Climate Change, Extreme Heat, and Health in West Africa

Sciences économiques et sociales de la santé & traitement de l'information médicale
Aix-Marseille University
April 28, 2026

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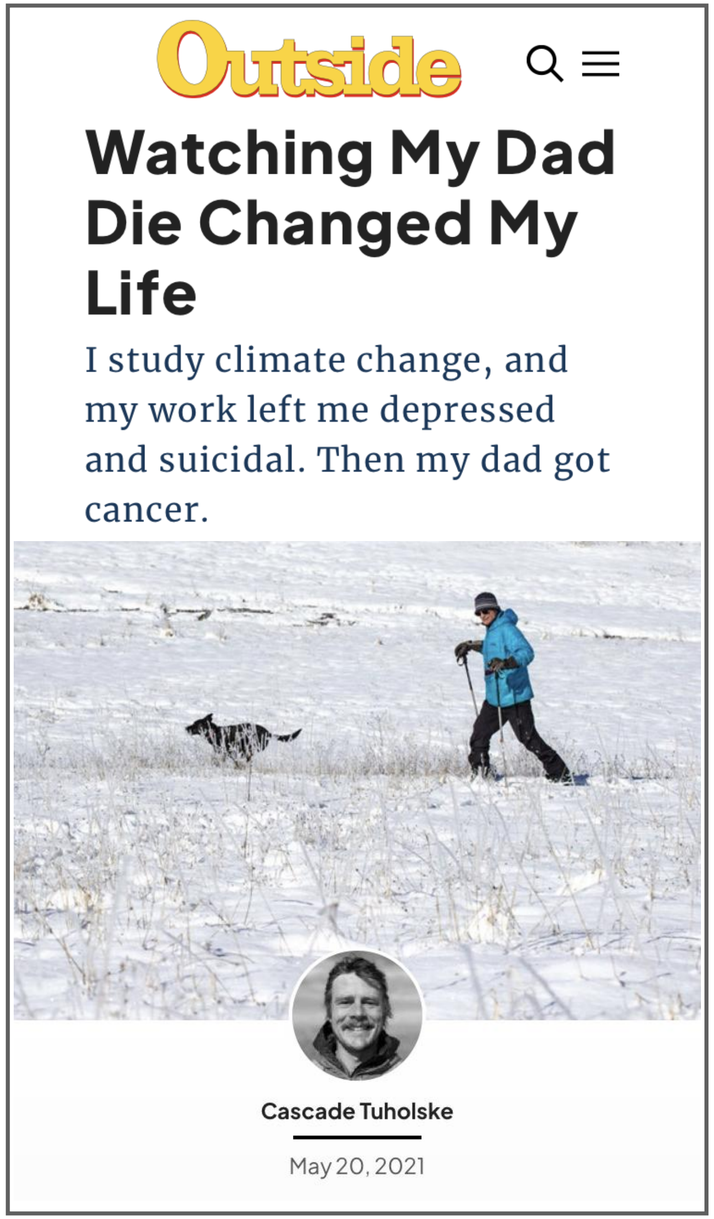
Dept. of Earth Sciences, Montana State University

Plan for Today

- Who I am & What I do (briefly)
- Fundamental Research Questions
- Extreme Heat Research Examples
- Current Wellcome Trust Projects in Ghana
- New “Heat Extremes & Risk Observatory – Ghana (HERO-GH)” at AMU

Who I am

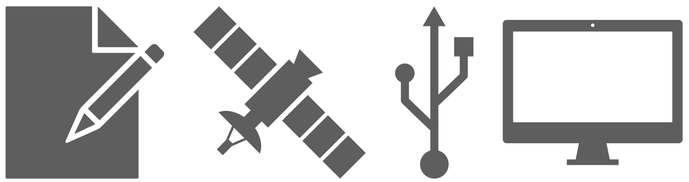
- I like to ski … and surf … and bike.
- Climate change lifelong existential crises
- BA International Affairs (2010),
  The George Washington University
- PhD (2020) + MA (2016) Geography,
  University of California, Santa Barbara.
- Postdoc Research Fellow (2020-2022),
  Earth Institute, Columbia University
- Assistant Professor (2022 - present),
  Montana State University



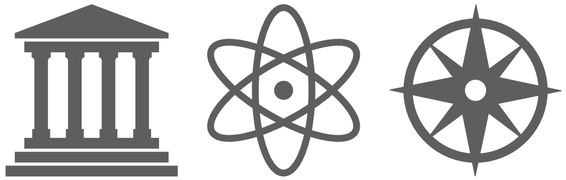
What I do

Human-Environment Geographer

Climate change impacts on human health, food security, and demographics



Household survey data collection; machine learning analysis of remote-sensed imagery; geo-statistical algorithms on high-performance computers



Foster international & interdisciplinary collaborations; inform policy; engage public and media

Core Questions:

1. Where is exposure to climate extremes – like heat waves – worsening?
2. How does land-cover and land-use change (LCLUC) modify the impacts of heat waves?
3. How does exposure to extreme heat impact human health and what interventions reduce harm?
4. How is climate change altering food systems/security, and in turn, affecting human mobility and demographic patterns?
5. What is the relationship between climate change and political instability?

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Heat Impacts On Human Health

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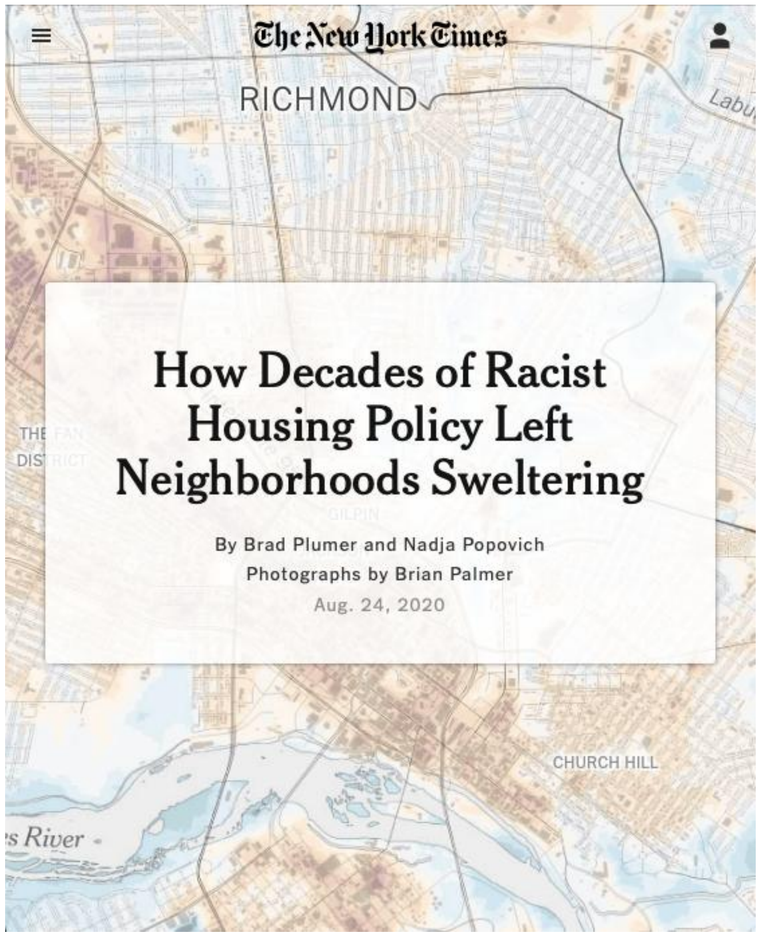
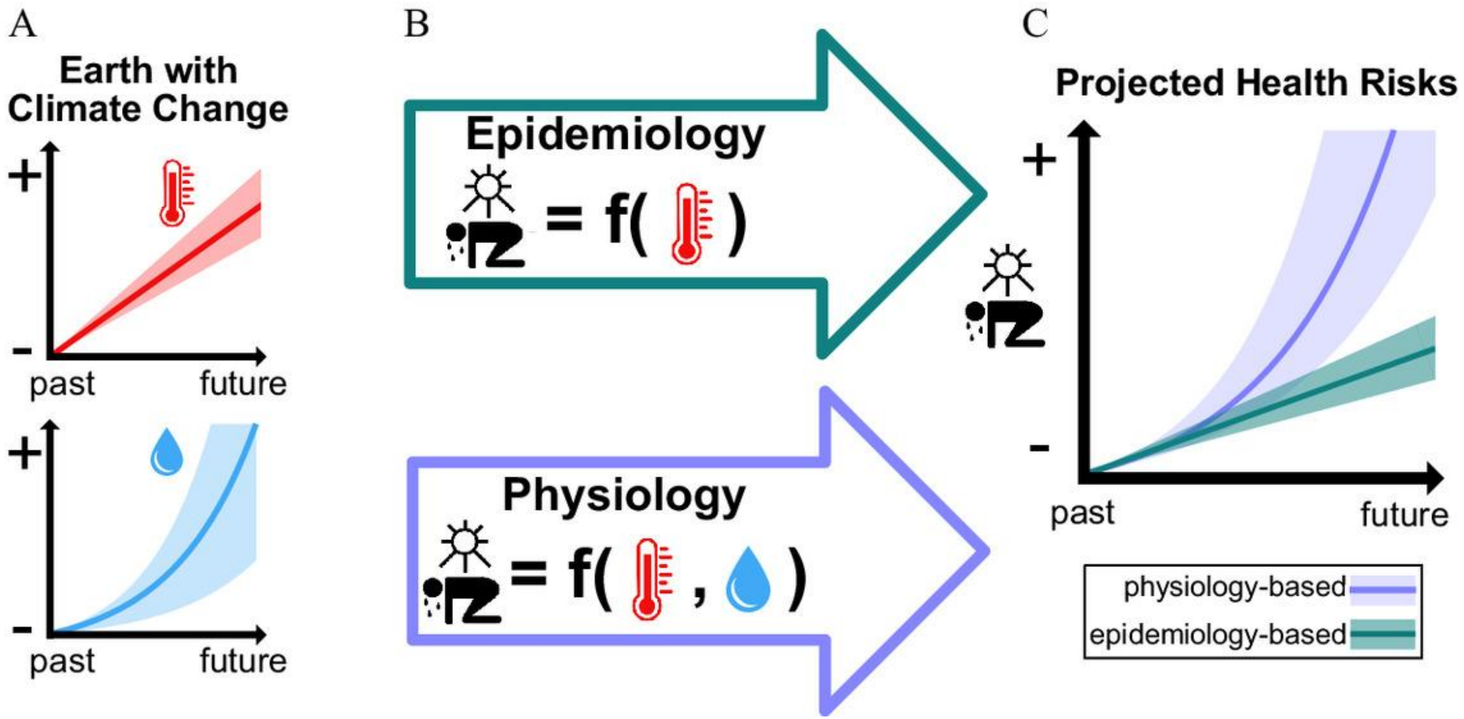
Environment ▸ Climate crisis Wildlife Energy Pollution Green light
Extreme heat
Schools close and crops wither as 'historic' heatwave hits south-east Asia
Governments across region grappling for response as temperatures soar to unseasonable highs
Children play in portable pools, a project from the local government, to beat the heat in Manila, Philippines. Photograph: Noel Celis/AFP/Getty Images
Rebecca Ratcliffe South-east Asia correspondent
Thu 4 Apr 2024 06.02 EDT

EUROPE
npr
Heat waves in Europe killed more than 61,600 people last summer, a study estimates
JULY 12, 2023 · 11:39 AM ET
By Rachel Treisman
A girl refills her bottle with water from the "Fontana della Barcaccia" fountain in Rome in during the heat wave of July 2022.
Andreas Solaro/AFP via Getty Images



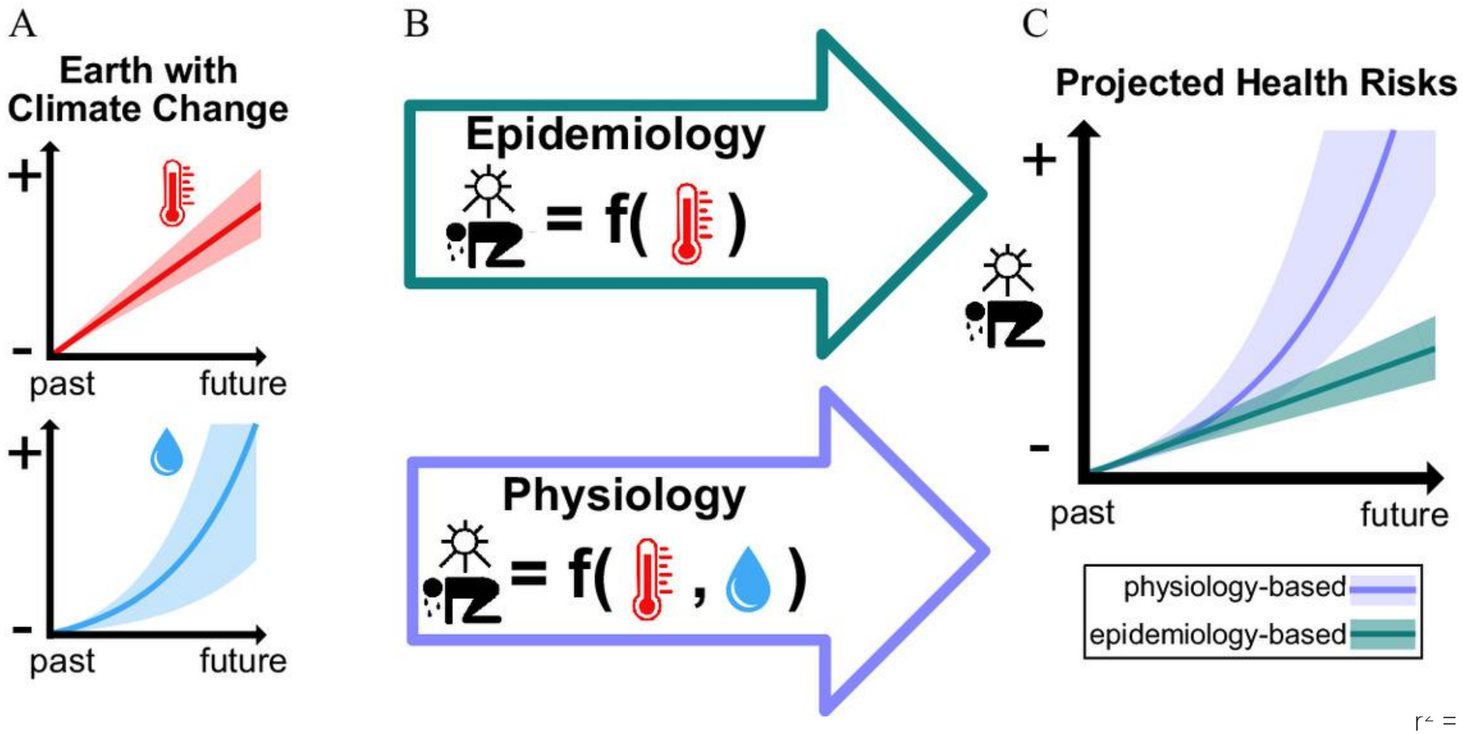
The New York Times
RICHMOND
How Decades of Racist Housing Policy Left Neighborhoods Sweltering
By Brad Plumer and Nadja Popovich
Photographs by Brian Palmer
Aug. 24, 2020
CHURCH HILL

Heat Impacts On Human Health

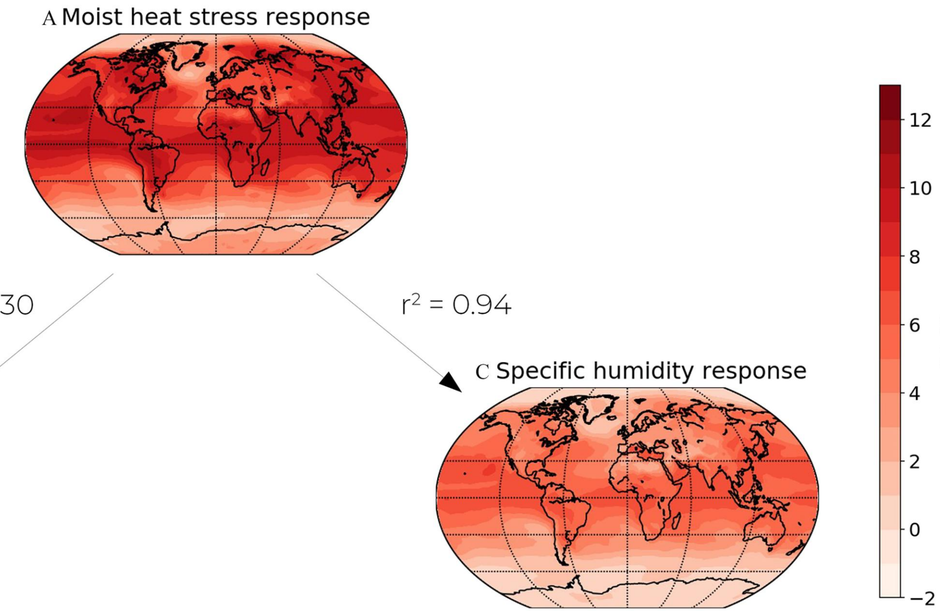


Source: Baldwin *et al.* 2023

Heat Impacts On Human Health



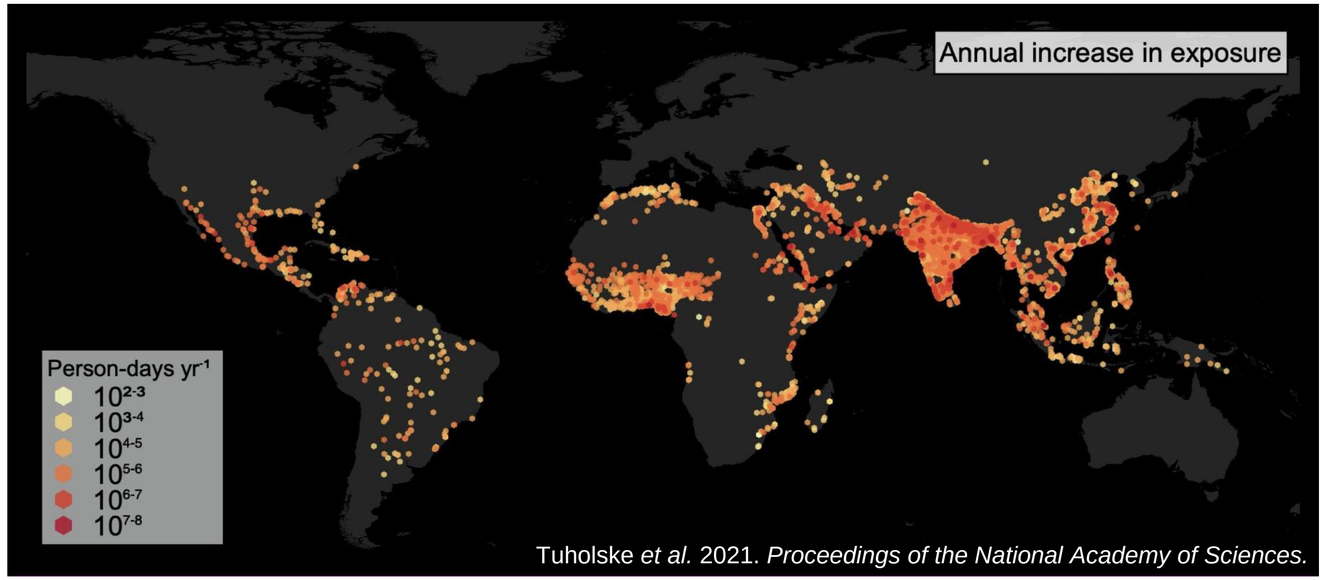
The relationship between moisture and temperature is really important for climate projections due to **exponential scaling of humid-heat.**



Source: Baldwin *et al.* 2023

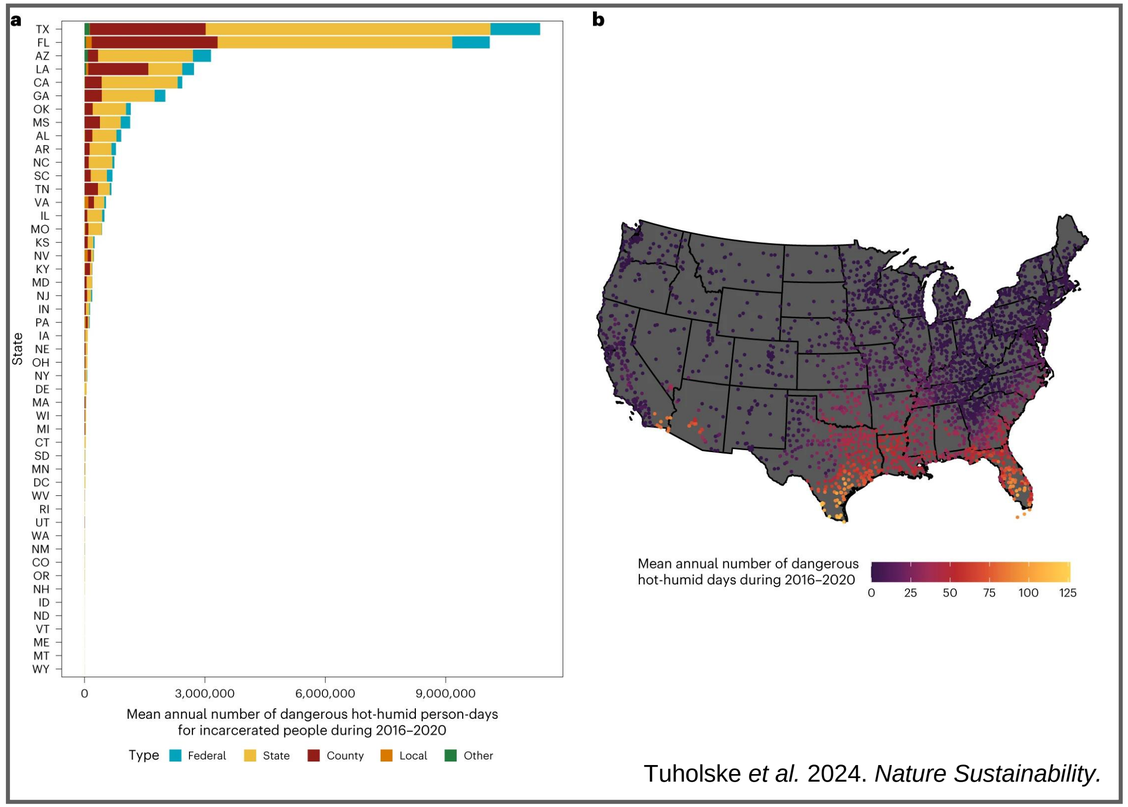
Measuring Changes in Heat Exposure

Global Urban Extreme Heat Exposure



Global urban extreme heat exposure increased 200% during 1983 - 2016, but city-level patterns are highly spatially heterogeneous.

U.S. Prison Extreme Heat Exposure



Nearly 1 million people (45% of total) live in U.S. prisons where dangerous heat increased during 1982-2020. Texas and Florida are hotspots of concern.

Heat Impacts On Human Health

Science

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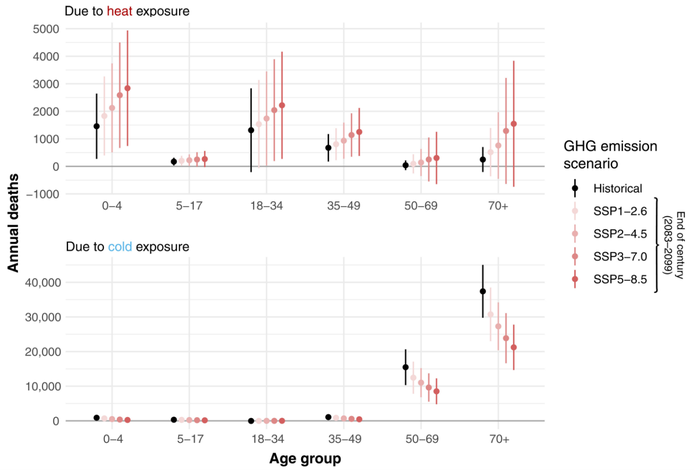
HOME > SCIENCE ADVANCES > VOL. 10, NO. 49 > HEAT DISPROPORTIONATELY KILLS YOUNG PEOPLE:...

RESEARCH ARTICLE | ENVIRONMENTAL STUDIES

Heat disproportionately kills young people: Evidence from wet-bulb temperature in Mexico

ANDREW J. WILSON, R. DANIEL BRESSLER, CATHERINE IVANOVICH, CASCADE TUHOLSKE, COLIN RAYMOND, RADLEY M. HORTON, ADAM SOBEL, PATRICK KINNEY, TEREZA CAVAZOS, AND JEFFREY G. SHRADER fewer Authors Info & Affiliations

SCIENCE ADVANCES • 6 Dec 2024 • Vol 10, Issue 49 • DOI: 10.1126/sciadv.adq3367



ELSEVIER

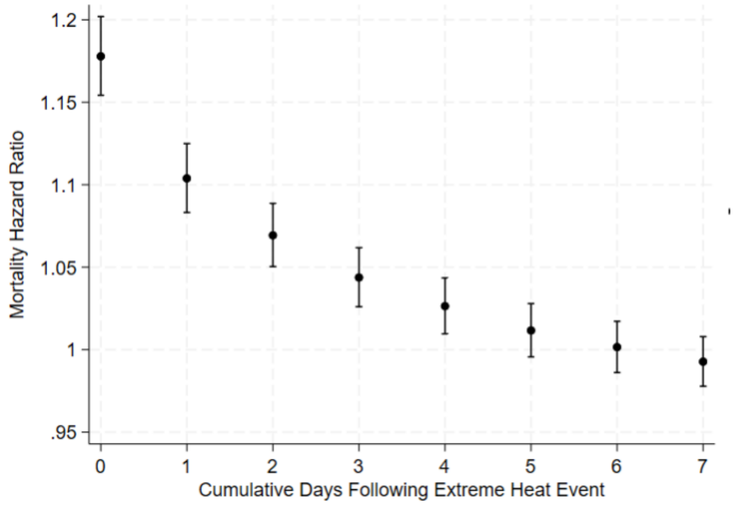
American Journal of Kidney Diseases

Volume 84, Issue 5, November 2024, Pages 582-592.e1

Original Investigation

Extreme Humid-Heat Exposure and Mortality Among Patients Receiving Dialysis

Matthew F. Blum [2], Yijing Feng [3], Cascade P. Tuholske [4 5], Byoungjun Kim [6], Mara A. McAdams DeMarco [6], Brad C. Astor [1 2], Morgan E. Grams [7]



ELSEVIER

Environmental Research

Volume 266, 1 February 2025, 120557

Prenatal exposure to heat and humidity and infant birth size in Ghana

Aalekhya Reddam [a], Mohammed Nuhu Mujtaba [b], Cascade Tuholske [c d], Seyram Kaali [b], Kenneth Ayuurebobi Ae-Ngibise [b], Blair J. Wylie [a e], Danielle N. Medgyesi [a], Ellen Boamah-Kaali [b], Andrea A. Baccarelli [a], Oscar Agyei [b], Steve N. Chillrud [f], Kwaku Poku Asante [b], Darby W. Jack [a], Alison G. Lee [g 1], Sulemana Watara Abubakari [b 1]

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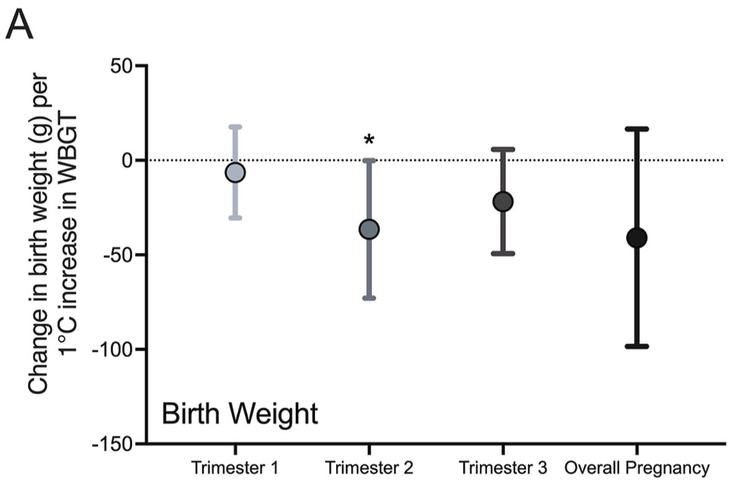
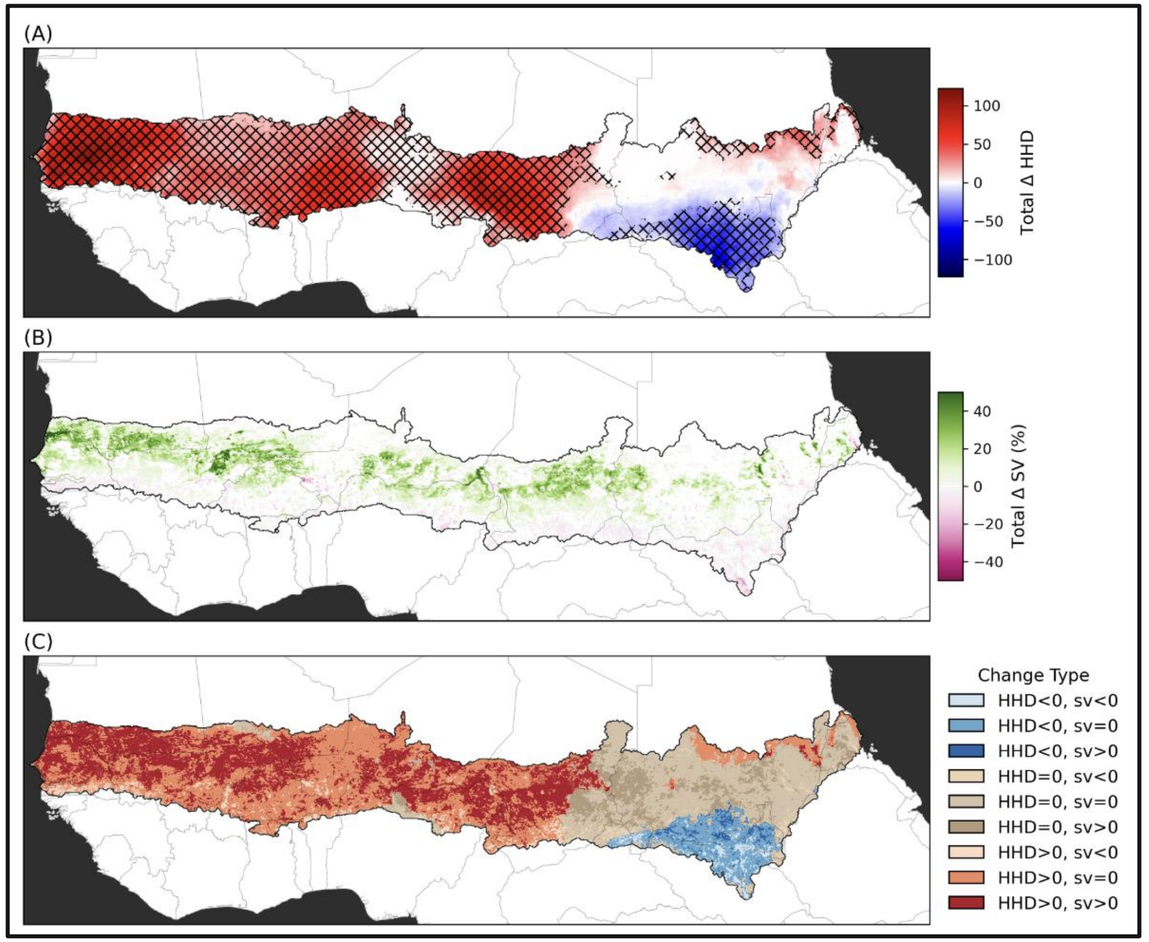


Co-PI (NASA)

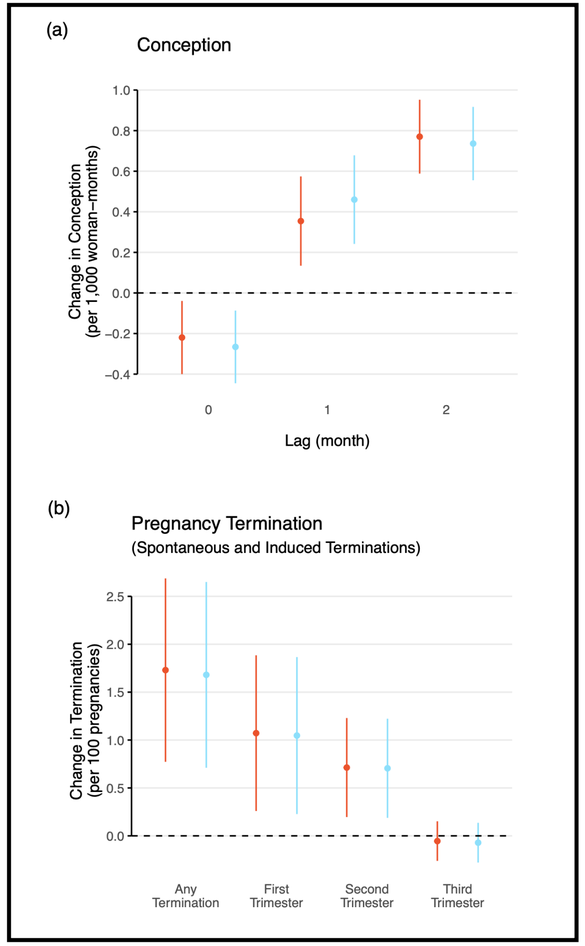
Heat, Land-Cover Land-Use Change, & Health in Sub-Saharan Africa

Increasing humid-heat extremes in Africa's Great Green Wall.



Tuholske *et al.* In Prep.

Humid-heat shifts conceptions and increases pregnancy termination risks in Nigeria



Brooks, Tuholske, *et al*. In Press.
Proceedings of the National Academy of Sciences

Current Project 1

Building a climate cohort to monitor health impacts of climate change in Ghana

Co-Investigator Project Years 2024-2027

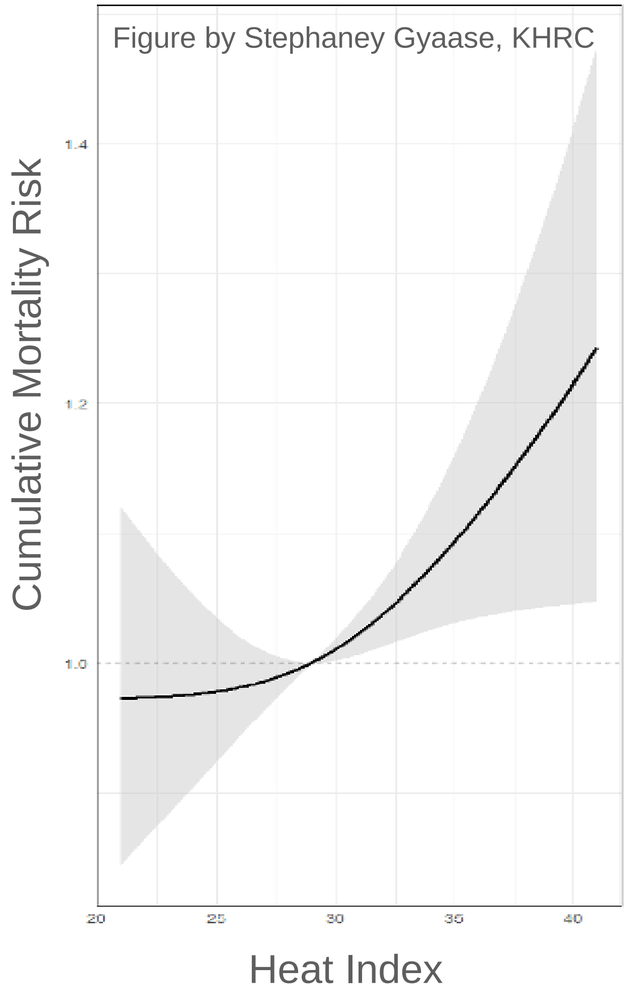
- Led by the **Kintampo Health Research Center**, with Columbia University and Mount Sinai Hospital
- Leverage large (>100,000) Health and Demographic Surveillance System (NHDSS) maternal mortality data
- Ghana Randomized Air Pollution and Health Study (GRAPHS) pregnancy cohort (1,500 participants)
- My responsibly: heat data development, assimilation, and use; lead
- Capacity building key component: Climate and health data science workshops

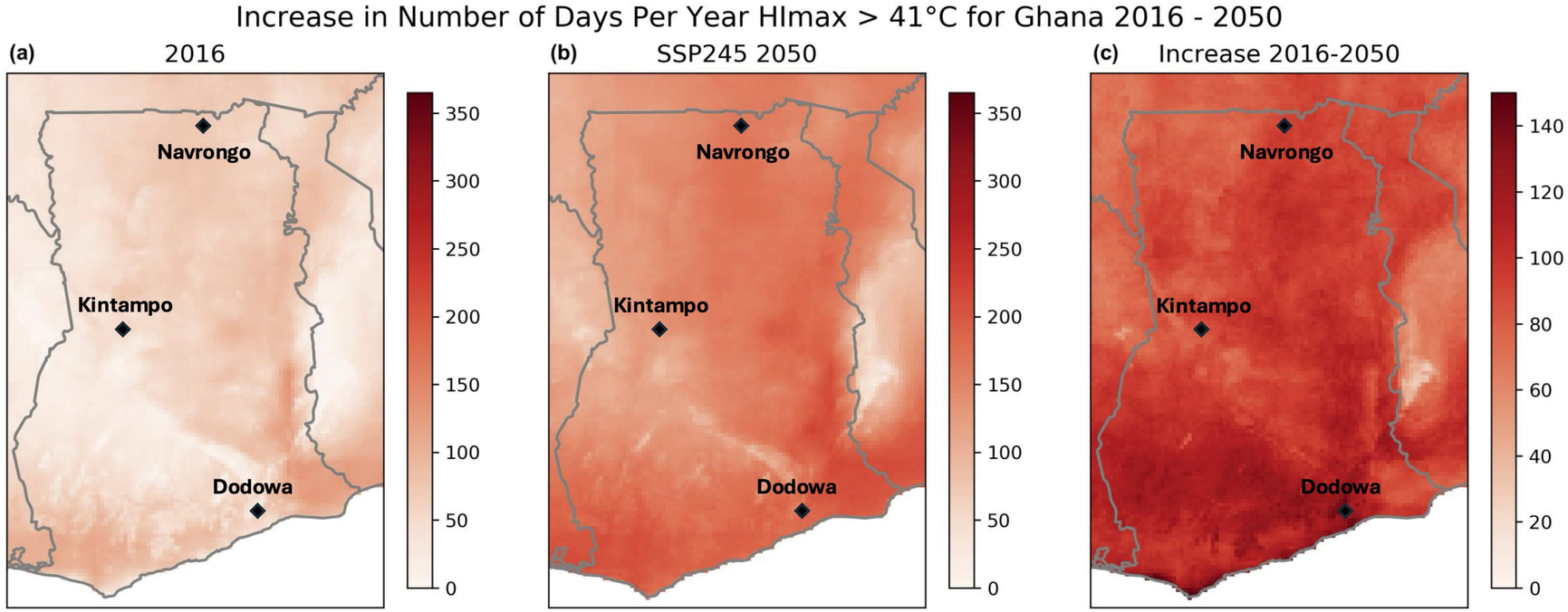
KINTAMPO HEALTH RESEARCH CENTRE
GHS-MOH
RESEARCH TO POLICY

wellcome

Funded By Wellcome

Current Project 1





Funded By Wellcome

Current Project 2

Investigating the pathways linking heat exposure to mental health outcomes: mechanisms and interventions in a Ghanaian cohort (HEAT-MIND)

Climate and Mental Health Award: Uncovering mechanisms between heat and mental health ›

Year of award: **2025**

Dr Kenneth Ae-Ngibise
Kintampo Health Research Centre, Ghana

Dr Robbie Parks
The Trustees of Columbia University in the City of New York, United States

Prof Cascade Tuholske
Montana State University, United States

Dr Alison Lee
Icahn School of Medicine at Mount Sinai, United States

Funded By Wellcome

Current Project 2

Co-Investigator Project Years 2026-2030

- Work Package 1: Existing pregnancy cohort (GRAPHS) to test if heat exposure is associated with maternal stress and identify multiple plausible mechanistic mediators.

- Work Package 2: New pregnancy cohort to understand how biological, social and psychological mechanisms link prenatal heat exposure to maternal depression and anxiety and examine effect modification by other exposures

- Work Package 3: Pilot a heat warning system to reduce the impact of ambient heat on maternal mental health.

Investigating the pathways linking heat exposure to mental health outcomes: mechanisms and interventions in a Ghanaian cohort (HEAT-MIND)

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Montana State University, United States

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Icahn School of Medicine at Mount Sinai, United States

Funded By Wellcome

Heat Extremes & Risk Observatory – Ghana (HERO-GH)

- Partner with Kintampo Health Research Center (KHRC)
- Project Years 2026-2029
- Work Packages (WP) aims are to:

1. Understand heat exposure varies across micro-climates over space and time
2. Test if land-cover adaptations – like cool roofs – can reduce heat exposure
3. Develop climate attribution workflows to understand how climate change direct impacts human health

HERO-GH WP 1

Micro-Climate Measurement & Climate Data Validation

- Deploy in-situ indoor/outdoor sensors in houses, schools, clinics, fields, and shops

- Compare heat stress: dry-air temperature, heat index, wet bulb temperature, wet-bulb globe temperature

- Estimate variation in micro-climate exposure diurnally and seasonally

- Validate climate reanalysis (e.g. ERA5, ERA5-Land, etc.) and weather forecasts (ECWMF & NOAA)

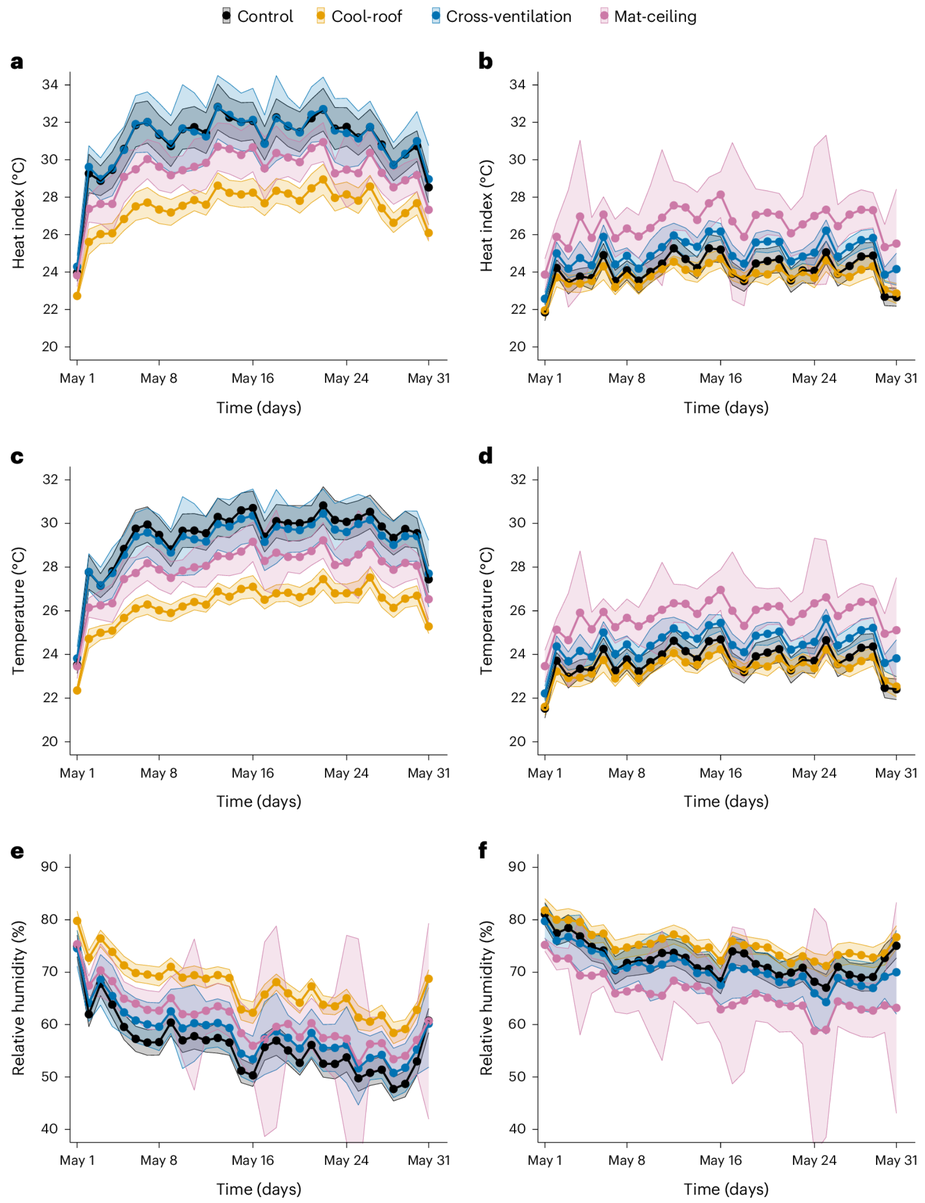
HERO-GH WP 2

Weather Research and Forecast (WRF) Modeling

- WRF numerical models that resolve 4-dimension physical processes to predict weather over a given region.

- WRF simulations test how vegetation, building density, and surface albedo modify hazardous heat.

- Inform which land-cover and land-use change (LCLUC) climate adaptations are most effective at reducing harm from heat exposure.

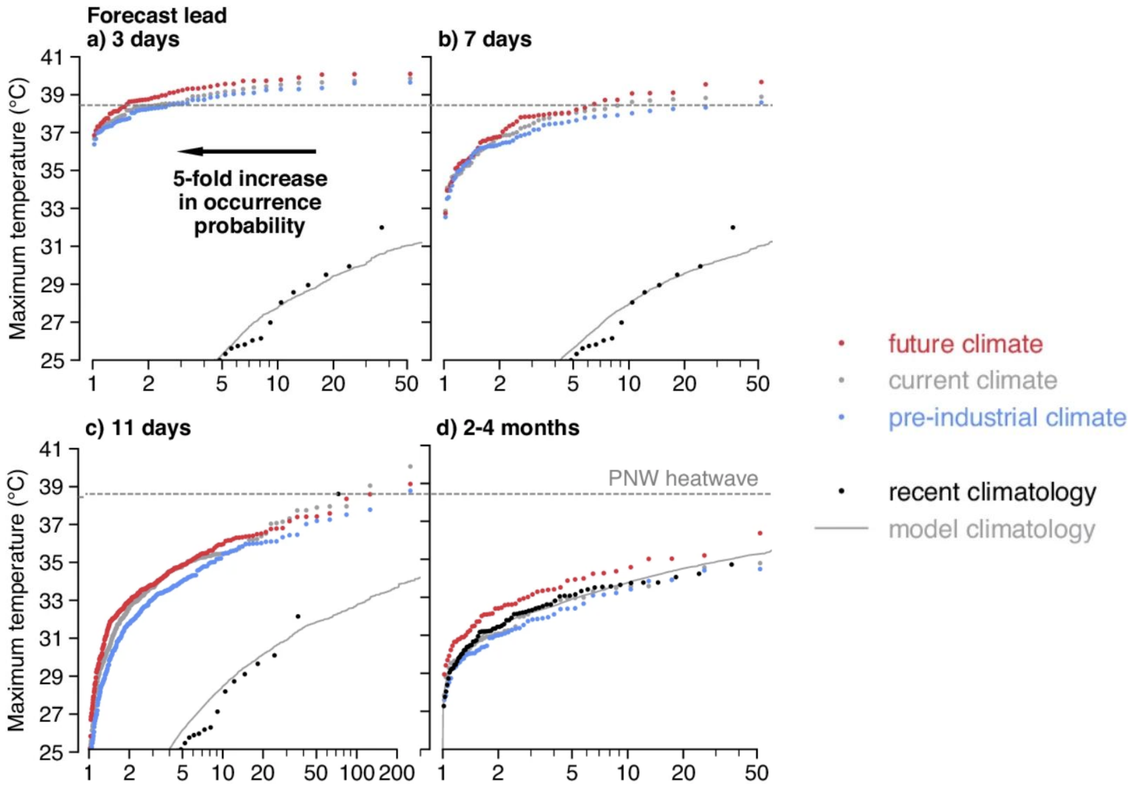


Source: Abong'o *et al*. 2026. *Nature Medicine*

HERO-GH WP 3

Climate Attribution for Health Analysis

- Use ERA5 data to identify most extreme (e.g. 99.99th percentile) heat waves the since 1950.
- Identify relevant meteorological variables for initial conditions for WRF model simulations at 4-day, 7-day, and 10-day forecast lead times.
- Counter factual simulations with effects of climate change removed using CMIP6.
- Develop infrastructure for rapid climate attribution for heat waves in Ghana.



Source: Leach *et al*. 2024. *Nature Communications*

Synergies with AMU

With SESSTIM:

- QuanTIM research team: Axis 1 and Axis 2
- ERC MOSAIC - geospatial data assimilation
- Work with Santé publique France
- Teaching and graduate student mentorship

With LPED:

- CARDIMED - climate & geospatial analysis
- POMAF - potential quantitative predictions of mobility

With MESO CENTRE

- Weather and climate modeling
- geospatial analysis

With ISSPAM, ITEM, DÉPARTEMENT GÉOGRAPHIE, etc.

- Research collaborations
- Undergraduate research opportunities
- PhD student mentorship
- Master's teaching
- Summer School
- Workshops

Merci beaucoup!

Questions?