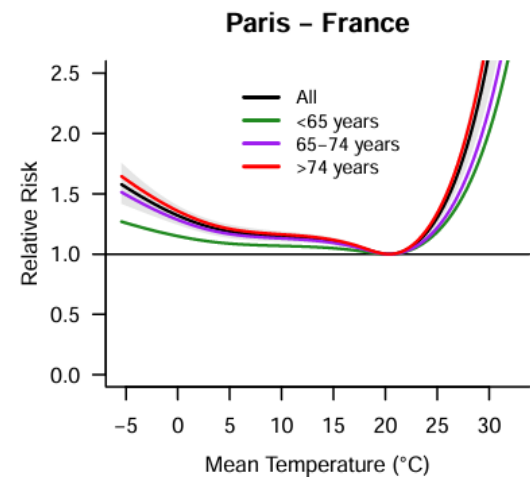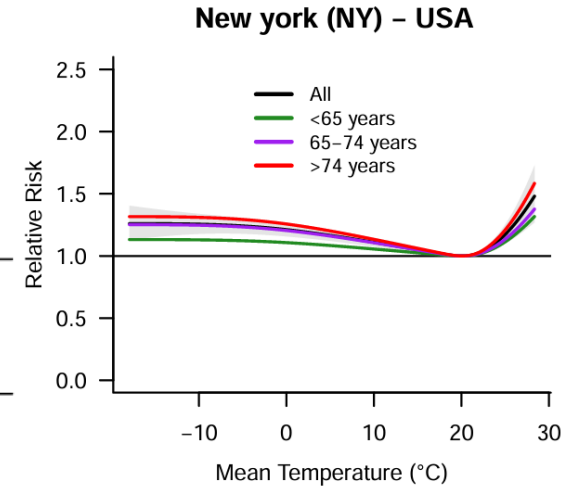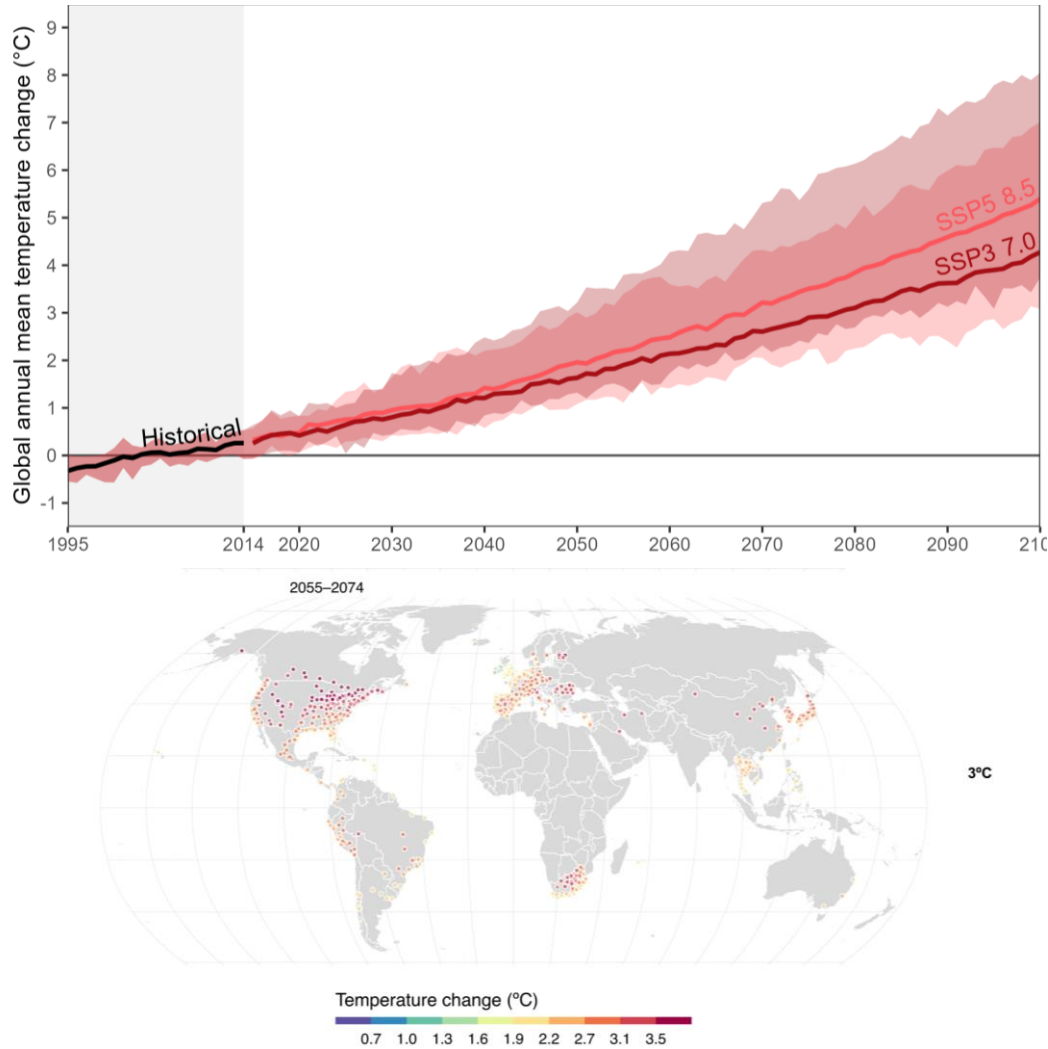
- **Chen** et al, *Nature Communications.* 2024

Net increase in **cold-related** mortality: 0.1%–0.4% at 1.5–3 °C global warming.
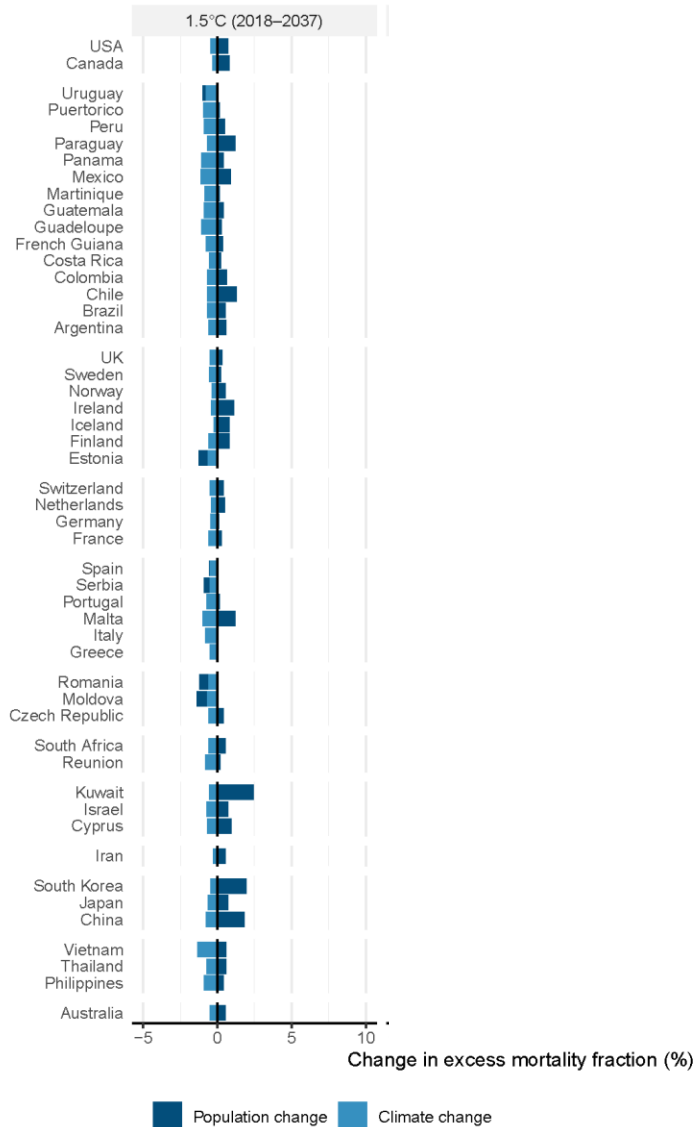
0.5% 1.0% 2.5%

- **Chen** et al, *Nature Communications.* 2024

Source: *U.S. EPA*

Climate change tends to increase ozone in already polluted regions
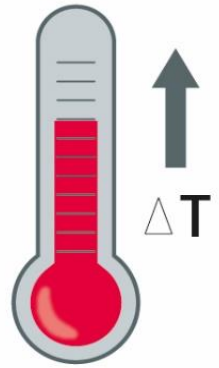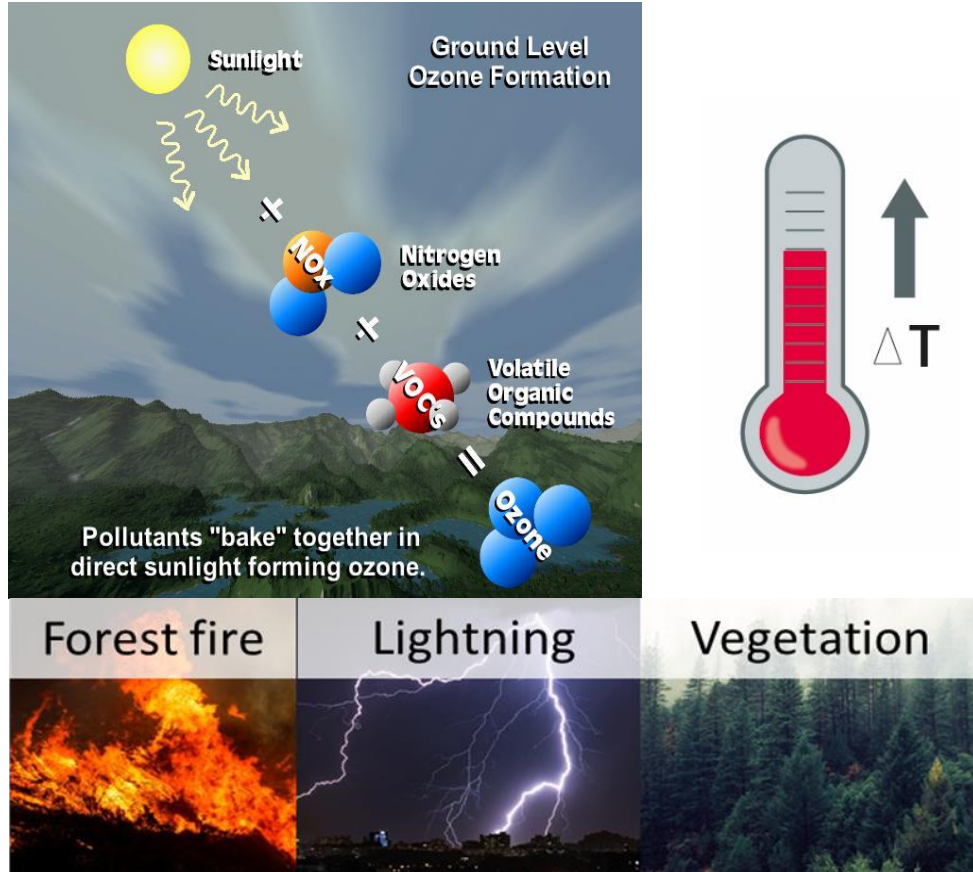
Changes in emissions and climate
+
Changes in baseline mortality rate
+
Changes in population size
=
Future changes in ozone-related deaths

SSP 1-2.6   SSP 2-4.5

SSP 3-7.0   SSP 5-8.5
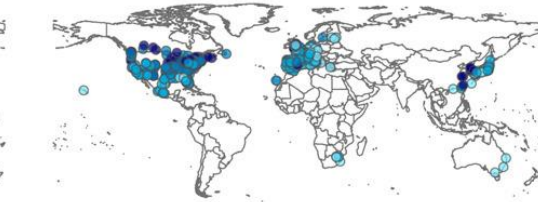
O$_3$-related mortality   -109 to -8%   -8 to 27%   27 to 56%   56 to 79%   79 to 442%

- **Domingo** et al, *One Earth*. 2024

Challenges and opportunities in Climate Change and Health

- **Health impact assessment of climate change**

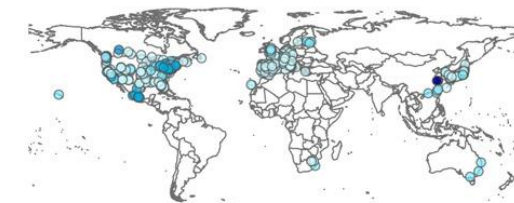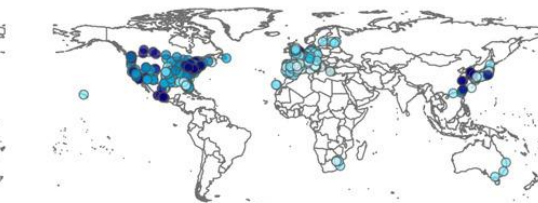| Study Population	×	Baseline Rate of Health Outcome	×	Expected Change in Exposure	×	Exposure Response Function	=	Future Health Impact

Population change	Climate-sensitive outcome	Coarse spatio-temporal resolution	Limited ERFs	Co-benefits of mitigation
Demographic change	Lack of quality data	Detection and attribution	Compound risks	Future adaptation

Uncertainty

Where can epidemiologists start studying climate health? Finding data on climate-related exposures and projections

Data on climate-related exposures

- **Daily temperature/humidity**
  - Weather stations
  - Reanalysis data (e.g., ERA5-Land)
- **Air pollution**
  - Local EPA monitoring stations
  - GlobalHighAirPollutants (GHAP): daily 1km grid
  - Satellite-derived PM2.5 and NO2 at 1km grid from Washington University in St. Louis
- **Drought**
  - Global Standardised Precipitation-Evapotranspiration Index (SPEI) database at 0.5-degrees grid
- **Floods**
  - Dartmouth Flood Observatory

Climate model outputs

- **Temperature/humidity**
  - NASA Earth Exchange (NEX) Global Daily Downscaled Projections (GDDP) dataset: daily 25 km grid
  - The Inter-Sectoral Impact Model Intercomparison Project (ISIMIP)
- **Air pollution**
  - Aerosols and Chemistry Model Intercomparison Project (AerChemMIP)
  - **Collaborators** in Climate/Atmospheric Sciences!

Climate and Health Outcomes Research Data Systems (CHORDS)

The CHORDS Platform aims to lower the bar for such research by providing:

1. A glossary of terms to aid researchers seeking to understand the space
2. A catalog of data resources, data sets, and tools for researchers to use
3. Precomputed data sets that are aligned to common spatial and temporal dimensions for use by researchers
4. Examples of impactful studies to guide researchers
5. Use cases and vignettes of using tools to conduct place-based health studies

This is a BETA Release – please let us know of any improvements we can make. Contact Us

Overview	Browse Catalog	Toolkit & Use Cases	Highlighted Research	Literature Portal	Glossary

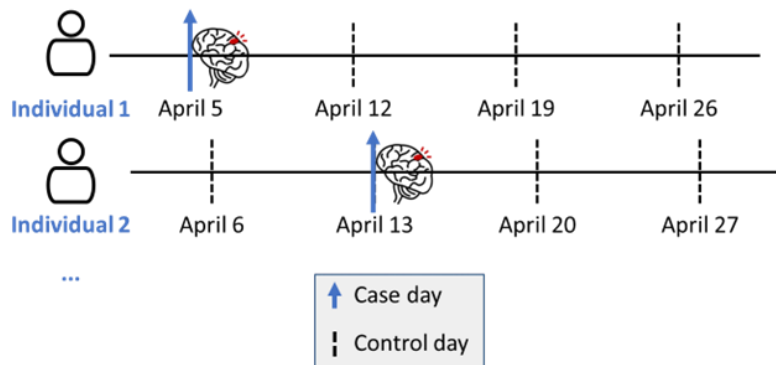https://niehs.github.io/chords_landing/index.html

Example: Short-term heat exposure and stroke risks

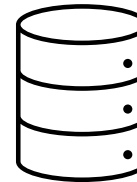A National stroke registry/cohort/ insurance claims database

Time-stratified case-crossover design

↑ Case day
┊ Control day

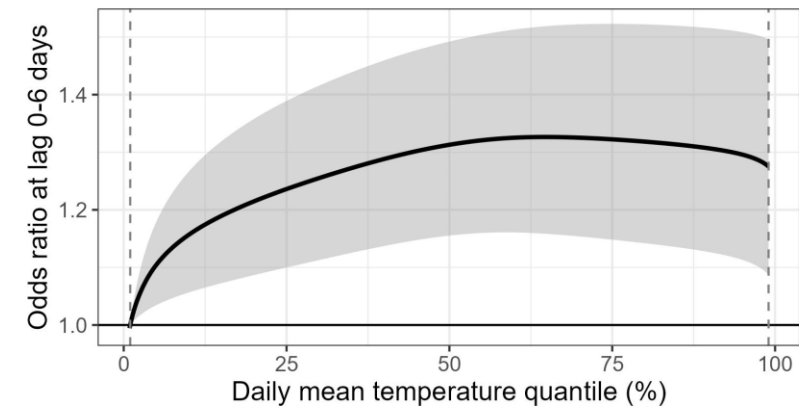**Daymet** 1 km x 1 km gridded daily temperature data

Temperature (°C)
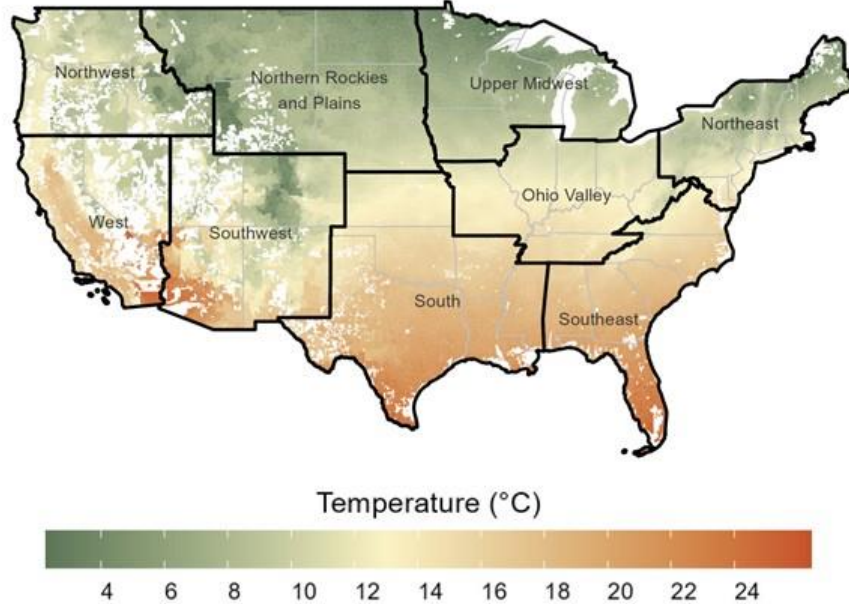
Data linkage
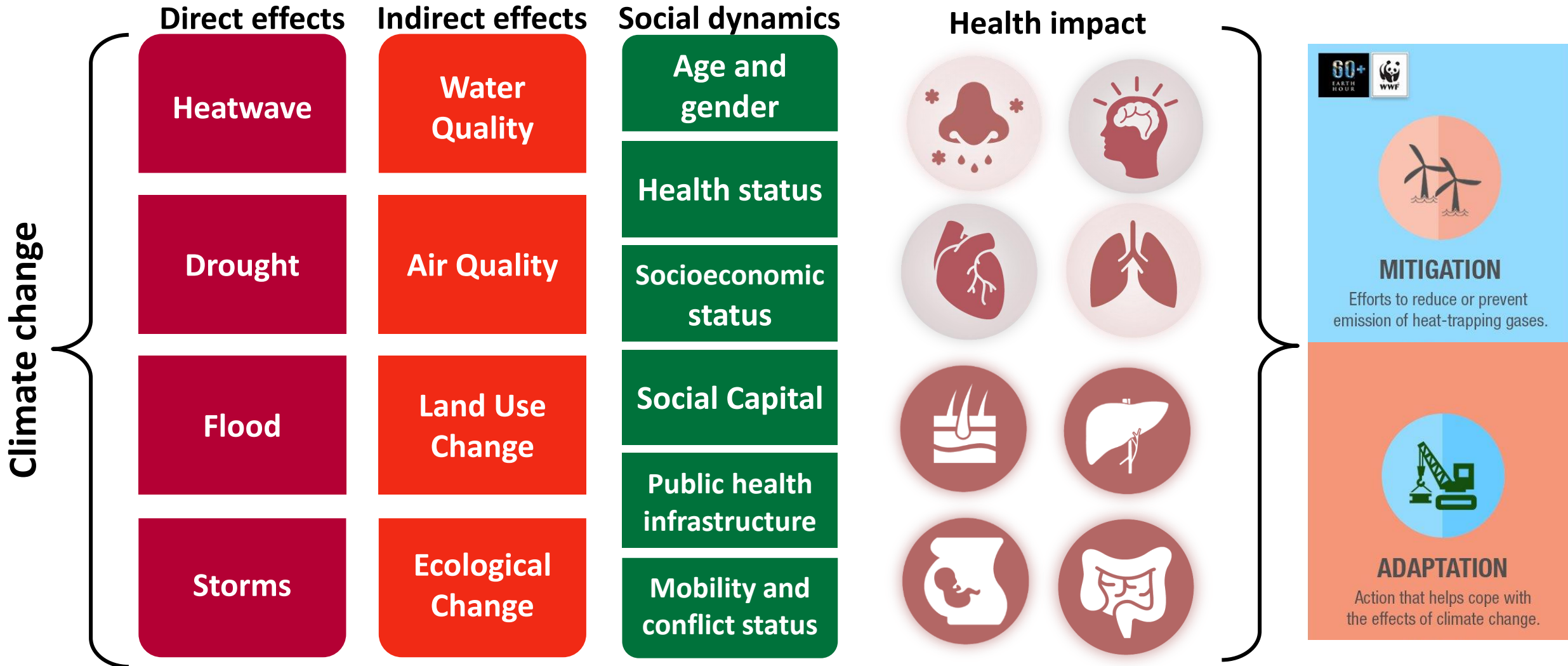

Exposure-response function

Two-stage model
Stage 1: Climate-region-specific models
Stage 2: Meta-analysis

- **Chu** et al, *JACC. In press.*

Summary: Climate changes health and _epidemiology_ plays a central role in studying climate-health linkages

Climate change

Direct effects
- Heatwave
- Drought
- Flood
- Storms

Indirect effects
- Water Quality
- Air Quality
- Land Use Change
- Ecological Change

Social dynamics
- Age and gender
- Health status
- Socioeconomic status
- Social Capital
- Public health infrastructure
- Mobility and conflict status

Health impact

MITIGATION
Efforts to reduce or prevent emission of heat-trapping gases.

ADAPTATION
Action that helps cope with the effects of climate change.

Thank you! 谢谢！ Danke!