RESEARCH ON TAP

Climate Change & Health: Understanding and Reducing Impacts

Wednesday, January 26, 2022

bu.edu/research/events

BOSTON UNIVERSITY

Boston University Office of Research

Agenda

- Welcome Remarks
- Presentations
  - Gregory A. Wellenius
  - Amruta Nori-Sarma
  - Amelia Wesselink
  - Jonathan Jay
  - M. Patricia Fabian
  - Lucy R. Hutyra
  - Pamela Templer
  - Ian Sue Wing
  - Arunima Krishna
  - Joshua Goodman
  - Peter Garik
  - Dennis Carlberg
- Q&A
- Closing Remarks

Welcome and Setting the Stage

Gregory A. Wellenius

Professor of Environmental Health
Director, BU Program in Climate and Health

The message about climate change is simple ….

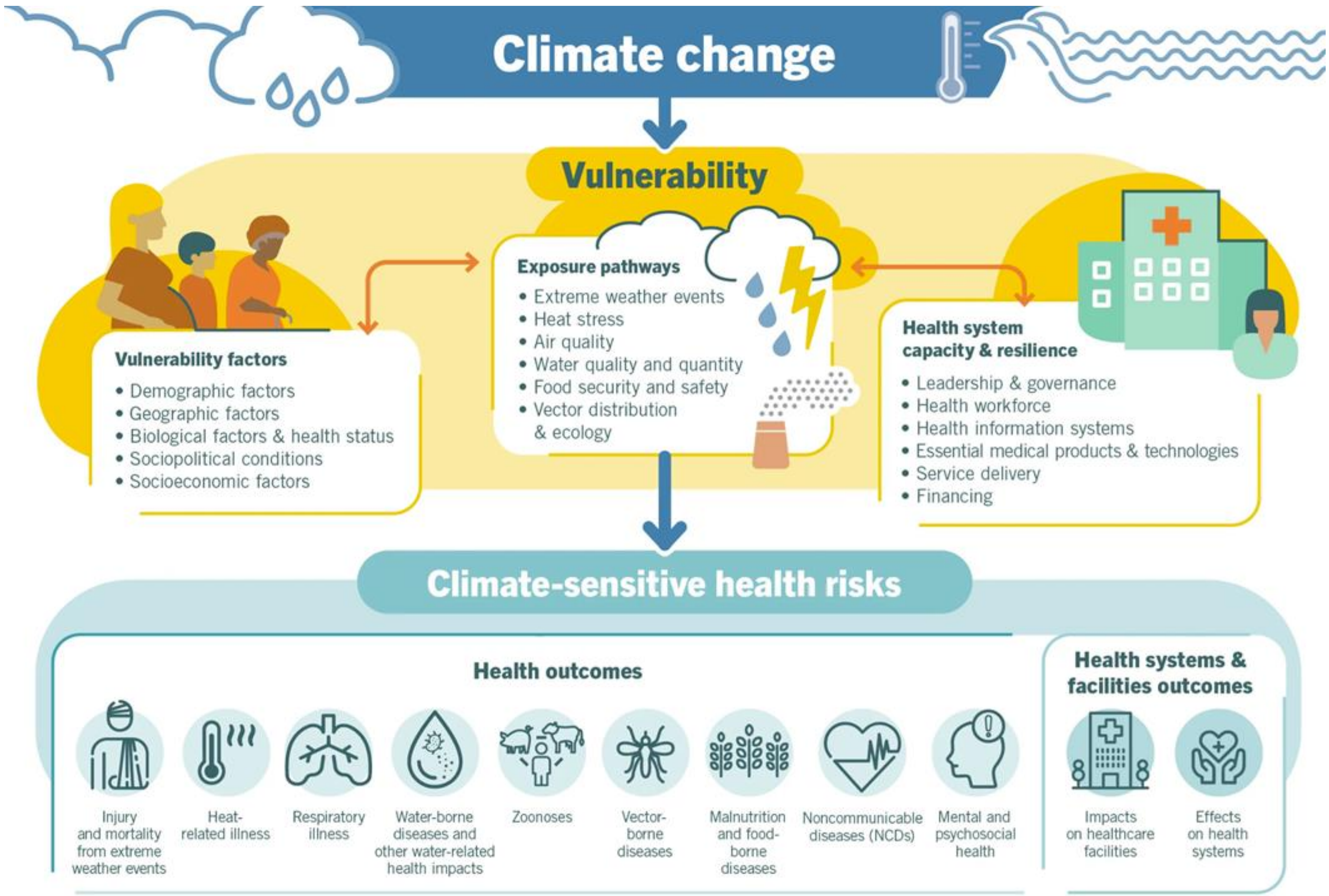
- It’s real
- It’s us (caused by humans)
- Experts agree
- It’s bad
- There’s hope (it’s solvable)

*Dr. Ed Maibach

The message about climate change is simple ….

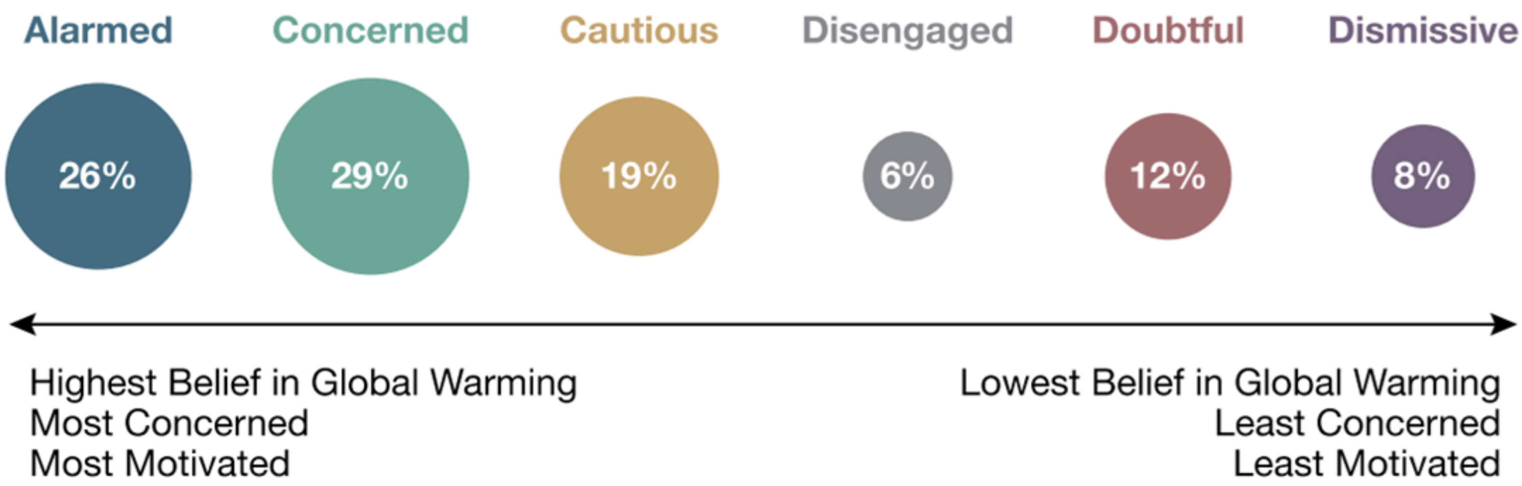
- It's real: 73%
- It's us (caused by humans): 60%
- Experts agree: 57%
- It's bad: 42 - 73%
- There's hope (it's solvable)

*Yale Program on Climate Change Communication


Climate change
Vulnerability
Vulnerability factors
• Demographic factors
• Geographic factors
• Biological factors & health status
• Sociopolitical conditions
• Socioeconomic factors
Exposure pathways
• Extreme weather events
• Heat stress
• Air quality
• Water quality and quantity
• Food security and safety
• Vector distribution & ecology
Health system capacity & resilience
• Leadership & governance
• Health workforce
• Health information systems
• Essential medical products & technologies
• Service delivery
• Financing
Climate-sensitive health risks
Health outcomes
Injury and mortality from extreme weather events
Heat-related illness
Respiratory illness
Water-borne diseases and other water-related health impacts
Zoonoses
Vector-borne diseases
Malnutrition and food-borne diseases
Noncommunicable diseases (NCDs)
Mental and psychosocial health
Health systems & facilities outcomes
Impacts on healthcare facilities
Effects on health systems

WHO, 2021

Global Warming's Six Americas
December 2020



December 2020 ($n = 1{,}036$)

YALE PROGRAM ON Climate Change Communication

GEORGE MASON UNIVERSITY CENTER *for* CLIMATE CHANGE COMMUNICATION

Goals for Today

- Recognize climate change as a threat to our health and wellbeing
- Celebrate BU as a global leader in this space
  - Disciplinary excellence on cross-disciplinary teams
  - Think. Teach. Do.
- Build even more collaborations
- Work together for change

Presenters

- Amruta Nori-Sarma
  Environmental Health
- Amelia Wesselink
  Epidemiology
- Jonathan Jay
  Community Health Sciences
- M. Patricia Fabian
  Environmental Health
- Lucy R. Hutyra
  Earth & Environment
- Pamela Templer
  Biology
- Ian Sue Wing
  Earth & Environment
- Arunima Krishna
  Public Relations
- Joshua Goodman
  Education, Economics
- Peter Garik
  Science Education
- Dennis Carlberg
  VP for University Sustainability

Climate Change Impacts on Health and Wellbeing in Vulnerable Communities

Amruta Nori-Sarma

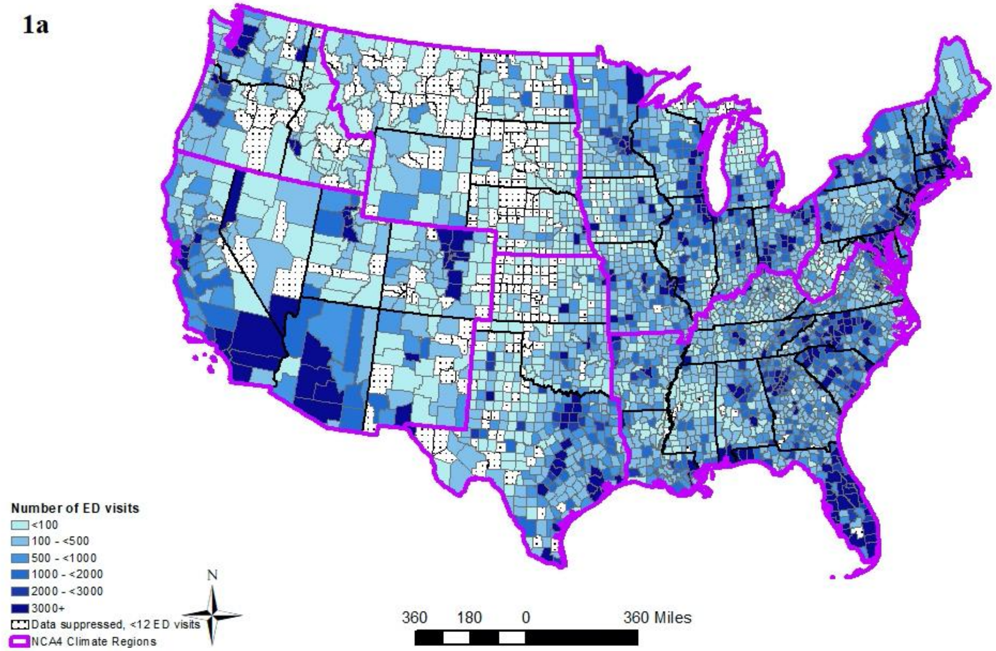
Assistant Professor
Environmental Health, SPH

Climate and Mental Health

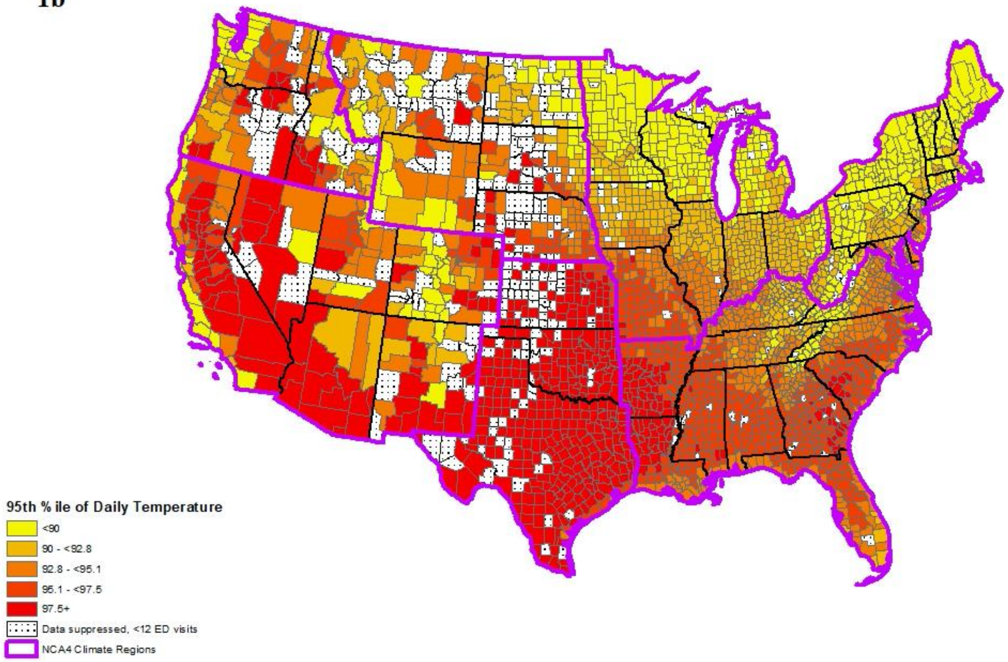
- Much is known about the physical impacts of climate change (including increasing temperature impacts on health)
- Less is known about the impact of increasing temperatures and climate-related extremes on mental health and wellbeing
- Our recent research aims to understand the mental health impacts of increasing temperatures

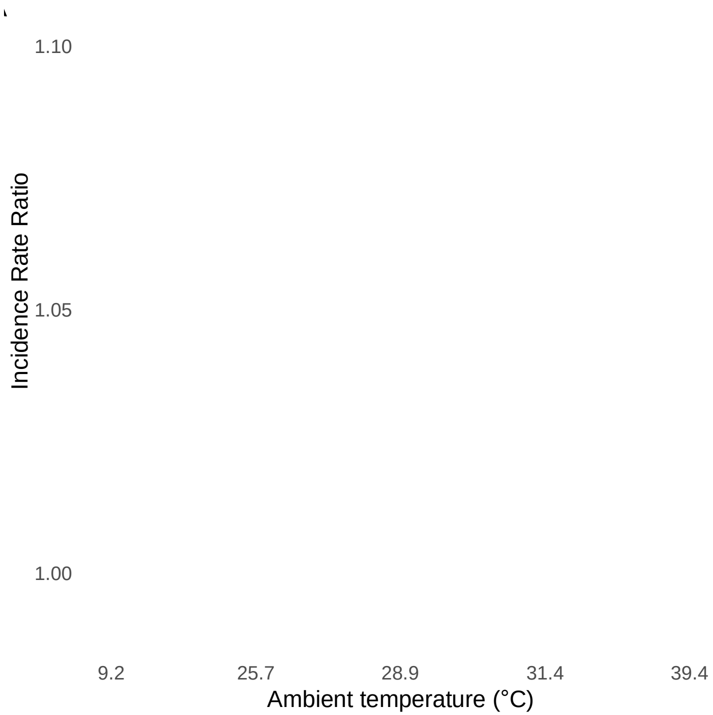
Maps of Contiguous US Showing County-Level Data on Number of Emergency Department (ED) Visits and Warm-Season Temperatures

1a



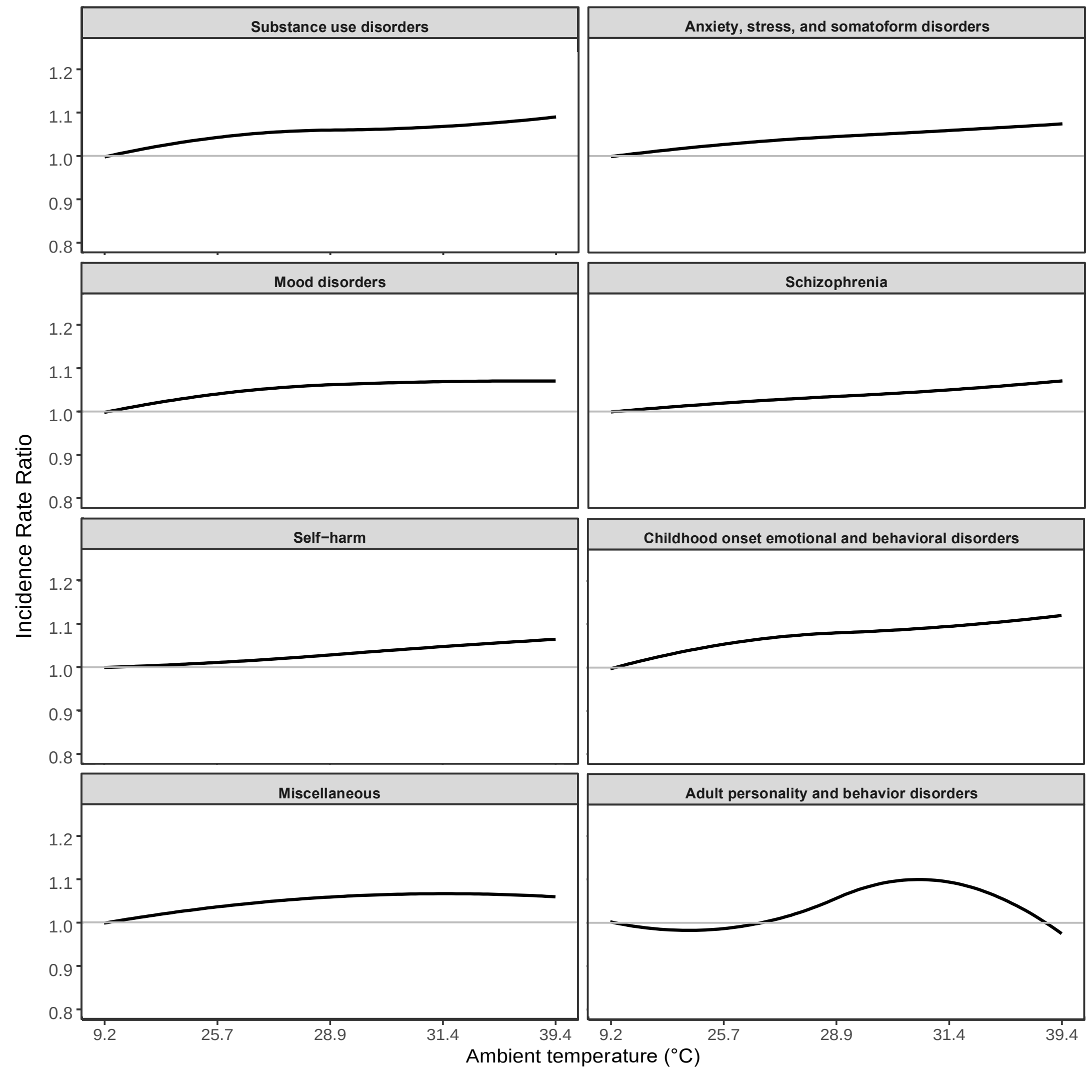
1b





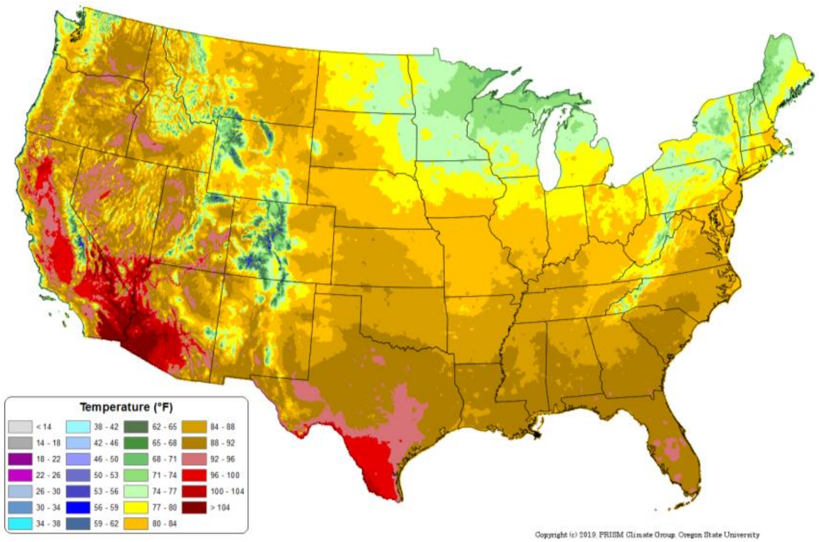
Cumulative Exposure-Response Curve of the Association Between Warm-Season Temperatures and Emergency Department Visits for Any Mental Health Condition

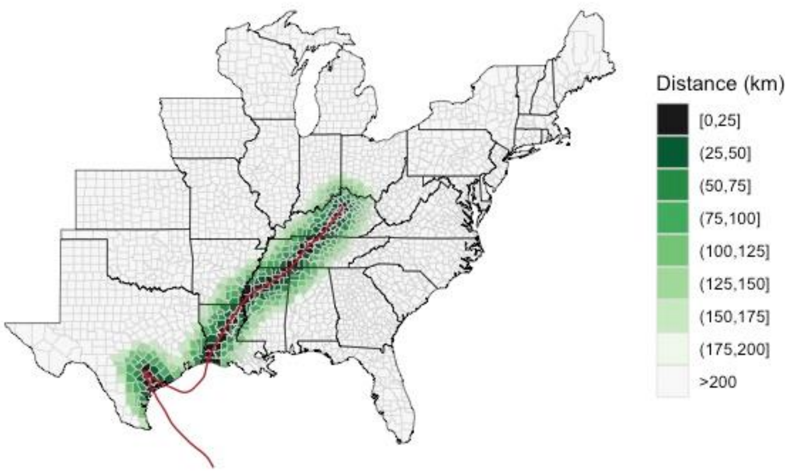
Cumulative Exposure-Response Curve of the Association Between Warm-Season Temperatures and Emergency Department Visits for Specific Mental Health Conditions



What's next

Average of Daily Maximum Temperature, August 2017 (PRISM Data)





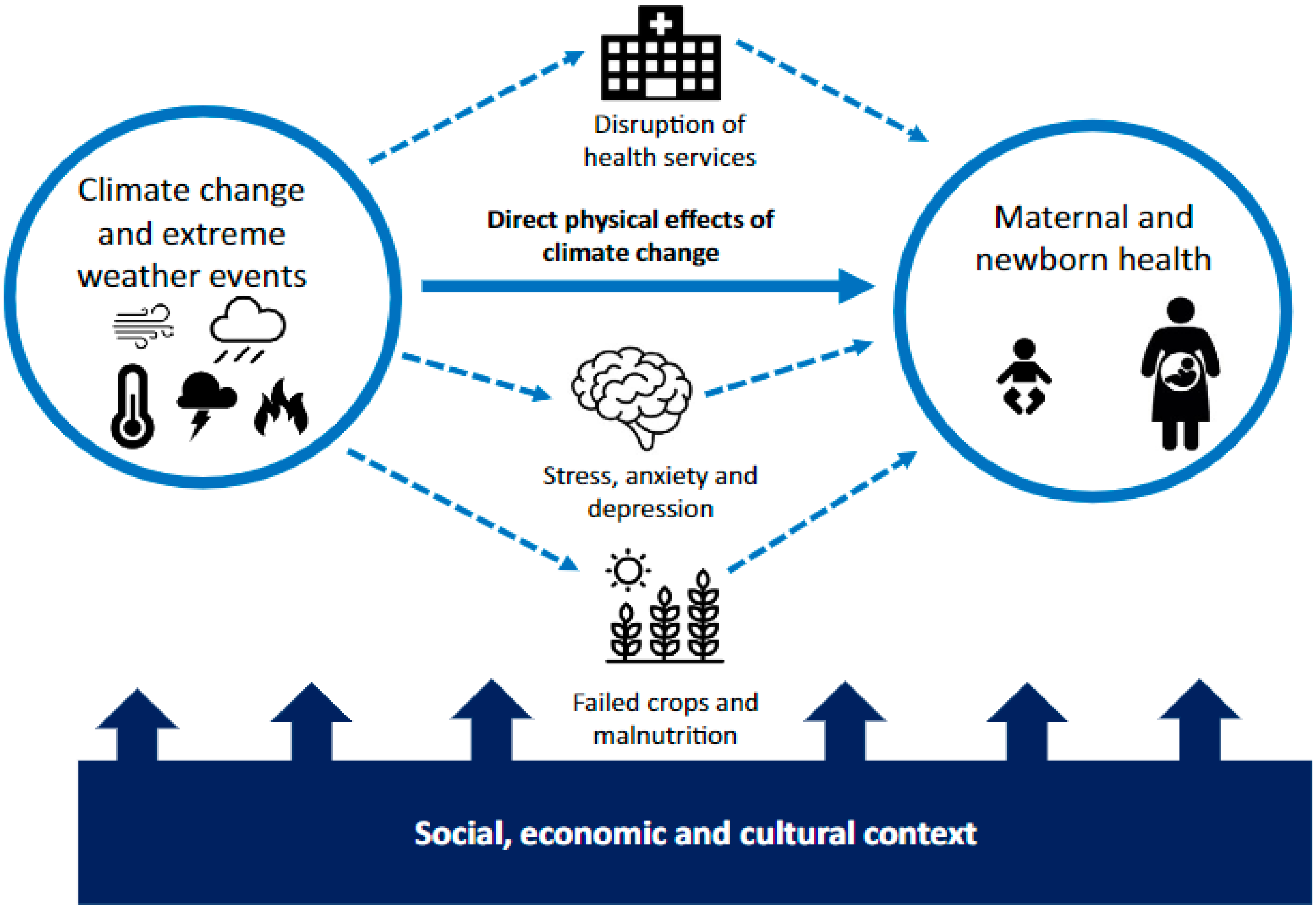
US Counties affected by Hurricane Harvey, Aug 2017 (R Hurricaneexposure package)

How is Climate Change Shaping Human Reproduction?

Amelia K. Wesselink

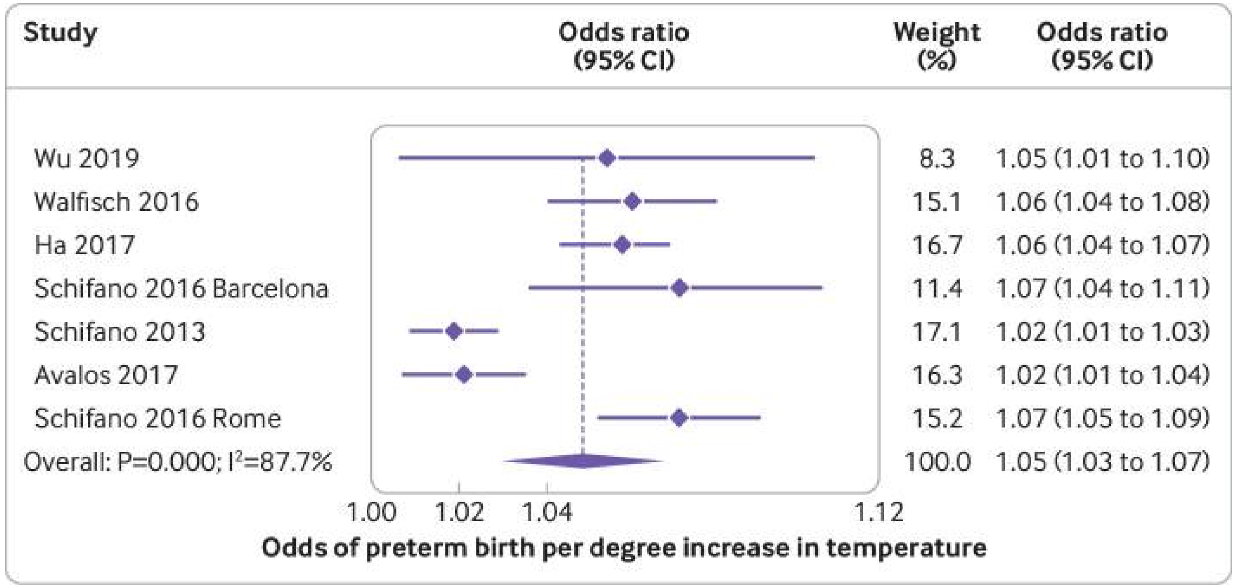
Research Assistant Professor
Department of Epidemiology
BU School of Public Health

Climate change and reproductive health



Roos et al. 2020 *Acta Obstet Gynecol Scand*

What do we know?



Note: Weights are from random effects analysis

Preconception	Pregnancy			Postpartum/early life	
Fertility	*Miscarriage*	*Adverse pregnancy conditions*	*PTB*	*Postpartum depression*	
	Birth defects		*LBW*		*Neonatal & pediatric health*
			Stillbirth		

BOSTON UNIVERSITY

Boston University Office of Research

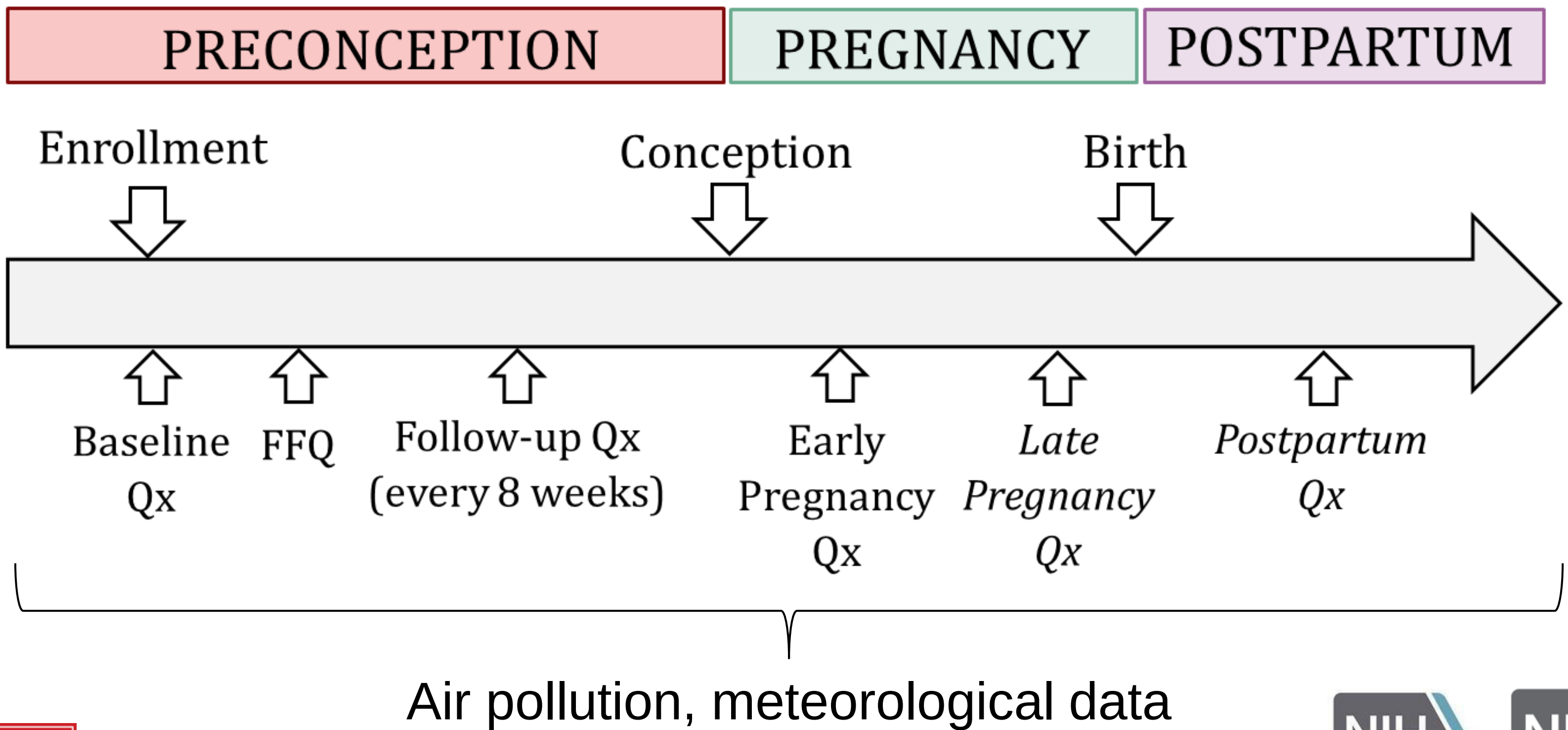
Chersich et al. 2020 *BMJ*

Internet-based TTP studies

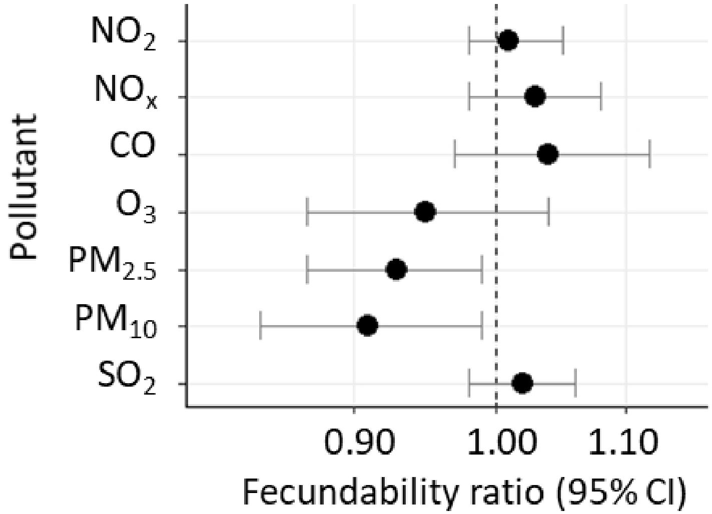
PRESTO
Boston University Pregnancy Study Online

Eligibility criteria:

- Age 21-45 years
- Resident of U.S., Canada, or Denmark
- Trying to conceive with fertility treatment

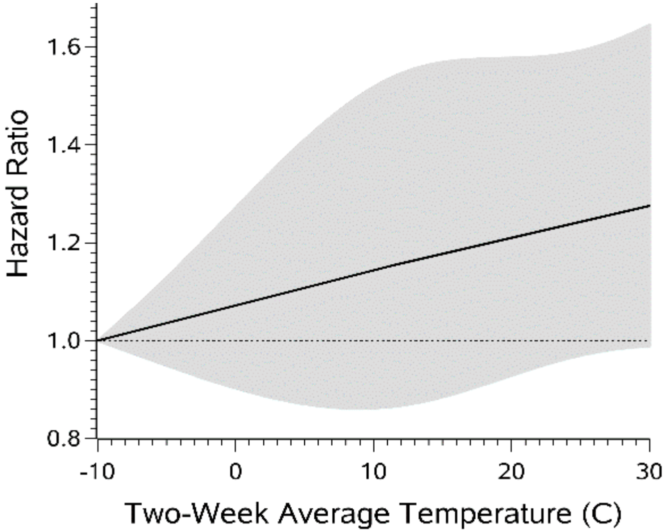


Air pollution, heat, and reproductive health



PM concentrations related to reduced fecundability in Denmark.

Wesselink et al. 2022 *Paediatr Perinat Epidemiol*



Higher temperatures related to increased miscarriage risk in US and Canada

Preliminary data

A pilot study of personal heat exposure among couples trying to conceive

BUSPH internal funding

Collaborators & Contact Information

- Boston University
  - Lauren A. Wise (PI: PRESTO)
  - Elizabeth E. Hatch (PI: SG/SF)
  - Tanran R. Wang
  - Mary D. Willis
  - Gregory A. Wellenius
  - Shengzhi Sun
- Aarhus University
  - Ellen M. Mikkelsen
  - Henrik Sorensen
  - Matthias Ketzel
- University of Washington
  - Joel D. Kaufman
  - Adam A. Szpiro
- Oregon State University
  - Perry Hystad
- Tufts University
  - Kipruto Kirwa

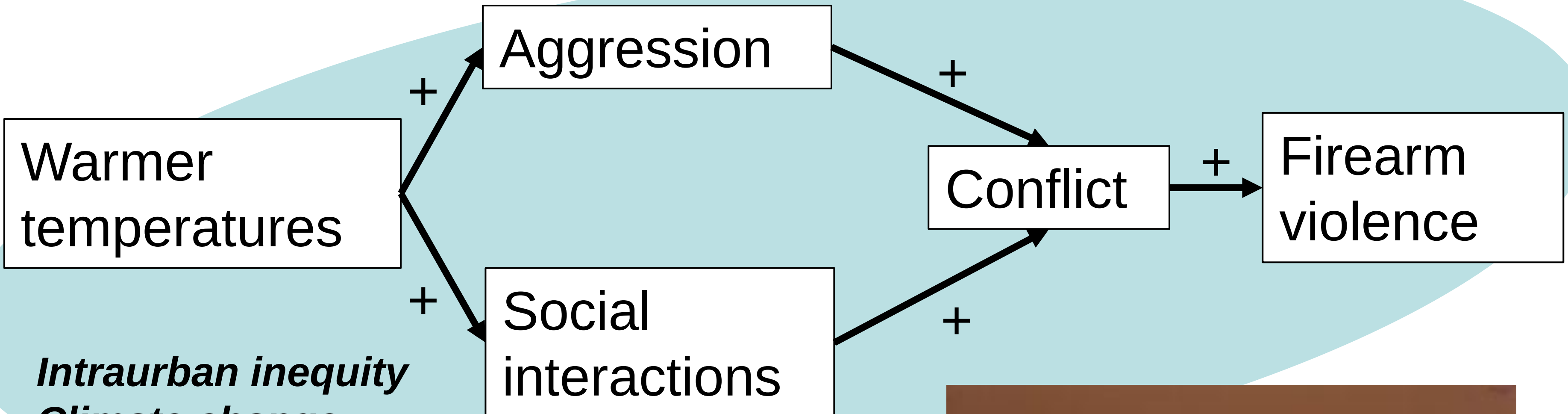
Contact me:
akw23@bu.edu
@AKWesselink

Daily Temperature and Firearm Violence: A Time Series Analysis from 100 U.S. Cities, 2015-2020

Jonathan Jay

Assistant Professor
Department of Community Health Sciences, SPH

Heat and firearm violence



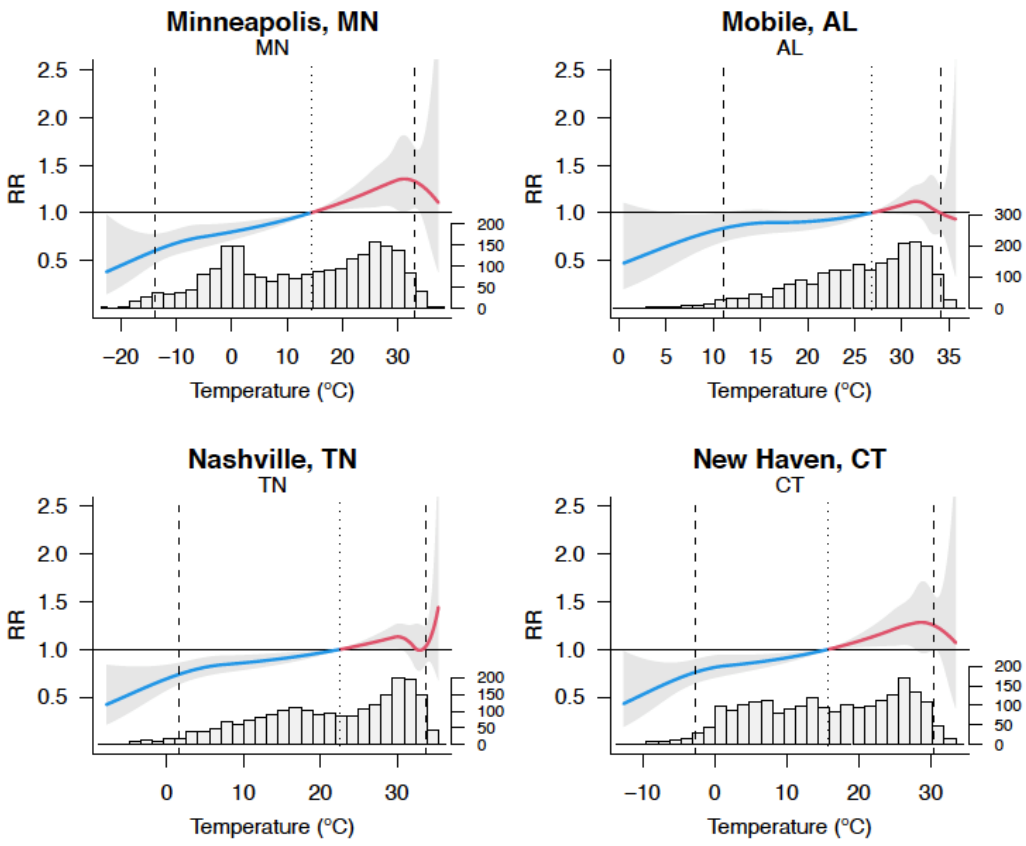
- ***Intraurban inequity***
- ***Climate change***

Work in progress (Lyons et al)

- **Design**: time series
- **Setting**: 100 U.S. cities with most firearm violence incidents (2015-2020)
- **Exposures**: daily maximum temperature by city [NLDAS-2]
- **Outcomes**: daily firearm violence incident count [Gun Violence Archive]
- **Covariates**: day of week
- **Models**: Distributed lag non-linear model (DLNM) with meta-regression

Results (provisional)

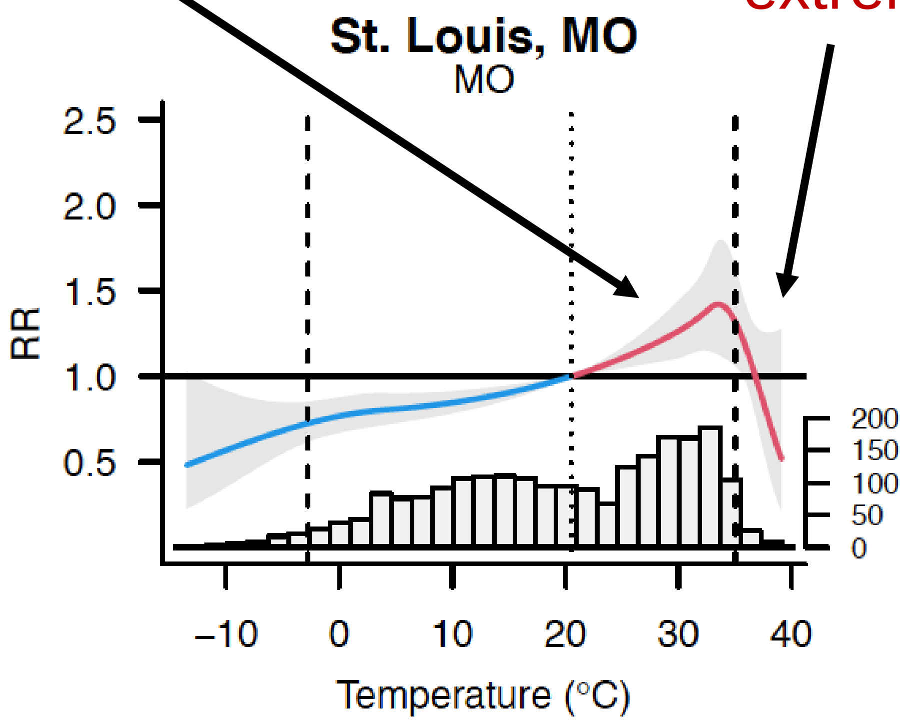
- In city-level analyses, heat-GV relationship holds across varying urban settings
- In pooled analyses, **attributable risk fraction** for heat days was 7.01% (5.96, 7.57)



Unpacking non-linear (?) associations

GV risk increase as temperature increases

Steep drop (?) at extreme heat levels



Authors:
Vivian Lyons (UW)
Emma Gause (UW)
Keith Spangler (BU)
Greg Wellenius (BU)
Jonathan Jay (BU)

Climate Adaptation and Mitigation Interventions in the Built Environment

M. Patricia Fabian

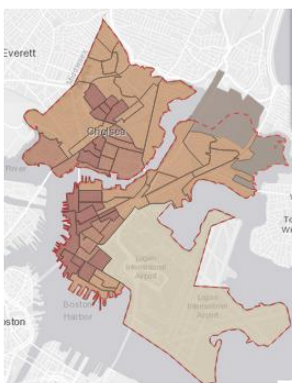
Associate Professor

Department of Environmental Health, School of Public Health

Optimizing climate adaptation and mitigation interventions and extreme heat in vulnerable communities

Community heat event in Chelsea, MA

Temperature & biometric sampling



Heat vulnerability index

Greenness (NDVI)

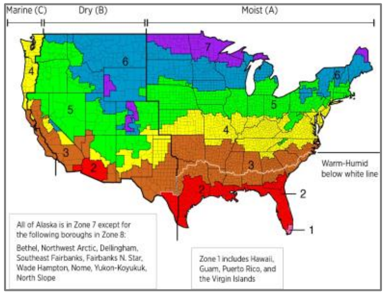
C-HEAT

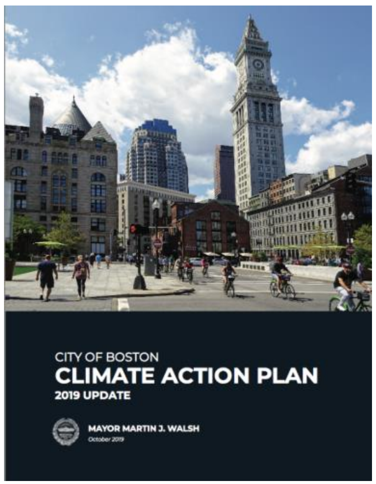
Madeleine Scammell
Associate Professor

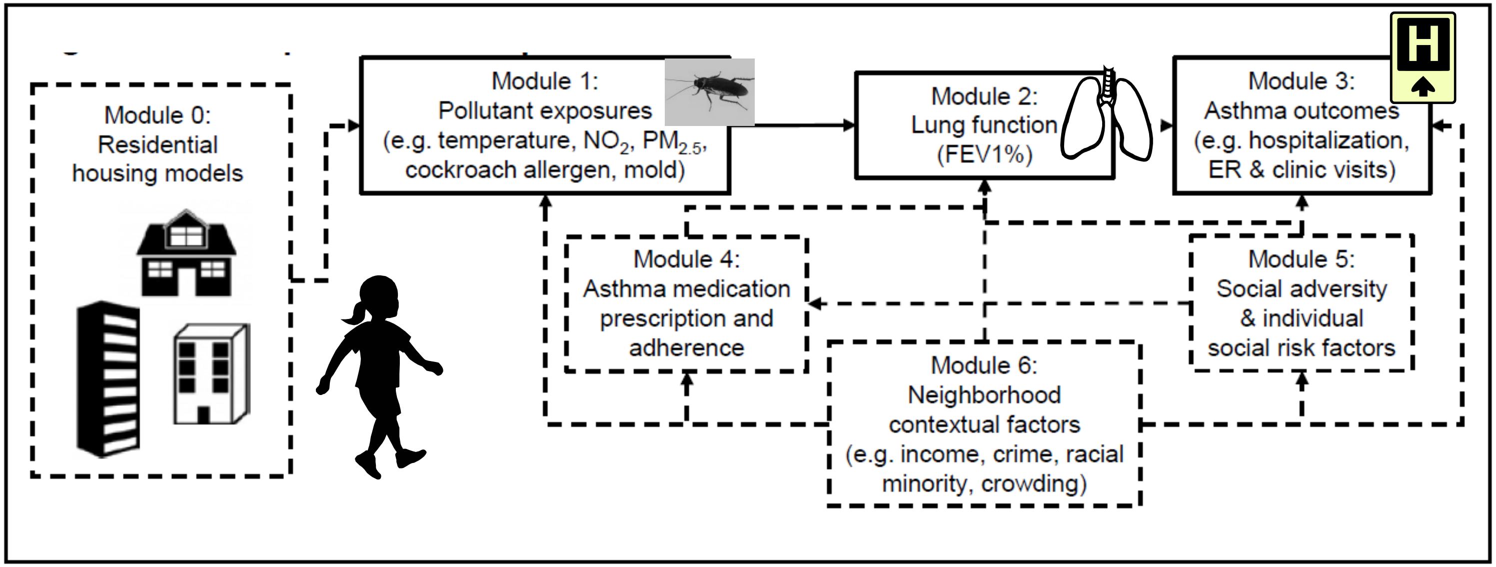
Researcher-Community-City collaboration to:

- Identify
  - Heat islands
  - Vulnerable neighborhoods
  - Built environment infrastructure
- Inform city investments in
  - White roofs
  - Greenspace
  - Pervious surfaces
- Support community resilience through
  - Park design
  - Engagement and education
  - Data for grants, reports & policies

The impact of climate, climate mitigation interventions, & resident behavior on health using systems science models







Quantifying tradeoffs between:

- Energy for heating or cooling
- Indoor comfort
- Indoor air quality (air pollution & Covid)
- Asthma exacerbations
- Healthcare utilization

ASTHMA
Asthma simulation tool for housing & medication adherence

Kate Connolly
PhD student

How Can We Better Manage the Urban Heat with (Re)Development Choices?

Lucy R. Hutyra

Professor of Earth & Environment
College of Arts & Sciences

BOSTON UNIVERSITY

Temperatures across cities are uneven. Land cover and land use determine the spatial variation in temperatures within cities.

We are working with the BPDA to explore redevelopment policies for tackling heat

boston planning & development agency

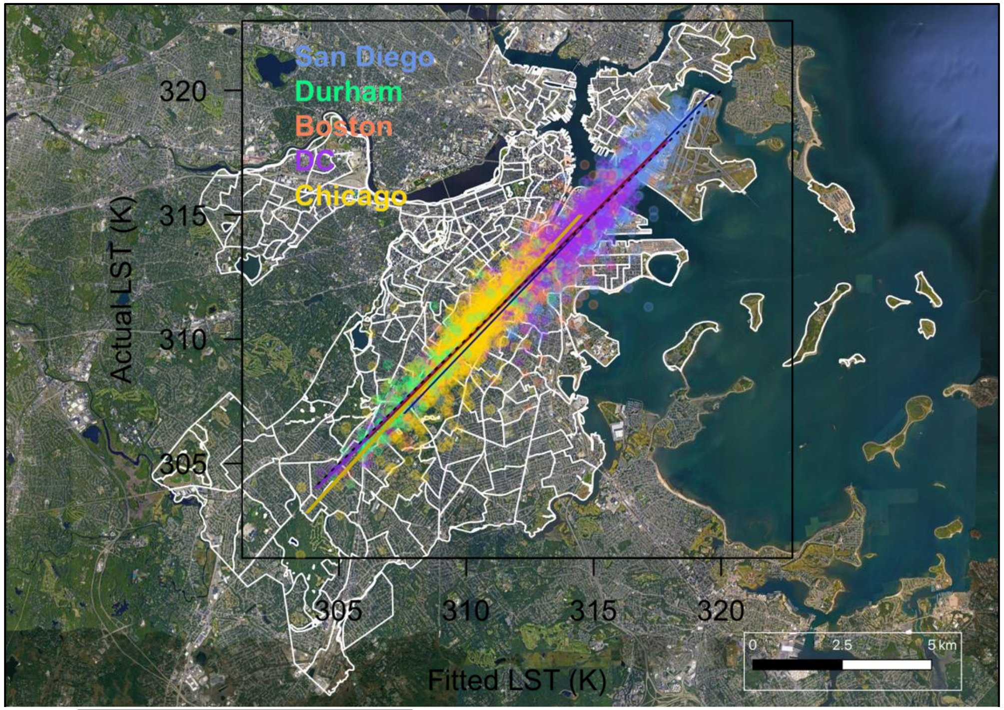
Land Surface Temperature

Canopy Cover

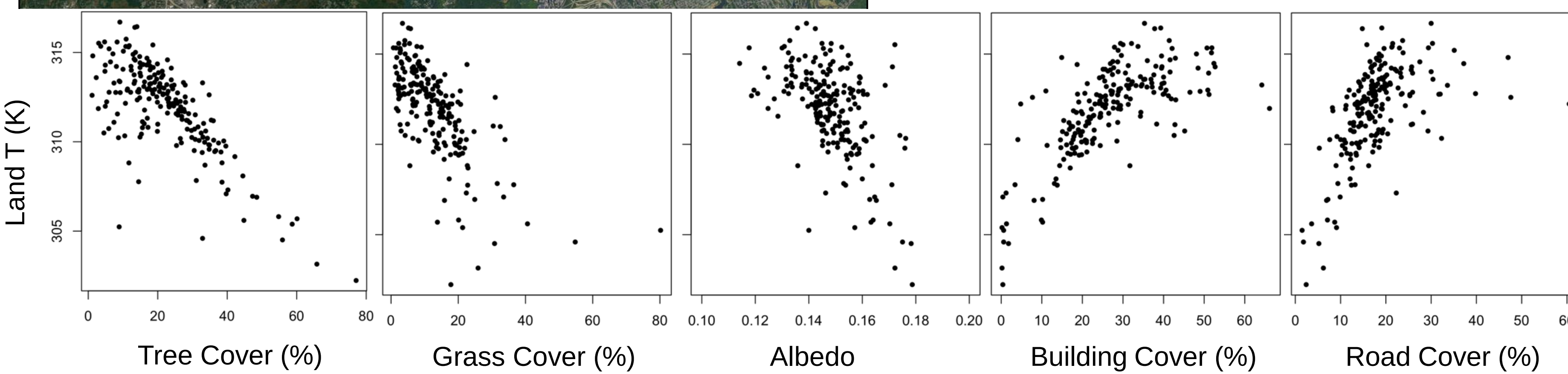
PREPARING FOR CLIMATE CHANGE

Climate Ready Boston is our initiative to get the City ready for the long-term impacts of climate change.

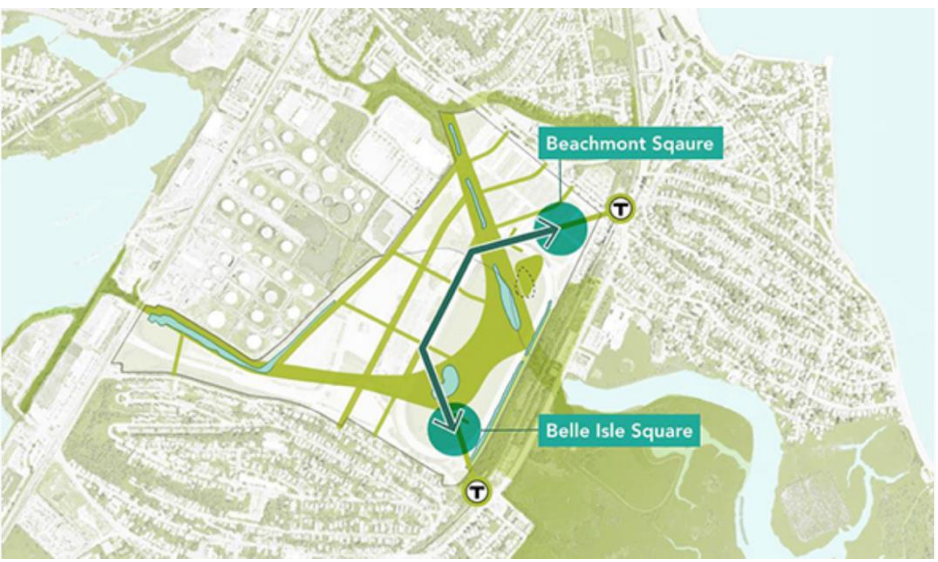
BOSTON UNIVERSITY



Building statistical models of how land characteristics affect temperatures at parcel and census block group scales



BOSTON UNIVERSITY



Census Tract: 59

Percent Tree Cover: 14.9

Percent Grass Cover: 34

Percent Road Cover: 7.7

Percent Building Cover: 4.1

Percent 'Other Paved' Cover: 38.3

Percent Bare Earth Cover: 0

Percent Water Cover: 1.1

Albedo: 0.16

Name	Value	
Tree	14.9	
Grass	34	→ 20%
Road	7.7	
Building	4.1	→ 36%
Other Paved	38.3	→ 20%
Bare Earth	0	
Water	1.1	
Albedo	0.16	→ 0.25

Estimated Mean Summertime LST: 309.04
Sum of LC %: 100

→ 310.4

→ 307.8

BOSTON UNIVERSITY

Multiple pathways to cool with landcover, bit it's not a one size fits all solution.

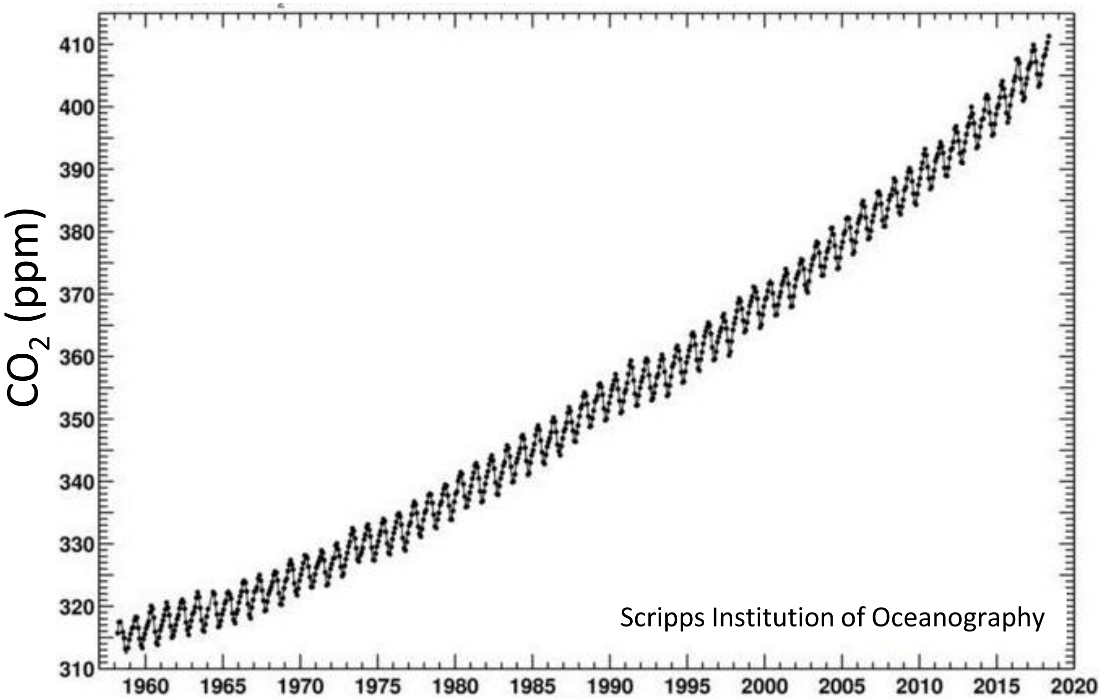
Albedo Before: 0.16
Albedo After: 0.19

Climate Change & Health: Understanding and Reducing Impacts Through Forest Ecosystems and Urban Trees

Pamela Templer

Professor
Department of Biology, CAS

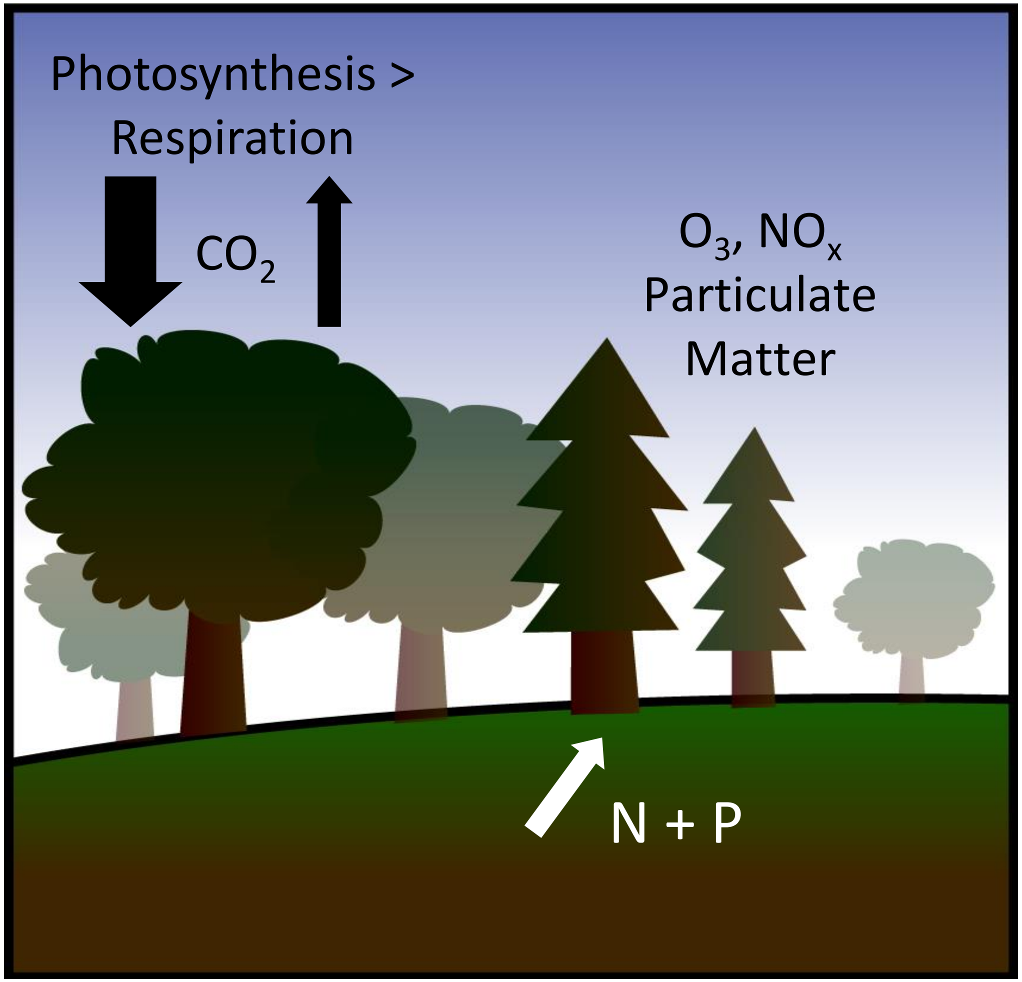
Rising CO_2 Concentrations and Climate Change



Leading to:

- Rising global temperatures
- Sea level rise, flooding, droughts, heat waves, wildfires, air pollution
- Reduced winter snowpack

Role of Forests in Climate and Human Health



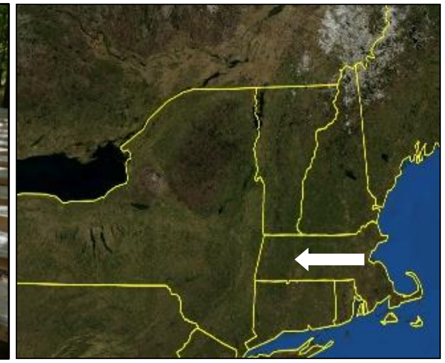
- Climate Mitigation
  CO_2 uptake by ecosystems around the globe offset 30% human emissions of CO_2
- Climate Adaptation
  Trees cool temperatures and improve air and water quality
- Threats to Forest Health
  - Water stress
  - Extreme weather events
  - Air pollution
  - Land-use change
  - Smaller snowpack

Experiments We Conduct

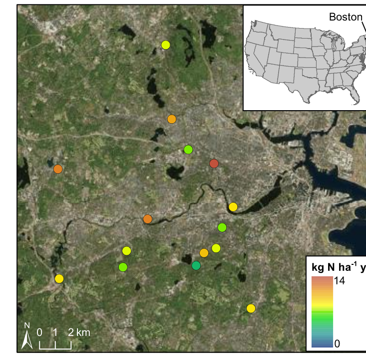
Warm forests

Create droughts

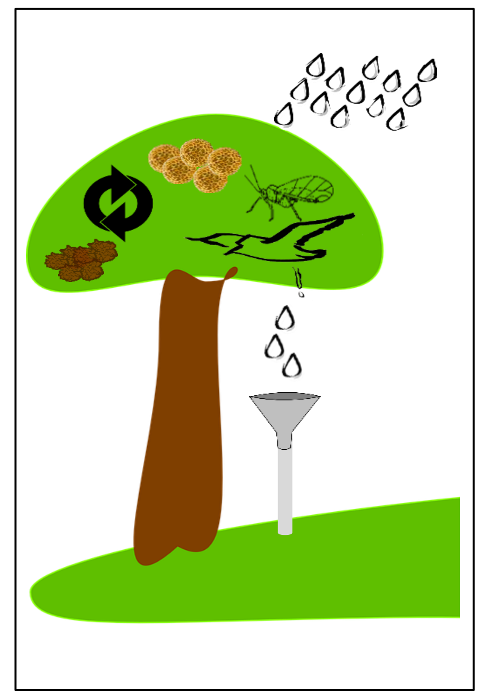
Urbanization



Sample cities

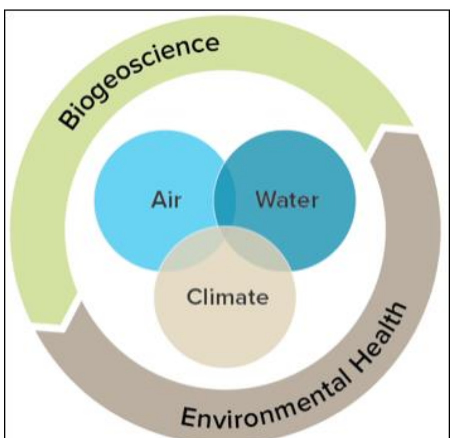


Measurements We Make



Education and Science-Policy Integration

Train Ph.D. students in Biogeoscience, Environmental Health, Statistics to work with policy-makers, non-governmental organizations, and private sector to solve urban environmental challenges



YOUTH ENVIRONMENTAL ALLIANCE IN HIGHER EDUCATION

Connects multiple universities around the globe to empower students to address global environmental problems

sites.bu.edu/urban

ptempler@bu.edu

yeah-net.org

Technology Adoption as Climate Adaptation: Evidence from US Air Conditioning*

Ian Sue Wing

Professor

Dept. of Earth & Environment, CAS

Collaborative research with Erin Mansur, Dartmouth College

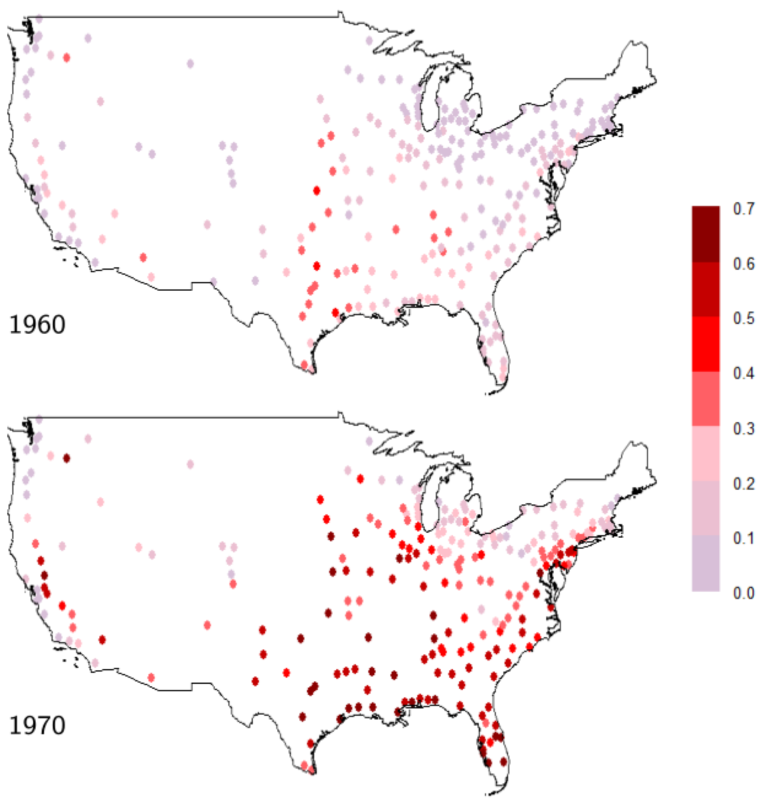

TRAVEL INFORMATION & RESERVATION OFFICE, CONN
JAKSON
SilentPower
Kelvin

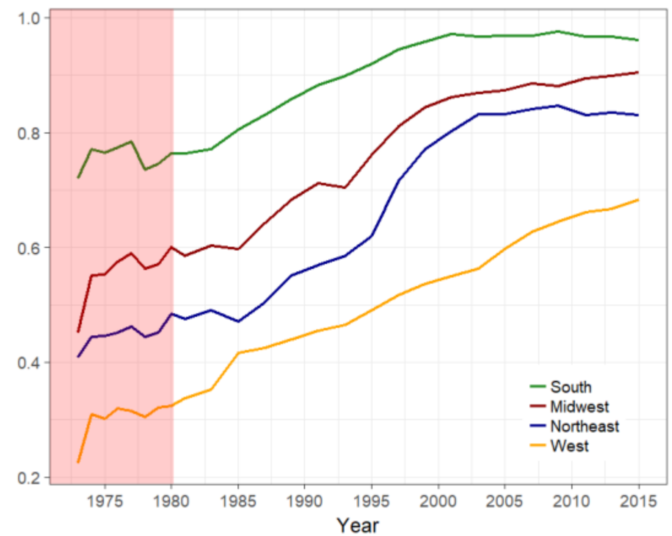
Extensive Margin Adaptation to Heat: AC Adoption and Utilization

- Climate change ⇒ energy system impacts via investment in space conditioning capital (especially air conditioners) + concomitant shifts in energy consumption (especially electricity) via Δ utilization of heating/cooling capital stocks.
- ↑ penetration of AC in developing countries, especially in the tropics where extreme high temperature exposures are projected to increase substantially (IEA 2009; Davis and Gertler, 2015; Davis et al, 2021), inducing large increases in electricity consumption (Van Ruijven, 2019)
- What is the risk of a positive feedback from adaptation to energy use, and warming? Answers require understanding of the joint decisions to adopt AC and consume electricity to maintain thermal comfort.1960, ’70 and ’80 US Census waves provide a rare observational opportunity!
- Implications of US historical experience for AC adoption and energy use as adaptation to climate warming—especially in developing countries in the tropics

Latitudinal (Climatic) Gradient of Historical AC Adoption

1930-60 AC penetration was primarily driven by factors other than temperature—income, education and electricity prices in the commercial sector (Biddle, 2011), and housing policies that helped create markets for residential AC (Ackermann, 2002).





Annual Housing Survey/American Housing Survey

1960	1970	1980
12.6%	35.8%	58.5%

(Biddle, 2008)

Urban Residents' Joint AC Adoption and Cooling Electricity Use Decisions

AC adoption and electricity demand amplification, household j in SMSA $s(j)$ and decade t

$$\mathbb{E}\{\Pr AC_{j,t}\} = \delta ACshare_{s(j),t-1} + \mathcal{F}(\overline{DD}_{s(j),t}; \beta^K) + controls \quad (1a)$$

$$\mathbb{E}\{\ln Q_{j,t}\} = \eta AC_{j,t} + \mathcal{F}(AC_{j,t} \times DD_{s(j),t}; \psi^Q) + \mathcal{F}(DD_{s(j),t}; \theta^Q) + controls \quad (1b)$$

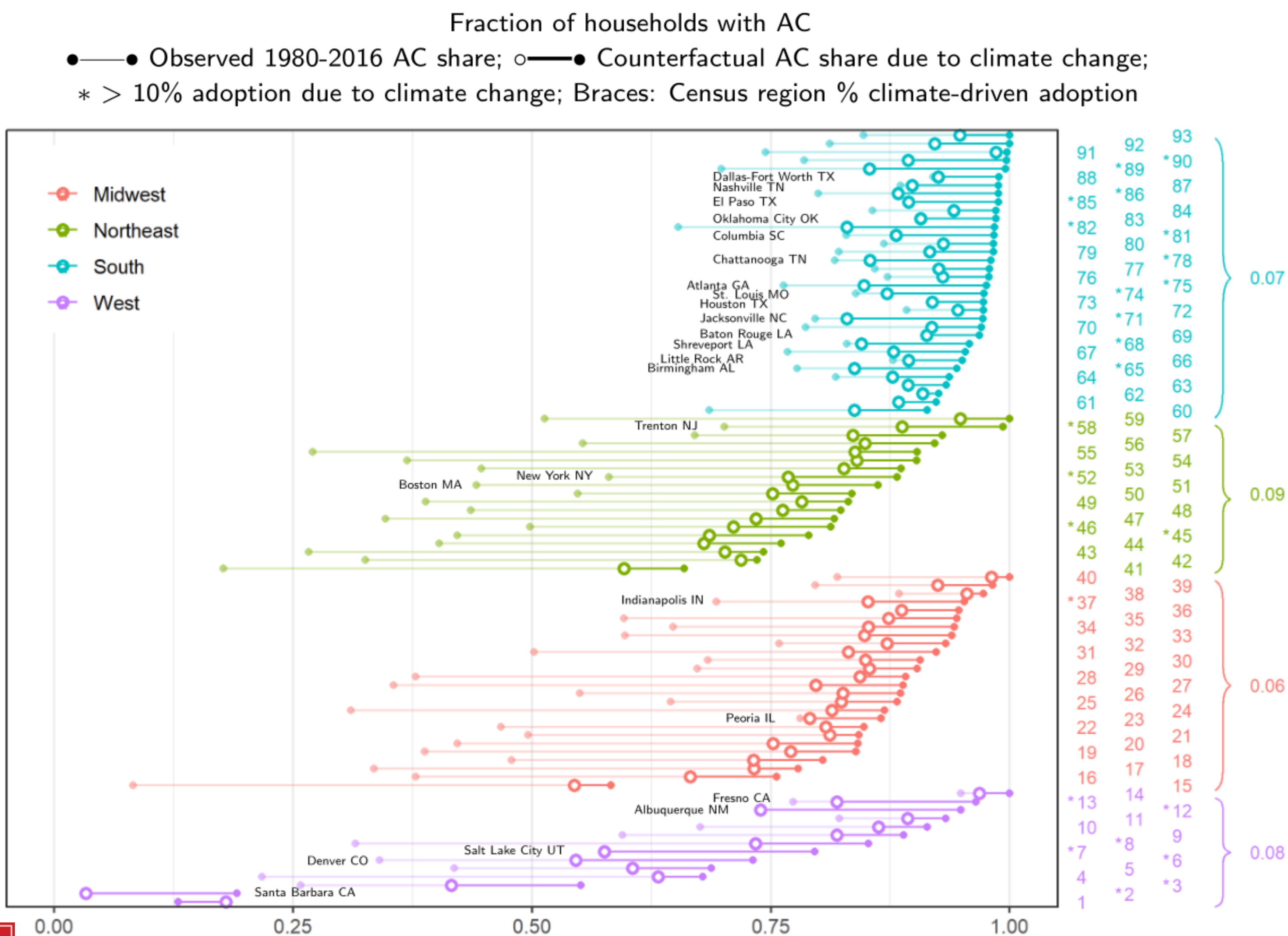
3 million households in 251 cities from 1970 and 1980 Census public use microsamples

- ACshare = share of households in county i or SMSA s with air conditioning of any kind
- AC = dummy indicating whether household j has air conditioning of any kind
- Q = annual houshold electricity consumption (MWh)
- Demographic controls: household size, race, income, telephone/vehicles available
- House characteristics controls: age, number of rooms
- Instrument for AC in eq. (1b) using SMSA lagged adoption

NASA GLDAS2 0.25-degree gridded 3h temperature fields:

- $\overline{DD} = \{\overline{HDD}, \overline{CDD}\}$ prior decade annual average heating and cooling degree days (climate)
- $DD = \{HDD, CDD\}$ current year heating and cooling degree days (weather)

Historical Warming Drives One-Third of 1980-2016 AC Adoption



Boston University Office of Research

Climate Change Impacts Across Cities

Combine estimated responses to SMSAs' contemporaneous, decadal CDDs with projections from Petri and Caldeira (2015).

AC Penetration

- 1-sd increase relative to 1980 mean decadal CDDs (1,058 → 1,906 degree days) ⇒ 37% more AC adoption
- 1981-2010 to 2080-2099, RCP 8.5: Boston MA climate shifts from 1980 New York NY to 1980 Jacksonville NC (500 → 1,700 degree days) ⇒ 50% higher AC penetration

Electricity Use

- Electricity demand amplification negligible < 1,000 degree days, increases linearly with larger heat exposures ⇒ >50% of intensive-margin adjustment in energy consumption in the hottest cities where AC penetration saturates
- 1981-2010 to 2080-2099, RCP 8.5: Chicago IL climate shifts from 1980 New York NY to 1980 El Paso, TX (680 → 2,060 degree days) ⇒ 60% increase in AC penetration, 4 x extensive margin consumption, 2 x total electricity use

Acknowledgements

Financial Support

Frederick L. Pardee Center for the Study of the Longer Range Future, Boston University

National Science Foundation Network for Sustainable Climate Risk Management (SCRiM), cooperative agreement GEO-1240507

US Dept. of Energy Office of Science, Biological and Environmental Research Program, Earth and Environmental Systems Modeling, MultiSector Dynamics, contract no. DE-SC0016162

Climate Change Disinformation Susceptibility: A Typology of Disinformation-Susceptible Publics

Arunima Krishna, PhD

Assistant Professor
Department of Mass Communication, Advertising, and Public Relations
College of Communication
@ArunimaKPhD

Identifying Disinformation-Susceptible Publics

- Situational motivation in problem solving
- Negative attitudes
- Knowledge deficiency → prior acceptance of disinformation messages

Classifying Publics

- Situational motivation → High (score of 1), Low (score of 0)
- Extreme attitudes → High (score of 1), Low (score of 0)
- Knowledge deficiency → High (score of 1), Low (score of 0)

Respondent No.	Motivation	Attitude	Knowledge
1	0	1	1
2	1	1	1
3	1	0	0
4	1	0	1
5	0	0	1

	Low Knowledge Deficiency		High Knowledge Deficiency	
Situational Motivation	**Low Extreme Attitude**	**High Extreme Attitude**	**Low Extreme Attitude**	**High Extreme Attitude**
Low	LLL	LHL	LLH	LHH
High	HLL	HHL	HLH	HHH

Disinformation-Amplifying Publics

Disinformation-Receptive Publics

Disinformation-Vulnerable Publics

Disinformation-Immune Publics

	Low Knowledge Deficiency		High Knowledge Deficiency	
Situational Motivation	Low Extreme Attitude	High Extreme Attitude	Low Extreme Attitude	High Extreme Attitude
Low	84	21	49	228
High	178	18	30	21

Disinformation-Amplifying Publics

Disinformation-Receptive Publics

Disinformation-Vulnerable Publics

Disinformation-Immune Publics

Heat and Learning

Joshua Goodman

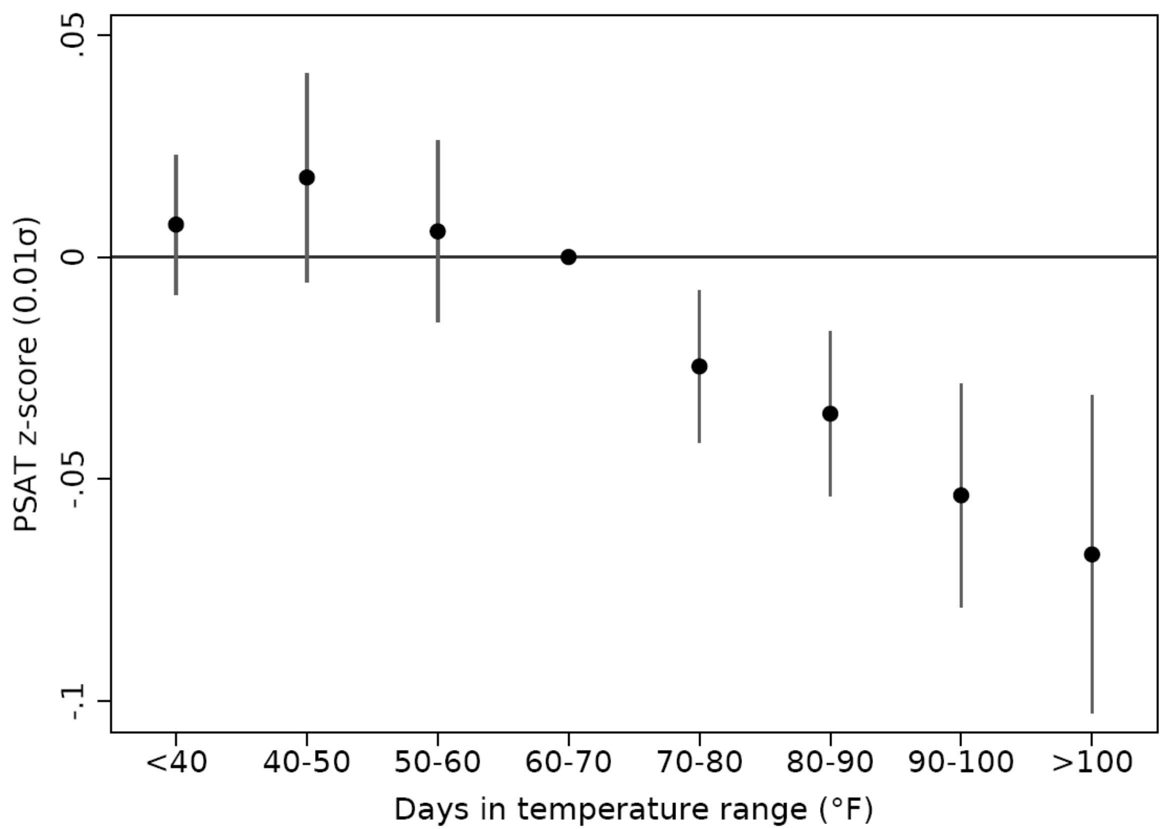
Associate Professor
Wheelock College of Education | Department of Economics

How does heat affect students?

- We know that heat makes it harder to concentrate, so that taking a test on a hot day results in a lower score.
- But does heat have longer lasting effects? Does it interfere with learning?
- Whether heat affects learning has implications for climate change's impact on economic growth, which heavily depends on human capital.
- Comparing students more and less exposed to heat doesn't identify causal effects because hot areas differ in all sorts of ways than cool areas. So we:
    1. Compare 10 million PSAT retakers to themselves over time
    2. Compare all U.S. school districts and all PISA-taking countries to themselves over time
- We estimate how the same student/district/country performs after the prior school year is hot vs. cool.

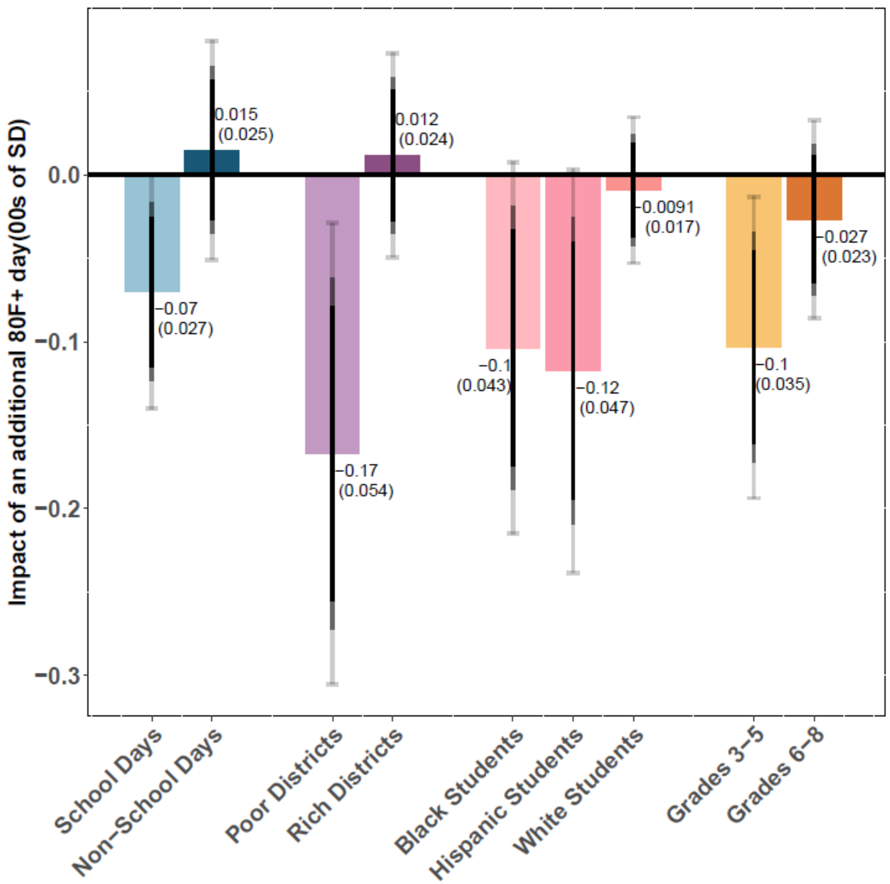
U.S. high schoolers

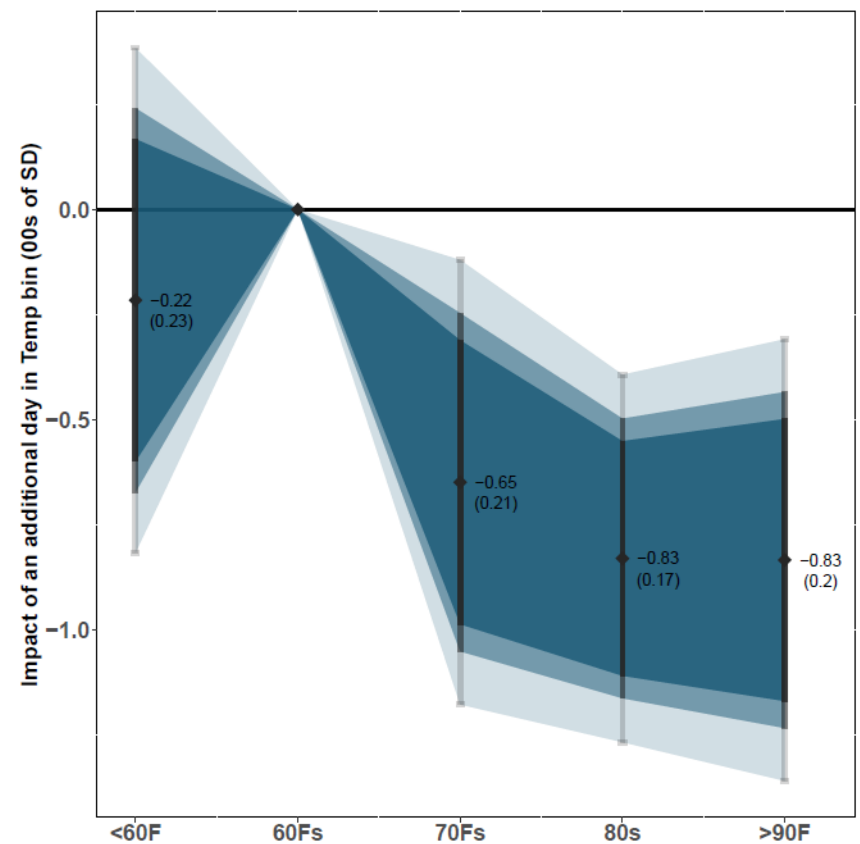
- PSAT retakers score worse on the take preceded by a hotter school year.
- **Extreme heat is worse than moderate heat**, with effects increasing linearly with temperature above 70F and no clear effect of cold.
- **Only heat on school days matters**, not weekends or summer heat.



All U.S. 3rd-8th graders, plus other countries

- Left: Hot school years lower scores of younger U.S. students, **moreso for Black, Hispanic and low income ones** (consistent with PSAT data).
- Right: Same patterns holds internationally, with countries doing worse than themselves following school years that are unusually hot.





Mechanisms and policy responses

- Evidence is consistent with heat reducing efficacy of learning time via **physiological impacts** on students/teachers, making it harder to focus.
- We also show **school air conditioning** appears to mitigate these effects.
- Heat's impact is most negative for students with the fewest school- and home-based resources for **adapting to temperature shocks**.
- Hot school days account for about **5% of the racial achievement gap**.
- Investing in **school infrastructure** likely improves equity and has positive social benefits given the returns to improved human capital.
- References:

  - Park, R. Jisung, Joshua Goodman, Michael Hurwitz, and Jonathan Smith. 2020. "Heat and learning." *American Economic Journal: Economic Policy* 12(2): 306-39.
  - Park, R. Jisung, A. Patrick Behrer, and Joshua Goodman. 2021. "Learning is inhibited by heat exposure, both internationally and within the United States." *Nature Human Behaviour* 5(1): 19-27.

Who Is BU GLOBE Mission Earth?

Peter Garik

Clinical Associate Professor

Science Education, Wheelock

GME Collaborators:

Bruce Anderson, Earth and Environment, CAS

Donald DeRosa, Science Education, Wheelock

Caleb Farny, Mechanical Engineering, ENG

Sara Feit, Science Education, Wheelock

Funded by NASA Science Activation 2016 - 2025

BU GLOBE Mission Earth: Overview and Purpose

- Introduce GLOBE and NASA Learning Assets in Grades K-16
- Engage students in Citizen Science
- Engage students in place-based research
- Students may present in Science Research Symposia
- Emphasis on high need school districts

What Is GLOBE?

GLOBE = Global Learning and Observations to Benefit the Environment

- International science education program
- Provides students and the public worldwide with the opportunity to participate in data collection and the scientific process
- Encourages meaningful contributions to our understanding of the Earth system and global environment.

126 Countries

37,929 Schools

42,369 Teachers

2,826,276
Measurements this month

Why NASA?

- NASA needs satellite verification from ground up, not just space down, as well as answers to questions about the four spheres (atmosphere, biosphere, hydrosphere, geosphere) not addressable from space.
- Citizen Science with GLOBE Observer, and student projects, addresses this need.
  - Cloud Challenges
  - Trees Challenges
  - Mosquito Habitat Mapper
  - Land Cover Mapping
  - Phenology
  - Water Quality

A Challenge is a call for citizen scientists to collect data of a particular type or in a particular place (or series of places).

Where We Work and What We Do

Where we work:

- Providence Public Schools District
- Greater Boston region schools

What we do:

- Facilitate professional development workshops
- Co-plan/teach in schools
- Provide equipment
- Organize Science Research Symposia
- Create engineering design projects

With whom do we collaborate:

- Collaborating with the URBAN Project to bring doctoral trainees into schools as mentoring subject matter experts.
- Nationally work with NASA Langley Research Center, University of Toledo, Tennessee State University (HBCU), and WestEd/Berkeley.

Looking Forward

Goals for Collaborating with Other BU Investigators and Educators

- BU GME encourages place-based research by students. This has overlap with public health research.
- BU GME works to connect Citizen Science with stewardship of the Earth.
- BU GME plans more work in the BPS and Greater Boston school districts.
- BU GME wants to exploit BU's resources with faculty and students as subject matter experts for K-12 education.

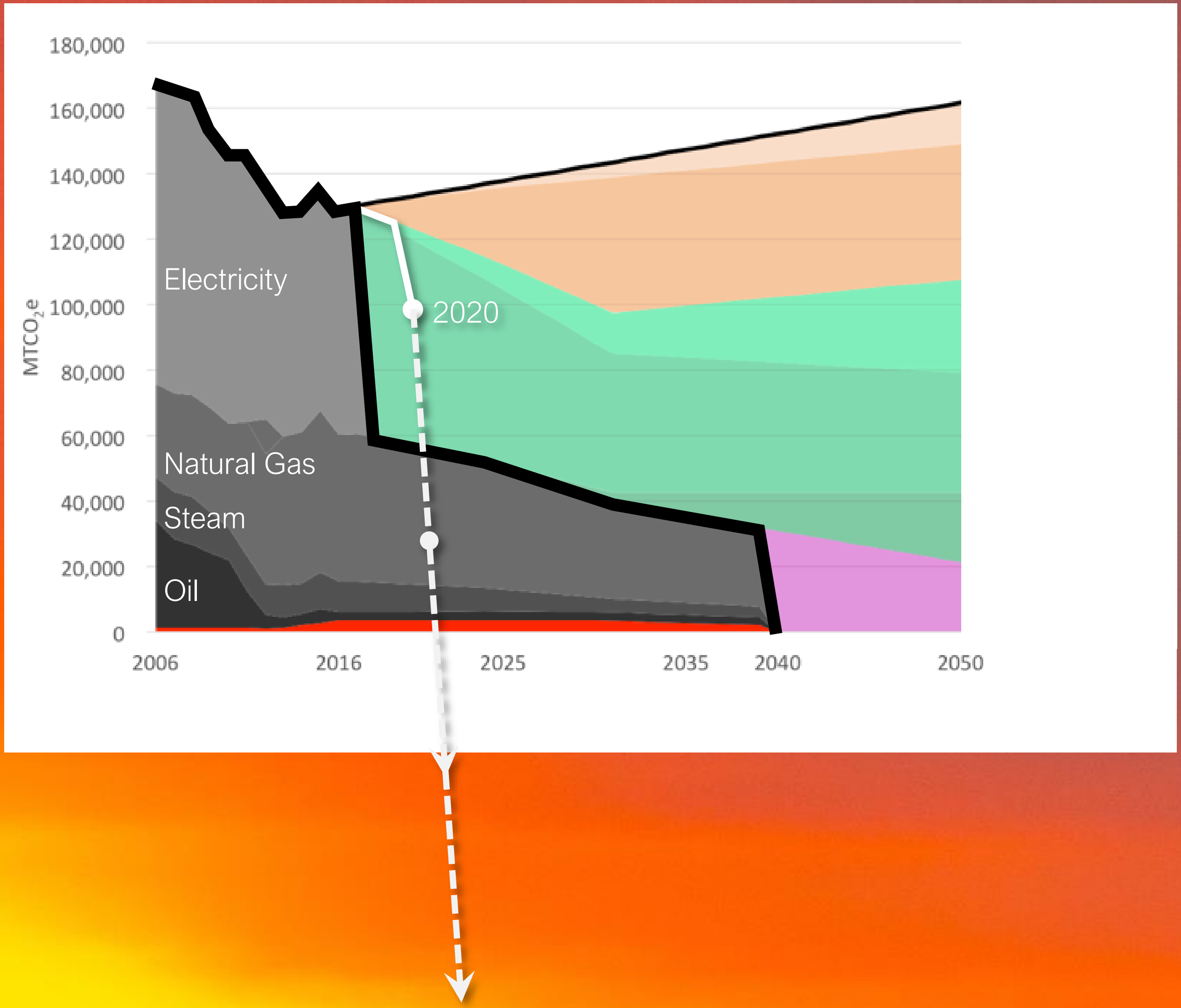
Climate, Health, & Market Transformation

Maximizing the Benefits of Renewable Energy Procurement

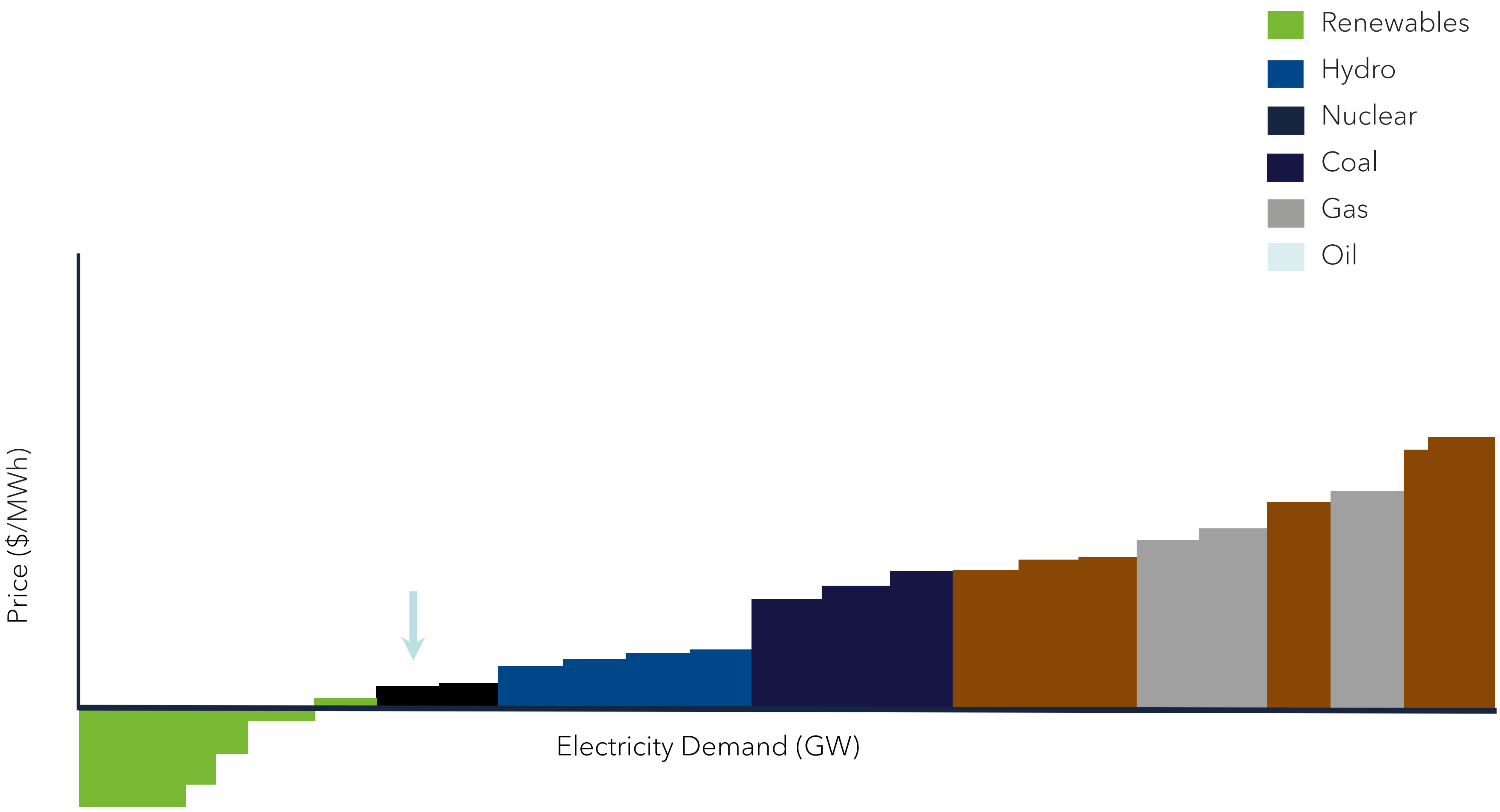
Dennis Carlberg, AIA, LEED AP BD+C

Associate Vice President for Sustainability
BU Sustainability
Adjunct Assistant Professor
Department of Earth & Environment

BU Wind


180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
MTCO2e
Electricity
Natural Gas
Steam
Oil
2020
2006
2016
2025
2035
2040
2050

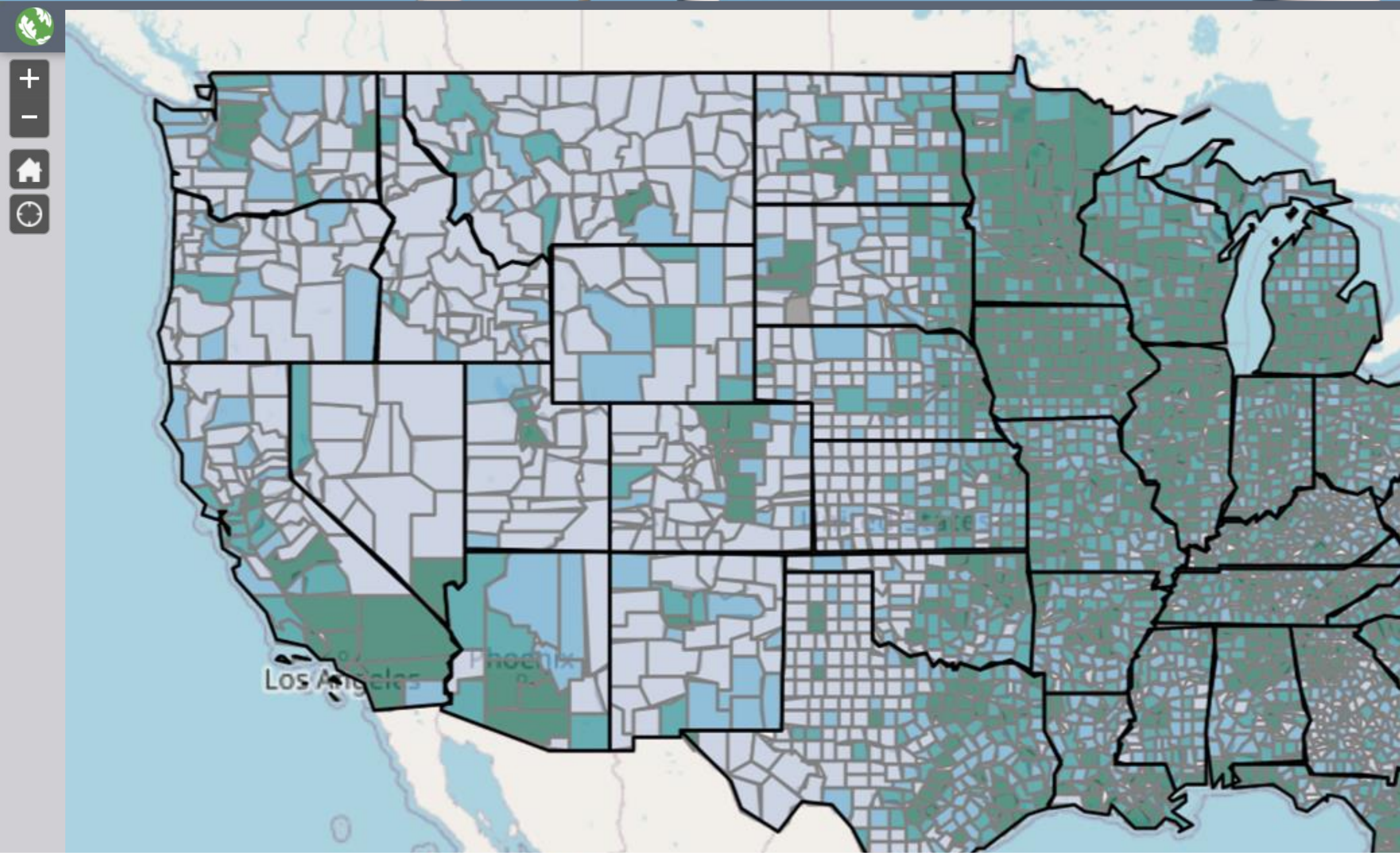
Marginal Emissions Analysis



BU Wind Criteria

- **Match 100% of University's Electricity Demand**
- **Impact, New Build (Additionality)**
- **Maximize GHG Reduction (CO_2e lb/MWh)**
- **Project Economics (strong NPV/MWh)**
- **Green-e Certified RECs**
- **Education & Research Opportunities**
- **Environmental & Health Co-benefits**
- **24/7 Carbon Free Electricity**
- **Data-driven Environmental & Health Co-benefits**

Emerging Tools



The EPA COBRA & AVERT tools

Q&A

UPCOMING EVENTS

Learn more & RSVP: bu.edu/research/events
Topic ideas & feedback: bu.edu/research/topic-ideas

RESEARCH ON TAP

Health Misinformation: How it Affects Society and How We Can Deal With It
February 10, 2022 | 4-5:30 pm

RESEARCH HOW-TO

The Lab to Market Transition: Lessons from Faculty, Students, and Other Research Staff
February 16, 2022 | 4-5:15 pm

A Deeper Dive into SciVal: Data and Metrics
March 15, 2022 | 1-2:30 pm