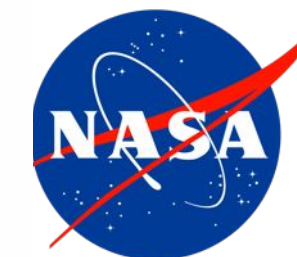# A Remote Sensing Analysis of Heat Stress, LCLUC, and Women's Health in Sub-Saharan Africa

**May 9, 2023**
**NASA LCLUC Science Team Meeting 2023**

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School of Public Policy, University of Connecticut

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Dept. of Earth Sciences, Montana State University

# This work is supported by …

| Nina Brooks | Principal Investigator | University of Connecticut , Hartford , USA |
|---|---|---|
| Cascade Tuholske | Co-Investigator | Montana State University, Bozeman, USA |
| Chris Funk | Collaborator | University of California, Santa Barbara , USA |
| Kathryn Grace | Collaborator | University of Minnesota, Minneapolis, USA |
| Kwaw Andam | Collaborator | International Food Policy Research Institute , Abuja, Nigeria |
| Shraddhanand Shukla | Collaborator | University of California, Santa Barbara , USA |
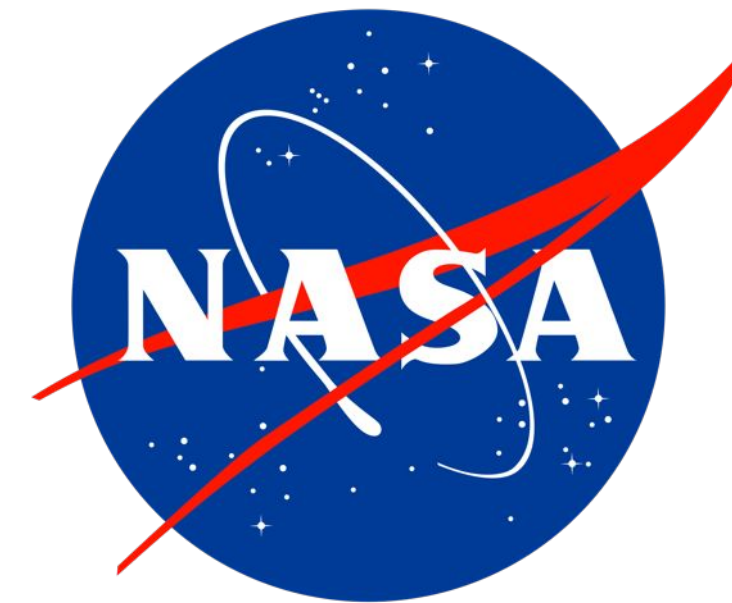
# Plan for Today

- Who I am (briefly).

- Research Objectives.

- Preliminary Results

- New Collaborations

- Questions

# Who I am

- Missoula, Montana native.

- Climate change has been an existential personal crises since I was 12.

- BA International Affairs (2010), The George Washington University.

- Bad at political organizing. Also bad at international development. **But enjoy teaching.**

- PhD (2020) + MA (2016) Geography, University of California, Santa Barbara.

- Earth Institute Postdoc, Columbia University

- Assistant Professor, Montana State University

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## Outside

Q ≡

## Watching My Dad Die Changed My Life

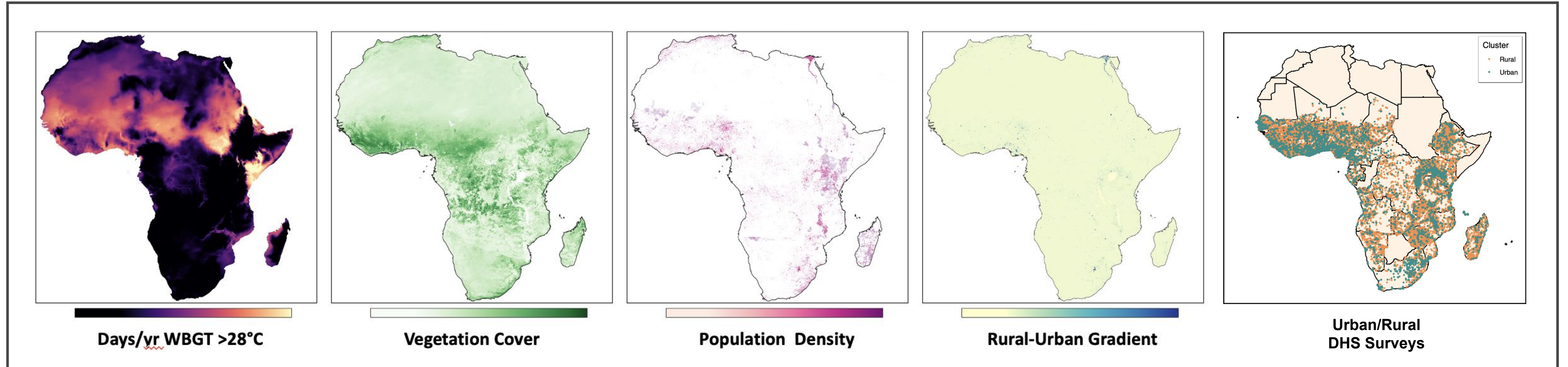I study climate change, and my work left me depressed and suicidal. Then my dad got cancer.

**Cascade Tuholske**

May 20, 2021



A fine day in Montana, January 1 2021

IFPRI · NASA · UCONN UNIVERSITY OF CONNECTICUT · MONTANA STATE UNIVERSITY

# Research Objectives



Days/yr WBGT >28°C · Vegetation Cover · Population Density · Rural-Urban Gradient · Urban/Rural DHS Surveys

1. Measure and map changes in extreme heat event characteristics and exposure

2. Identify interactions hotspots between extreme heat events characteristics exposure, and LCLUC

3. Quantify the impacts of heat-stress and LCLUC on maternal reproductive and child health

4. Conduct a High-Resolution Case Study for Nigeria

# Obj 1 - Measure and map changes in extreme heat event characteristics and exposure

**Data advancements**

- CHIRTS-daily most accurate, high-resolution (0.05°) daily temperature record from which we can measure changes in duration, frequency, and intensity of both hot-humid and hot-dry extreme heat events from 1983 - 2016.

- Long term Global Land Change (0.05°) measures annual fractional land cover for tree canopy, short vegetation, and bare ground from 1982 - 2016 using the AVHRR satellite record.

- Global Human Settlement Layer SMOD and Pop datasets provide settlement type and populations for 1975, 1990, 2000, and 2015.

**Research advancements**

- Map how hot-humid and hot-dry heat waves varied by land cover and demographic change across Africa.

# Obj 2 - Map interactions hotspots between extreme heat exposure and LCLUC

**Methodological advancements**

- Apply & compare standard approaches and **machine learning** approaches to identifying LCLUC-heat hotspots

- Explore different **spatial & temporal scales for identifying hotspots**, given the long time series of the data

**Research advancements**

- Link hotspots to maternal reproductive and child health outcomes to see how "hotspot" areas fare compared to "average" areas.

# Obj 3 - Assess the impacts of heat-stress and LCLUC on maternal reproductive and child health

**Research advancements**

- Extreme LCLUC humid-heat impacts on child health & pregnancy outcomes (e.g., infant mortality, stunting/wasting, and birthweight)

- Emphasis on (stated) fertility intentions and fertility control (via contraceptive use)

- Examination of **cumulative shocks/repeated exposures** and maternal reproductive and child health outcomes

# Obj 4 - Conduct a High-Resolution Case Study for Nigeria

**Data Advancements**

- From a remote-sensing standpoint, the Africa-wide LCLUC-heat-population analysis is coarse-grained.

- Leverage higher-resolution LCLUC processes (Landsat, Worldview, PlanetScope etc.) to construct a high-res dataset of heat and LCLUC

**Research advancements**

- A 5 x 5 km pixel may have the same LCLUC-heat-population dynamics. But the **sub-pixel LCLUC dynamics may be heterogeneous**.

- For example, examine how increased irrigation practices correlate with long-term increases in hot-humid heat & how this relates to maternal/child health outcomes in Nigeria
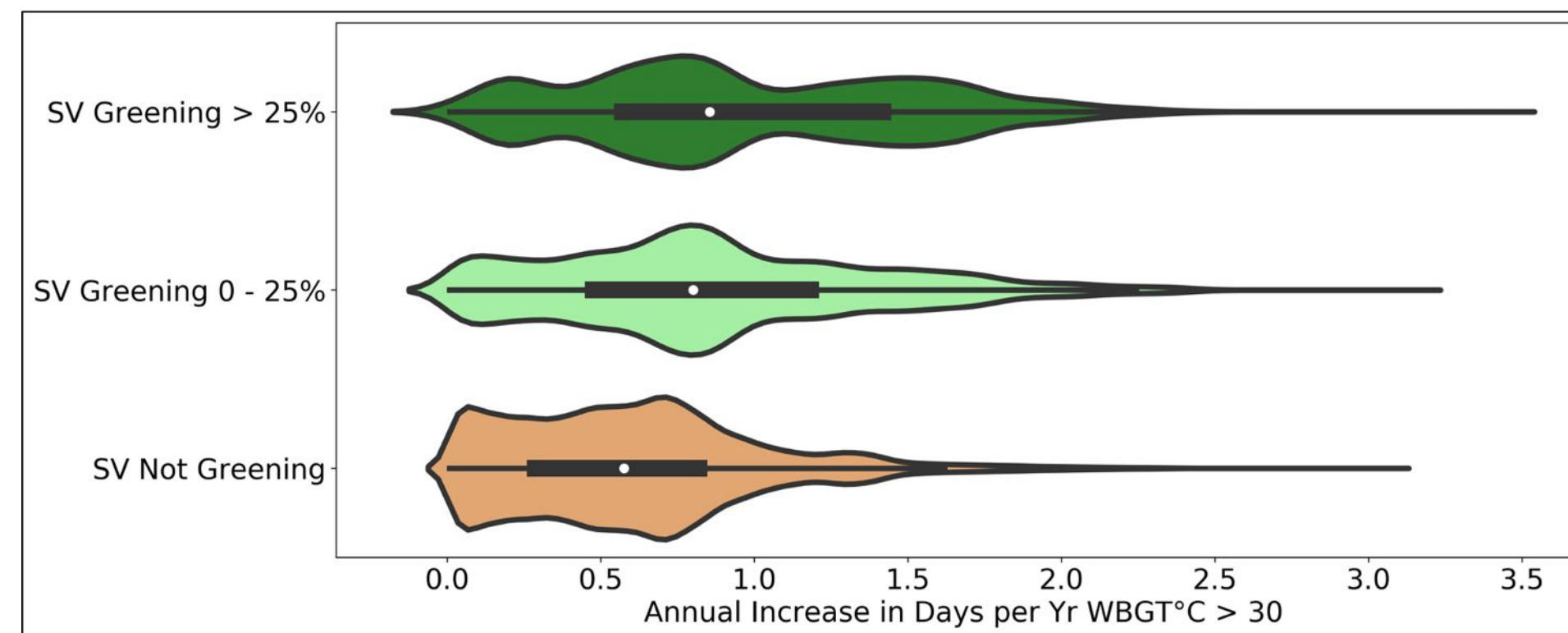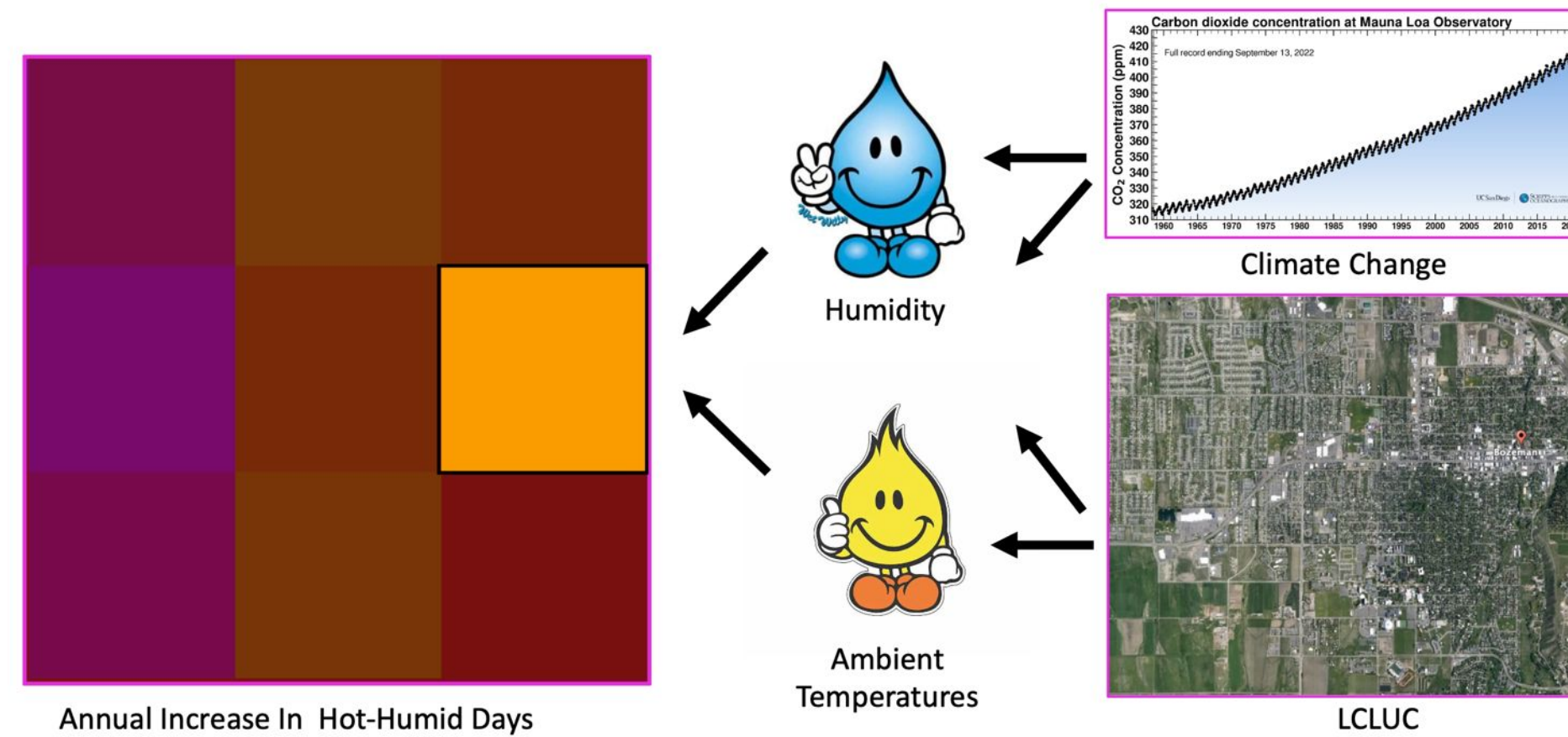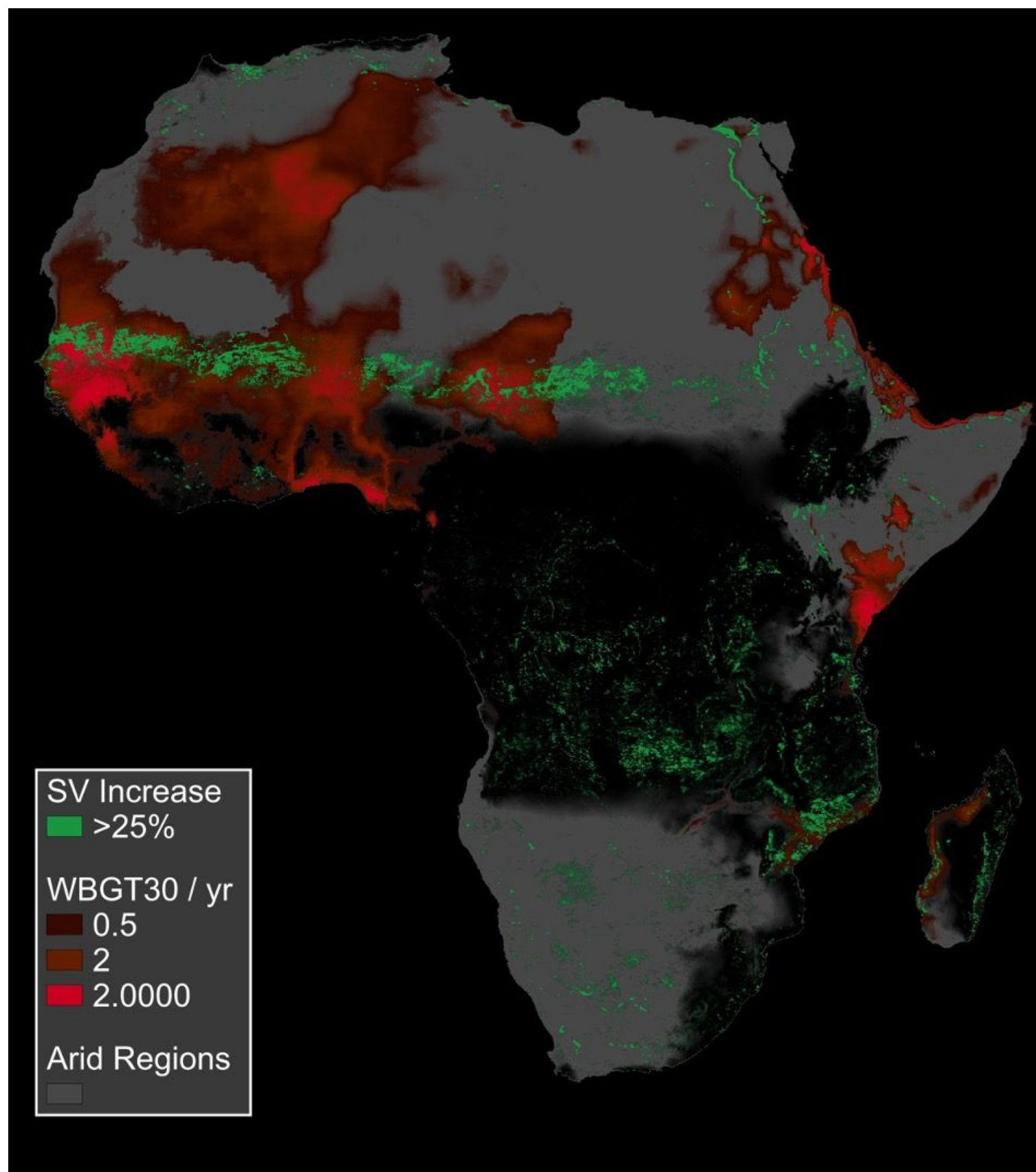
# Obj 1 – Preliminary Results

Days per year WBGTmax > 28°C, 1983
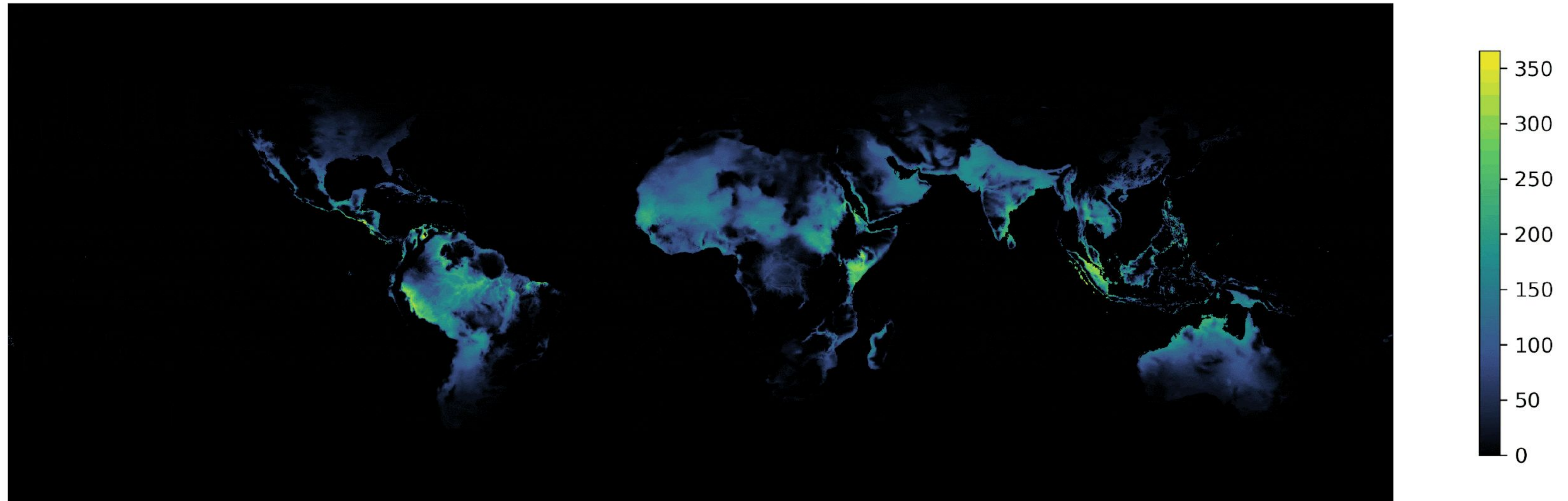


- Observational annual count of dangerous WBGTmax days to be released by **NASA SEDAC**

- CHC-CMIP6 projections: High-resolution (°0.05) **humid-heat projections for 2030 and 2050** based on CHIRTS-daily and CMIP-6 SSP245 and SSP585.

- Led by **Emily Williams** at UCSB Climate Hazards Center.

# Obj 1 & 2 – Preliminary Results



- What is the relationship between the "**Great Green Wall**" and changes in humid-heat extremes in the African Sahel?

- Preliminary findings show that **extreme humid-heat is increasing fastest is areas that are greening in the Sahel.**

- This may be due to **added atmospheric moisture from vegetation** in a normally dry land region.

- Findings indicate that the **Great Green Wall may not be a pathway to poverty reduction.**

# Obj 1 & 2 – Preliminary Results

- We now know approximately how many people live in cities, but we don't know much about **urban demographic structure**.

- Understanding urban demographics can help us better plan for exposure to **climate hazards**, economic productivity, understand political instability, sustainable development, etc.

- Map dependency ratio across urban settlements: (1) available labor; (2) **"dangerous" men problem**; (3) low tax base, etc.

- Work led by **Andrew Zimmer**, MSU Postdoc with Earth Sciences & new **GeoSpatial Core Facility**.
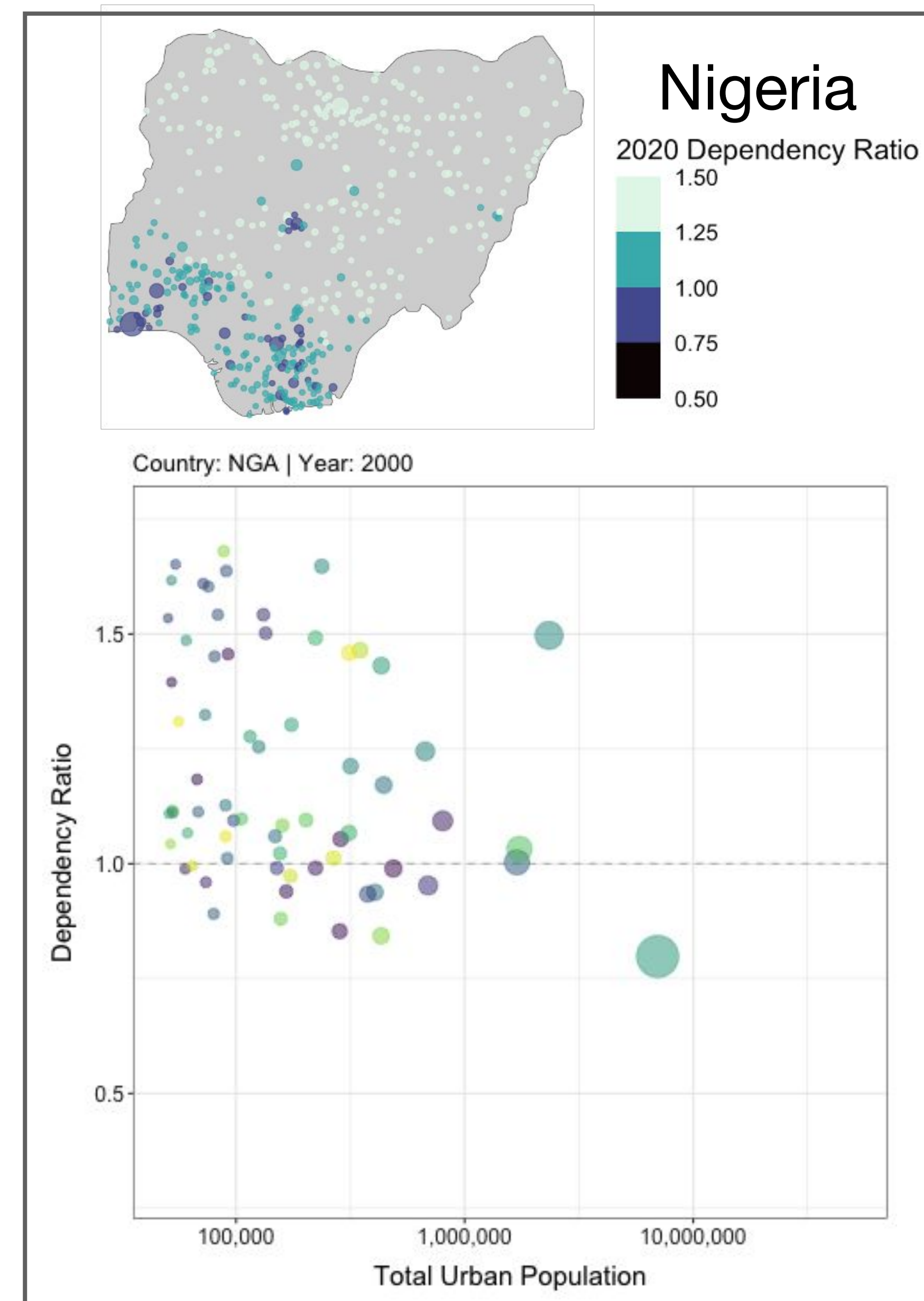


Data: Worldpop & EU JRC

# Obj 3 & 4 – Preliminary Results

- Assess humid-heat and LCLUC on fertility outcomes: pregnancies, births, terminations, and contraceptive.

- Using six waves of Demographic Health Surveys for Nigeria and will expand analysis to all of sub-Saharan Africa with DHS surveys.

- **Spatial clustering ("hot-spots") of humid-heat and parity.**

- **Association between pregnancy loss & humid heat.**

- Work assisted by **Katie McMahon**, geography graduate student at UC Santa Barbara.
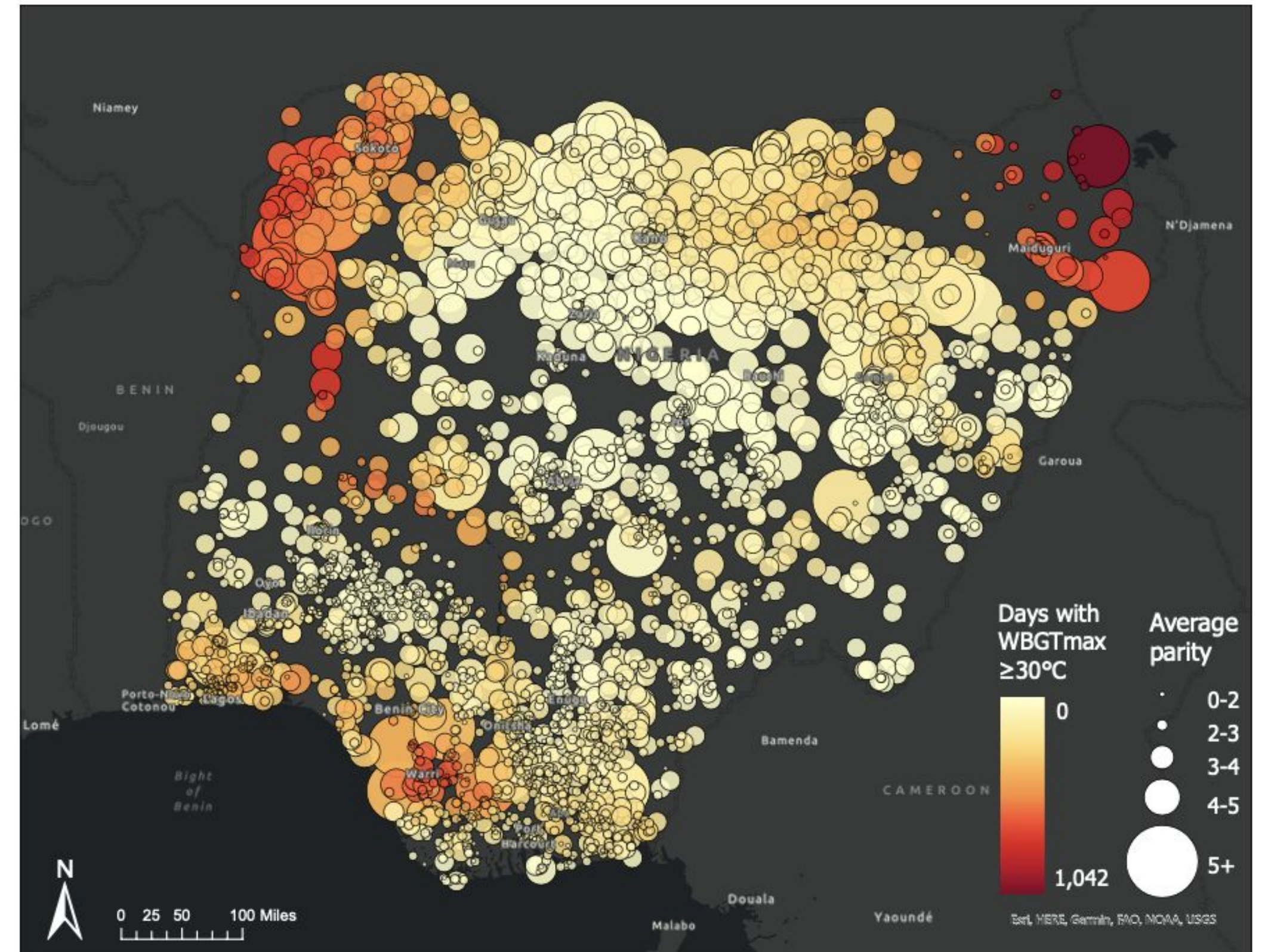


(b) Long-run extreme humid heat exposure and average parity, by DHS cluster. Symbol color corresponds to the number of days during the 10-year period preceding the DHS survey for which WBGTmax exceeded 30°C. Symbol size corresponds to average parity (the number of births by a single mother) of a given DHS cluster at the time of survey.

# New Collaborations

- Now collaborating with NIH-funded team at the **Kintampo Health Research Centre (KHRC)**, Mount Sinai, and Columbia University's Mailman School of Public Health.

- Ghana Randomized Air Pollution and Health Study (GRAPHS): **unique Pregnancy cohort (n=1414 pregnancies)** recruited in 2013 with active, mother-child longitudinal follow-up through age 13.

- We are now working with GRAPHS Team to use both LCLUC & humid-heat.

- Figure by **Aalekhya Reddam,** postdoc at Columbia University.
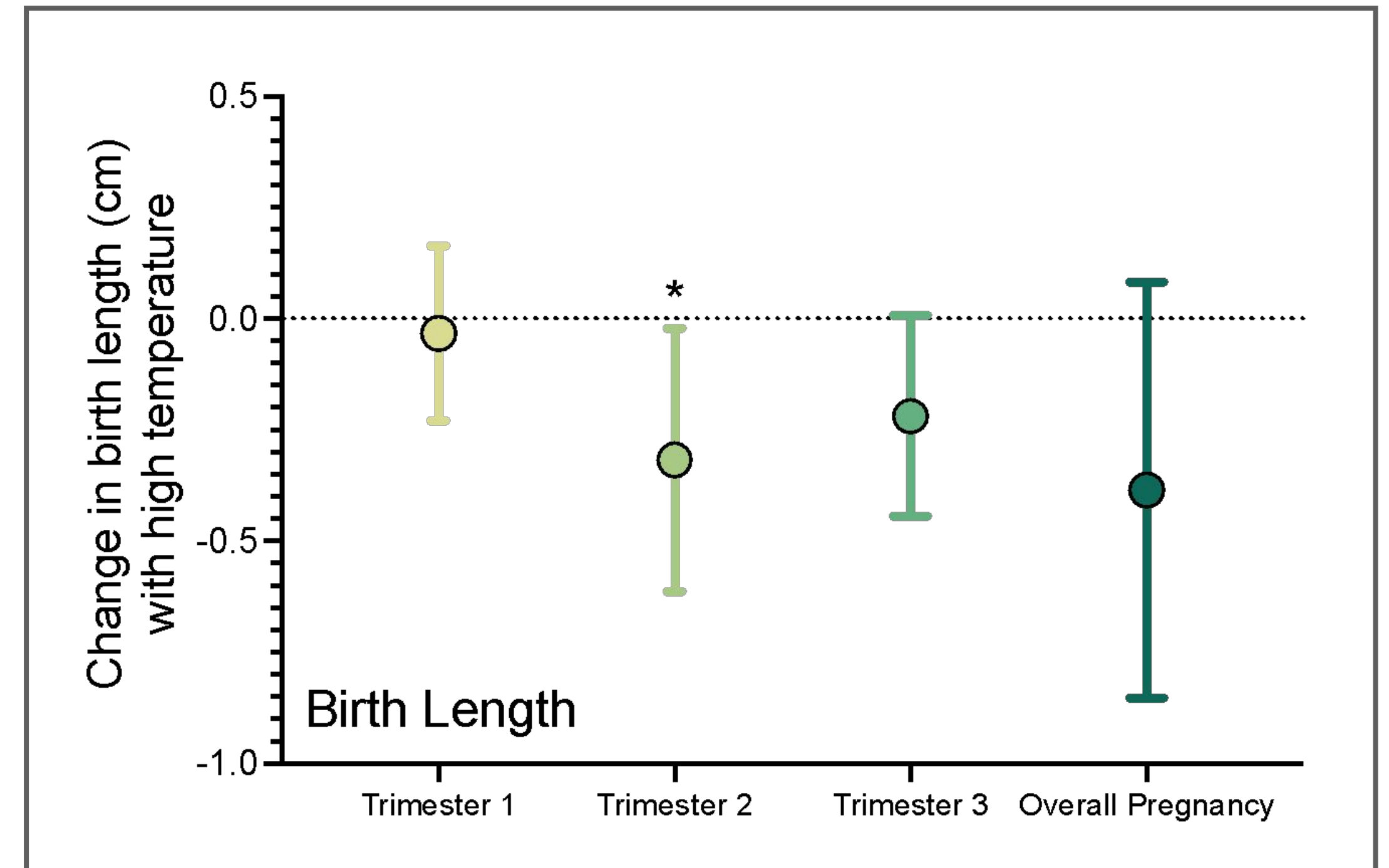
# THANK YOU!
# QUESTIONS?

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